The Black Box ToolKit v2

User Guide

Credits:

Author: Dr. Richard R. Plant, C.Psychol, CSci, AFBPsS

Covers the following hardware:

The Black Box ToolKit v2
BBTK Opto-detectors
BBTK Digital Microphones
BBTK Digital Sounders
BBTK Breakout Board
BBTK 16 Channel TTLe Expansion Board
BBTK Response Pad

For the following platforms:

Microsoft Windows XP SP3, Vista SP2 (x32/x64), Windows 7 SP1 (x32/x64)
Windows 8 (x32/x64), Windows 8.1 (x32/x64) & Windows 10 (x32/x64)

Contact details:

The Black Box ToolKit Ltd
PO Box 3802
Sheffield
S25 9AG
UK

Phone: +44 (0)114 303 00 56
Fax: +44 (0)114 303 46 56

Email: info@blackboxtoolkit.com
support@blackboxtoolkit.com
sales@blackboxtoolkit.com

Web: www.blackboxtoolkit.com

Contents

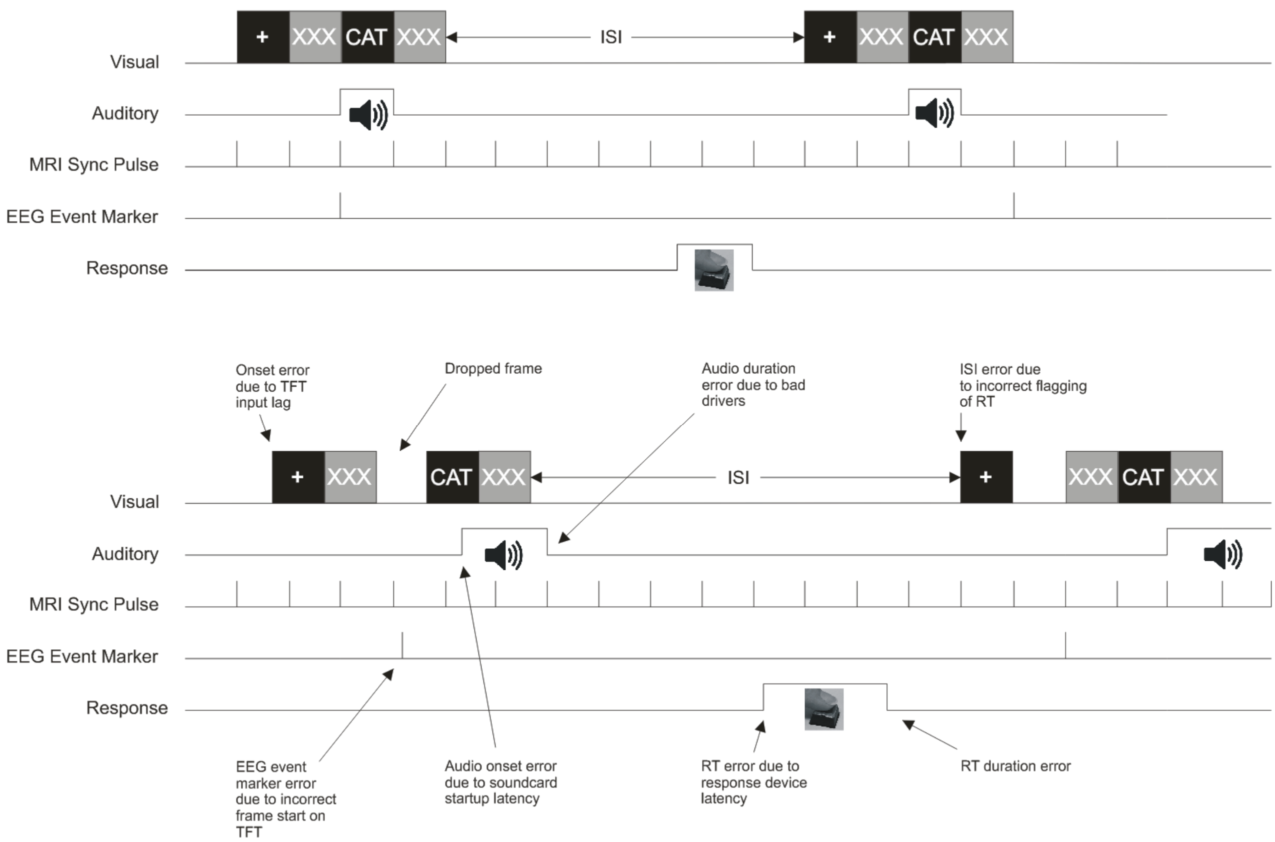
1. Introduction

1.1 Background

Computers, whilst ramping-up in terms of clock speed, are actually no more accurate than those of a decade ago. In fact quite the reverse can be true with today's modern multi-tasking operating systems. Even if you make use of a recognised experiment generator, there is little assurance that your stimulus and response timings are "millisecond accurate". Many packages promise to achieve "millisecond precision". Unfortunately there is a subtle, yet important, difference between "accuracy" and "precision". Millisecond precision simply means that timings are reported in units of a millisecond – there is no assurance that the actual timings are accurate!

By using the Black Box ToolKit v2™, or BBTK™ for short, you can check the presentation and response timing accuracy of the majority of paradigms in use today. If you are measuring presentation or response events in units of a millisecond, you should be using the toolkit as a matter of course.

Achieving the best possible stimulus display timing is becoming more important as researchers push the envelope with the types of studies they run and data they collect. Synchrony between visual and auditory materials for example is often prone to larger variation than many researchers acknowledge. Response timing can also be affected adversely. The mere act of swapping one response device for another can statistically alter your results. This is a proven fact – what's more, without checking you would never know! Typical sources of error over the idealised conceptual experimental model are shown below for a simple priming study.



Within any study that has not already been "calibrated" using the Black Box ToolKit there is almost guaranteed to be one or more sources of uncontrolled timing error; be this within presentation or response timing or between various pieces of external equipment, e.g. EEG, MRI, Eye Trackers etc. Such error can adversely effect statistical power, introduce conditional bias, make replication difficult, and lead to spurious effects. This is before one verifies the paradigm to ensure that it is actually doing what it has been designed to do. Honest mistakes in scripting can lead to presentation errors that are hard to detect due to high presentation rates.

By using the BBTK you can help ensure that:

- Your experiment is performing as intended in terms of presentation and synchrony. For fast presentation schedules it can be difficult for the researcher themselves to spot errors unaided
- You can tune presentation schedules to achieve the best possible presentation accuracy and consistency (if you don't know what's broken you can't fix it!)
- Your external equipment is synchronized as accurately as possible, e.g. EEG, MRI, Eye Trackers etc.
- You know what the absolute error and variance is within your chosen response device – remember these can vary enormously! Armed with this knowledge you may decide to change device or perform a post-hoc statistical correction
- You improve your chances of replication and internal consistency
- Above all you improve the quality and respectability of your research

1.2 How can I Ensure my Timing Accuracy is as Good as it Could be?

The ethos of the BBTK is to allow researchers to benchmark their paradigm in-situ and without modification by means of an easily programmable "virtual human". By making use of a wide range of external sensors the toolkit can detect a variety of stimulus materials when presented. Depending on programming it can generate a response at a known onset and for a given duration. The toolkit can detect visual stimuli, auditory stimuli or any TTL signal. Responses can be made using TTL signals, switch closures (button/key down) or through a tone generator to trigger voice keys etc. Stimulus detection and resulting responses are recorded with sub-millisecond accuracy.

Conceptually the BBTK offers much the same functionality as an eight channel digital signal generator and a 12 channel digital oscilloscope. Unlike a signal generator and oscilloscope which typically costs many thousands and are difficult to use, the BBTK enables the researcher to check most paradigms in-situ in less than 30 minutes. Even with a modern signal generator and scope you cannot hope to virtualise human senses and response characteristics – with the BBTK you can do just that! Timing analysis of events is accomplished using a virtual 20-channel Logic Analyser style display. Moveable cursors allow event timing to be measured relative to any two points. By default 12 lines show detected stimuli and eight lines show the simulated responses made by the toolkit and fed into the remote PC running the paradigm being benchmarked.

2. Frequently Asked Questions

Researchers, academics and technical staff from around the world are equally concerned about timing and often contact us with specific questions. By analysing trends, we have put together this FAQ that should help answer many of your questions and allay any concerns you may have. This FAQ is an ideal place to start if you are new to the Black Box ToolKit and maybe a little unsure of how you could use it within your own area of expertise.

2.1 General

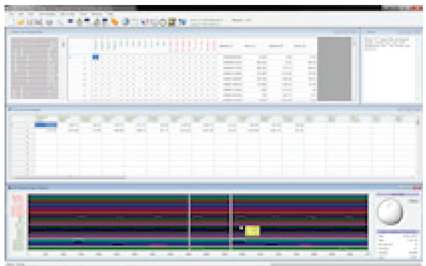
What is the Black Box Toolkit and Why Should I use it?

The Black Box ToolKit is a device that lets you quickly and easily check your own millisecond timing accuracy in terms of stimulus presentation accuracy; stimulus synchronization accuracy; and response time accuracy.

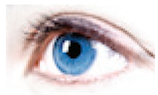
Researchers within the behavioural sciences regularly make use of computer-based paradigms. Most assume that the computer accurately presents stimulus materials and records responses as programmed. However research has shown this expectation is often misplaced. Presentation, synchronisation and response timing errors can be caused by many factors. Whether you make use of a commercial experiment generator or write custom software, you are likely to succumb to such errors. Inconsistent timing can lead to spurious conditional effects, poor replicability and bad science.

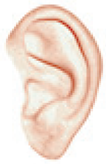
The ToolKit has been specifically developed to help researchers address timing issues related to their own paradigms running on their own hardware. The ToolKit operates as a virtual human programmed to respond to stimulus presentations and generate appropriate responses very accurately. It can step through your whole experiment as if it was a human participant. Typically external sensors are hooked up to a second PC, Mac or Linux box to detect stimulus presentations. A generation interface is used to feed a response into the paradigm under test. The ToolKit measures the timing of all stimulus, synchronization and response events extremely accurately, allowing the researcher to compare timing measured by their own equipment with actual real world timings. The ToolKit can also work with up to 36 I/O TTL lines when used in fMRI studies, for EEG event marking or eye tracking.

Easy-to-use software allows for graphical control of monitored stimulus events, synchronization triggers and responses to generate. A virtual 20 channel scope is used for analysis. Cursors allow measurement of timing between any two points and each events onset, offset and duration is shown in detail in a spreadsheet view.



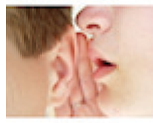
What can I Measure With The Black Box Toolkit?





The ToolKit offers various sensors that can be attached externally to a second computer system running an experiment. These sensors detect when a visual stimulus is displayed, audio is played, a TTL signal is received, or when a human presses a remote response button. All testing can be done without modifying your experiment, in situ, on your own equipment by virtue of the use of external sensors.

Three versions of the ToolKit are available: Entry (12 channel), Pro (20 channel) and Elite (36 channel). They differ in the number of channels available and the number of sensors supplied is specific to the package purchased.



A summary of all the channels and features offered is shown below (36 channel Elite model):

- Opto-detectors: Up to 4 screen regions can be monitored for visual stimuli
- BBTK microphones: Up to 2 high performance digital mics for timing auditory stimulus presentations
- BBTK sounders: Up to 2 high performance digital tone generators for triggering your own voice keys
- Active Switch Closure: Up to 4 Active Switch Closure leads for triggering buttons/keys on your own devices a though a human participant had pressed them
- BBTK response pad: A 4 button BBTK response pad for accepting responses from human participants. Active Switch Closure leads from the pad allow you to trigger up to 4 buttons/keys on your own response device
- TTL input: Up to 10 TTL input channels allow you to time TTL signals sent from external equipment, e.g. fMRI, EEG, eye trackers etc.
- TTL output: Up to 10 TTL output channels allow you to event mark individual stimuli or response events
- Robotic Response Key Actuator: The RKA can press keys on your own response devices, e.g. laptop keys, response pads, Android tablets, iPads, touch screen phones etc.

In short, the ToolKit can be used to test the timing of virtually any experimental paradigm by acting as a highly accurate virtual human pre-programmed to respond to stimuli and automatically step through your experiment. The exact timing of any event, on any sensor or response channel, is logged with sub-millisecond accuracy enabling you to quickly determine real world accuracy.

Where required it can even take over all presentation and response timing duties from your own hardware meaning you can be sure of sub-millisecond presentation and response timing in situations that are traditionally impossible, e.g. video clip presentation and response timing.

How Common are Conditional Biases That Affect Presentation and Response Timing?

Unfortunately they have existed in every paradigm we have looked at regardless of platform, operating system, or whether a commercial experiment generator has been used or not. In all cases the researcher has been unaware of the magnitude of presentation, synchronisation, or response biases. More worryingly on many occasions there has been a conditional bias caused by the equipment itself. For example in cross modal studies it is common for trials where audio is present to have markedly different response timing characteristics. This can account for apparently statistically significant experimental results that lead to spurious conclusions.

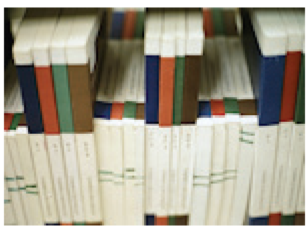
The latest research also suggests that human participants are actually much faster processors of information than previously thought. In the case of vision, Thurgood, Whitfield & Patterson, 2011, showed that humans could recognise the outlines of animals with 83% accuracy at exposure times of just one millisecond when using specialist presentation devices. This makes accurate presentation, synchronisation and response timing even more critical.

In the majority of cases timing errors can be improved by use of the Black Box ToolKit. Either experimental parameters can be altered or post-hoc statistical manipulation can be carried out (where response data has a low variability and constant absolute error).

Why do I Need to Check Every Paradigm? Can't I Just Benchmark the PC, Mac or Linux System the Experiment is Running on?

Unfortunately not. Benchmarking a PC, Mac or Linux system in traditional terms, e.g. to obtain a MIPS rating, doesn't tell you how the system will perform in the real world. In short, it is a synthetic benchmark. In much the same way benchmarking one paradigm doesn't tell you how another will perform on the same hardware even if the two paradigms appear similar. Any settings change in the experiment generator, or third party software, is also likely to have an effect. What is more it is hard to account for human error on the part of the experimenter when creating experiments without independently and objectively checking presentation and response timings. Often presentation, synchronisation and response errors are undetectable by the experimenter, but go on to affect the perceptions and performance of real participants.

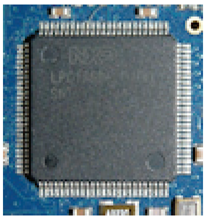
Which Academic Journals are Requesting That Authors Validate Their Timings?



Currently most journals are not requesting that authors formally specify that they have tested the timing characteristics of their study. However this will be changing in the near future with many journals setting the trend by requesting that authors submit their software, scripts and data for inclusion within a repository. The current focus on replication across the field is testament to the fact that journal editors and reviewers are tightening their criteria for publication. Whilst we accept that academics follow best endeavours, on many occasions it is useful to know the timing limits on a given study and how the author verified timing accuracy.

In addition within academic publications it is often difficult to unpick the contribution to timing that may have come from an uncontrolled source. By testing the timing of computer-based paradigms this also helps ensure that successful replications are more likely. In fields such as priming there is still active debate on the direction of some findings and in general researchers are seeking out ever smaller and smaller differences between conditions. In both cases self-validation of timing is crucial in order to avoid statistically significant results that are purely due to equipment variation.

How can your Software/Kit get Accurate Timings When my Experiment Generator Can't?



The Black Box ToolKit is based around a 32 bit ARM CPU, like the one in most iPhones and Android handsets and has 2 MB of onboard RAM for storing its firmware and settings and 8 MB of RAM for storing timing data. Once you have told it what stimuli to respond to it will automatically step through your whole experiment and timestamp any stimulus events, synchronisation markers and responses with sub-millisecond accuracy. This is done independently of the PC which hosts the ToolKit as its USB link is only used for programming and subsequently uploading the data at the end of a sequence. Once running the ToolKit operates completely independently. The Black Box ToolKit can be thought of as a small computer dedicated to helping you improve your timing accuracy.

Can I Test the Timing of my Mac or Linux Based Experiment? What About Other Platforms or Equipment Like MRI, EEG and Eye Trackers?

Yes. You can test the timing characteristics of any experiment on any platform. This is because the kit behaves like a virtual human and operates non-invasively. It has a range of external sensors, response mechanisms and TTL input and output lines which hook up to your own equipment to measure presentation, synchronisation and response accuracy.

2.2 Using the Black Box ToolKit

What's do the Terms Host and Remote mean?

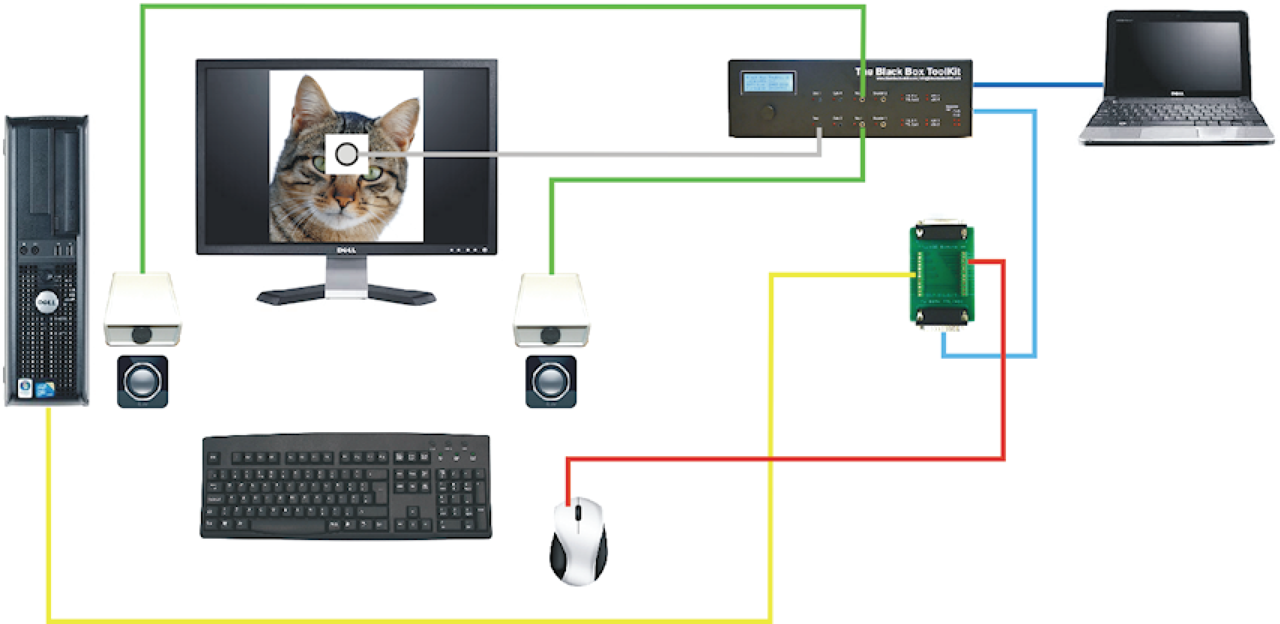
The term Host is used to refer to the Microsoft Windows based PC that has the Black Box ToolKit physically plugged into its USB port and runs our PC Software (Windows XP, Vista, 7, 8, 8.1 or 10). This PC controls the BBTK and analyses data. It could be a PC desktop, laptop or netbook. By using VMWare, Parallels, VirtualBox or Boot Camp this also lets you control the BBTK from other platforms. In addition by using the BBTK API you can also control and analyse data using your own custom written software, e.g. MATLAB, PsychoPy etc.

Whereas the term Remote is used to refer to the PC/MAC/Linux system that is running the experiment you are interested in checking the timing of. Remember that the Remote could also refer to other specialist equipment, e.g. MRI scanner, EEG machine, eye tracker etc.

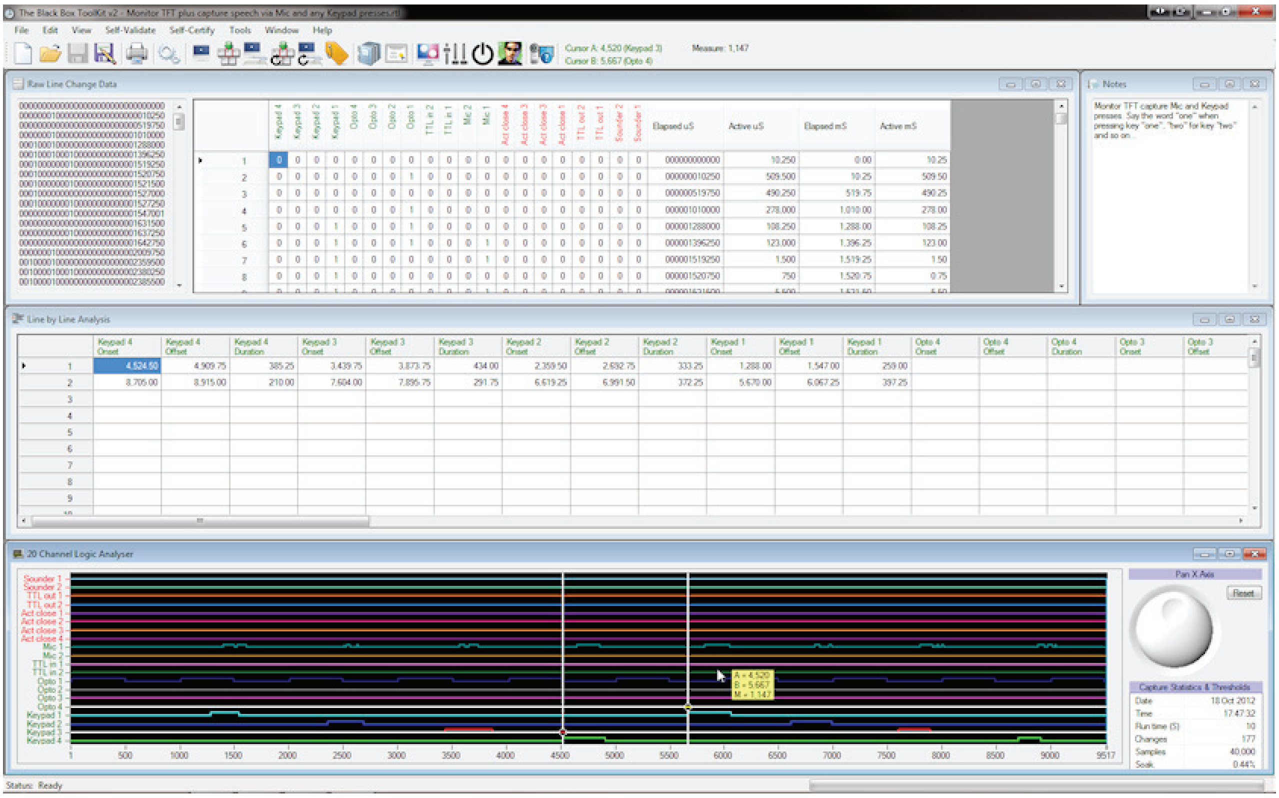
How do I Check Whether Visual and Auditory Stimuli are Synchronised?

To check the synchrony of visual and auditory stimuli you would attach one or more opto-detectors to your remote screen, i.e. the computer running the experiment (shown in grey below). Then place one or more BBTK microphones next to your remote speakers (green). To provide a baseline you could also attach a TTL lead from the parallel port of your remote PC to the BBTK breakout board (yellow). If your PC does not have a parallel port you could use a BBTK USB TTL event marking module instead. To utilise this TTL synch signal you would program your experiment generator script to output a TTL signal at the onset of the presentation of the visual stimulus. An Active Switch Closure (ASC) lead could be wired from the breakout board of the BBTK (light blue) to the left mouse button of your remote PC (red) so as to trigger a response when each stimulus image is detected.

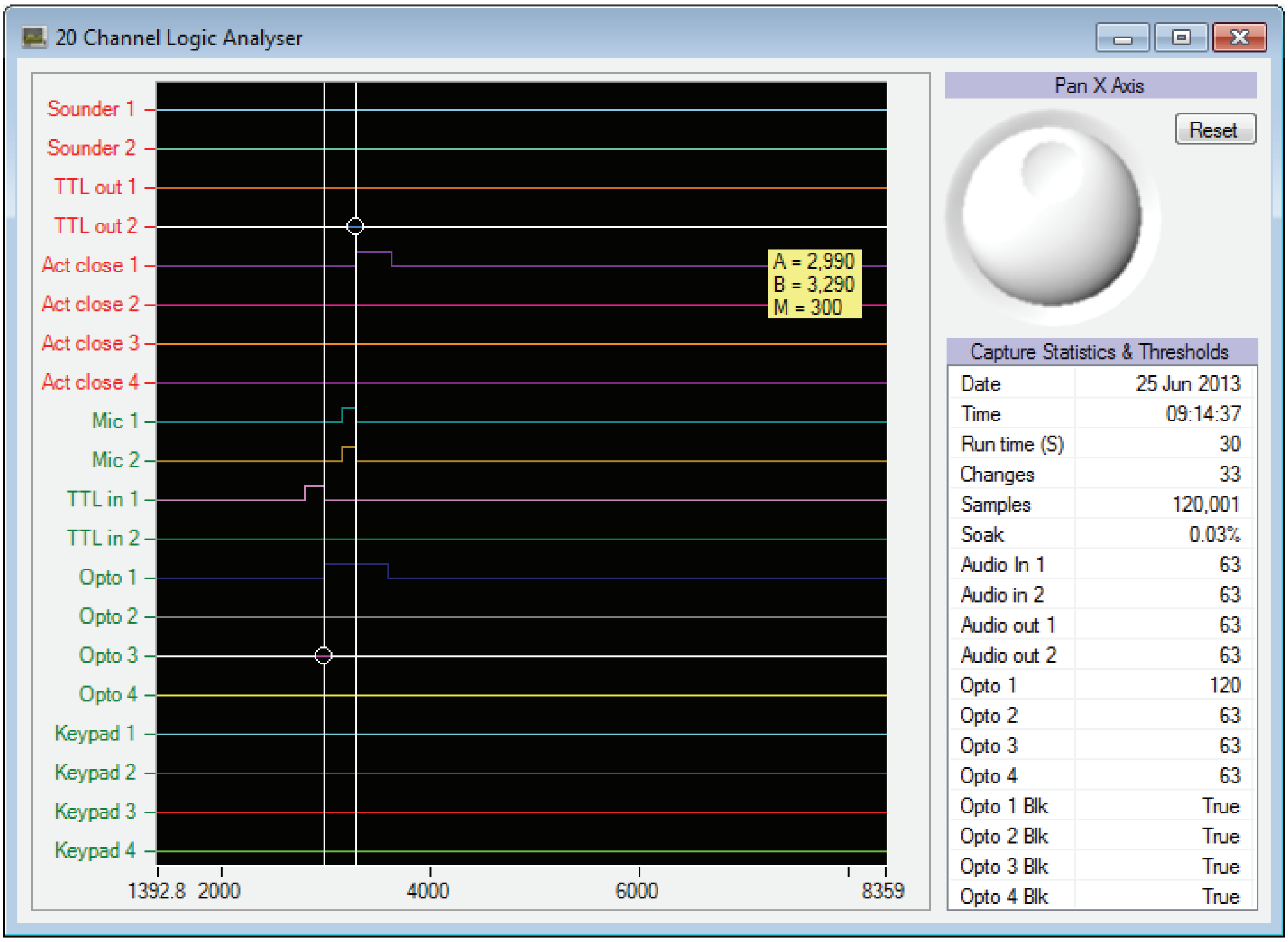
The collection of timing data and generation of responses is controlled by a second host PC/Laptop/Netbook that is connected to the BBTK via USB (blue). The Digital Stimulus Capture And Response (DSCAR) module of the BBTK PC Software would be run from this second host PC in order to detect visual stimuli and make responses. In this example DSCAR has been instructed to respond after 300mS by pressing the left mouse button using an ASC lead (red).



Once the BBTK has automatically stepped through your whole experiment, timing data will be presented for analysis. One spreadsheet view displays raw timing data whilst a second displays changes across up to 36 channels, e.g. visual stimulus onset, offset and duration in milliseconds. A graphical 20 Channel Logic Analyser enables you to compare the timings of any events by means of two draggable measurement cursors.



In this example we can see that the TTL signal from the remote PC running the experiment appears on TTL in 1 before the onset of the visual stimuli on Opto 1. The onset of both should be synchronised and any difference between the two is likely to be due to the input lag of the display device. That is, the inherent delay between requesting an image be displayed and when it physically appears. This delay is usually caused by the display devices electronics and any image processing. On the same trace we can see that the two mics detected the leading edge of a stereo tone later than the onset of the visual presentation. Such delays can be caused by sound card startup latency where the intended tone appears at the speakers much later than requested due to the sound cards electronics. Act close 1 shows when the BBTK generated a response relative to the onset of the visual stimulus image. In this case a yellow tooltip shows that the true RT is 300mS.



By comparing the true RT generated by the BBTK against that recorded by the experiment generator it is possible to calculate the level of response timing error in the paradigm.

How do I use The BBTK Robotic Key Actuator to Press Keys on a Laptop or Response Pad to Check Response Timing?

The Robotic Key Actuator (RKA) is designed to press a key on a response device without having to dismantle it to physically wire an Active Switch Closure (ASC) lead from the BBTK. Once calibrated the RKA is consistent to around 1-2mS when pressing keys. The RKA has an adjustable plunger that can be moved either horizontally or vertically to enable perfect positioning and a foam pad to provide cushioning for your response device.

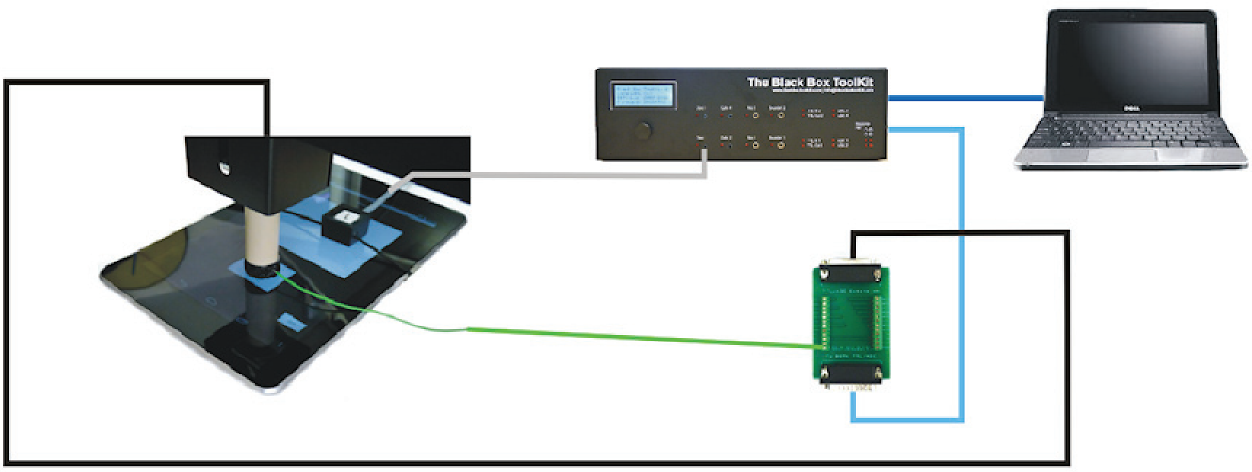
In the example shown the RKA is pressing the space bar on a Netbook keyboard in response to a visual stimulus detected on an opto-detector (shown in grey below). The RKA is controlled via a special trigger lead (black) from the breakout board and is activated by a TTL Out 1 signal from the BBTK that tells it when to press and for how long.

To provide a baseline you could also attach a TTL lead from the parallel port of the remote laptop/PC to the BBTK breakout board (yellow). If your PC does not have a parallel port you could use a BBTK USB TTL event marking module instead. To utilise the TTL synch signal wire you would program your experiment generator script to output a TTL signal at the onset of the presentation of a visual stimulus. The breakout board itself is connected to the BBTK via a 25-way cable (light blue).

The collection of timing data and generation of responses is controlled by a second host PC/Laptop/Netbook that is connected to the BBTK via USB (blue). The Digital Stimulus Capture And Response (DSCAR) module of the BBTK PC Software would run from this second host PC in order to detect stimuli and make responses with known RTs. Once the BBTK had automatically stepped through your whole experiment, timing data would be presented for analysis. To calculate the RT error introduced by your response device you would compare the RT recorded by your experiment generator with the true RT generated by the BBTK.

How do I use The BBTK Robotic Key Actuator to Make Responses on an iPad, Android Tablet or Other Touch Screen Device?

In addition to being able to press keys on your own response devices the Robotic Key Actuator (RKA) can also make responses on capacitive touch screen hardware. This is accomplished using a piece of high density electroconductive foam which is grounded to the breakout board (shown in green below).



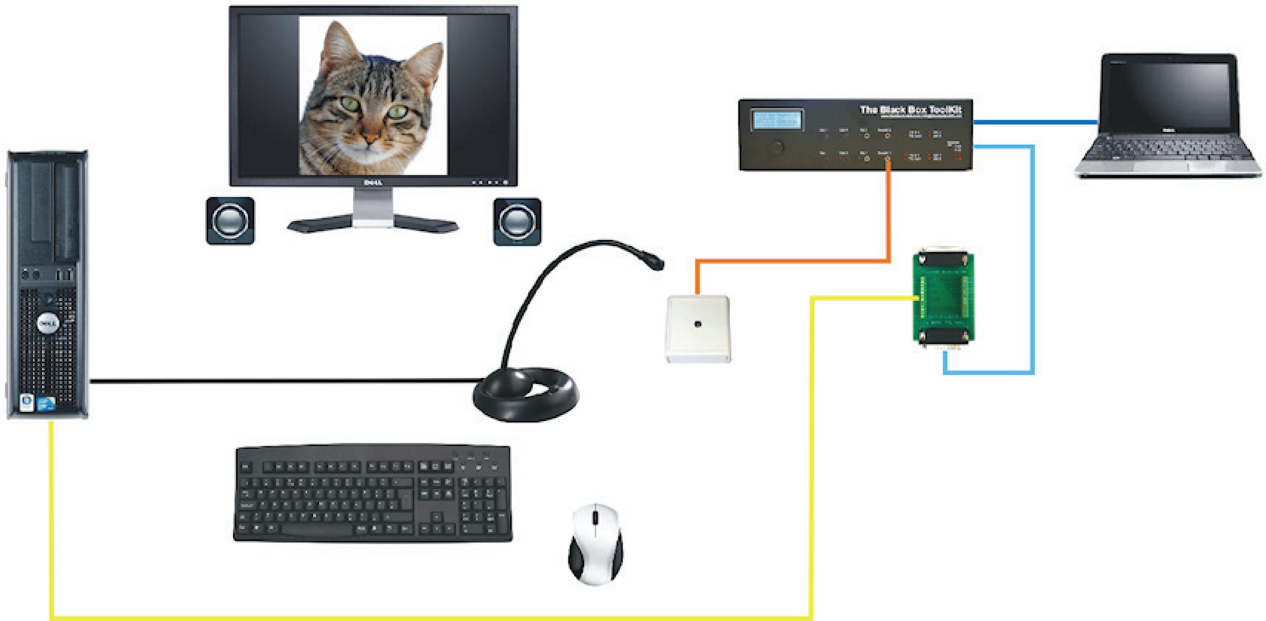
Once calibrated and a small air gap set, the RKA is consistent to around 1-2mS when registering touches and releases. The RKA has an adjustable plunger which can be moved either horizontally or vertically to enable perfect positioning. The electroconductive foam pad also provides cushioning for your touch screen device.

In the example shown the RKA is touching the screen in response to a visual stimulus detected on an opto-detector (grey). The RKA is controlled by a special trigger lead (black) from the breakout board and is activated by a TTL Out 1 signal from the BBTK that tells it when to press and for how long. The breakout board itself is connected to the BBTK via a 25-way cable (light blue).

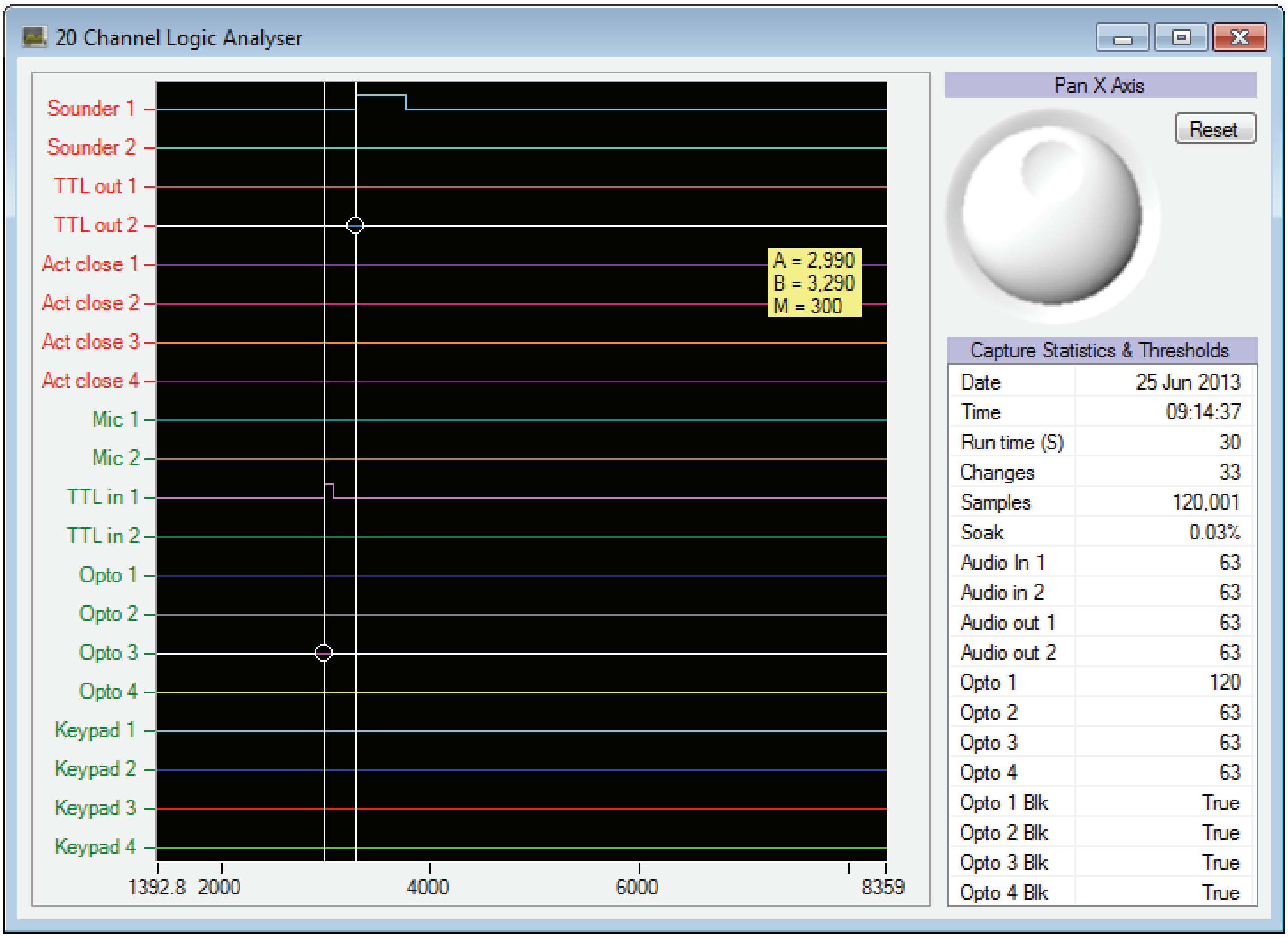
The collection of timing data and generation of responses is controlled by a second host PC/Laptop/Netbook that is connected to the BBTK via USB (blue). The Digital Stimulus Capture And Response (DSCAR) module of the BBTK PC Software would run from this second host PC in order to detect stimuli and make responses with known RTs. Once the BBTK had automatically stepped through your whole experiment, timing data would be presented for analysis.

How do I Test the Response Latency of a Voice Key?

One of the few reliable ways to test the response latency of a voice key is to use a TTL signal from an experiment generator to indicate when it is ready to accept a response and then to generate an independent tone using a sounder. In the example shown below a TTL signal could be sent from the experiment generator into TTL In 1 (shown in yellow below) of the BBTK via the breakout board. Using Digital Stimulus Capture And Response (DSCAR) you could construct a sequence that triggered on every TTL In 1 signal and in response generated a tone after 300mS using a BBTK Sounder (orange). This tone should trigger the experiment generators voice key (black) and register a RT of 300mS should everything be working correctly. Any deviation from the intended true RT of 300mS is likely to be due to the latency of the voice key hardware and detection routine within the experiment generator software.



The collection of timing data and generation of responses is controlled by a second host PC/Laptop/Netbook that is connected to the BBTK via USB (blue). Once the BBTK has automatically stepped through your whole experiment, timing data would be presented for analysis. To check timings you would use the 20 Channel Logic Analyser to confirm that each tone was generated on Sounder 1 300mS after the onset of the TTL in 1 signal from the experiment generator as shown below.



To automate the process of checking RTs and ISIs you could copy and paste the Line By Line Analysis spreadsheet into Microsoft Excel and enter a formula rather than drag the measurement cursors around to check individual timings.

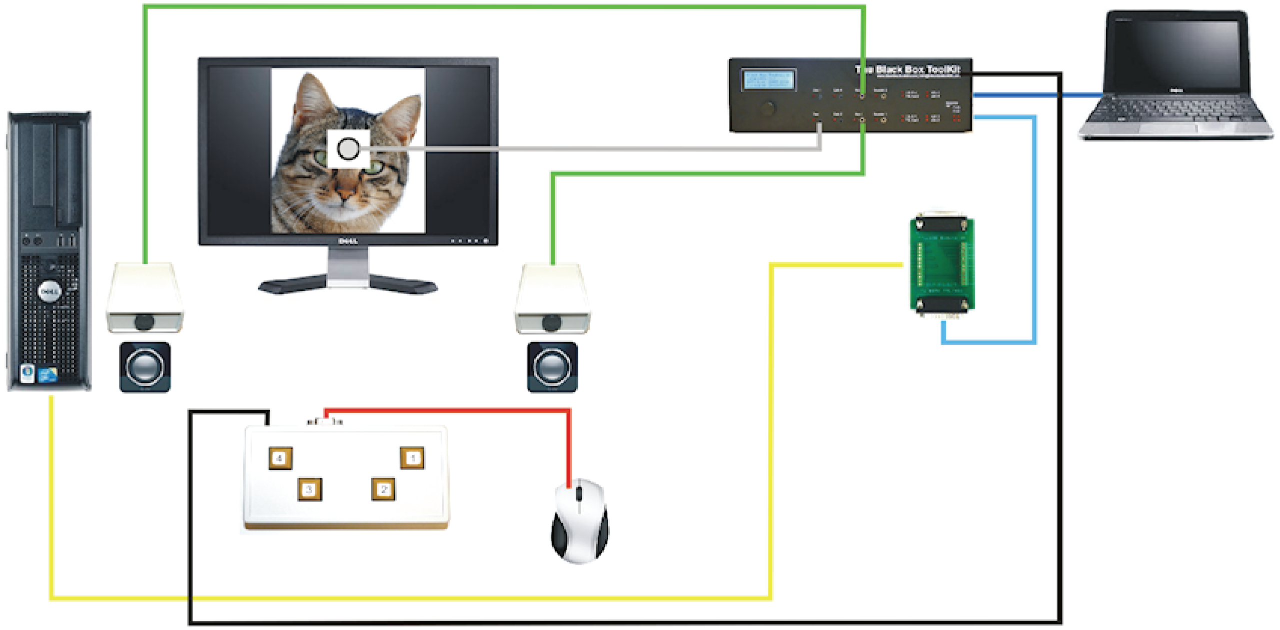
How can I use Video Clips and Obtain Accurate Timing?

Traditionally experiment generators are extremely poor at timing when a video stimulus is playing. Using the BBTK response pad together with our Digital Stimulus Capture (DSC) software can help you obtain sub-millisecond accurate presentation and response timings. In this scenario the experiment generator is only presenting the video and all timing duties are taken over by the BBTK.

To achieve this level of accuracy you would use a video editor to superimpose a white 32x32 pixel event marker block at the start of each scene you were interested in. Other frames should have a black block at the same position so that they don't activate the BBTK opto-detector. Typically event markers are placed at the bottom corner of a video so that the opto-detector can be covered up by a custom made secondary frame obscuring the bottom 32 pixels of the monitor.

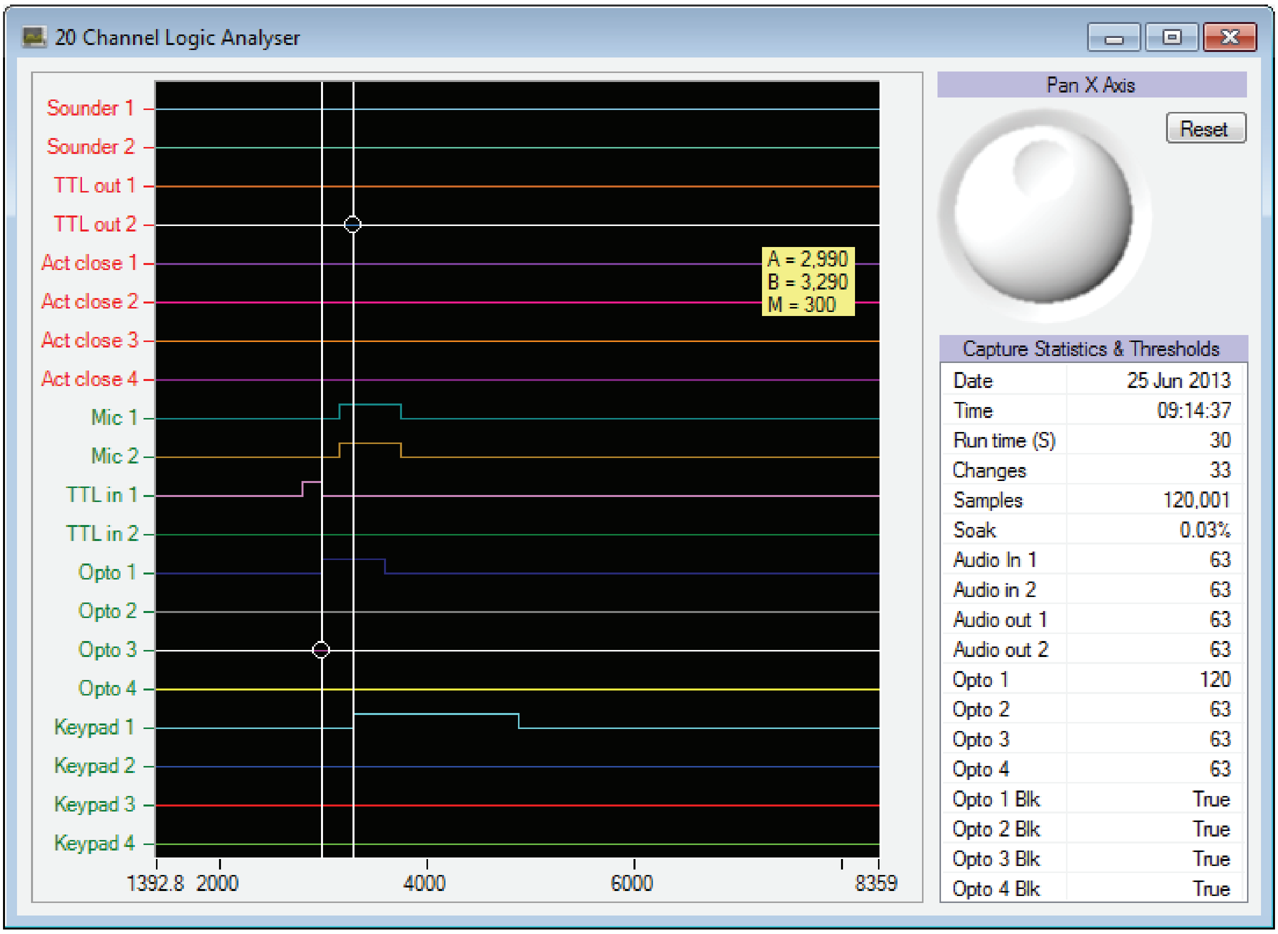
In the example shown below an opto-detector is attached to the screen to detect the event marker (shown in grey below). To provide a baseline you could also attach a TTL lead from the parallel port of the remote laptop/PC to the BBTK breakout board (yellow). If your PC does not have a parallel port you could use a BBTK USB TTL event marking module instead. To utilise this TTL synch signal wire you would program your experiment generator script to output a TTL signal at the onset of the presentation of a visual stimulus.

The breakout board itself is connected to the BBTK via 25-way cable (light blue). Two BBTK mics could be placed next to your speakers to timestamp any audio (green). Finally to accept responses a 4 button BBTK response pad is connected to the main unit (black) and an Active Switch Closure (ASC) lead tacked to your own response device button (red). When a key is pressed on the BBTK response pad your own response device would be simultaneously triggered as though a button on it had been pressed.



When your experiment was complete you would use the 20 Channel Logic Analyser to check for the occurrence of the white event marker on the scenes you were interested in (Opto 1). You could then use the cursors to measure the RT between the appearance of the reference block and a response button being pressed on Keypad 1 (300mS in this example). Any sounds played by the video would be shown on Mics 1 and 2.

If you wanted to check for TFT monitor input lag, or the lag between when the experiment generator thought it had correctly event marked the desired frames, you would check the sync of the TTL signal sent to the BBTK relative to those events (TTL in 1). For example, by subtracting the image onset from the TTL signal this gives a measure of the input lag and the inherent delay in your equipment and experiment generator.

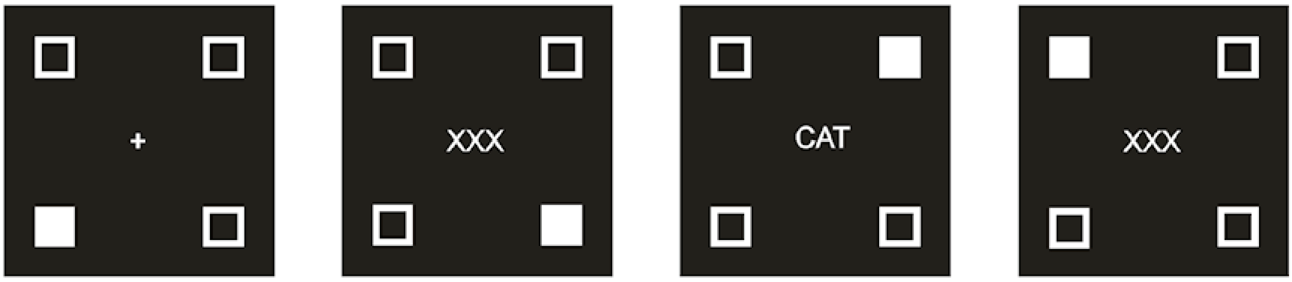


Because your own response device would be triggered when you press a response key on the BBTK keypad (red) you could compare what your experiment generator recorded against the true RT recorded by the BBTK to calculate response timing error.

To automate the process of determining true RTs you could copy and paste the Line By Line Analysis spreadsheet into Microsoft Excel and enter a formula to calculate each RT based on the onset of the videos event marker.

How do I Check the Timing Accuracy of a Visual Priming or RSVP study?

For priming or RSVP studies you may wish to make use of multiple white opto-detector markers (up to 4 on the Pro and Elite models) so that you can detect each fixation, prime, mask and so on. If you don't want to activate an opto on a particular prime or mask you will need to have black event markers at all other opto locations as shown below.



In this example opto 1 might be located to bottom left of your remote screen (fixation), opto 2 bottom right (mask), opto 3 top right (prime), opto 4 top left (mask). Where no optos should be triggered a black marker should be displayed. Typically this will be where the background is pure black and no event markers are displayed. By using all four optos you can monitor for the onset, duration and offset of each visual event on fixation frames, primes and masks.

To provide a baseline you could also attach a TTL lead from the parallel port of your remote laptop/PC to the BBTK breakout board. If your PC does not have a parallel port you could use a BBTK USB TTL event marking module instead. To utilise this TTL synch signal wire you would program your experiment generator script to output a TTL signal at the onset of the presentation of a prime or mask. By subtracting the opto-detector onset from the TTL signal onset this gives a measure of the input lag and the inherent delay in your display equipment and experiment generator.

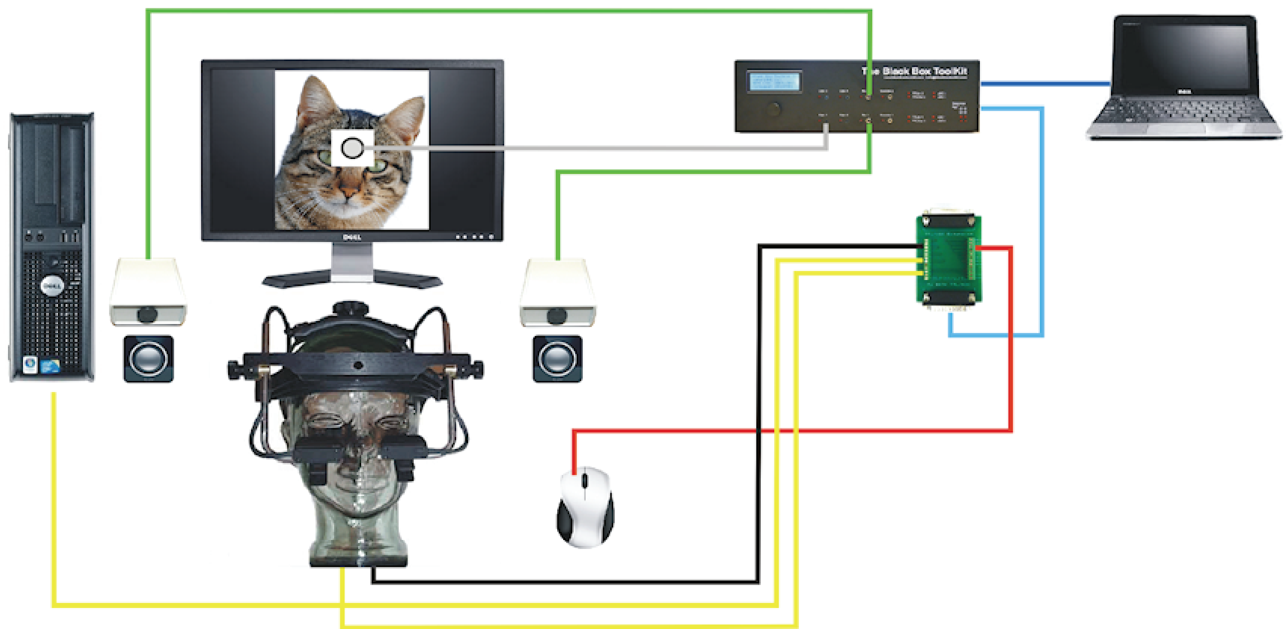
How can I use The BBTK to Check AOA Timings With an Eye Tracker?

The BBTK has up to 20 TTL input and output channels that can be used to event mark stimuli, capture synchronisation signals and record responses when performing eye tracking. This lets you check whether stimulus presentations and responses are temporally yoked to TTL AOA markers from your eye tracker – you can compare the events your experiment generator, or eye tracking hardware and software timed against real world event timings measured by the BBTK.

In the simple eye tracking scenario shown an experiment generator is presenting an image and playing a tone through a set of speakers. To check timing accuracy an opto-detector (shown in grey below) could be positioned on the remote screen so as to detect the onset and duration of each visual presentation. To record the timings of audio presentations one or more BBTK microphones could be placed next to the remote speakers (green).

An AOA signal, or event marker, from your eye tracker could be fed into TTL In 1 of the BBTK breakout board (yellow) in order to provide a gaze dependent reference. A second TTL from your experiment generator could be connected to TTL In 2 (yellow). To utilise this second TTL signal you would program your experiment generator to output a TTL signal at the onset of each visual presentation. This would enable you to check the level of lag inherent in the display device and eye tracker being used. A third TTL signal (black) could be fed back into the eye tracking hardware from the BBTK to act as an external event marker, e.g. to indicate when the speakers were producing sound.

An Active Switch Closure (ASC) lead could be wired from the breakout board of the BBTK to the left button of the remote mouse (red) so as to trigger a response with a known RT when each stimulus image is detected, e.g. 300mS. The breakout board itself is connected to the BBTK via a 25-way cable (light blue).



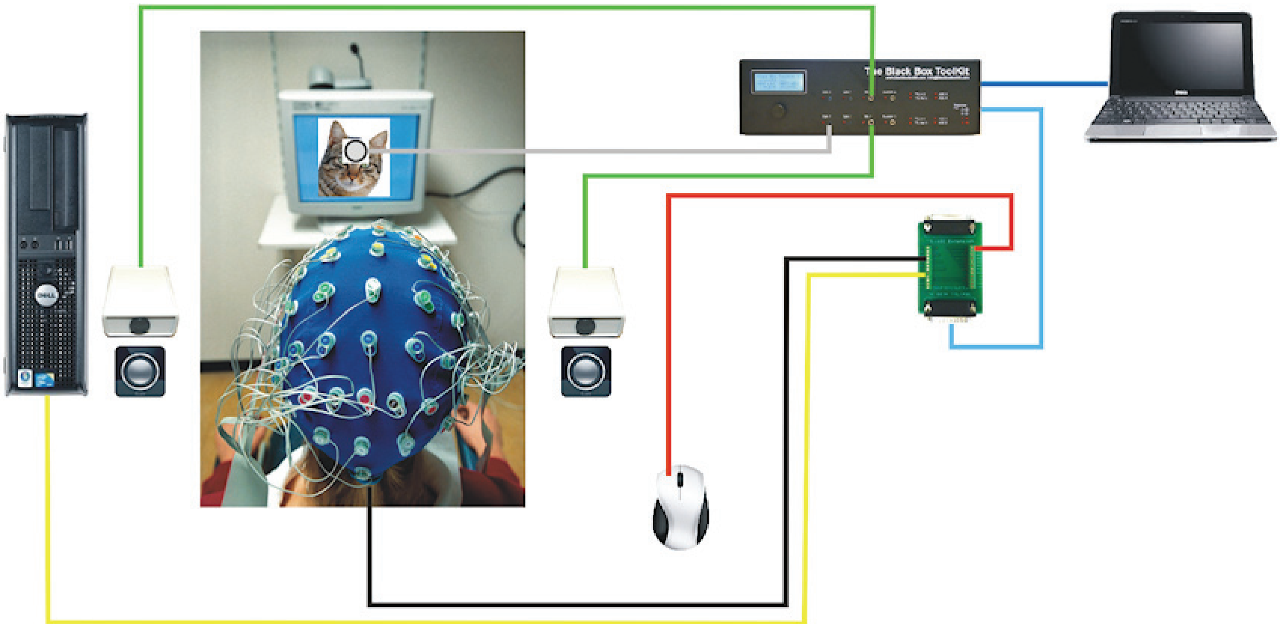
The collection of timing data and generation of responses is controlled by a second host PC/Laptop/Netbook that is connected to the BBTK via USB (blue). The Digital Stimulus Capture And Response (DSCAR) module of the BBTK PC Software is run from this second host PC in order to detect stimuli, record TTL events, act as an external event marking device and make responses with known RTs. Once the BBTK has automatically stepped through your whole experiment, timing data will be presented for analysis. By comparing the RT recorded by your experiment generator against the true RT generated by the BBTK, i.e. 300mS, you will be able calculate response error.

How do I Event Mark Stimulus or Response Activity on an EEG trace?

The BBTK has up to 10 TTL output channels which can be used to event mark stimuli, synchronisation triggers and responses on an EEG trace. For example, when a stimulus or patterns of stimuli are detected, a TTL event marker can be generated on any given channel. If the BBTK is making a response with a known RT, a temporally yoked TTL marker can be generated to signify the onset of that event. This lets you compare the events your experiment generator, or EEG hardware and software, timed against the true event timings recorded by the BBTK.

In the simple EEG scenario shown an experiment generator is presenting an image and playing a tone through the left or right speaker. To check the synchrony of a visual and auditory stimulus you could attach one or more opto-detectors to the remote screen (shown in grey below). Then place one or more BBTK microphones next to the remote speakers (green). To provide a baseline you could also attach a TTL lead from the parallel port of the remote PC to the BBTK breakout board (yellow). If your PC does not have a parallel port you could use a BBTK USB TTL event marking module instead. To utilise this TTL synch signal wire you would program your experiment generator to output a TTL signal at the onset of the presentation of the visual stimulus. An Active Switch Closure (ASC) lead could be wired to the breakout board of the BBTK (light blue) and then to the left mouse button of the remote PC (red) so as to make a response when each stimulus image is detected.

When the BBTK physically detects a visual stimulus it could feed a TTL signal/event marker (black) into your EEG amplifier so as to mark the true onset. Alternatively when the BBTK generated a response with a known RT by closing the switch on your mouse via an ASC lead, a simultaneous TTL marker could be generated.

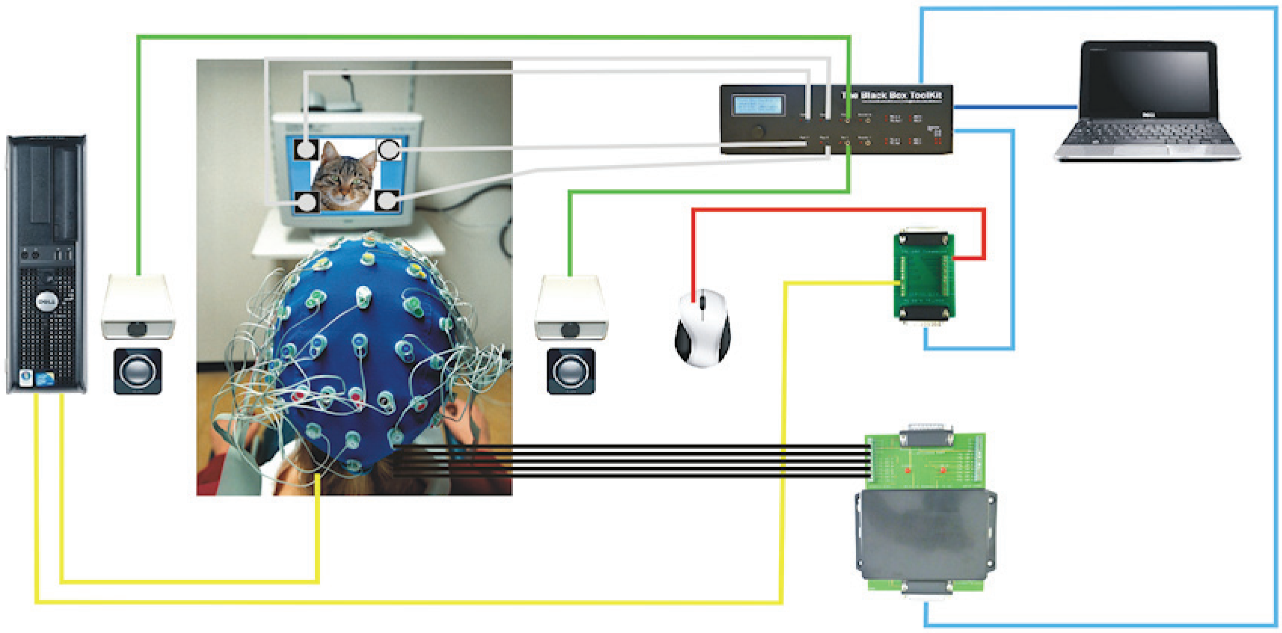


The collection of timing data and generation of responses is controlled by a second host PC/Laptop/Netbook that is connected to the BBTK via USB (blue). The Digital Stimulus Capture And Response (DSCAR) module of the BBTK PC Software is run from this second host PC in order to detect stimuli, synchronisation triggers and make responses with known RTs. Once the BBTK has automatically stepped through your whole experiment, timing data will be presented for analysis. In addition to being able to check stimuli timings, by comparing the RTs recorded by your experiment generator against the true RTs generated by the BBTK you would also be able calculate response error.

How do I Event Mark Complex Stimulus, Synchronisation or Response Activity on an EEG Trace?

The BBTK has up to 10 TTL output channels which can be used to event mark stimuli, synchronisation triggers and responses on an EEG trace. For example, when a stimulus or patterns of stimuli are detected, TTL event markers can be generated on specific channels tied to the stimulus location or type of stimulus. If the BBTK is making a response with a known RT, a temporally yoked TTL marker can be generated to signify the onset and duration of that event. This lets you compare the events your experiment generator, or EEG hardware and software, timed against the true event timings measured by the BBTK.

In the more complex EEG scenario shown an experiment generator is presenting a series of images and playing a tone through the left or right speaker. For example, four opto-detectors (shown in grey below) could be positioned on the remote screen so as to detect the onset and duration of four continuous frames in a priming study. At each position black/white markers would indicate the fixation frame, the mask, the prime and the backward mask. When each frame was detected by the BBTK it would event mark each onset/duration on four separate TTL Out lines (black) which would be fed back into your EEG amplifier so as to mark the true onset/duration on one of four channels. In this case the four additional TTL lines are provided by the 16 channel TTL expansion module connected to the BBTK (light blue).



To time audio presentations you would place one or more BBTK microphones next to the remote speakers (green). To provide a baseline you could also attach a TTL lead from the parallel port of the remote PC to the BBTK breakout board (yellow). If your PC does not have a parallel port you could use a BBTK USB TTL event marking module instead. To utilise this TTL synch signal wire you would program your experiment generator to output a signal at the onset of each visual presentation. A second TTL line (yellow) would normally be connected from your presentation PC to your EEG amplifier/second PC. Depending on your exact configuration it may be possible to tap into this TTL line and simultaneously feed that into the BBTK breakout board rather than connect up a second line.

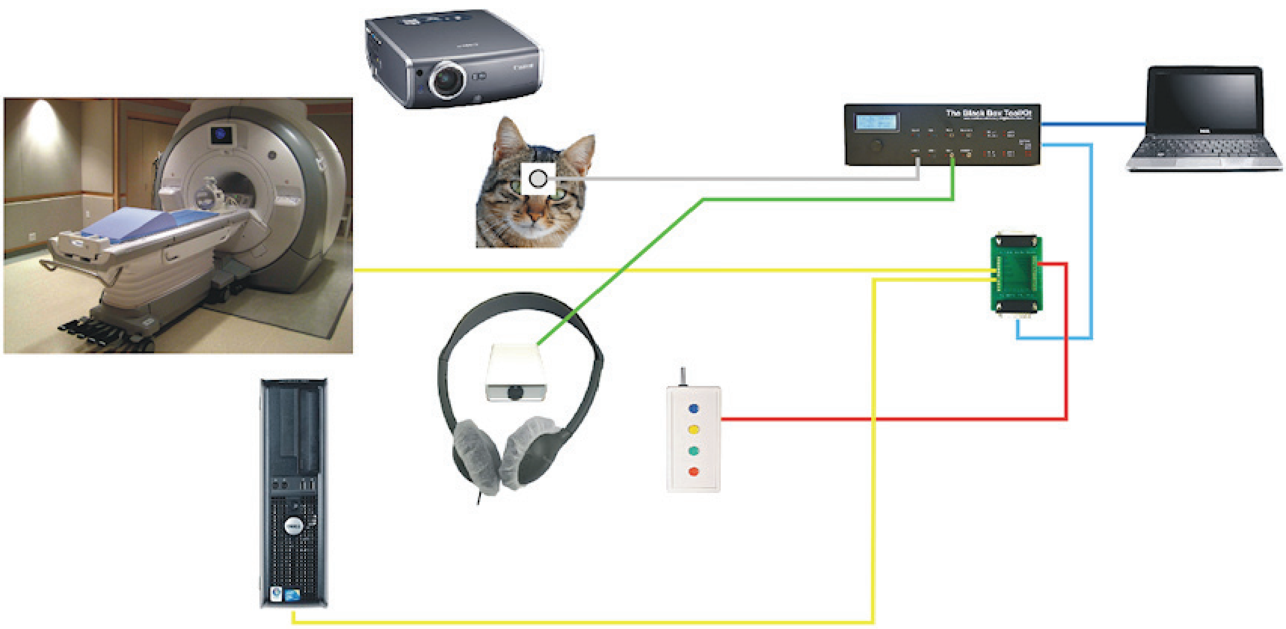
An Active Switch Closure (ASC) lead could be wired from the breakout board of the BBTK (light blue) to the left mouse button of the remote PC (red) so as to make a response when each stimulus image is detected. When the BBTK generates a response at a known RT by closing the switch on your mouse via an ASC lead, a simultaneous TTL Out (black) marker could be sent. This would give a total of five independent TTL event marking channels which covered all visual stimuli and each response. If required it would be possible to add more TTL event marking lines to mark events on other EEG channels, e.g. to mark true left and right tone onset and duration.

The collection of timing data and generation of responses is controlled by a second host PC/Laptop/Netbook that is connected to the BBTK via USB (blue). The Digital Stimulus Capture And Response (DSCAR) module of the BBTK PC Software is run from this second host PC in order to detect visual stimuli, synchronisation triggers and make responses with known RTs. Once the BBTK has automatically stepped through your whole experiment, timing data will be presented for analysis. In addition to being able to check stimuli timings, by comparing the RTs recorded by your experiment generator against the true RTs generated by the BBTK you would also be able calculate response error.

How do I use a MRI Synchronisation Trigger Pulse or Reference Signal in fMRI?
The BBTK has up to 20 TTL input and output channels, which can be used to event mark stimuli, capture scanner sync pulses and record responses when performing fMRI. This lets you check whether stimulus presentations, synchronisation triggers and responses are temporally yoked to the TTL sync pulse from the scanner – you can compare the events your experiment generator, or MRI hardware and software timed against real world event timings measured by the BBTK.

In the simple MRI scenario shown an experiment generator is presenting an image via a data projector positioned outside the scanner room and playing a tone through a set of pneumatic headphones. To check timing accuracy an opto-detector (shown in grey below) would be positioned on the remote screen so as to detect the onset and duration of each visual presentation. To record the timings of audio presentations one or more BBTK microphones would be placed next to the remote headphones (green). To register responses with a known RT an Active Switch Closure (ASC) lead could be wired from the breakout board of the BBTK (light blue) to a button of the remote MRI response pad (red) so as to trigger a response when each stimulus image is detected.

The scanner sync pulse would normally be fed into TTL In 1 of the BBTK breakout board (yellow) to provide a reference signal. A second TTL line from your experiment generator could be connected to TTL In 2. To utilise this second TTL signal wire you would program your experiment generator to output a signal at the onset of the presentation of the visual stimulus. This would enable you to check for the level of input lag inherent in the data projector being used or any synchronisation issues.



The collection of timing data and generation of responses is controlled by a second host PC/Laptop/Netbook that is connected to the BBTK via USB (blue). The Digital Stimulus Capture And Response (DSCAR) module of the BBTK PC Software is run from this second host PC in order to detect visual stimuli, synchronisation triggers and make responses with known RTs. Once the BBTK has automatically stepped through your whole experiment, timing data will be presented for analysis. In addition to being able to check stimuli and synchronisation timings, by comparing the RTs recorded by your experiment generator against the true RTs generated by the BBTK you will also be able calculate response error.

All connections should be made outside of the scanner room via a patch panel as currently we do not advise, nor endorse, the use of any BBTK sensors or other equipment inside the scanner room. No part of the BBTK should be considered scanner safe.

2.3 Correcting timing errors

My Chosen Response Device is Adding to Response Timing. What Should I do?

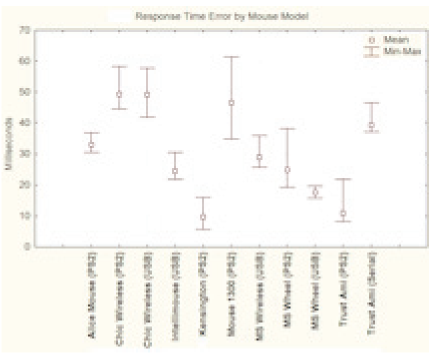
The first thing to do is establish the contribution the device is adding using a BBTK. Once this has been established you need to determine its variability and decide whether this is acceptable within your current study. If the absolute error is consistent and variability low it may be possible to subtract the error post hoc so that RTs more closely reflect what the true RT would have been.

One could measure this by telling your experiment generator to output a TTL signal when presenting a stimulus. This could be used as a trigger by the BBTK that would then generate a response with a known RT that could be fed into your own response device via an Active Switch Closure (ASC) lead. Alternatively the BBTK Robotic Key Actuator (RKA) could be used to respond on your own response device. Detecting stimuli and responding with a known RT would be controlled by the Digital Stimulus Capture And Response (DSCAR) module of the BBTK PC Software. If a TTL output cannot be made by the computer you are using to run the experiment you would need to examine whole system timing. To improve whole system timing accuracy you would make alterations to your experiment which tightened presentation, synchronisation and response timing, e.g. by moving a visual presentation back in time to realign it with an audio stimulus.

You should bear in mind the absolute error of a response device may also affect when a stimulus presentation is terminated and the next presentation made. It could also affect synchronisation between other hardware you may be using, e.g. EEG, fMRI, eye trackers etc.

Unless you are using a response box from a recognised manufacturer reducing response timing error may mean that you need to empirically test several different pieces of hardware with a BBTK in order to find the one with the least error, e.g. when using keyboards as response devices.

How do I Plot the Absolute Error and Variability of my Response Device?



Depending on whether you used Digital Stimulus Capture And Response (DSCAR) to generate responses, or the BBTK response pad to actively trigger your own response device, the analysis method will vary. If you used DSCAR you will have entered a fixed delay, i.e. RT, which will have elapsed before a response was made. This is a known delay and should match the response time recorded by the experiment on the remote computer if there is zero error. To calculate the absolute error, response times from your experiment can be pasted into Microsoft Excel and subtracted from the true response time. Variability in the response device can be ascertained using standard statistical functions such as STDEV etc.

If you wanted to achieve a more humanistic pattern of RTs, you might have used Digital Stimulus Capture (DSC) together with the BBTK response pad (depending on model of response pad) and Active Switch Closure (ASC) lead tacked to the primary button of your response device. In this scenario a human participant will have responded to each stimulus, e.g. a bitmap, by pressing a response key on the BBTK response pad. Each time a key was pressed, the ASC flying lead from the pad will have simultaneously closed a button on your own response device. As each response will have been generated with a different RT this means that you will need to use the BBTK data analyser to work out the true RT for each press. This can be done using the measurement cursors or via the spreadsheet view. If using the cursor method, the first cursor should be placed on the leading edge of the stimulus event and the second on the leading edge of the pad button being pressed (assuming RTs are recorded by your experiment in relation to stimulus onsets). A response time can then be read off – you will need to do this for as many responses as you wish to analyse. In effect you have calculated each true RT – if there were zero error these should match each RT recorded by your experiment. Any difference represents the absolute error. Response times from the remote experiment can be pasted into Microsoft Excel and then subtracted from each true response time. As before, variability in your response device can be calculated using standard statistical functions such as STDEV etc.

I've Found an Error in the Synchrony Between my Visual or Auditory Stimuli. How do I Correct this?

Typically you will need to retest the paradigm using a BBTK after making incremental corrections to the stimulus onset times or durations. For visual stimuli this may mean that you need to move a presentation forward along the timeline and start accepting responses earlier. If images are presented for longer than expected you may also need to alter durations. Such corrections may also involve various manipulations specific to the software you are using, e.g. in E-Prime you may need to cache images using the canvas object or alter the timing mode etc. At the most extreme it could mean using another display device.
Alternatively you could also manipulate the stimulus materials themselves. For example if a tone is played for longer than expected you could use a sound editor to shorten the duration so that it matched that intended when presented by the experiment generator. Another example is where you may need to insert silence into a sound files beginning to ensure that the actual sound is produced at the speakers at exactly the same point as a visual stimulus is presented.

In short you may need to move stimulus materials forward or backwards along the experimental timeline to ensure they are physically presented at the correct time. This can mean reducing or elongating the durations of stimuli in what may at first seem a counterintuitive way. You may also need to start accepting responses earlier, or later, than initially intended. For example, rather than time RTs from the onset of a visual stimulus you may need to time them from the onset of a TTL signal, or other event marker, that you initiated. If your TFT monitor inherently has 30mS of input lag when displaying images, you could time RTs from 30mS after the experiment generator requested the image be displayed, e.g. from a TTL event marker. In this example the 30mS correction would realign the stimulus in terms of what physically happened in the real world and the timings the experiment generator subsequently recorded. Once you have used a BBTK to empirically discover the direction and scale of timing errors you are in a much better position to make such corrections.

There is a Synchronisation Error Between my Experiment and Third Party Equipment (EEG, MEG, fMRI, Eye Tracker). How do I Correct This?

If you are presenting stimuli based on a TTL sync signal from third party equipment such as EEG, MEG, fMRI, eye tracker etc, it may be that your experiment generator reacts to it later than intended. For example, TFT input lag may mean that a stimulus image is displayed 50mS later than the sync signal is sent. Through previous testing you may have established that the input lag of your particular TFT monitor is 30mS. In this case the additional 20mS would be likely to be caused by delays within the experiment generator and/or computer system. To correct the late display relative to the sync signal you would need to move the signal forward by 50mS in time so that the visual presentation was correctly aligned in the real world. Typically this would need to be done in the equipment generating the sync signal. On some occasions the 50mS delay may still exist, but simply be timeshifted forward by 50mS.

To correct a timeshifted delay you may need to send two TTL sync signals from your equipment where the first is a "dummy signal" that is used to trigger the experiment generator to display the image and the second is the real sync signal, i.e. 50mS later to correct for the error described above. You would need to program your experiment generator to display the image on the first and time RTs from the second signal. This would temporally align the display of the image with the "real" sync signal, i.e. the second one.

On the other hand if there is a consistent timing error relative to a regular reference pulse, e.g. as in fMRI, you may need to temporally realign the signal itself. This may mean altering the frequency or duration of the pulse. To do this you should consult the reference guides for the equipment that is generating the signal and the experiment generator you are using.

Should I Look at Whole System Timing to Improve my Accuracy?

The short answer is yes! Whole system timing is where you consider the timing accuracy of everything as a cohesive unit. By "system" we mean your computer and Operating System, your presentation devices, response devices and any other third party hardware you interact with, e.g. EEG, MEG, fMRI, eye trackers etc.

This means that you need to use a BBTK to evaluate every aspect of your timing, i.e. presentation, synchronisation and response. Once you have a set of baseline timings you should then make small incremental changes that lead to improvements in accuracy when measured empirically with a BBTK. This may on occasion mean that you need to make adjustments that at first seem counterintuitive. For example, by reducing the length of a sound file so that it plays for the correct duration on your specific sound card, amplifier and speakers, or by playing it earlier to realign it with a visual stimulus.

You may also need to apply some lateral thinking to improve your timing. This could mean rather than timing responses from the onset of a stimulus image, to time RTs from a "phantom" TTL pulse you generate 30mS later to account for a 30mS input lag in the TFT you are using. It could also mean that you need to reconfigure any third party equipment to work in a slightly different way. For example, to modify the way it sends sync signals to, or from, your equipment in terms of pulse frequency, duration or number. It can also mean that you need to change some of the equipment you are using, e.g. a specific keyboard or mouse. At the most extreme it can mean that you may need to consider using a different experiment generator or modifying your own code. It is now accepted that different experiment generators may be more suited to some research areas than others.

*2.4 What's the Best X? – The Curate's Egg**

What's the Most Accurate Experiment Generator for Presentation and Response Timing?

Some experiment generators are strong in one area and weak in others. In an ideal world one might consider using a mix of experiment generators and custom written software. However to discover in which areas a particular piece of software is strong you will need to use the Black Box ToolKit to confirm this. In addition you should bear in mind that the same piece of software can perform very differently on two computer systems. Again this is a prerequisite for using the Black Box ToolKit.

Which Brand/Model or Computer is the Most Accurate?

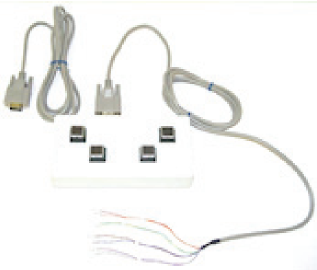
Unfortunately all computer systems vary in terms of their timing accuracy. This means it is impossible to identify a single "best system" as there are so many variables that need to be considered. Manufacturers typically change the components they build into computer systems on a batch-by-batch or month-by-month basis which makes it hard to recommend one brand or model over another. In effect you should consider computer systems as being commodity items. Two identical looking systems may actually be very different internally and have different levels of timing accuracy as timing accuracy is often tied to the hardware. The way the Operating System is configured can also have an affect, as can installed software, drivers and virus checkers which is why you should use a Black Box ToolKit to check your own timing accuracy.

What's Best for Visual Presentation: a CRT, TFT or Data Projector?

Depending on the context you wish to use the display device in and the paradigm in question, the balance varies. For example, for RSVP and priming or experiments where synchronisation is important, the only realistic option remains a CRT. In general data projectors have the worst input lag, with TFTs somewhere in the middle. Input lag means that images are not displayed when requested as the display devices electronics takes time to process the image and physically display it. Unfortunately an experiment generator only knows about the time it requested the image be displayed and not when it physically appeared on-screen.

Researchers need to be aware of the mechanics of how different types of displays work and their likely impact on timing accuracy. By using a Black Box ToolKit you can help ensure that the timing characteristics of your own specific display device are accounted for. We appreciate that CRT displays are not always available, or practicable, and so there may be mitigating circumstances for using devices with inferior timing characteristics.

What's the Best Response Device?



Depending on the experiment you are running you may be limited in your choice of response device. Ideally you should use a recognised manufacturer's response box, or pad, as this is likely to have a small internal delay that contributes relatively little to response time error. However, it is worth bearing in mind some computer mice can have an equal, or better variability, as compared with some experiment generator vendors own devices. Combined with a small absolute error such mice can offer a viable alternative, which can cost many hundreds of times less in some cases.

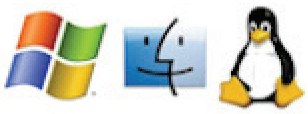
Typically much of the inaccuracy response devices contribute to RTs is due to inherent delays within the hardware itself. For example a typical keyboard can add approximately 30~70mS to the true RT. Much of this variability is due to a scanning, or polling loop, where key states are checked and then reported to the computer. Any response device which has buttons, or keys, that need to be checked or its position monitored, e.g. a computer mouse, will most likely make use of polling loops and have an inbuilt level of absolute error and variability.

You should bear in mind that manufacturers' of input devices, e.g. mice, keyboards, sound cards are under no obligation to make them millisecond accurate. So long as they work as intended and are electrically safe they are suitable for sale. The online gaming community are quite fanatical about mice, as for them fast responses are important and can give them a competitive edge. A Google search for "fastest mouse response for gaming" will give you a good insight into timing characteristics of widely available mice. However, you should bear in mind that manufacturers are liable to change components within input devices even though they may look the same externally. As a result you are advised to test the timing accuracy of your own response devices using a Black Box ToolKit.

I can Connect my Response Device by Either USB or Serial. What Interface is Best?

Research has shown that although interfaces differ in transfer speed the actual response accuracy is largely determined by the response hardware itself and not the bandwidth of the connection to the computer. That is, how quickly the devices internal microcode scans for button, or key presses, in a polling loop. This is illustrated by the fact that a mouse that offers both USB and PS/2 interfaces actually changes response characteristics when the interface is changed. Simply by swapping the interface, two different pieces of microcode are used. Each has its own timing characteristics independent of the type of connection to the computer. As a result response devices should be checked independently using a Black Box ToolKit to ascertain their contribution to timing error. You should also be wary of convertors which offer serial to USB interface conversion as often they can add an unknown contribution to timing.

PC/MAC/Linux... Which is Best?



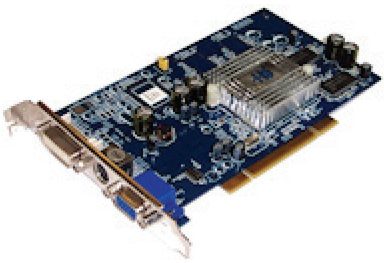
As is the case with experiment generators one cannot recommend one platform over another as each has its own specific strengths and weaknesses. Most modern operating systems are multitasking and therefore the inherent risk of inaccurate timing is always a possibility. As timing inaccuracy is caused by a combination of hardware and software interaction making any generalisable prediction as to accuracy impossible.

Soundcards... Which one Should I buy?

All soundcards are susceptible to soundcard startup latency. This is the time it takes a sound to physically emerge at the speakers versus the time the computer requests the sound be played. Generally more expensive soundcards have lower startup latencies as compared with those that are integrated within a computers motherboard, e.g. AC97 or Intel High Definition Audio (also called HD Audio or Azalia). Typically cards that offer ASIO drivers have better quality hardware and drivers and therefore tend to have lower startup latencies. To be certain of the contribution your soundcard is making to audio presentation delays you will need to check startup latencies using a Black Box ToolKit.

For computer based musicians soundcard latencies are crucial. A Google search for "sound card startup latency" will help you identify inherently fast cards. For an acceptable "feel" when playing a sound, the latency should be in the range of 10mS or lower. Unfortunately most soundcards have much higher latencies, which can be as high as several hundred milliseconds.

Which Graphics card?



Typically all cards that support Microsoft DirectX should in theory be capable of very fast display/buffering times. However you should bear in mind that some drivers are better than others. Once you have checked a paradigm with the Black Box Toolkit you are advised not to update any system drivers without retesting. In addition some drivers offer advanced options such as tick boxes that allows you to sync the card with the refresh signal, e.g. ATI's Catalyst drivers. Various settings can alter display performance and should be checked if you have problems. You are advised to consult various gaming websites as again display performance is crucial for gamers.

A Google search for “fast graphics card for gaming” will help you identify good cards and those with known problems.

Are Faster Multi-core Processors Better Than Slower Ones?

Not necessarily as there are no guarantees that a faster system doesn't have other "issues" that prevent accurate timing. For example drivers, add-in cards, installed software, background tasks and the like will have an affect on your ability to obtain millisecond accurate presentation, synchronisation and response timings. Computers that have a faster GHz rating don't necessarily have more accurate clocks. To find out more about clock drift Google "PC clock drift". Some PCs' clocks can gain over 10 minutes per day whilst others loose time. This is due to the quality of the crystal oscillator on the motherboard and it is this that provides a base for all millisecond timing.

In addition use of multi-core processors with, or without Hyper-Threading, does not automatically mean that timing will be any better. In fact, many multi-core systems actually perform worse than equivalently clocked single core systems. Remember the vast majority of software is not optimised to run on multi-core, or Hyper-Threaded, systems.

What Does the Term "Curate's Egg" Mean?

A curate is a term used in various Christian religions to describe a priest who is not a parish priest but operates in effect as his or her deputy. Some larger parishes may have more than one curate. Most curates are eventually raised to become a parish priest in another parish as the older priests retire or die.

The expression "a curate's egg" meaning something that is partly good and partly bad and thus not wholly satisfactory, arises from the publication of a cartoon in Punch on 9 November 1895. The cartoon, drawn by George du Maurier and entitled, "True Humility", featured a timid looking curate taking breakfast in his bishop's house. The bishop says, "I'm afraid you've got a bad egg, Mr Jones". Apparently trying not to cause offence the curate replies, "Oh, no, my Lord, I assure you that parts of it are excellent!". http://en.wikipedia.org/wiki/Curate's_egg

2.5 Technical

How Does the Kit Connect to the Host PC?

The BBTK connects to a standard Microsoft Windows XP, Vista, 7, 8, 8.1 or 10 (32 or 64 bit) machine via a USB 2 or 3 port. This host PC controls the BBTK and is used to analyse timing data once collected from the remote system. If you are making use of the API you can control the BBTK from any system that supports the serial protocol over USB via a virtual COM port, e.g. Mac, Linux etc.

What's the Difference Between Passive and Active Switch Closure?

Passive Switch Closure is where a flying lead from your response device switch is fed into the BBTK. So when you press a button on your response device its timing characteristics are also recorded by the BBTK at the same time as your own experiment (response onset and duration are recorded).

Active Switch Closure is where a flying lead is attached to your response device switch from the BBTK. BBTK applications such as DSCAR (Digital Stimulus Capture And Response) can then close the switch of your response device as if it had been pressed by a human participant once a stimulus was detected. However this won't include physical key or button travel time.

How Many Active Switch Closures can I Trigger When Using the BBTK's Response Pad?

Depending on the model of BBTK response pad you have purchased it has four buttons that can be mapped, via Active Switch Closure leads, to buttons or keys on your own response devices.

Environmental Considerations

When using the opto-detectors you are advised to work in a room illuminated by natural lighting. Artificial fluorescent lighting for example can inadvertently activate the sensitive opto-detectors. Typically this will appear as mains frequency hum when you analyse your data (regular spaced peaks at 50/60 Hz).

Indirect artificial lighting is generally suitable or as an alternative mask out the back of the polycarbonate opto-detector with opaque tape.

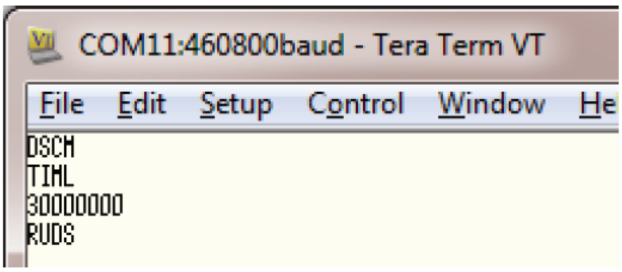
Will Your Kit Work in our MRI Scanner Room?

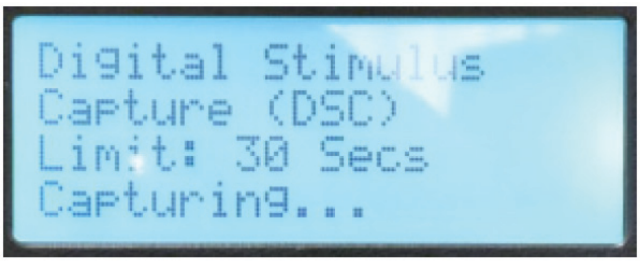
Currently no parts of the BBTK should be considered scanner safe. To utilise the BBTK you are advised to make use of a patch panel and tap into sync signals, video I/O, audio, responses etc. from there.

It is likely that it will be possible to check the timing accuracy of presentation and response equipment outside of the scanner room, e.g. data projectors, headphones, response pads etc, whilst running the identical paradigm.

Is There a Mac/Linux Version of the Software? Is There an API?

Currently we only supply our BBTK control and analysis software as a Microsoft Windows application. However, you can use the BBTK API to control and analyse data using any platform that supports the standard ASCII/text protocol over serial. The BBTK is physically connected by USB but is accessed via a virtualised serial COM port. This means that you can control the BBTK from MATLAB, PsychoPy or any other software, or platform, that supports a COM port, e.g. Mac, Linux etc. You also have the option to run the BBTK Windows software using a Virtual Machine on your chosen platform.





The BBTK itself is controlled using simple four letter commands and line change event data/time stamps are streamed back after a testing session has reached a set time limit. The serial terminal example shows four commands that instruct the BBTK to capture events across any of its input channels and then upload data after 30 seconds. The LCD screen of the BBTK is shown for reference. A printed API user guide is supplied with certain models. Alternatively this can be purchased as an optional item with any model.

We've Built Some Custom Response Equipment. How do we Link to the TTL Interfaces Offered by the Kit?

To make use of the BBTK's TTL I/O interface you need to be able to generate TTL signals that present 0V to 3~5V signals. Where the change from 0 to 3~5V indicates a change in activity, e.g. MRI scanner sync pulse, visual stimulus image onset etc. In addition the BBTK can generate TTL signals in order to mark event activity or stimuli onset, e.g. conditional EEG event marking, simultaneous TTL signal with a response action such as an Active Switch Closure (where a response key is closed on your own device).

Depending on which version of the BBTK you purchased it will have between two and 20 TTL I/O lines. To increase the number of TTL lines available an expansion pack offering an additional 16 TTL lines can be used with any BBTK (ships with the Elite by default).

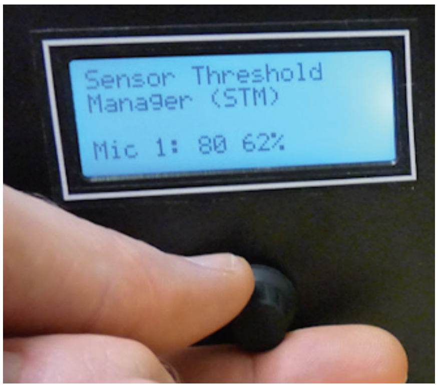
How Many Screen Regions can I Monitor at Once?

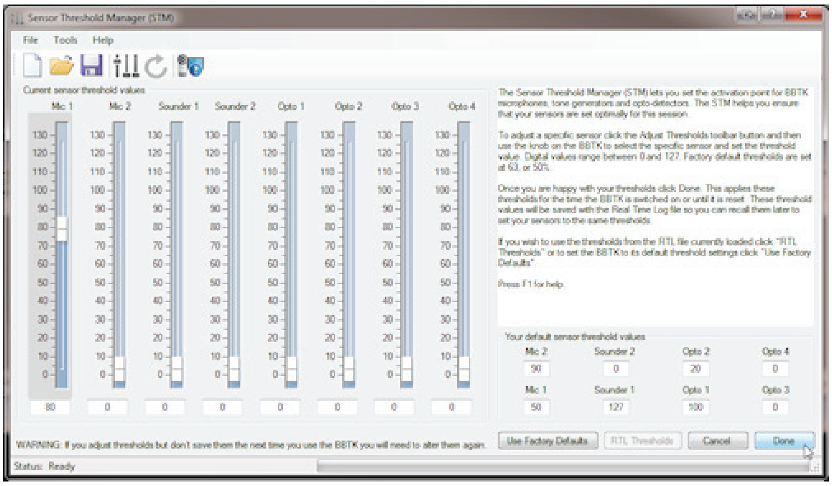
The Entry level BBTK can make use of a maximum of two opto-detectors, and the Pro and Elite four. By default they ship with one, two and four opto-detectors respectively. Opto-detectors can be used with TFTs, CRTs, data projectors or any other device that switches between no, or little light/black, and bright light, i.e. black and white event markers.

The BBTK Elite allows you to monitor up to four separate regions simultaneously. You can instruct the BBTK to trigger a response when it detects activity on one or more opto-detectors. Alternatively it can conditionally event mark based on logic you predefine, e.g. conditional event marking using TTL signals/channels on an EEG trace.

How do I Adjust the Sensitivity of the Kits Sensors?

The sensitivity of the BBTK's sensors, e.g. opto-detectors, mics etc. are digitally adjusted and range between 0~127. In general they should be adjusted in line with the performance characteristics of a human. Simply, place the sensors where you'd expect a human to be looking or listening. Then using the Sensor Threshold Manager (STM) adjust the sensitivity via the rotary encoder (turn and push knob) on the front panel of the BBTK until the activity lights illuminate and dim when the stimulus is removed. As threshold values change a digital value will be simultaneously displayed on the BBTK LCD and in our PC Software.

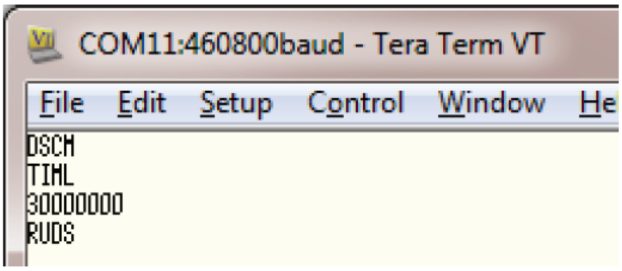


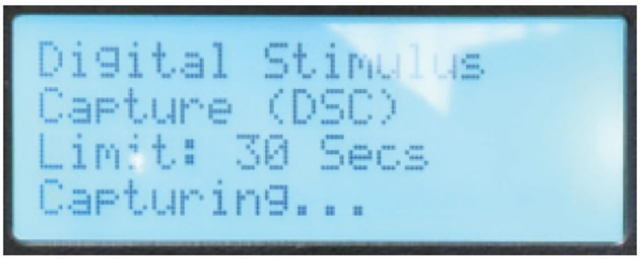


Digital thresholds for each sensor can be saved and recalled at any time. To help aid consistency, the current sensor threshold values are saved with timing data files. If you are using the BBTK with your own software, via the BBTK API, you can read and set sensor thresholds individually when required.

Can I use the Kit with Third Party Experiment Generators or Software I Wrote Myself?

Yes. You can use the BBTK API to control and analyse data using any platform that supports the standard ASCII/text protocol over serial. The BBTK is physically connected by USB but is accessed via a virtualised serial COM port. This means that you can control the BBTK from MATLAB, PsychoPy or any other software, or platform, that supports a COM port, e.g. Mac, Linux etc.





The BBTK itself is controlled using simple four letter commands and line change event data/time stamps are streamed back after a testing session has reached a set time limit. The serial terminal example shows four commands that instruct the BBTK to capture events across any of its input channels and then upload data after 30 seconds. The LCD screen of the BBTK is shown for reference. A printed API user guide is supplied with certain models. Alternatively this can be purchased as an option item with any model.

How do I Link the Kit up to my MRI Scanner Sync Pulse so that I can Relate Presentations to Actual Acquisitions?

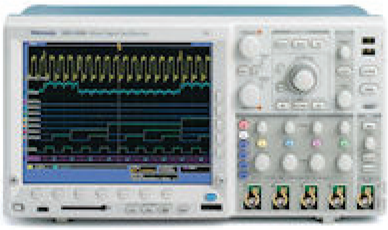
The kit provides up to 10 TTL input lines (3~5V). Any of these can be used to track the scanner sync pulse. You are advised to alter your scanner sync pulse characteristics so that it is long enough to be detected by the BBTK and easily seen by you within a timing validation run, e.g. 10-20mS width, high active.

When you assess the timing accuracy of your experiment you will also capture the scanner sync pulse as well as visual and auditory presentations and subsequent responses. In the 20 channel logic analyser you will be able to see the relationship between the scanner sync pulse, visual and auditory presentations and any responses. With this additional data you should be able to correlate brain activity on any given acquisition with a specific presentation and subsequent response data.

The BBTK can also feed TTL signals back into your scanner software in order to provide event markers for stimulus, synchronisation or response events. Up to 10 TTL output lines are available for this purpose.

2.6 Bench Test Equipment Comparisons

Can I use the Kit Like a Traditional Digital Oscilloscope?



No. The BBTK only supports binary states on each input and output line, either on or off, TTL +3~5V and 0V, or switch closure active or not active.

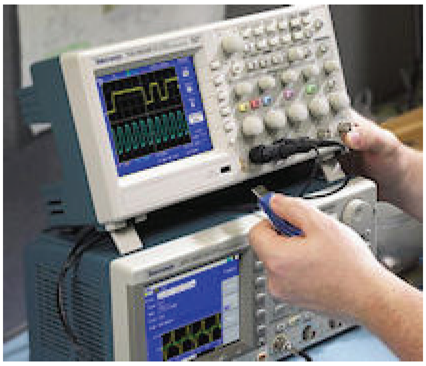
In addition there is no live moving graphical display as with a traditional oscilloscope. Instead data is analysed graphically once collected. You can think of the BBTK as offering the same functionality as a binary state 36 channel digital oscilloscope or logic analyser.

Can I use the Kit Like a Traditional Pulse/Function Generator?

Yes. However the BBTK only supports binary states on each output line as a square wave, TTL +3~5V and 0V, or switch closure active or not active. Whereas traditional function generators let you create different forms of waves and also vary the voltage. The BBTK enables you to create an infinite number of regular square wave TTL events across up to 36 channels.

In some respects the function generation part of the BBTK is more advanced than a traditional device. For example, each event can have any onset and pulse width and events can occur on any line or channel. Traditional function generators do not allow you to vary onsets and widths on an event-by-event basis.

Can I do what the Black Box ToolKit does with a Digital Oscilloscope and Signal Generator?



No. In effect you would need a 20 channel digital oscilloscope/logic analyser to monitor inputs and a 16 channel function generator to generate responses. This type of setup would be prohibitively expensive and would mean that several devices would need to be daisy chained together to achieve the same number of channels. In addition making the oscilloscope/logic analyser talk to the function generator on an event-by-event basis would be extremely difficult, if not impossible; as such equipment is not designed to work in this way. Remember the BBTK can respond on an event-by-event basis to stimuli and generate patterns of responses as if it were a human participant. All parameters can be set quickly and easily and results are displayed graphically in 20 channel logic analyser. Each event onset, offset and duration is simultaneously displayed in spreadsheet windows for rapid analysis.

The BBTK also allows you to respond in different ways to different stimulus patterns, plus the characteristics of each response itself can be altered on an event-by-event basis. The complexity of using standard oscilloscopes and function generators together is simply too great an overhead as compared with the simple graphical interface of the BBTK.

What's the Typical Sampling Rate of the Black Box ToolKit?
When compared to bench equipment the kit samples at relatively low rates. Although the ARM chip in the BBTK runs with a clock speed of 96 MHz (96 million instructions per second) we have chosen to downsample to 6 kHz on a highly precise interrupt driven basis. The external crystal clock that we use for timestamping data is running with nanosecond precision.

This is because unlike bench equipment the BBTK allows you to replay all event data captured over periods of many minutes using its 8 MB of internal RAM. Digital oscilloscopes/logic analysers sample at much higher rates but can only replay events over a very short period, e.g. a second or two, and across many less channels, e.g. 2 to 4 channels for a typical oscilloscope/logic analyser.

By sampling at 6 kHz this gives us enough accuracy to be confident we are measuring and generating events with sub-millisecond accuracy, i.e. six samples per millisecond across 36 channels. The graphical 20 channel logical analyser lets you zoom in to compare any two or more events at the millisecond level whereas the raw data spreadsheets report the same events with sub-millisecond precision. Because the BBTK runs independently of the PC and has its own CPU and external crystal clock, you can be sure of its accuracy.

2.7 Training, Demos & Consultancy Services

Our Department Would like you to Come and Give a Talk. Would you be Willing to do this? What About Training?
Yes. As standard we charge a daily rate plus expenses. Talks and visits typically include grounding in the academic timing literature, a live demo of the Black Box ToolKit, a Q & A session and an interactive forum where we can advise on your specific paradigms.

Please feel free to contact us to discuss your requirements.

We'd like to Integrate Some Best Practice Guidance Into the way we Teach Undergraduates in the use of Experiment Generators. Could you Advise us?
Yes. Typically we help construct high quality teaching materials that can be delivered to students during research methods courses. There are worked examples with common experiment generators and resources which highlight potential sources of error and workable solutions. As part of the experience we favour one onsite visit where we can demonstrate errors and take part in Q & A sessions with students. Please feel free to contact us to discuss your requirements.

Our Study is Time Critical and we Need to Have Validated Results Together with Independent Timing Certification. Do you Offer a Consultancy Service?

Yes. We offer a service whereby we can visit onsite to test your specific equipment and paradigm. Alternatively we can test your software or hardware in our lab on calibrated computer systems and tablets. Whether we test onsite or in our own lab, either option will result in an independent timing certification report and detailed advice on how to improve your accuracy.

As part of our ongoing dedication to improving timing accuracy across the field we also offer a cost-effective in-house hardware design and build service. This means we can help provide hardware for custom applications that require accurate timing. Please feel free to contact us to discuss your requirements.

2.8 Contacting us & Ordering

How do I Order?

The first step in the process is to request a formal quotation. This is valid for 30 days and prices are tied to Pounds Sterling (GBP) as we are based in the UK. We will convert prices to your local currency based on the date the quote was issued. Each quote will also include worldwide shipping and insurance as standard. If you need to discuss your requirements in more depth we will be happy to help advise.

If you decide to place an order we will require an official Purchase Order with EU VAT number if applicable. Next we will usually invoice you on a Pro Forma basis, i.e. payment in advance, as the majority of our sales are outside the UK. Once we receive cleared payment shipping is usually within five working days. All shipments are dispatched using a fully tracked signed for service.

Do you Offer Multi-pack Discounts?

Yes. We have priced the Black Box Toolkit very competitively in terms of the functionality it offers. It is priced at approximately the equivalent cost of a mid to high-end laptop and we hope that organisations that are serious about the quality of their science will purchase a Black Box ToolKit for each of their research groups. For individual quotes please contact us directly.

I Need to Talk Specifics

If you need to talk about BBTK functionality you should talk to us directly and we will be glad to advise based on your query. Please note we are unable to give specific advice on timing issues unless you are one of our BBTK users as this will count as technical support.

3. Hardware & Software Requirements

3.1 Host PC hardware requirements

The host PC is the computer which has the BBTK physically plugged into it and runs the suite of data collection and analysis tools.

Minimum

- 1GHz CPU
- 1Gb RAM
- 1024x600 display
- 75Mb of free Hard Drive space
- Free USB 2 port
- Microsoft Windows XP SP3

Recommended

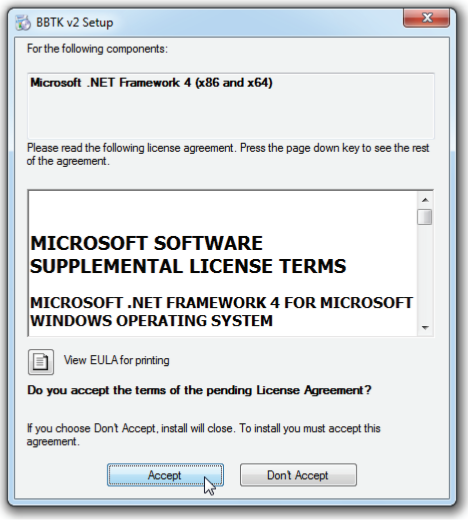
- 3GHz Multi-core CPU or better
- 4Gb RAM
- 1280x1024 or higher display
- 75Mb of free Hard Drive space
- Free USB 2/3 port
- Microsoft Windows 7 SP1 or later (32 or 64 bit)

4. Installing and Configuring The Black Box ToolKit

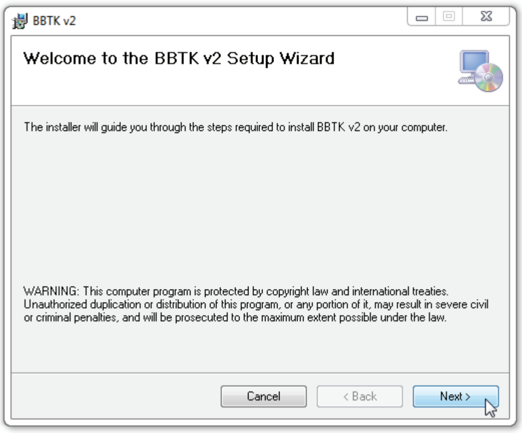
4.1 Installing the Black Box ToolKit PC Software

To install the BBTK software on your PC you should be logged into Windows with Administrator rights. If you have a CD it should automatically start when inserted. Otherwise double click on setup.exe.

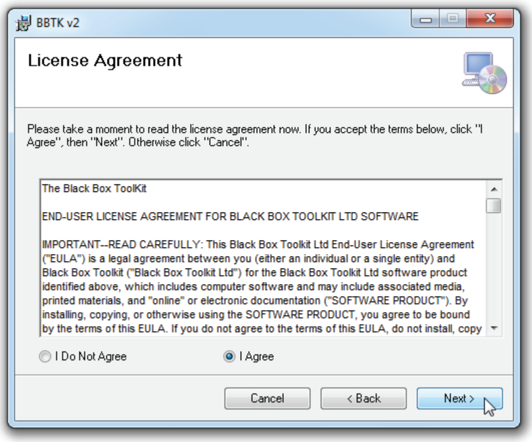
DO NOT CONNECT YOUR BBTK to your PC whilst installing the PC Software as you need to install several drivers for it to function correctly first.



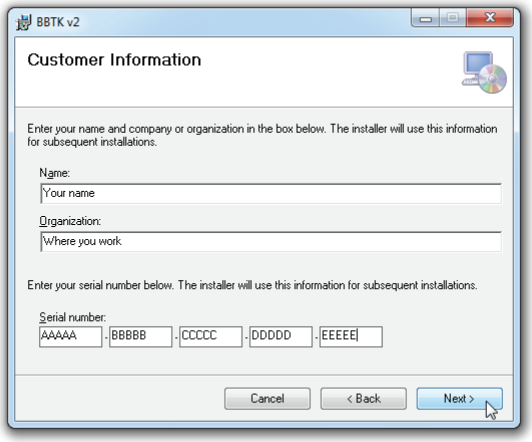
Depending on whether or not you have the Microsoft .NET framework already installed on your PC you may be prompted to install it before you can install the BBTK PC Software.



Once the BBTK setup starts you will be presented with a Welcome dialog. To begin installing click Next.

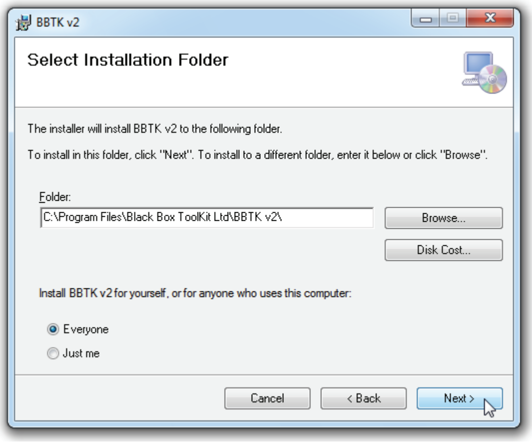


Any additional information will then be displayed. In order to install the software you will need to agree to the Licence Agreement.



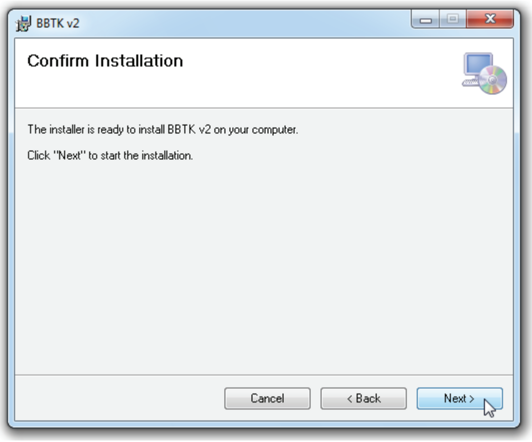
Next enter your details and serial number. Ensure you enter your serial number accurately as this helps with checking for updates and obtaining technical support.

Your serial number can be found on the back of the CD cover or on the underside of your BBTK itself.

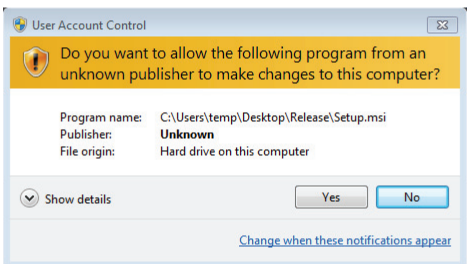


If you wish to change where the PC Software is installed browse to a different folder.

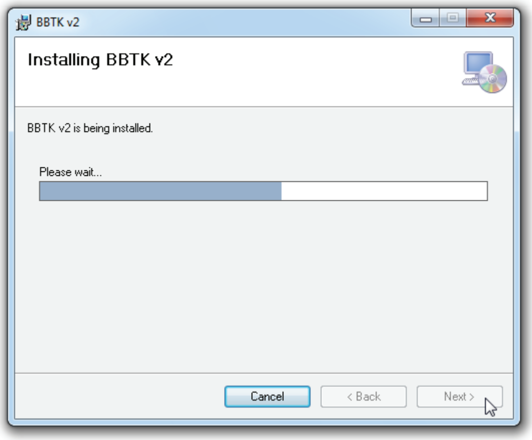
On some systems to aid compatibility, e.g. Windows 8, the PC Software will be installed to "C:\BBTKv2\" by default.



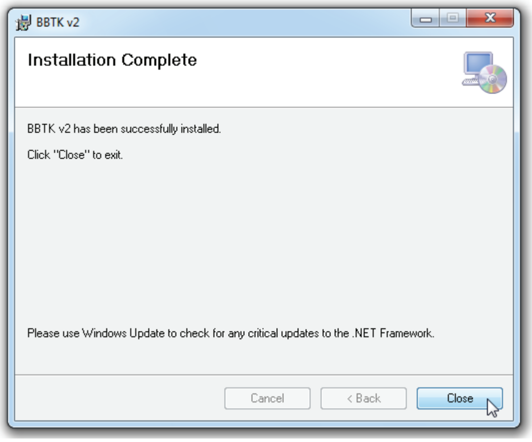
When you are happy with your choices click Next to start the installation.



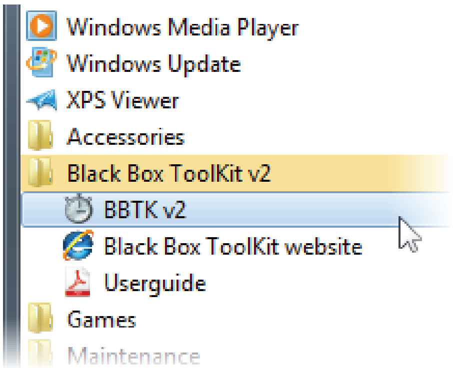
Depending on how your computer is configured you may need to acknowledge the User Account Control dialog that confirms you want to allow the BBTK installer to make changes to your computer.



The PC Software will now be installed.



To finish the installation click on Close.

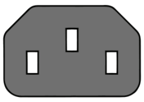


Depending on which version of Windows you have installed a Black Box ToolKit v2 on a folder should have been placed under the Start menu.

4.2 Powering up the Black Box ToolKit

The PSU supplied with the BBTK is a switch mode power supply that outputs 5V (with a positive centre pin). It will work on mains supply voltages 100V-240V and is suitable for use in most regions.

You should only use the power supply supplied with your BBTK. Use of any other power supply will void your warranty.



The BBTK PSU is not supplied with a mains power lead.

You will need to source an IEC C13 female lead (IEC 60320). These are standard computer power supply leads that will be terminated in a plug suitable for your regions mains power company’s outlets. You should ensure that this is has a 3A fuse (where applicable).

To power up the BBTK, plug the C13 lead into the supplied PSU and then into your power company's outlet. Once you have turned on the power plug the 3.5mm adapter into the rear of the BBTK.

You should use the power switch on your power company's outlet to turn the BBTK on and off in future.

When you are not using the BBTK you are advised to turn off the power and also unplug the USB lead from your PC.

4.3 Installing a Black Box ToolKit Flash Memory Driver

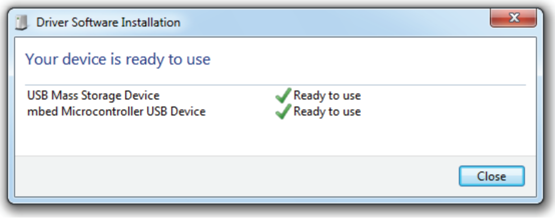
The Black Box ToolKit has an internal 2Mb Flash Memory Drive that is used to store its firmware together with any configuration files. As with traditional USB memory sticks Windows needs to install a driver for this memory to appear as a standard driver letter.

This makes it much easier to update firmware as new versions become available. To update the firmware on your BBTK you would simply copy a BIN file to the BBTK drive letter. This can be accomplished in a matter of seconds using the drive letter and copy and paste!

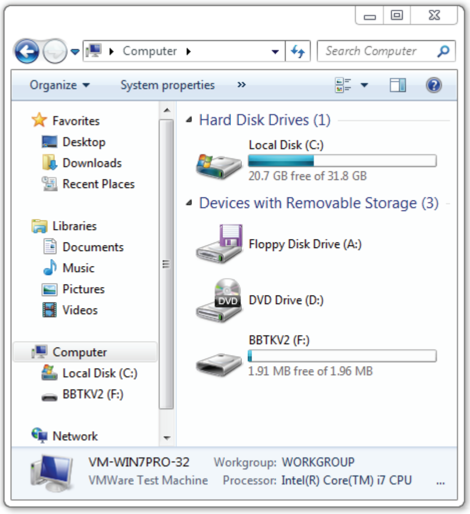
To begin the process power up the BBTK by plugging it into the supplied power adapter as described above.

ENSURE THAT YOU ARE CONNECTED TO THE INTERNET

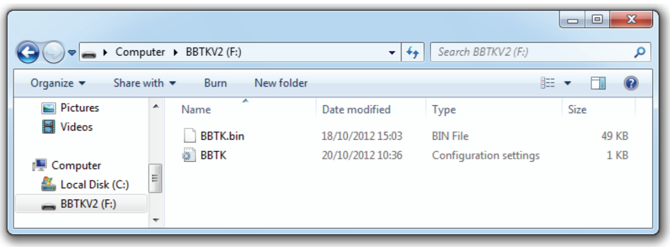
Next choose a free USB port on your PC and plug in the BBTK. You are advised to use the same USB port consistently. Where possible avoid using a USB hub.



At this point Windows Update should automatically recognise the BBTK and install drivers that allow it to function as a USB Flash Drive (like a memory stick).



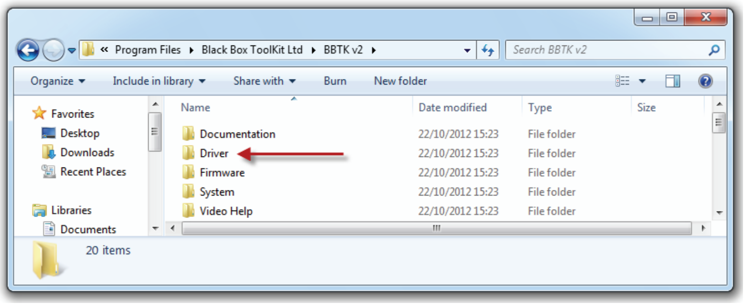
As can be seen in this example a new drive letter F: has appeared.



On the BBTK flash drive there should be two files. BBTK.bin is the firmware that powers the ARM CPU and the second is an ini, or configuration file, that lets you set the communication speed between your PC and the BBTK.

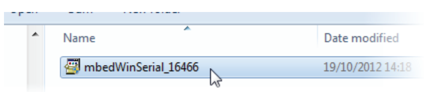
4.4 Installing the Black Box ToolKit Virtual Serial Port Driver

Before your PC can communicate directly with the BBTK you must install a driver from ARM Ltd that allows it to function when connected to a USB port. This allows it to send data to and from the PC once it has finished capturing or generating data.

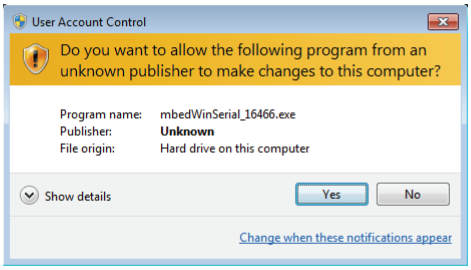


By default the Driver you need to install is placed in your Program Files folder under the BBTK v2 folder.

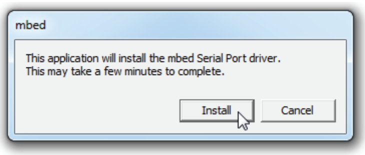
Alternatively there is a copy in the Driver folder of your installation CD.



Navigate to the Driver folder and double click on the driver file to install it.

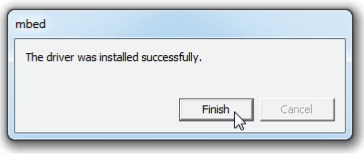


Depending on how your computer is configured you may need to acknowledge the User Account Control dialog that confirms you want to allow the driver to make changes to your computer.

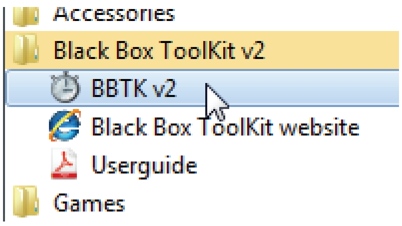


Click on Install to begin the driver installation.

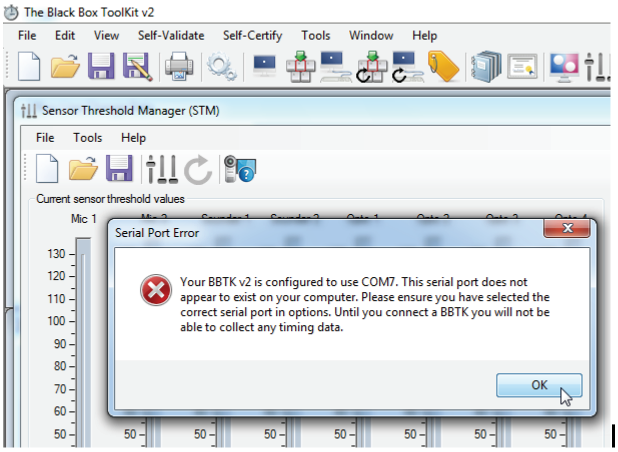
Depending on how your computer is configured you may need to confirm that you want to install the driver from ARM. We recommend that you Always trust software from “ARM Ltd”.



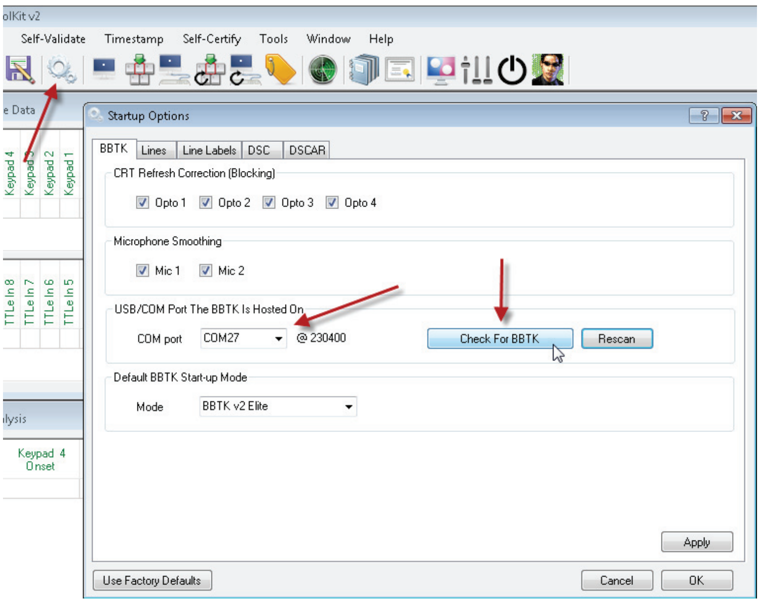
Once the driver has installed click on Finish.



The final step is to tell the BBTK which USB/virtual serial COM port it is connected to the PC by. To do this start the BBTK PC Software via it's entry under the Start menu.



When you start the BBTK PC Software for the first time you will receive an error as it doesn't know which USB port it is attached to. Click on OK to dismiss the error message. Then click on Cancel to cancel the Sensor Threshold Manager dialog.

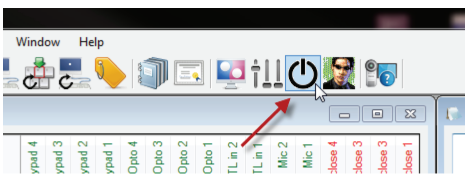


Now click on the Options toolbar button. Select the COM port the BBTK is located on from the drop down and then click on the Check For BBTK button.

If the BBTK is connected to that port you should receive an acknowledgement message. To save click on Apply and then OK. If a BBTK is not detected select another COM port and try again.

If not all COM ports are listed in the drop down you may need to click on Rescan to add them.

If your BBTK cannot be automatically detected consult the troubleshooting section of this guide.



To check your settings are correct you are advised to reset the BBTK using the reset toolbar button. Alternatively close and reopen the PC Software.

If this fails close the PC Software and power cycle the BBTK by unplugging the USB lead and then removing the power. Wait a few seconds, then replug the USB and the reapply the power. Finally start the PC Software.


```
Black Box ToolKit 2
Copyright (c)
BBTK Ltd 2003-2016
Firmware: 20160301
```

When the BBTK resets, or is first powered on, it should display a copyright notice along with a firmware version on its LCD screen similar to the one shown.

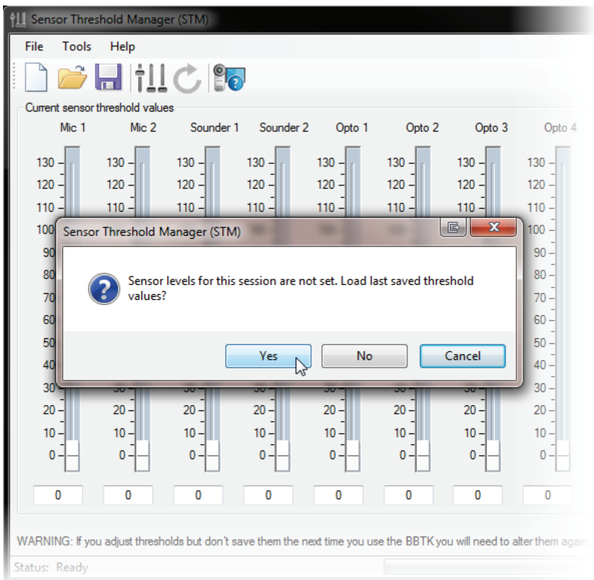
```
Connected Host PC

Communication Speed
230400
```

When you start the PC Software it should attempt to connect to the BBTK via the COM/USB port you chose. If successful you should see the Communication Speed displayed in bps on the BBTK LCD. By default this is 230,400 bps but could be slower depending on your Operating System.

```
Ready...
```

Once connected the default is for the BBTK to display “Ready…” indicating it is ready for use.



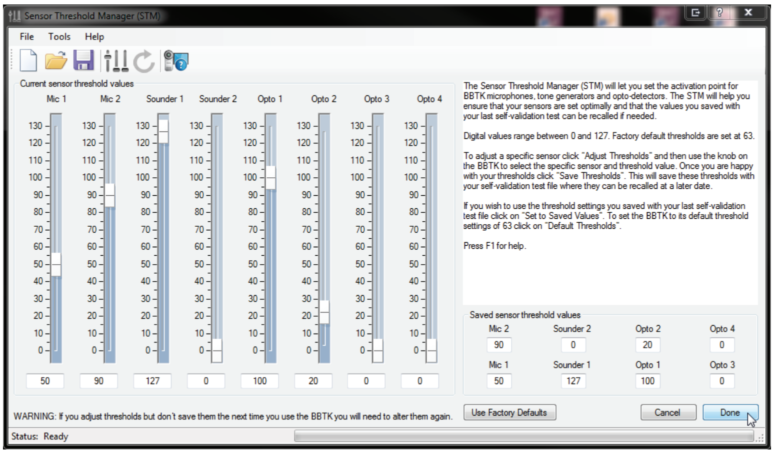
The PC Software will display the Sensor Threshold Manager dialog as you have either just reset the BBTK or started the PC Software.

On initial startup you will be prompted to load your last saved threshold values. Generally you should say Yes to this request. This basically sets the detection, or trigger levels, for the BBTK’s various sensors.

```
Sensor Threshold
Manager (STM)

Levels From PC...
```

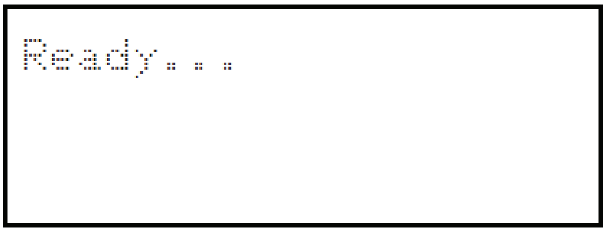
When you click on Yes the BBTK will display a message saying that it is setting its threshold levels from the PC.



The sensor threshold levels will change on the PC sliders once they are set on the BBTK.

Note: These sliders are indicators only and cannot be dragged using the mouse.

To close the dialog click Done.



Finally "Ready…" will be displayed.

Congratulations your BBTK is now fully configured and ready to use!

4.5 Rebooting your Black Box ToolKit

Occasionally you may need to reboot your Black Box ToolKit when a reset is ineffective. The basic procedure for rebooting is:

1. Unplug the USB lead from your host PC
2. Remove the power adapter from the BBTK or turn it of at the mains supply
3. Wait 5 seconds
4. Reapply power so that the Copyright and firmware version are shown on the LCD screen
5. Plug the USB back lead back into your PC

Depending on the cause of the issue you may need to reset the BBTK using the reset button on the PC Software toolbar to reconnect with the BBTK.

If you continue to have problems connecting quit the PC Software, carry out steps 1 through 5 and then restart the PC Software on your host PC.

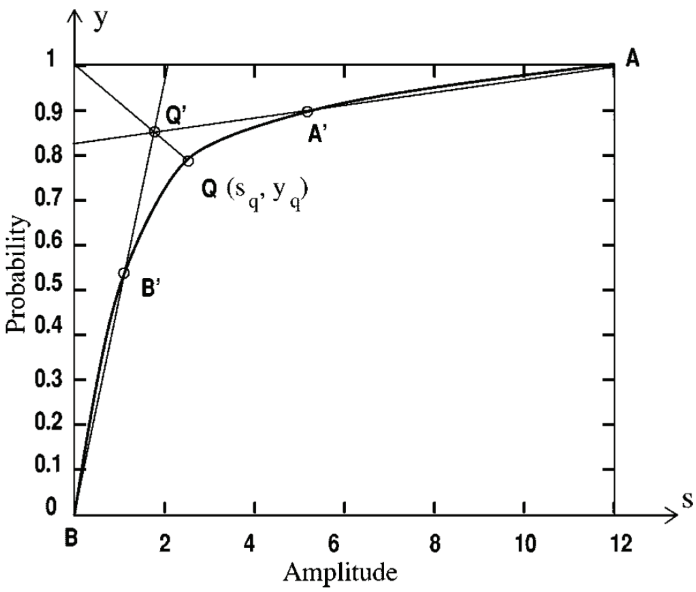
For more troubleshooting tips consult the dedicated troubleshooting section of this guide.

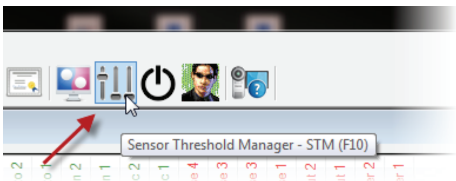
5. The Sensor Threshold Manager (STM)

5.1 Setting Sensor Activation Thresholds

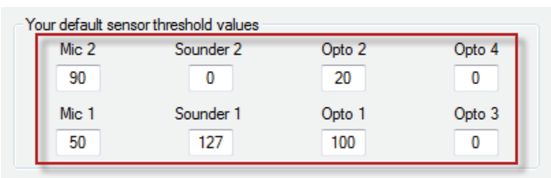
The Sensor Threshold Manager (STM) lets you set the activation point for BBTK Microphones, Sounders and Opto-detectors. The STM helps you ensure that your sensors are set optimally for detecting your stimulus materials. When you first start the PC Software or reset the BBTK the STM will automatically be displayed so that you can set sensor activation thresholds.

For example, you may need to adjust the activation point, or crossing threshold, for a BBTK microphone so that it just triggers for the volume level produced by your own sound outputs. Put simply the BBTK needs to know at which point on an analogue waveform it needs to trigger at. In the sample waveform shown below, trigger point Q' would need to be reached before the BBTK registers a stimulus. It is these points you are setting when you alter the thresholds on the BBTK using the STM.

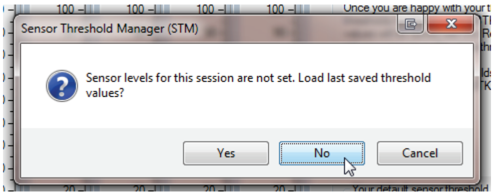




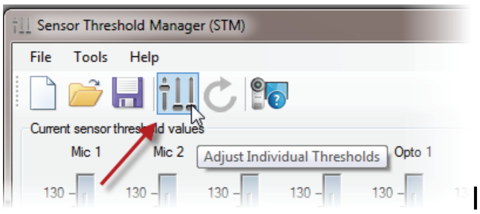
To adjust a specific sensor click the Adjust Thresholds toolbar button to start the STM.



You may at this point be asked if you want to load your default thresholds. These are the thresholds that are loaded by default each time you switch on the BBTK or reset it. They are shown in the lower right of the STM.



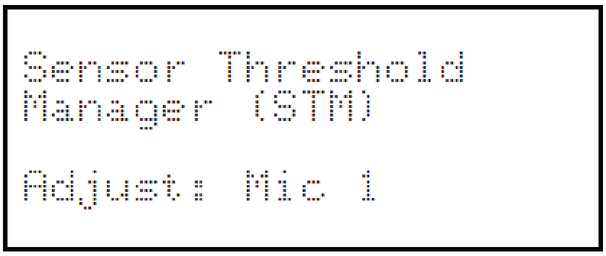
If you do want to load those values for this session click Yes. Click No if you wish to set the thresholds yourself.



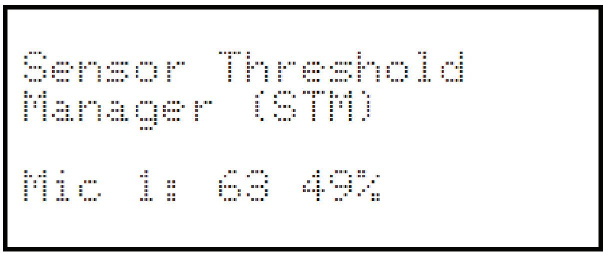
To begin to set thresholds yourself click the Adjust Individual Thresholds toolbar button.

The BBTK display will change to show you are about to set thresholds for various sensors.

To start setting the threshold levels press the command knob so that it clicks.



Now you will need to choose the sensor you want to adjust. Turn the command knob to select the sensor you want to adjust and then press it to select



Turn the command knob so that the activation point, or crossing threshold, changes.

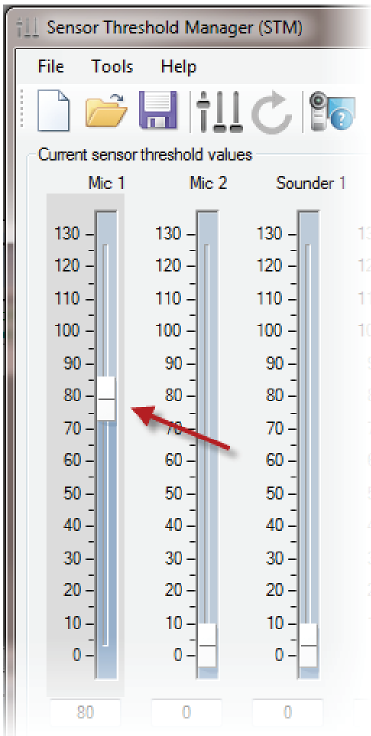
When setting thresholds it is crucial for optimal timing to have the threshold set appropriately.

Typically turn the threshold up to a point where the LED is permanently on when the stimulus is present. When the stimulus is not present the LED should turn off.

In the case of Mics if the desk in front of them is gently tapped the appropriate LED should flicker.

For opto-detectors you should set the threshold as high as possible so that when a white stimulus block is present on screen the LED is permanently lit. Then reduce it so that when a black screen, or black stimulus block, is displayed the LED just turns off. This may only require a small percentage point reduction.

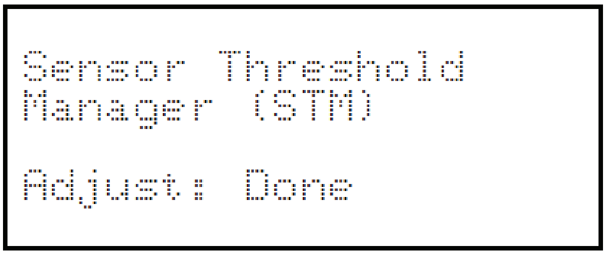
If you set your thresholds too low timing accuracy may be suboptimal.



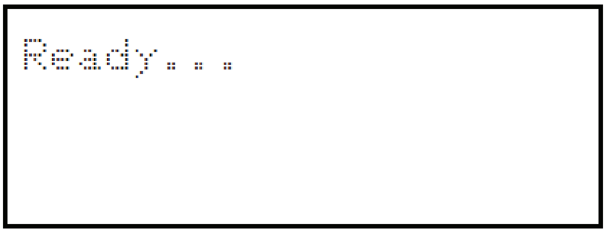
As you select the sensor to adjust the PC Software will highlight the sensor with a grey background.

When you adjust the various sensors the PC Software will show the indicators in the STM moving up and down as you turn the command knob on the BBTK.

When you are happy with your activation point press the command knob to return to the main sensor menu.

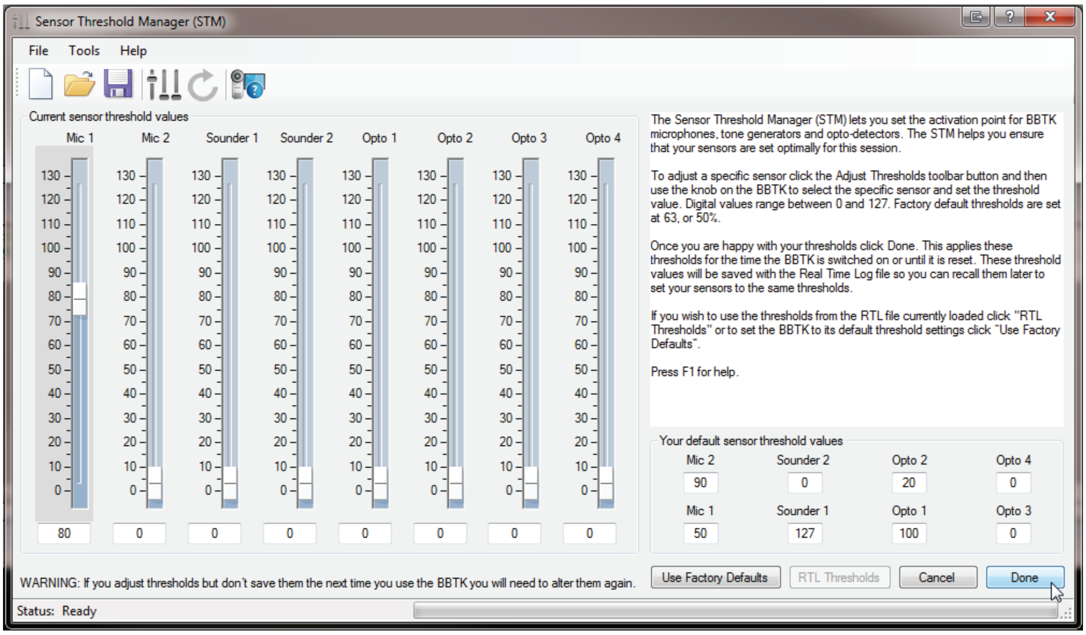


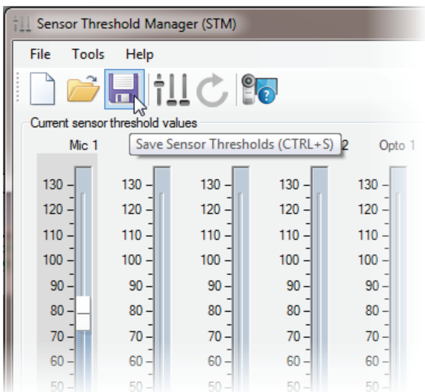
To finish select Done and press the command knob.



Ready… will then be displayed.

To use the activation thresholds set on the indicators for this session click on Done. These thresholds will be saved with the RTL file if you need to recall them later.



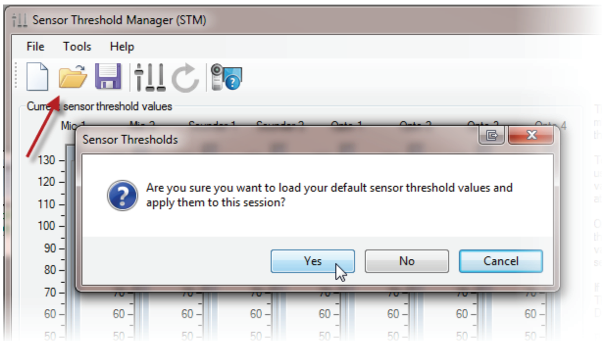


If you wish to make these activation thresholds the default each time you switch the BBTK on or reset it click the Save toolbar button.

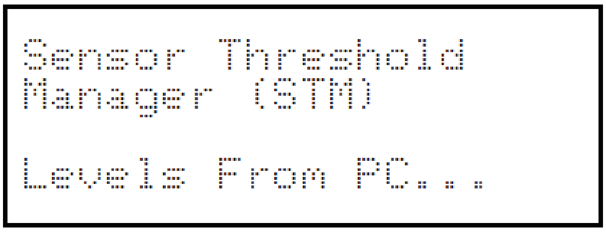
Your default values are those shown bottom right of the STM.

5.2 Reusing Activation Thresholds - Using Your Own Default Values

To save you from having to set thresholds each time you use the BBTK (or after you have reset it) you have three options. To load your own default values, load the factory defaults (50% on each sensor), or to set them to values that match the currently loaded RTL file.

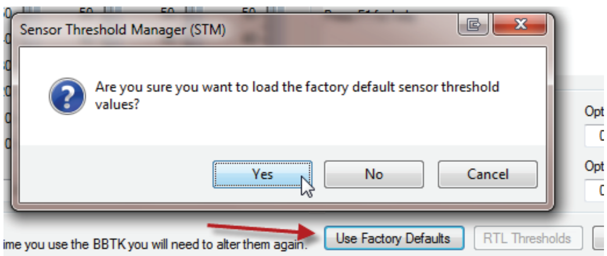


To set thresholds to your own default values, i.e. the ones you last saved, click the Open toolbar button.



When you click on Yes the BBTK will display a message saying that it is setting its threshold levels from the PC.

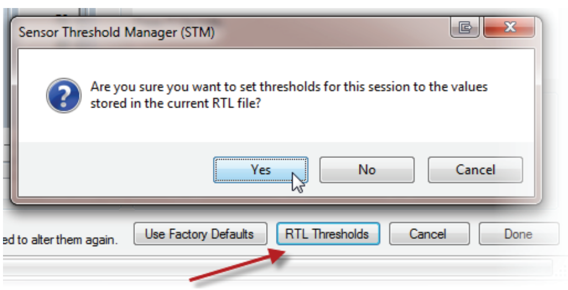
5.3 Using Factory Default Values



To set thresholds to the factory defaults of 50% for each sensor click Use Factory Defaults. Each sensor will be levelled to 63. To finish click Done.

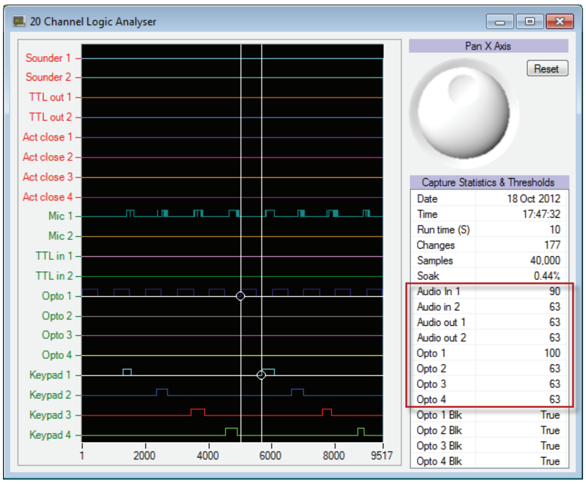
Unless you Save these levels they will only apply to this session.

5.4 Using Levels From the Currently Loaded RTL File

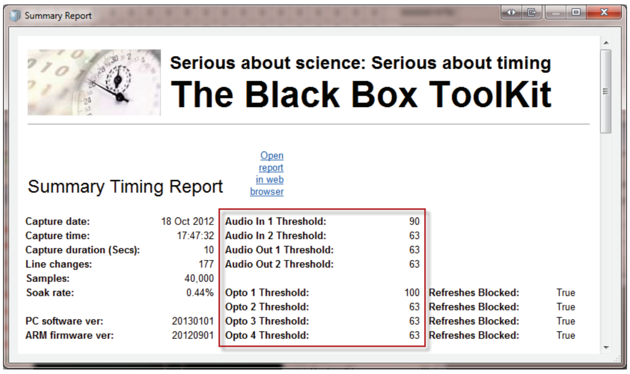


If you have loaded a RTL file for analysis or have just saved one you can set the thresholds to the values used to capture that self-validation run. Click RTL Thresholds to use those values.

Unless you Save these levels they will only apply to this session.



You can check what the activation thresholds are for the currently loaded RTL file by looking at the Capture Statistics & Thresholds statistics in the 20 Channel Logic Analyser.



Alternatively press CTRL+R to bring up a Summary Report.

You can also produce a Summary Report by clicking on the toolbar button.

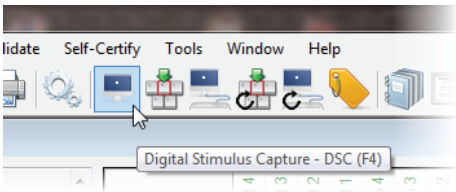
6. Self-Validating Stimulus Onsets and Durations with Digital Stimulus Capture (DSC)

The Digital Stimulus Capture (DSC) module allows you to self-validate the onset, duration and offsets of any of your stimulus materials across a range of modalities. Up to 12 stimulus input lines can be captured at any one time using the Professional version of the BBTK*.

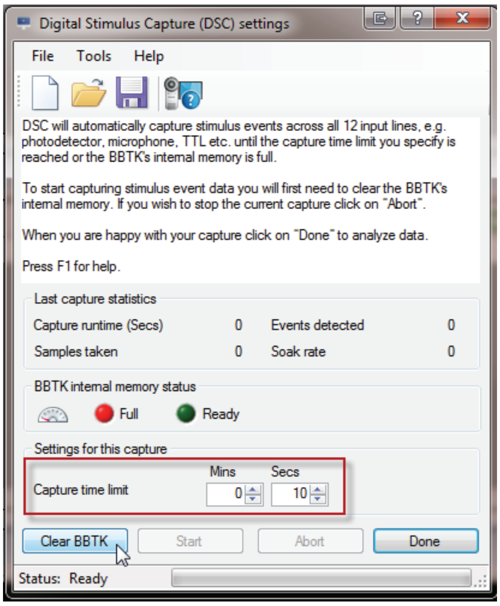
Standard sensors and input lines cover:

Sensor	No of sensors	Purpose
Microphone	2*	Detect audio stimulus presentations from your equipment.
TTL in	2*	Detect TTL (0~5V) digital signals from your equipment, e.g. EEG markers, fMRI etc.
Opto-detector	4*	Detect visual stimuli.
Keypad button	4*	Detect key presses on the 4 button BBTK response pad.

In principle each sensor, or line, operates in the same way. Each sensor detects an onset when an activation threshold is crossed (for more details see the section of this guide which covers the Sensor Threshold Manager). In the case of the TTL lines and the keypad buttons these thresholds cannot be set and are simply digital events, i.e. on or off, or key down or up.



To capture any events across the 12 input lines begin by starting the DSC module by clicking its toolbar button, pressing F4 or from the Self-Validate menu.

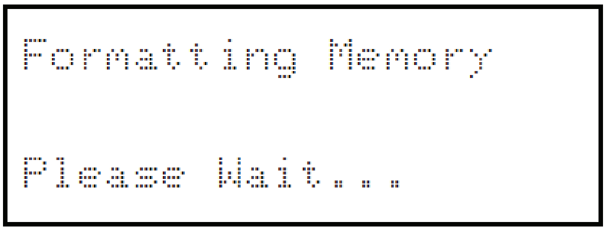


DSC only allows you to set a Capture Time Limit and nothing else.

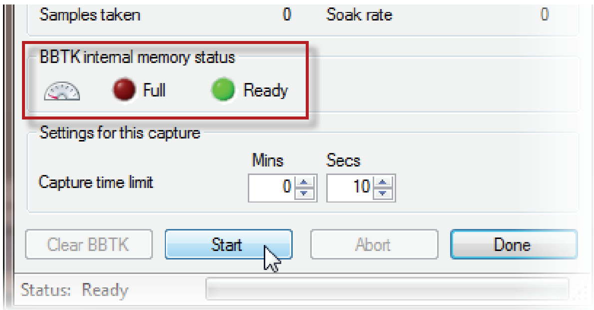
Here events on any of the sensors and lines will be captured for 10 seconds.

However we can't start to capture stimulus events as the BBTK Internal Memory Status is showing as full and the Start button is "greyed out".

As the BBTK contains its own memory, or RAM, we need to clear it first. To do this click Clear BBTK.

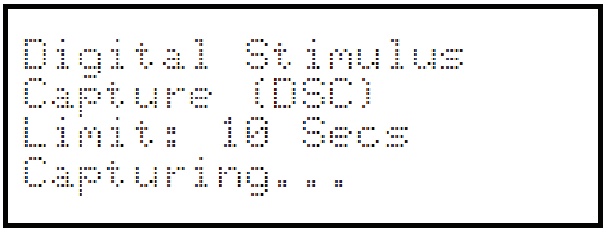


Depending on whether this is the first time you have cleared the memory since you switched on the BBTK or reset it “Formatting” or “Erasing” may be displayed. Erasing is generally fastest as it only clears previously used memory.



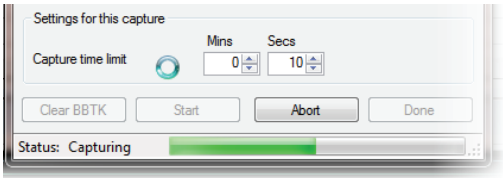
Once the BBTK internal memory has been cleared the status LED will go green and the Start button will be enabled.

Click Start to begin recording stimulus activity.



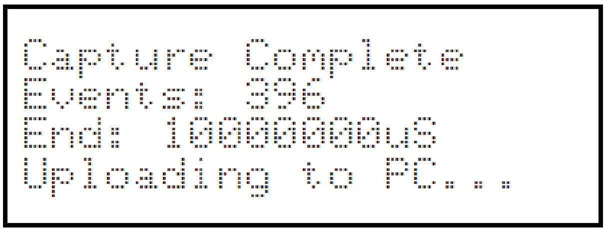
The display will show that the BBTK is capturing data. The time limit you set in seconds will also be shown.

If you wish to stop the BBTK you will need to click Abort or wait until the preset time limit.

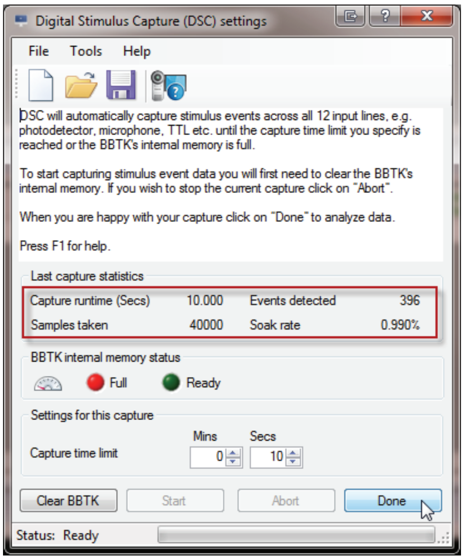


The PC Software’s Status will change and a progress bar showing how long has elapsed will appear.

Whilst we are capturing any stimulus events that cross the predetermined activation thresholds will trigger the corresponding LED on the front of the BBTK. Here Mic1 and Keypad button 1 are active.



After 10 seconds have elapsed the BBTK will indicate that the capture has completed. The number of line changes or Events will be listed along with a total runtime. Uploading… will be displayed as data is sent to the PC.



Whilst the data is being uploaded to the PC Software Uploading will be displayed in the Status bar and a progress bar will be displayed.

Once all the data has been uploaded from the BBTK's internal memory the Last Capture Statistics will be displayed.

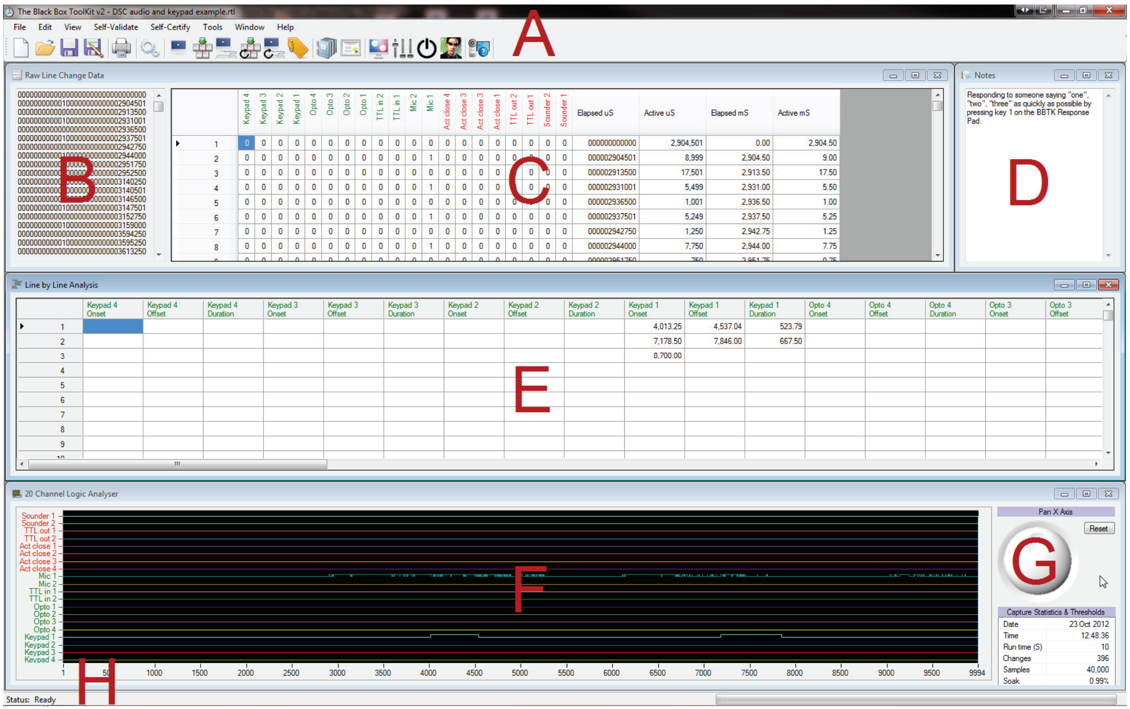
The Start button will be greyed out and the Internal Memory Status LED will turn red.

To repeat a capture click Clear BBTK and repeat the previous steps. To analyse any data captured click Done.

7. Analysing Captured Timing Data with the Logic Analyser

7.1 Key Parts of the Interface

The main interface of the BBTK PC Software is split into four MDI windows, a menu bar, a toolbar and a status bar with progress indicator shown at the bottom of the screen.



A Shows the menu bar and standard toolbar buttons. If you look at the menu items or hover over a button a shortcut key will be shown, e.g. CTRL+R for a summary report.

B Shows the raw capture data that is uploaded by the BBTK's ARM CPU after a capture. Depending on your version of the software this may or may not be shown.

C Shows the status of each line each time there was a change on any of the 20 BBTK lines (12 input sensors and 8 outputs). Elapsed time and durations are shown in uS (microseconds or millionths of a second) and mS (milliseconds or thousandths of a second).

D Shows a simple notepad that can be used to make notes that are saved with the Real Time Log (RTL) file.

E Shows the processed raw data. It shows the onset, offset and duration in mS (milliseconds) of each line. Note that a single sensor on period may appear as multiple line changes in C as other lines go on and off. Only in E can you get a clearer picture of what happened.

F Shows a Logic Analyser plot of the captured data (digital on and offs).

Note the Logic Analyser plot is only accurate to 1mS, whereas E is accurate to hundredths of a millisecond, i.e. two decimal places.

G Shows summary Capture Statistics & Thresholds. This provides details on capture date, time, runtime, number of line changes or events, samples taken, soak rate, sensor thresholds and whether the opto-detectors blocked together individual refreshes on a CRT.

H Shows the status bar and progress indicator. For example, when longer captures are plotted on the Logic Analyser this will show which lines are being analysed.

7.2 Checking a Simple Reaction Time Paradigm

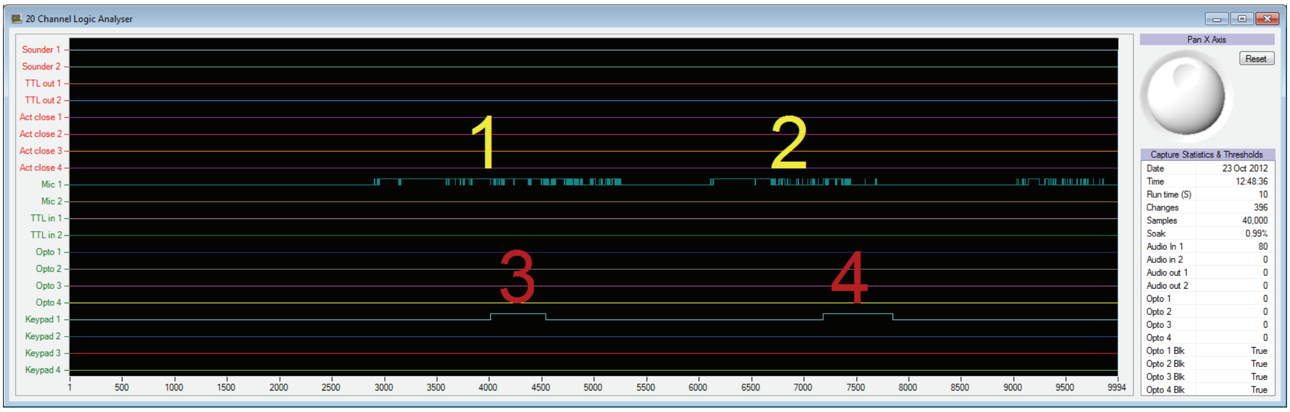
Checking how accurate your own hardware and software are is made straightforward with use of a BBTK. This checking is known as self-validation. Self-certification comes later when combined with an online repository which provides DOI's used to accompany published scholarly articles. The first is a private endeavour and the second is where you make your timing accuracy public along with your calibration data.

Usually when checking your timing the first place to start is the 20 Channel Logic Analyser. This shows input lines and sensors in green and output or generation lines in red against a time base in mS (milliseconds). Each line is shown in a different colour to help differentiate between them.

In the example shown lets imagine that the participants task was to respond to vocalisations as rapidly as possible by pressing key 1 of the BBTK response pad. From the screen grab below we can see that only two lines are active, Mic 1 and Keypad 1 (key 1 on the response pad).

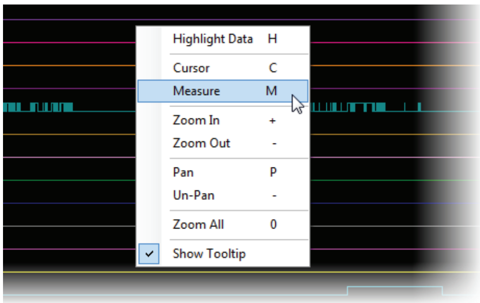
Hypothetically, a commercial Experiment Generator might also be recording the same actions and data via a scripted paradigm (this represents your experiment in this example). In effect the BBTK is piggy backing on the Experiment Generator to check its timing. We may have another microphone from the commercial Experiment Generator acting as a voice key and our BBTK response pad key may also be patched into the commercial Experiment Generators response pad so that when we press the key on the BBTK response pad that is simultaneously triggered as well (depending on your model of response pad).

In a perfect world both the BBTK and the commercial Experiment Generator would record exactly the same time. However this won't be the case as the commercial Experiment Generator will be running on a second PC and will suffer from imperfect timing.

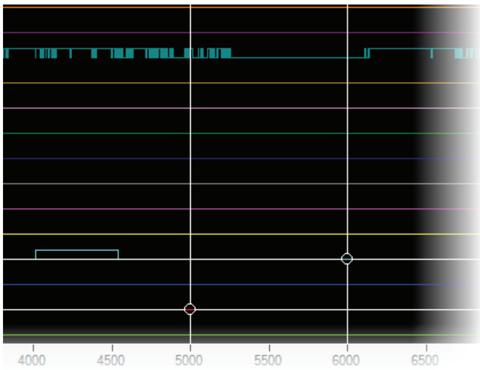


1 Shows the onset and duration of the first audio event (someone saying the word "one").
2 Shows the onset and duration of the second audio event (someone saying "two").
3 Shows the onset and duration of key 1 being pressed on the BBTK response pad in response to the word "one".
4 Shows the onset and duration of key 1 being pressed on the BBTK response pad in response to the word "two".

To work out the true Reaction Time, measured by the BBTK with mS accuracy and uS precision, we would simply need to compare the onset of Mic 1 events with the onset of Keypad 1 events. With the BBTK this is incredibly quick and easy to do.

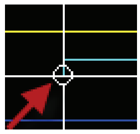


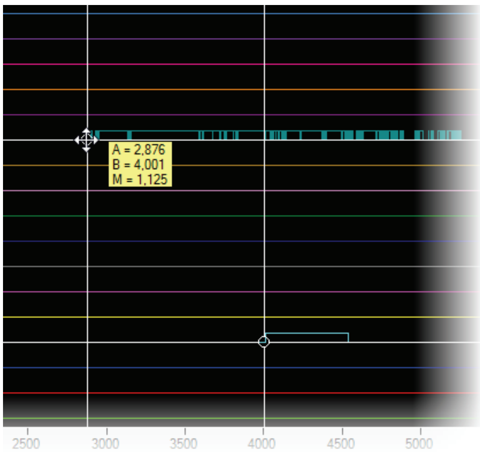
First we need to bring up two Measurement Cursors on the Logic Analyser plot. You can do this be right clicking anywhere on the plot and clicking Measure from the Context Sensitive Menu (or you can press the shortcut key M).



Two Measurement Cursors will then appear.

These can be dragged by the reticle between any line and point in time on the plot.





Initially we would drag Cursor A (left) to approximately the onset of the audio event on Mic 1 and Cursor B to the onset of the response pad Key 1 going down. Note how this is only done approximately in the first instance.

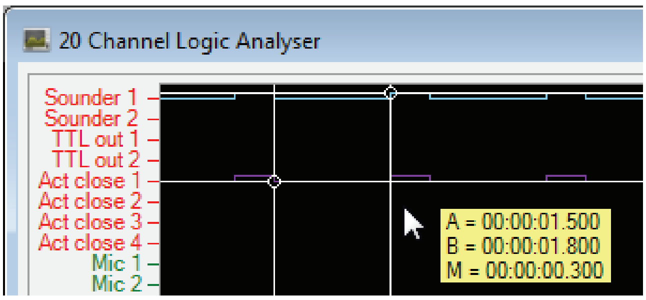
Time in mS is shown in the pop-up tooltip. A = Cursor A, B = Cursor B and M = the difference between the two.

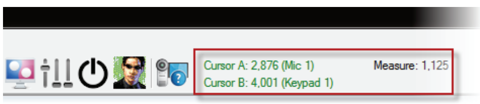
Depending on your version of the software, timings may be displayed in:

hours:mins:seconds.millesconds

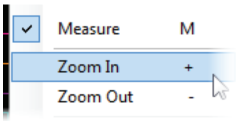
or

HH:MM:SS.mS

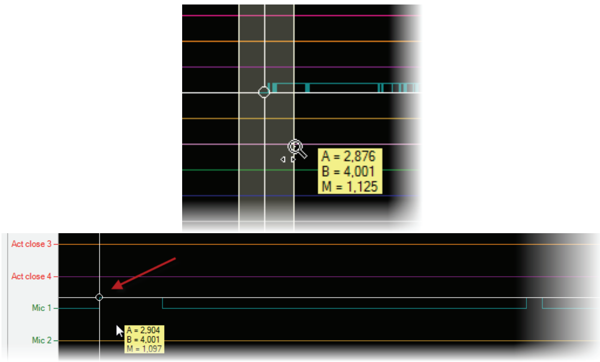




More detail is shown in the upper toolbar as you move the Measurement Cursors.

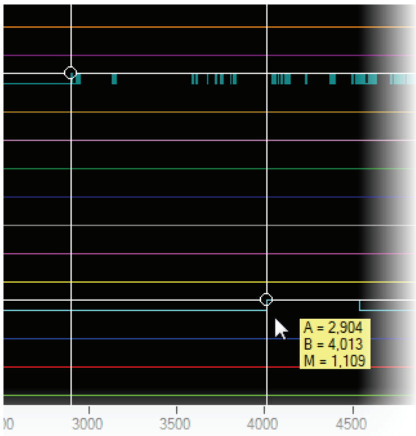


To obtain an accurate snap to each onset, right click and then click Zoom In. Or press + on the keyboard (next to backspace).



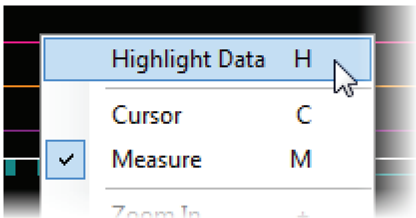
A magnifying glass cursor will then appear and you should click and drag around the vertical onset of the event you are interested in. This won't move the cursor line and you can Zoom in and out as many times as you like.

Here we can see that the onset of the actual event has been accurately snapped to after zooming in. You would repeat this process for Cursor B after Zooming out.



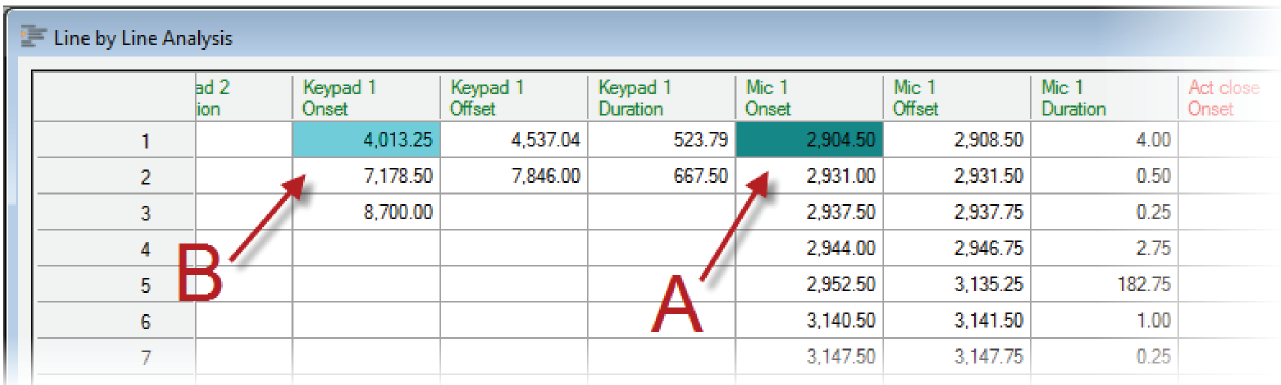
After Zooming in and snapping to the onset of both events we can read off that the actual **Reaction Time was 1,109mS**.

This is the figure which we would compare with that recorded by our commercial Experiment Generator. Any difference would be error due to hardware and software issues, problems with the experiment generator or human error when producing its scripts.



To further aid in analysis it's often useful to jump to the exact onset timings for both events in the Line by Line Analysis spreadsheet. As previously mentioned this spreadsheet is accurate to 100ths of a mS whereas the plot is accurate to 1mS due to the volume of data being plotted.

To highlight the events click Highlight Data or press H on the keyboard.



	ad 2 ion	Keypad 1 Onset	Keypad 1 Offset	Keypad 1 Duration	Mic 1 Onset	Mic 1 Offset	Mic 1 Duration	Act close Onset
1		4,013.25	4,537.04	523.79	2,904.50	2,908.50	4.00	
2		7,178.50	7,846.00	667.50	2,931.00	2,931.50	0.50	
3		8,700.00			2,937.50	2,937.75	0.25	
4					2,944.00	2,946.75	2.75	
5					2,952.50	3,135.25	182.75	
6					3,140.50	3,141.50	1.00	
7					3,147.50	3,147.75	0.25	

The Line by Line Analysis spreadsheet will automatically highlight the two onsets. Remember the second highlighted onset may not be visible unless you scroll around so that it is in view.

Here we can see that the onset of the Mic 1 event at Cursor A was 2,904.50mS and the Key 1 down event at 4,013.25mS. **So the Reaction Time accurate to 100ths of a mS was 1,108.75mS.** For more details on how the BBTK rounds data please consult the technical specifications.

Best of all you don't have to be that accurate with your cursors when Highlighting as the PC Software will automatically find the nearest associated onset relative to each cursor!

8. Additional Features of the Logic Analyser

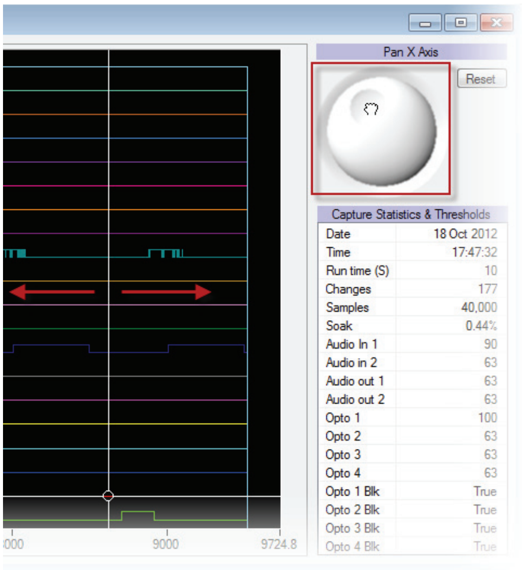
The 20 Logic Analyser has a number of additional features which help you analyse and self-validate your timing accuracy.

8.1 Shortcut Keys

Shortcut keys help you quickly work with timing data.

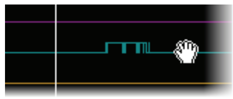
Shortcut	Purpose	Description
H	Highlight Data	Highlights the event onset near either Cursor (A) or Measurement Cursors (A & B) in the Line by Line Analysis spreadsheet.
C	Cursor	Provides a single Cursor A which can be used to pinpoint an elapsed time in mS on any line. Pressing C again will hide the Cursor.
M	Measurement Cursors	Provides two Measurement Cursors (A & B) which can be use to pinpoint two elapsed times in mS on any two lines. A measure M in mS will show the difference between them. M to cancel.
+	Zoom In	Zoom In to any part of the plot to clearly identify event onsets and offsets. Click and drag around the points you want to Zoom In to after pressing + (next to backspace) and the magnifying glass cursor appears.
-	Zoom Out	Zoom out. Undo the last Zoom In command. Features multiple levels of undo.
P	Pan	Pan lets you move the Zoomed plot left or right around your cursor. To Pan press P and click and drag the plot left or right.
-	Un-Pan	Un-Pan will undo any panning commands you recently issued. Features multiple levels of undo.
0	Zoom All	Zoom All will show all the captured data for the full capture duration. Equivalent to Zoom Extents.
Show Tooltip	Turn Off Measurement Tooltips	If you have a lot of data (or a slow computer) you might want to turn off the Tooltip to make manipulating the plot faster.

8.2 Using the Pan Jog Dial



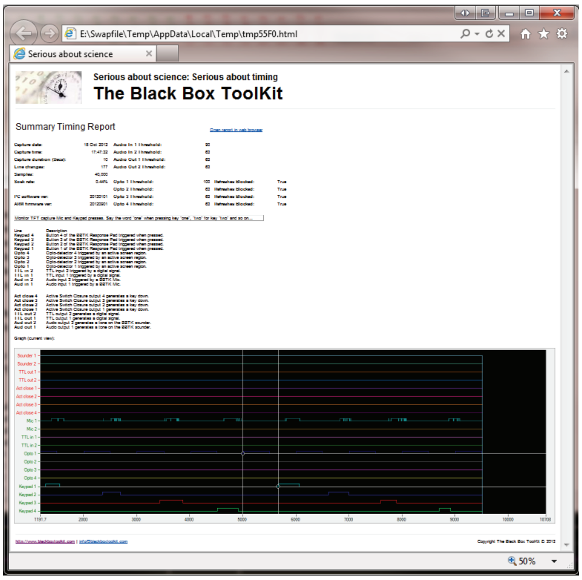
The Panning Jog Dial enables you to pan the whole of the Logic Analyser plot left or right.

This is in contrast to if you Pan (P) from the context menu which enables you to pan left or right one screen at a time. To pan using this method click and drag with the hand cursor.



Panning works at whatever level of Zoom you are at.

8.3 Producing a Summary Report with the Current Logic Analyser Plot

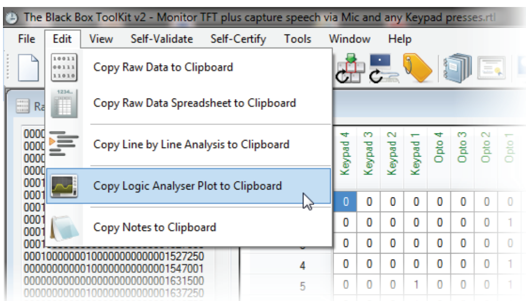


When you produce a Summary Report the plot view that you can see will be the one that is used. So if you have Zoomed In it is that Zoomed view that you will see in the report.

Press CTRL+R to bring up a Summary Report.

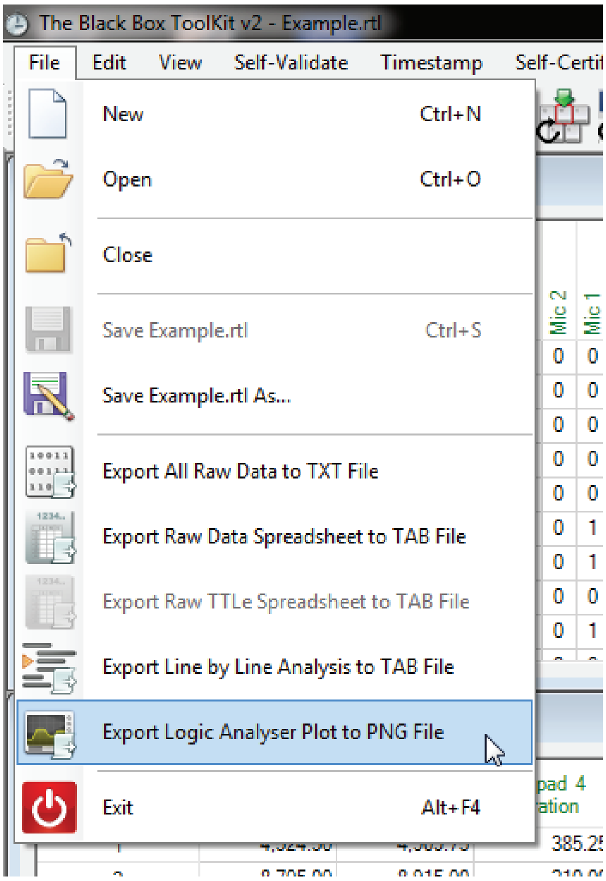
You can also produce a Summary Report by clicking on the toolbar button.

8.4 Copying a Logic Analyser Plot to the Clipboard



You can copy and paste the current Logic Analyser view into any other Windows application you like, e.g. Word. From the Edit menu select "Copy Logic Analyser Plot to Clipboard" and paste into your chosen application.

8.5 Exporting the Logic Analyser Plot to a PNG file



An alternative to Copy and Pasting the Logic Analyser Plot is to save the current view as a standard PNG (Portable Network Graphics) file.

From the File menu select “Export Logic Analyser Plot to Image”.

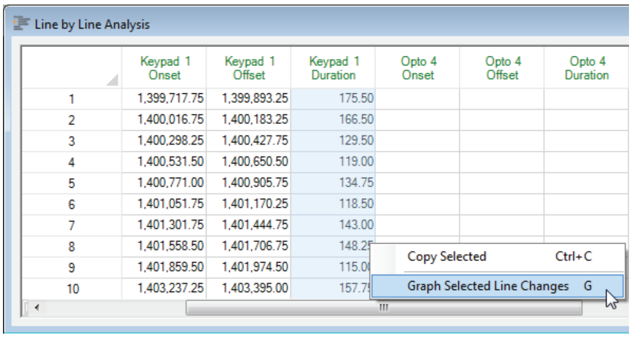
A standard File Save As dialog box will appear enabling you to choose where you save the image and what you call it.

You can save as many versions as you like, e.g. if you’ve zoomed and measured elapsed time you might want to save that view.

9. Line Change Graphs

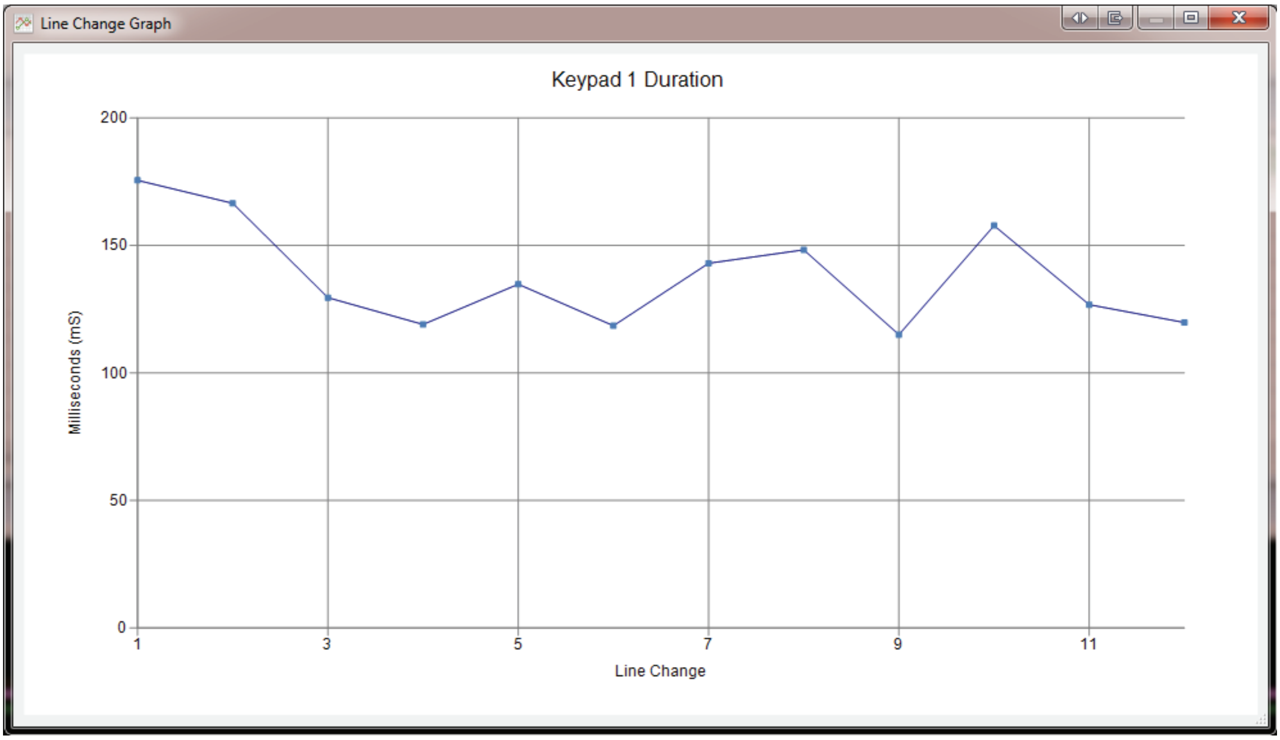
9.1 Quickly Visualising Line Change Data

To help you quickly visualise line changes for a single set of data the Line by Line Analysis spreadsheet enables you to graph up to 10,000 data points, or changes, on a single graph.

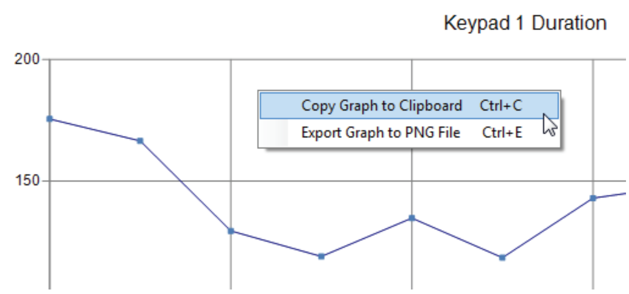


In the spreadsheet view highlight the line you are interested in by clicking and dragging over a range of data.

Then either right click and select Graph Selected Line Changes, or press G on the keyboard.



As can be seen in this example each selected data point has been plotted on a simple line graph. In this case the duration a response key was held down has been plotted.



If you wish to copy the line graph to the clipboard, or export it to a PNG file, right click and select Copy or Export.

Alternatively press CTRL+C for copy or CTRL+E for export.

10. Generating Events Using Event Generation (EG)

The Event Generation (EG) module allows you to generate a series of events with a known onset, offset and duration across a range of modalities. Events on one or more of the 8 output lines can be generated using the Professional version of the BBTK*.

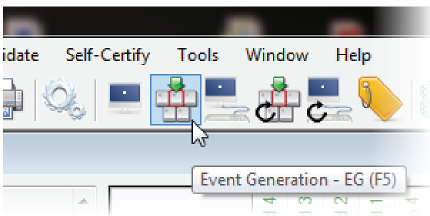
Standard modalities and output lines cover:

Sensor	No	Purpose
Sounder	2*	Produces a tone that can be used to trigger your own voice keys.
TTL out	2*	Produces TTL (0~5V) digital signals which can be fed into your own equipment, e.g. EEG machines, MRI scanners etc. This interface is also used for the BBTK Robotic Key Actuator (RKA), or Robotic Finger, which can press your own keys, buttons or touch sensitive screens, phones or tablets.
Active Switch Closure (ASC)	4*	Can be used to close a switch on your own devices to simulate a response, e.g. a key press on a keyboard. In effect the ASC lines are Solid State Relays (SSRs) that short switches out as though a push-to-make event has occurred. For details of how to wire ASC leads to keyboards etc. consult the wiring an ASC section of this guide.

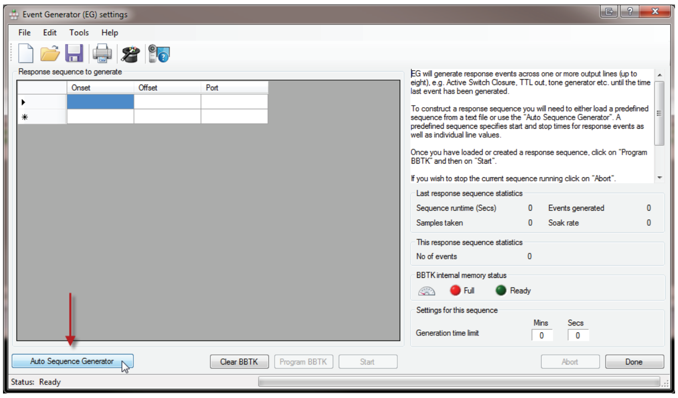
In principle each line operates in the same way in that you choose the line, or lines, you wish to activate an output on. The BBTK doesn't differentiate how the lines work, as it assumes all operate in a digital way. For example, as far as the BBTK is concerned a Sounder, or Tone Generator, has the same properties as a TTL out line (which may either act as an external event marker or may trigger the BBTK Robotic Finger to press a key on your own response device).

10.1 How to Generate Events Using the Wizard

Initially we would advise that you make use of the wizard style interface to help you generate events. This automatically generates onsets, offsets and durations for events very simply using a point and click interface.

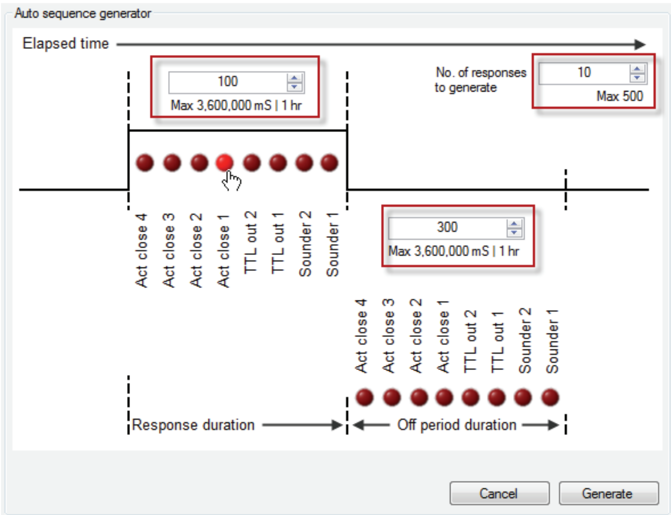


To generate events across the 8 output lines begin by starting the Event Generator (EG) module by clicking its toolbar button, pressing F5 or from the Self-Validate menu.



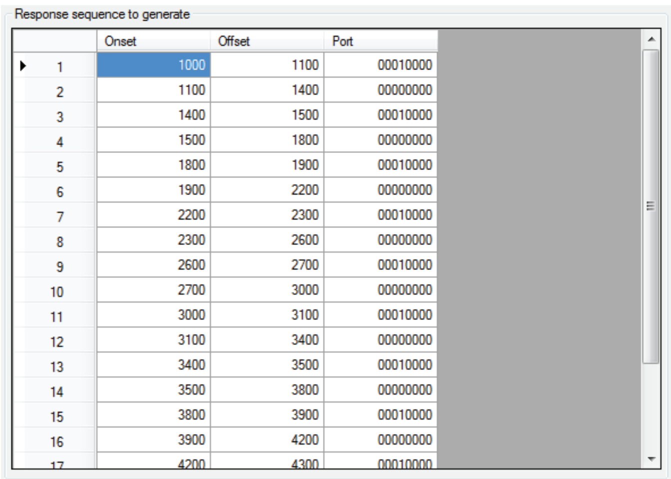
When the EG Module starts you will be presented with a spreadsheet view which has columns for Onsets, Offsets and a Port value. Onset and Offset are times in milliseconds since the start of the run and Port is a binary pattern indicating which lines should be on or off.

Click on Auto Sequence Generator to activate the Wizard.



The spreadsheet will be replaced by a graphical representation of the events you intend to generate and their timing characteristics. The graphic represents elapsed time, On events and Off events along with times for each (red boxes).

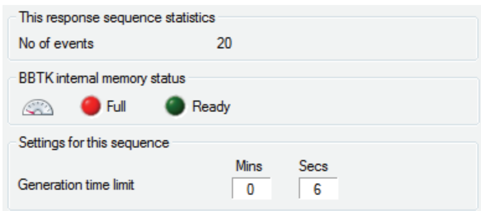
In the example shown the BBTK will generate an Active Switch Closure for 100mS and have an off period where nothing happens for 300mS. It will generate 10 On events to give a sequence of 20 events. Finally click on Generate to fill in the spreadsheet.


Response sequence to generate

	Onset	Offset	Port
1	1000	1100	00010000
2	1100	1400	00000000
3	1400	1500	00010000
4	1500	1800	00000000
5	1800	1900	00010000
6	1900	2200	00000000
7	2200	2300	00010000
8	2300	2600	00000000
9	2600	2700	00010000
10	2700	3000	00000000
11	3000	3100	00010000
12	3100	3400	00000000
13	3400	3500	00010000
14	3500	3800	00000000
15	3800	3900	00010000
16	3900	4200	00000000
17	4200	4300	00010000

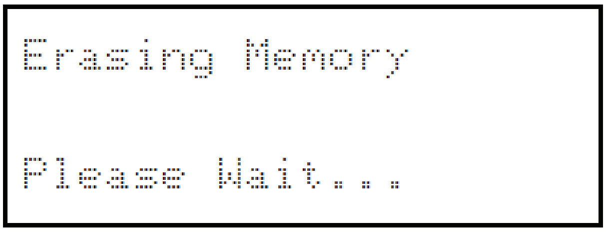
Each row in the spreadsheet is a single On or Off event. Events automatically start after 1 Second. So the Port value of "00010000" is generated at 1,000mS through 1,100mS for event 1, then event 2 takes over and is generated between 1,100mS and 1,400mS. A port value of "00000000" means all lines are cleared.

So from the spreadsheet we can see that regular events will be generated for 100mS and 300mS one after another. If you want to save this sequence click on the Save toolbar button.

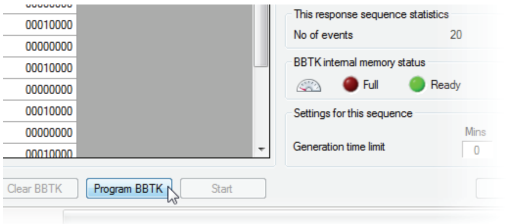


The status panel will show the number of events to generate together with how long it will take to generate the complete sequence.

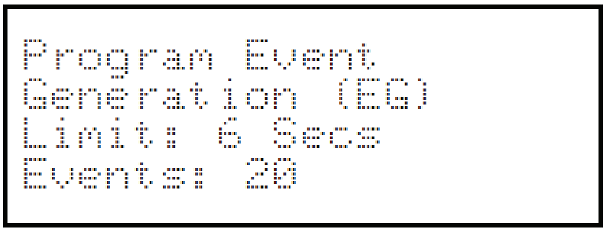
To begin click Clear BBTK.



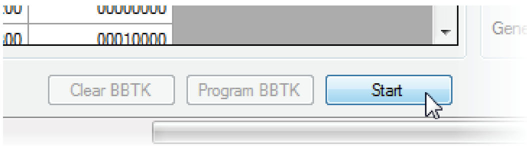
Depending on whether this is the first time you have cleared the memory since you switched on the BBTK or reset it "Formatting" or "Erasing" may be displayed. Erasing is generally fastest.



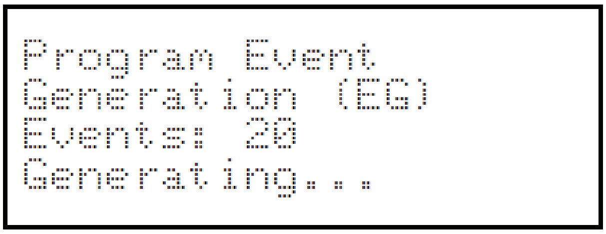
Once the BBTK internal memory has been cleared the status LED will go green and the Program BBTK button will be enabled. Click the Program BBTK button to load in the sequence to be generated.



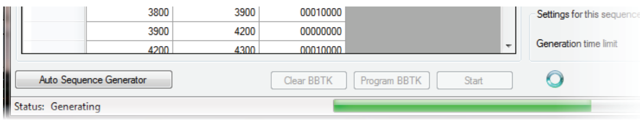
The display will show that the BBTK is being programmed. The time limit you set in seconds will also be shown along with the number of events to be generated.



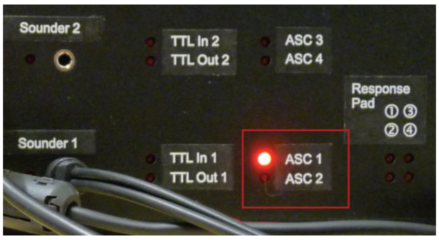
The Start button will now be enabled in the PC Software ready for you to tell the BBTK to generate the predefined sequence of events.



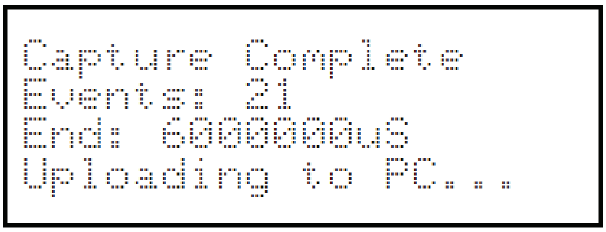
To Start generating the sequence click on Start. The BBTK display will now show that the events are being generated.



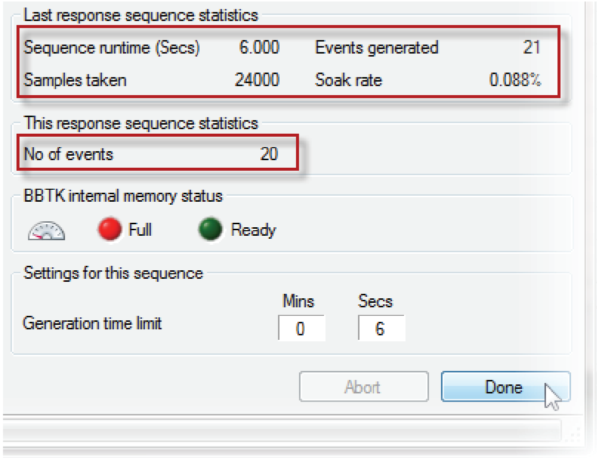
The PC Software's Status will change and a progress bar showing how long has elapsed will appear.



Whilst generating events the LED of the lines which are active will illuminate when an On event occurs. Here ASC 1 is active.



After 6 seconds have elapsed the BBTK will indicate that the capture has completed. The number of line changes or Events will be listed along with a total runtime. Uploading… will be displayed as data is sent to the PC.



Whilst the data is being uploaded to the PC Software Uploading will be displayed in the Status bar and a progress bar will be displayed.

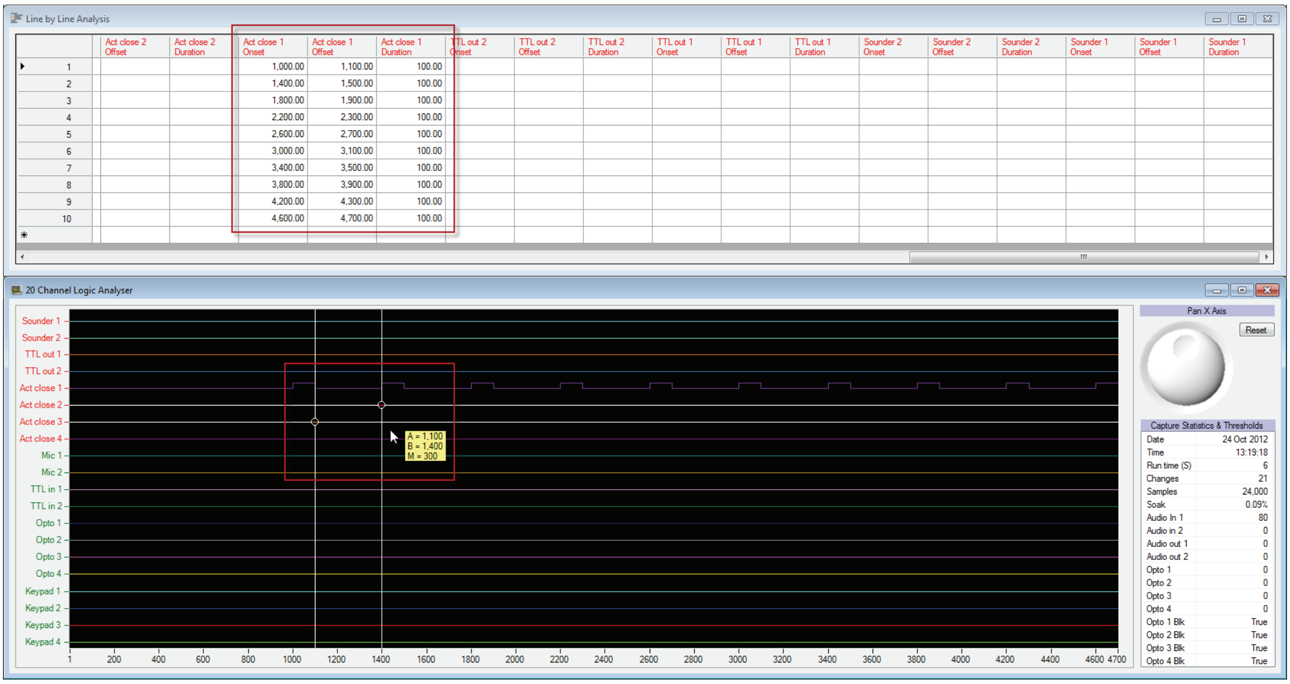
Once all the data has been uploaded from the BBTK's internal memory the Last Capture Statistics will be displayed.

The Start button will be greyed out and the Internal Memory Status LED will go red.

To repeat a sequence click Clear BBTK and repeat the previous steps. To analyse any data captured click Done.

The Logic Analyser will only display events being generated on any of the output lines indicated in red on the column headers and on the Y-axis of the plot. In the Line by Line Analysis spreadsheet we can see that 10 On events were recorded that lasted for exactly 100mS as intended. In the Logic Analyser plot we can see that InterStimulus Intervals were 300mS as intended, i.e. the Off periods.

Note that Events or Changes is listed as 21 rather than 20 as in actual fact the initial resting state of no events is counted as being an event.

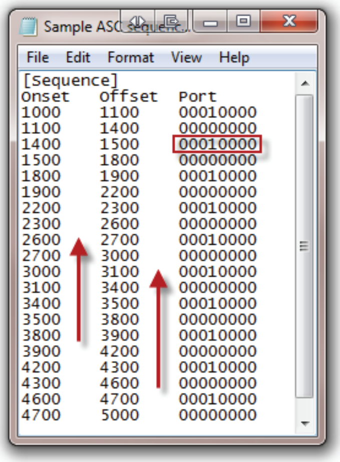


10.2 Advanced Use of the Event Generation Module

The Event Generation module lets you define sequences of events to generate manually as well as using the wizard. When you define sequences manually this lets you vary the length of any On or Off period individually rather than generate a fixed pattern of events as the Wizard allows.

By manually constructing your own sequences you can program a more variable schedule. That is, build-in human like variability in Response Times. For example, a more variable schedule of events using an Active Switch Closure might be more similar to a human tapping a key.

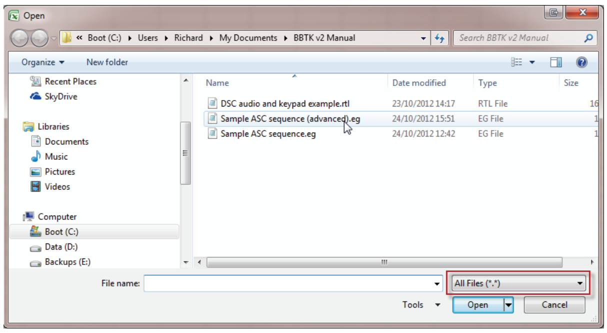
The easiest way to start defining your own schedules is to create one using the wizard as described in section 5.1, save it and then edit the resulting file in software such as Excel. EG files are saved with an ".eg" file extension and are standard ASCII TAB separated value files.



This is the result of saving the sequence described in the example in the previous section when opened in Windows Notepad.

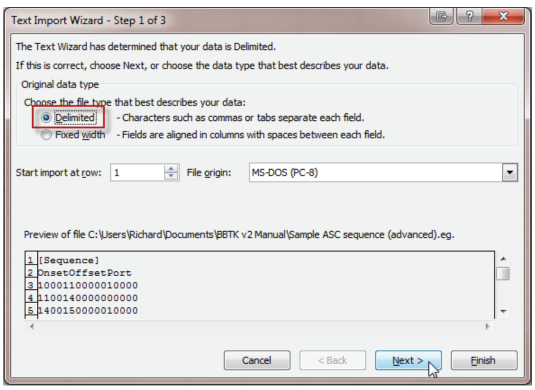
Onsets have their own column as do Offsets and Port values (ASC 1 is the Port value with a 1 in it, 00000000 is all lines off).

All values are separated by invisible TAB characters indicated by the red arrows. Any files you create or edit must adhere to this format or they may not work correctly.



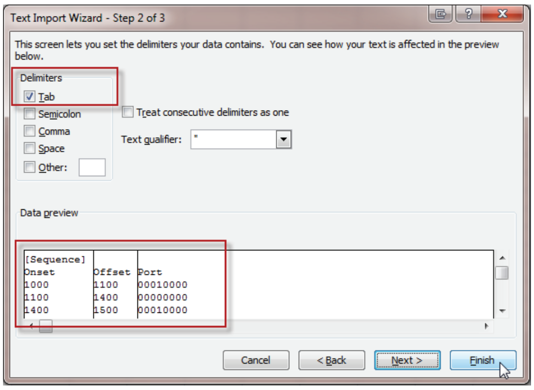
When opening EG files in Microsoft Excel for example ensure that you select the All Files (*.*) filter in the Open dialog box otherwise you won't see the .eg files.

Alternatively you can enter ***.eg** in the File name box and press enter.



The Excel Import Wizard should then start. Ensure the Delimited radio button is selected as we are delimiting columns by TABs.

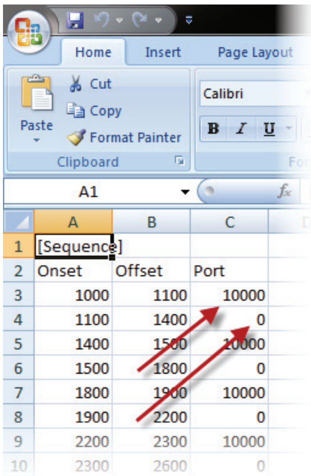
Then click Next.



Excel should automatically identify the file as being TAB separated. If not tick the Tab check box.

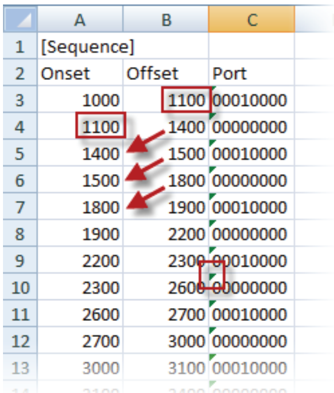
You should also see a preview of the three columns which should be split by the invisible TAB character.

Usually you can click Finish at this point and the file will be shown in Excel.



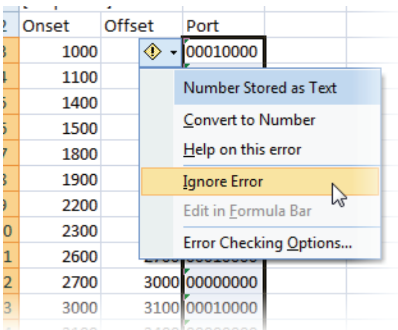
Note however that Excel does not display the Port values correctly. The Onset and Offset times in mS are displayed correctly though.

You will need to reset the Port values to their correct format, e.g. 10000 needs to be put back to, 00010000 in each cell. Do this by prefixing the cell content with a ‘ (apostrophe) and then enter 00010000. Do this again for 0 so it becomes ‘0000000. Remember the “1” at position 4 means ASC 1 is active.

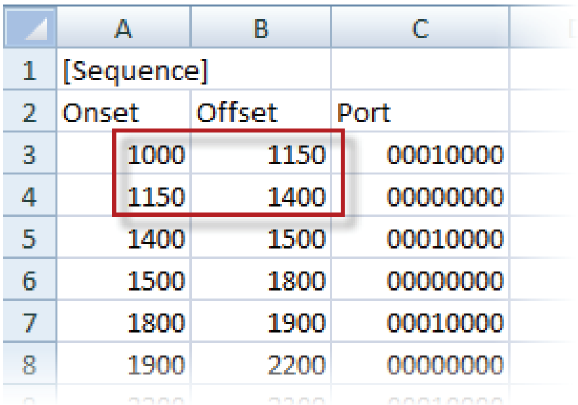


When editing sequence always ensure that the Offset of an event always equals the Onset time of the next event! Otherwise the sequence will not work when you load it back into the EG module.

Also Excel may flag the numbers with a quotation mark in front as a Text As Number error.

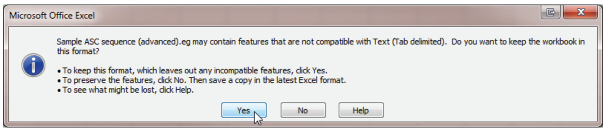


To dismiss the Text As Number warning in Excel highlight all the cells concerned and then click on the Ignore Error drop down.

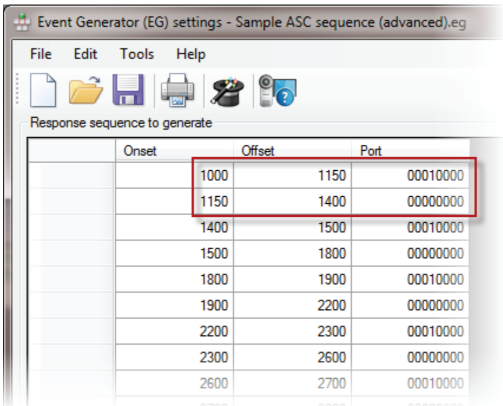


In the example shown I've modified the first event to last for 150mS (from 1,000mS through 1,150mS) and the ISI of Off period to be 250mS (from 1,150mS through 1,400mS).

So the RT is longer and the ISI shorter as compared with the original. Note how the Offset of the last event must equal the Onset of the next. The actual lines that are turned on remain the same (ASC 1).



Finally click on the Save toolbar icon to save the file. Excel will probably warn you that the file format chosen cannot save all the features that Excel offers. Ignore this information box and click Yes.

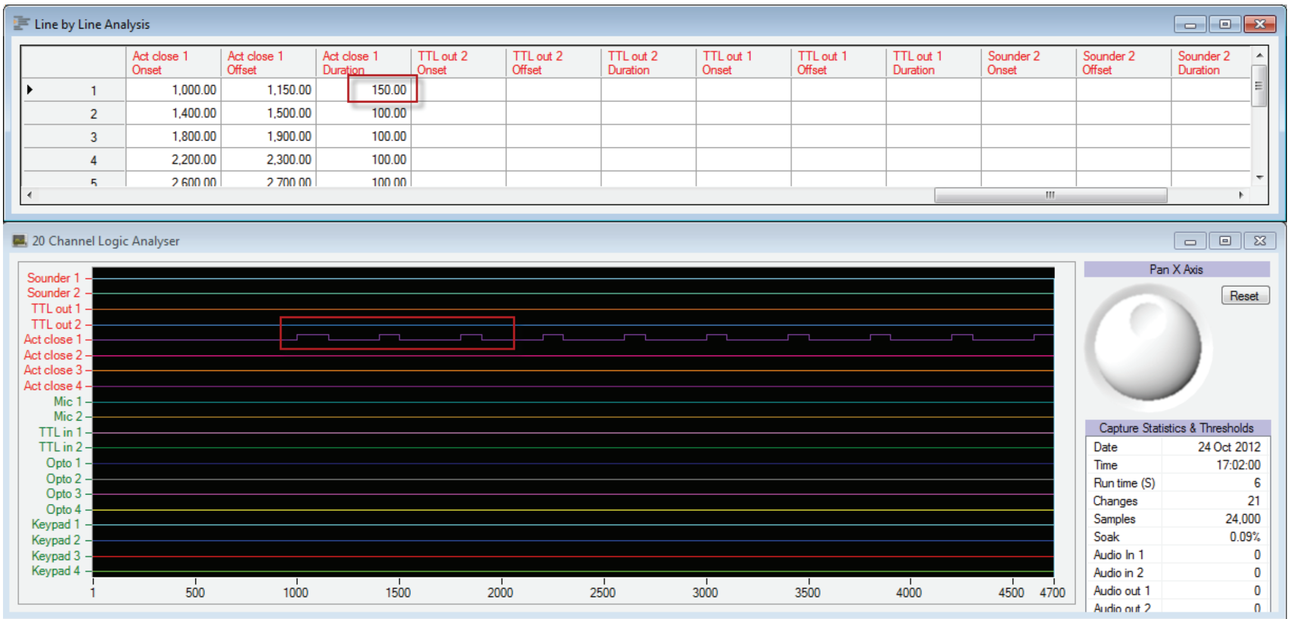


Close Excel and then load the file into EG by clicking on the Open toolbar button.

Here we can see that the first event we modified in Excel is replicated in the EG spreadsheet ready to be generated.

To run the new sequence as before click on Clear BBTK, Program BBTK and Start.

When we analyse the resulting data we can see that the first event is indeed longer and has a shorter ISI than the other events.



11. Generating Events Using Event Generation Pulse Train (EGPT)

The Event Generation Pulse Train (EGPT) module is very similar to the Event Generation (EG) module in that it allows you to generate a series of events with a known onset, offset and duration across a range of modalities. Events on one or more of the 8 output lines can be generated using the Professional version of the BBTK*.

The key differences are that the Pulse Train module does not collect any timing data that can be uploaded and analysed by the PC Software; it is not limited to a fixed number of events that it can generate (it can generate an infinite number of events); and it cannot vary timings on an event by event basis (it can only generate a fixed pattern).

EGPT operates like a standard bench Function Generator that generates square waves at a known frequency across up to 8 channels. One use for EGPT might be to send a regular series of event markers to an EEG machine or fMRI scanner using one of the TTL out lines. However you can make use of any of the output lines either individually or simultaneously should you wish.

Note that to stop a sequence you will need to click Abort which will reset the BBTK. Thus you are advised to Save your Sensor Threshold Settings before you use this module if you have customised them specifically, or reload an existing RTL file and set to those settings.

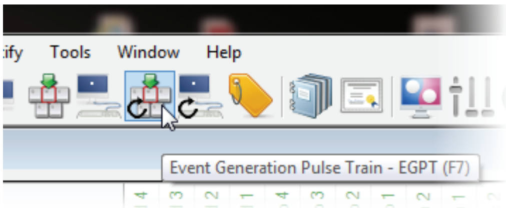
Standard modalities offered by the output lines cover:

Sensor	No	Purpose
Sounder	2*	Produces a tone that can be used to trigger your own voice keys.
TTL out	2*	Produces TTL (0~5V) digital signals which can be fed into your own equipment, e.g. EEG machines, MRI scanners etc. This interface is also used for the BBTK Robotic Key Actuator (RKA), or Robotic Finger, which can press your own keys, buttons or touch sensitive screens, phones or tablets.
Active Switch Closure (ASC)	4*	Can be used to close a switch on your own devices to simulate a response, e.g. a key press on a keyboard. In effect the ASC lines are Solid State Relays (SSRs) that short switches out as though a push-to-make event has occurred. For details of how to wire ASC leads to keyboards etc. consult the wiring an ASC section of this guide.

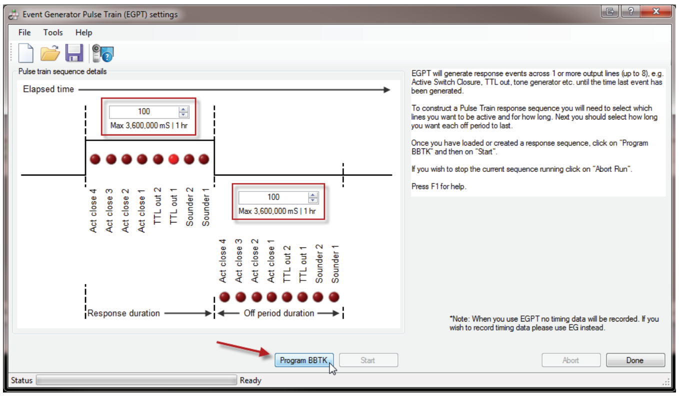
In principle each line operates in the same way in that you choose the line, or lines, you wish to activate an output on. The BBTK doesn't differentiate how the lines work, as it assumes all operate in a digital way. For example, as far as the BBTK is concerned a Sounder, or Tone Generator, has the same properties as a TTL out line (which may either act as an external event marker or may trigger the BBTK Robotic Finger to press a key on your own response device).

11.1 How to Generate an Unlimited Series of Events Using the Wizard

EGPT only provides a wizard style interface which automatically generates onsets, offsets and durations for events very simply using a point and click interface.

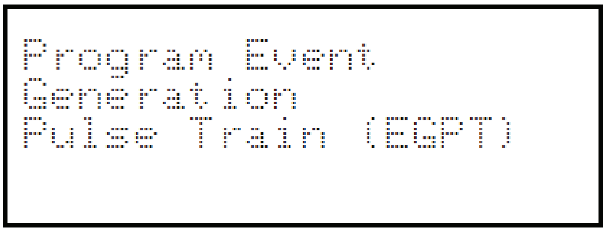


To generate events across the 8 output lines begin by starting the Event Generator Pulse Train (EGPT) module by clicking its toolbar button, pressing F7 or from the Self-Validate menu.

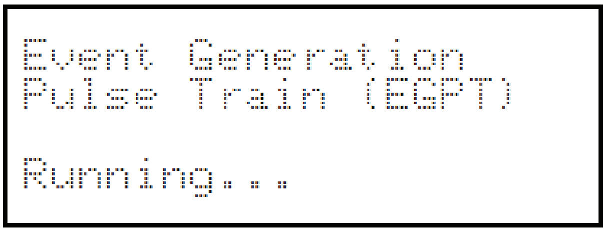


When the EGPT Module starts you will be presented with a graphical representation of the events you intend to generate and their timing characteristics. The graphic represents elapsed time, On events and Off events along with times for each (red boxes).

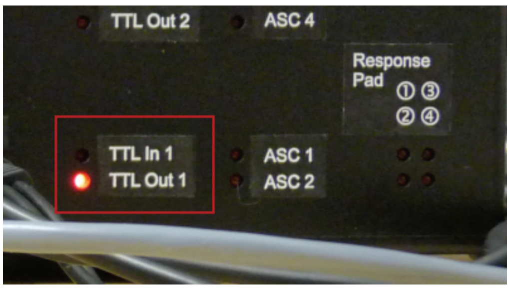
In the example shown the BBTK will generate TTL Out signals for 100mS and have an off period where nothing happens for 100mS.



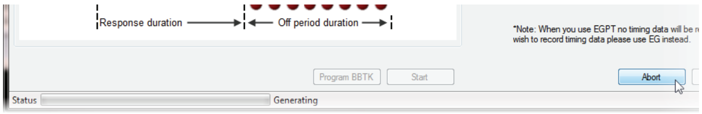
Once you are happy with your sequence click Program BBTK. This will tell the BBTK what events to generate and what their timing characteristics are. The BBTK display will inform you that it is being programmed.



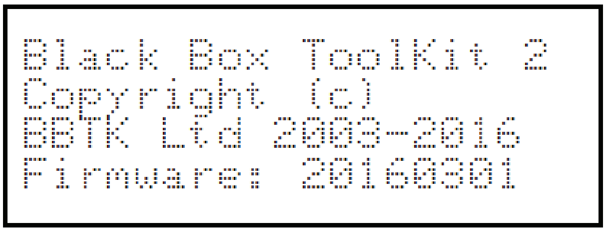
To run the sequence click Start. The BBTK display will change to Running and the PC Software will grey out the Program BBTK and Start button, whilst the Abort button will be enabled. The status bar will change to “Generating”.



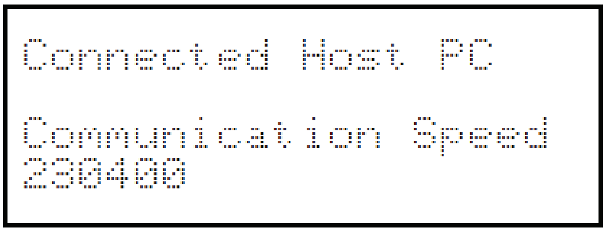
Whilst generating events the LED of the lines which are active will illuminate when an On event occurs. Here TTL Out 1 is active.



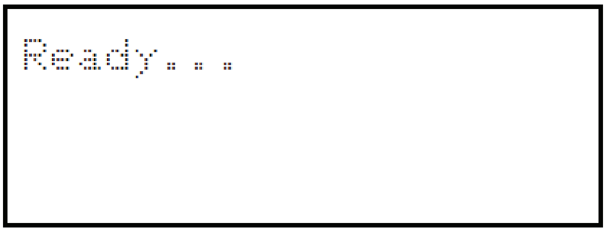
EGPT will run the same sequence of events until the BBTK is reset or switched off. To stop the sequence click Abort. This will in effect reset the BBTK.



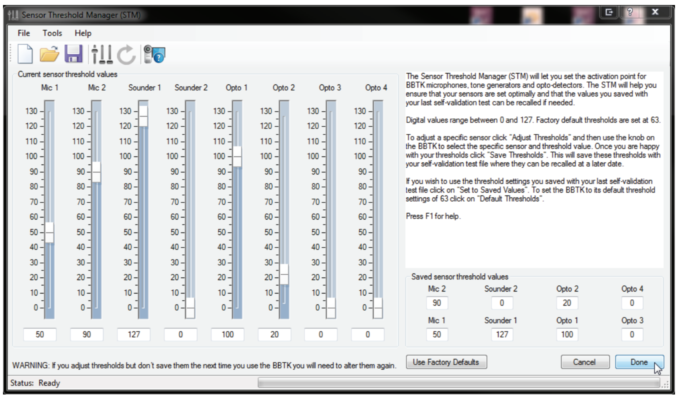
When the BBTK resets it should display a copyright notice along with a firmware version on its LCD screen similar to the one shown.



Next it should attempt to connect to the host PC via the COM/USB port you chose. If successful you should see the Communication Speed displayed in bps. By default this is 230,400 bps but could be slower depending on your Operating System.



Once connected the default is for the BBTK to display “Ready…” indicating it is ready for use.



The PC Software will display the Sensor Threshold Manager. At this point you can choose to load your default values, factory defaults, or choose settings from an open RTL file.

12. Self-Validating Stimulus-Response Paradigms with Digital Stimulus Capture And Response (DSCAR)

The Digital Stimulus Capture And Response (DSCAR) module allows you to self-validate the onset, duration and offsets of any of your stimulus materials across a range of modalities. Up to 12 stimulus input lines can be monitored at any one time using the Professional version of the BBTK*. In addition it allows you to simulate human or machine responses with known timing characteristics in response to a stimulus event or pattern of events across a range of modalities. Events on one or more of the 8 output lines can be generated using the Professional version of the BBTK*.

DSCAR is the cornerstone of the BBTK as it allows you to self-validate a complete experiment in terms of presentation, synchronisation and response timing accuracy. This allows you to compare the timing characteristics of your paradigm against what really happened in the physical world and to track down and eliminate sources of error. This is the key principle of self-validation and later the self-certification of your published articles and data. Think of DSCAR as a combination of the DSC and EG modules or as a person taking part in an experiment.

Standard sensors and input lines cover:

Sensor	No of sensors	Purpose
Microphone	2*	Detect audio stimulus presentations from your equipment.
TTL in	2*	Detect TTL (0~5V) digital signals from your equipment, e.g. EEG markers, fMRI etc.
Opto-detector	4*	Detect visual stimuli.
Keypad button	4*	Detect key presses on the 4 button BBTK response pad.

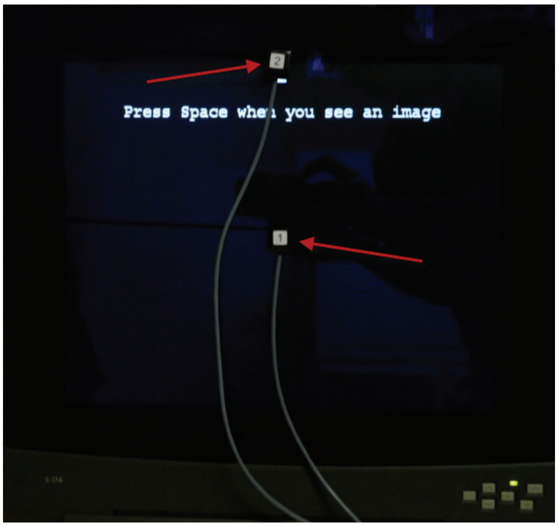
Standard modalities offered by the output lines cover:

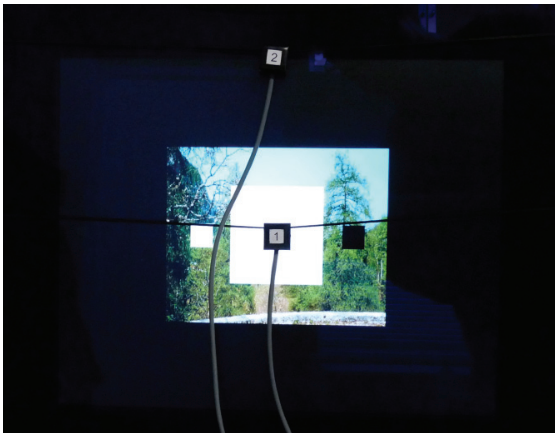
Sensor	No	Purpose
Sounder	2*	Produces a tone that can be used to trigger your own voice keys.
TTL out	2*	Produces TTL (0~5V) digital signals which can be fed into your own equipment, e.g. EEG machines, MRI scanners etc. This interface is also used for the BBTK Robotic Key Actuator (RKA), or Robotic Finger, which can press your own keys, buttons or touch sensitive screens, phones or tablets.
Active Switch Closure (ASC)	4*	Can be used to close a switch on your own devices to simulate a response, e.g. a key press on a keyboard. In effect the ASC lines are Solid State Relays (SSRs) that short switches out as though a push-to-make event has occurred.

So for example we can instruct DSCAR to look for a visual presentation on Opto 1, wait 300mS and hold down a response key for 100mS. By monitoring all 12 input modalities, or lines, we can see any stimulus event including the visual presentation. We could check any onset, offset and duration. By generating a response at a known Response Time after the onset of a visual stimulus we can be certain that we have given whatever paradigm we were testing consistent RTs. For example, it might be a commercial Experiment Generator presenting a simple visual Stimulus-Response paradigm. To check RTs we would simply compare the results it recorded against what RTs DSCAR generated, i.e. 300mS. Any difference from 300mS would be due to error. Obviously this error resides somewhere within the whole paradigm and needs to be investigated further.

12.1 How to Detect Stimuli and Generate Response Events Using the Wizard

Initially we would advise that you make use of the wizard style interface to help you detect and generate response events using DSCAR. This automatically helps you select which stimulus events trigger responses very simply using a point and click interface.





The paradigm we want to self-validate displays an image until the space bar on the keyboard is pressed.

The paradigm is constructed in a standard Experiment Generator. When a response is registered the image terminates and the Response Time recorded.

As an additional check we have programmed the paradigm to send a TTL signal (via the parallel, or LPT port) into BBTK TTL In 1 line as it starts to display the bitmap (to act as an event marker). If your PC does not have a parallel port you could use a BBTK USB TTL event marking module instead.

A fixation marker (white block) has been programmed to appear at the top of each screen during the ISI period (no stimulus display).

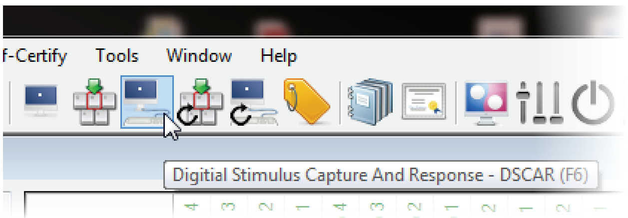
Stimulus bitmaps have been marked with a large white block to aid detection. The background has been set to black so that during the off periods the Opto-detectors are not triggered.

Opto 1 has been positioned to detect the main stimulus bitmap and Opto 2 to detect the ISI marker at the top of the screen.

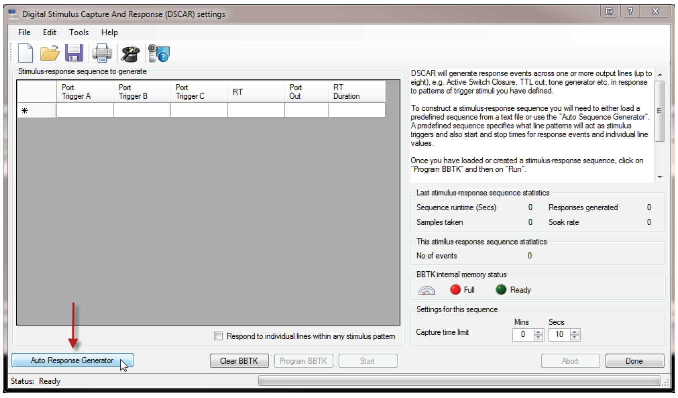
By using the BBTK we can answer quite a lot of timing critical questions with a very straightforward self-validation run using DSCAR.

The timing issues we might want to test for are:

1. Do stimulus bitmaps appear synced with the TTL signal produced by the Experiment Generator and sent to the PCs parallel, or LPT port? This is important if you are trying to sync with external equipment, e.g. EEG machines, fMRI etc. via the TTL signal. If your PC does not have a parallel port you could use a BBTK USB TTL event marking module instead.
2. Do stimulus images accurately terminate when responses are made?
3. Are ISIs 1,000mS as programmed into the Experiment Generator?
4. Are Response Times registered by the Experiment Generator accurate?

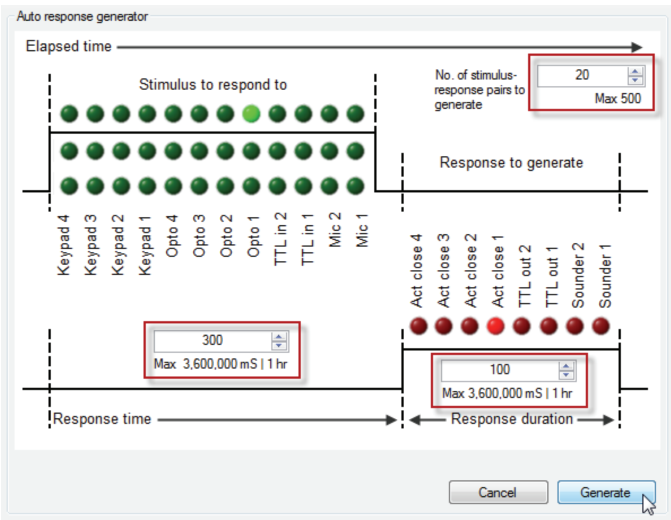


To start DSCAR click its toolbar button, press F5 or from the Self-Validate menu select Digital Stimulus And Response (DSCAR).



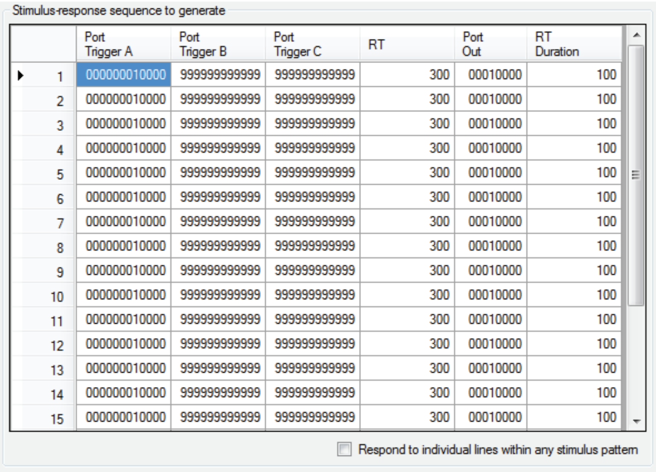
When the DSCAR Module starts you will be presented with a spreadsheet view which has columns for up to 3 trigger stimuli (Port Triggers), a RT, Port Out (events to generate) and a RT duration (how long the response event is active). RT and RT duration are times in milliseconds. Port is a binary pattern indicating which lines should be on or off.

Click on Auto Response Generator to activate the Wizard.



The spreadsheet will be replaced by a graphical representation of the trigger stimuli you wish to respond to and the response events you intend to generate (red boxes).

In the example shown the BBTK will generate an Active Switch Closure (key press) with an RT of 300mS after detecting a visual stimulus on Opto 1 (the stimulus bitmap). The response event (holding a key down) will last for 100mS. Up to 20 stimulus-response pairs will be worked through. Click on Generate to fill in the spreadsheet.



Stimulus-response sequence to generate

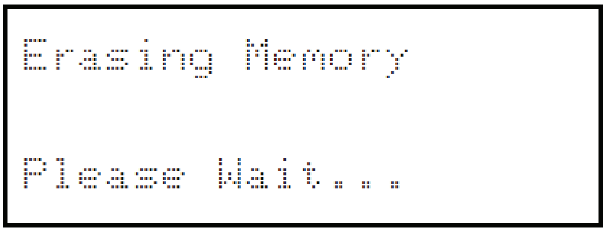
	Port Trigger A	Port Trigger B	Port Trigger C	RT	Port Out	RT Duration
1	000000010000	999999999999	999999999999	300	00010000	100
2	000000010000	999999999999	999999999999	300	00010000	100
3	000000010000	999999999999	999999999999	300	00010000	100
4	000000010000	999999999999	999999999999	300	00010000	100
5	000000010000	999999999999	999999999999	300	00010000	100
6	000000010000	999999999999	999999999999	300	00010000	100
7	000000010000	999999999999	999999999999	300	00010000	100
8	000000010000	999999999999	999999999999	300	00010000	100
9	000000010000	999999999999	999999999999	300	00010000	100
10	000000010000	999999999999	999999999999	300	00010000	100
11	000000010000	999999999999	999999999999	300	00010000	100
12	000000010000	999999999999	999999999999	300	00010000	100
13	000000010000	999999999999	999999999999	300	00010000	100
14	000000010000	999999999999	999999999999	300	00010000	100
15	000000010000	999999999999	999999999999	300	00010000	100

Respond to individual lines within any stimulus pattern

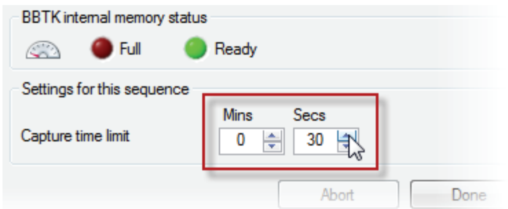
Each row in the spreadsheet is a single Stimulus-Response pair. So for example Port Trigger A "000000010000" means that if Opto 1 detects a stimulus, wait for 300mS (RT) and then generate a Port Out "00010000" response event (ASC key press) for 100mS.

So from the spreadsheet we can see that responses will be generated each time a stimulus image is detected. The 20 possible S-R pairings will be worked through in sequence as each is triggered. Port values of "999999999999" means don't look for a second or third stimulus type.

If you want to save this sequence click on the Save toolbar button.

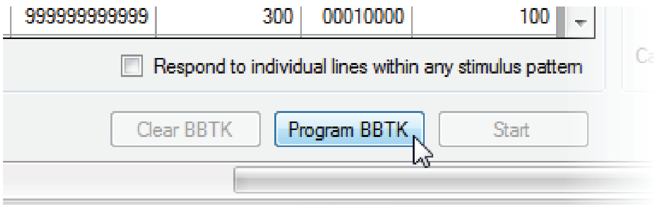


Click Clear BBTK to start validation. Depending on whether this is the first time you have cleared the memory since you switched on the BBTK or reset it "Formatting" or "Erasing" may be displayed. Erasing is generally fastest.

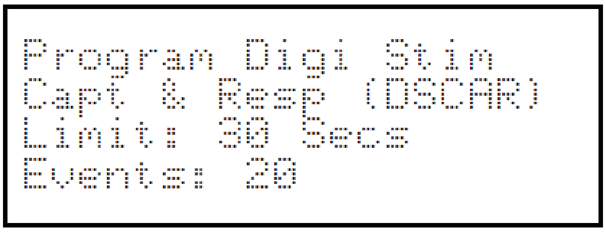


Once the memory has been cleared set the Capture Time Limit.

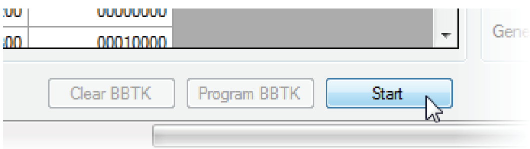
In this case the sequence will run for 30 seconds.



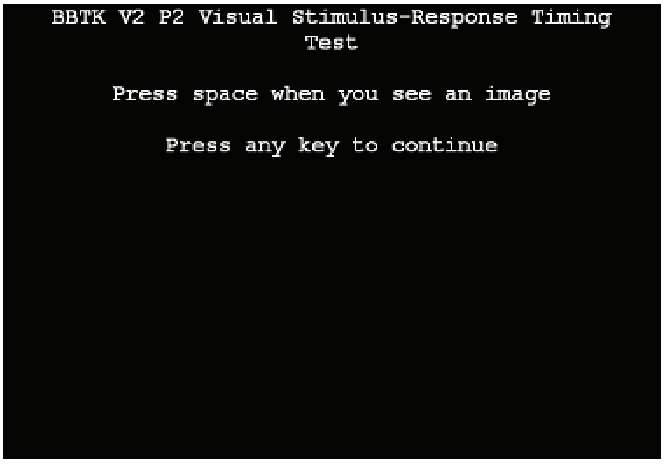
Once the BBTK internal memory has been cleared the status LED will go green and the Program BBTK button will be enabled. Click the Program BBTK button to load in the sequence to be generated.



The display will show that the BBTK is being programmed. The time limit you set in seconds will also be shown along with the maximum number of Stimulus-Response pairings (Events).



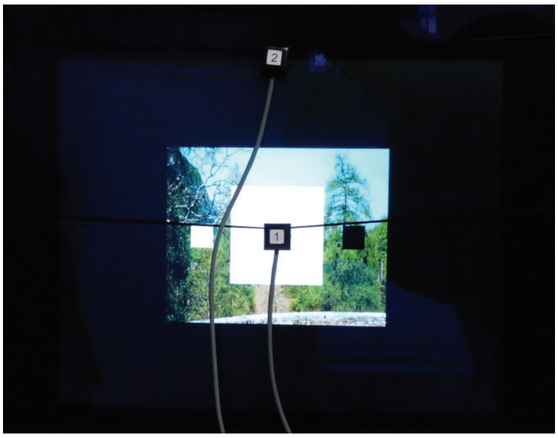
The Start button will now be enabled in the PC Software ready for you to tell the BBTK to start looking for stimulus images to trigger its responses.



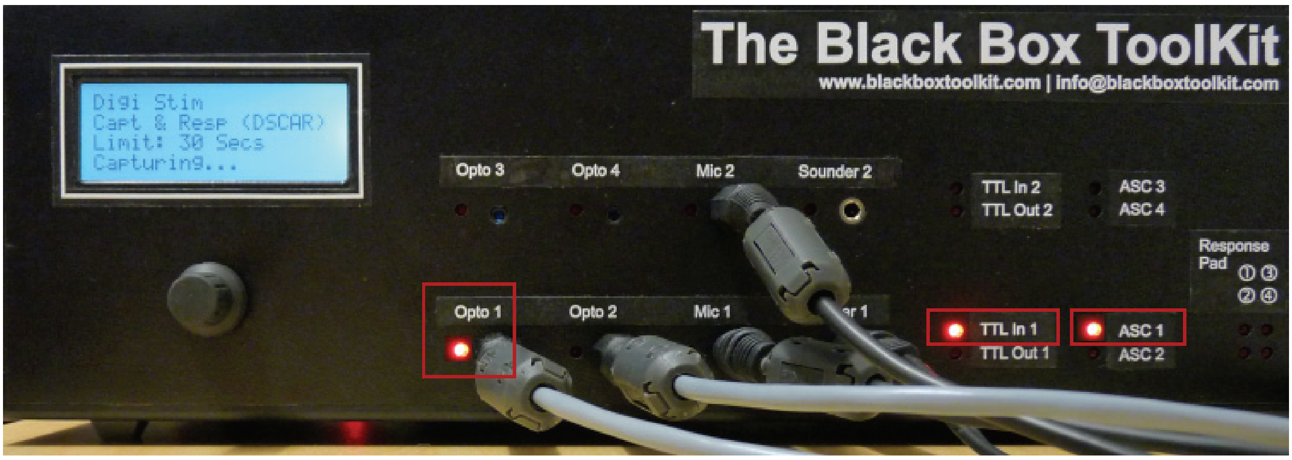
Start the paradigm on the PC running the Experiment Generator.

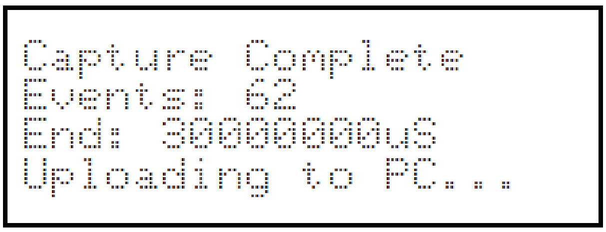
Ensure that no BBTK sensors are triggering and then click Start on DSCAR.

As quickly as you can start the paradigm on the Experiment Generator PC. That is, advance from the instruction screen to the first real trial where an image stimulus is presented. The BBTK should now automatically respond to each stimulus presentation.

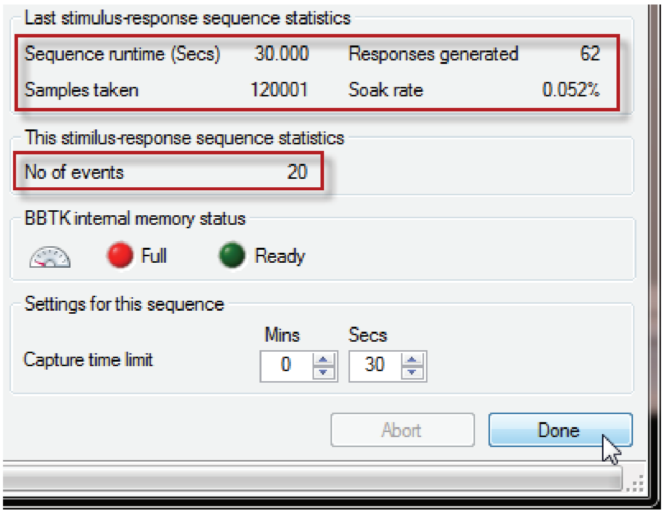


As each stimulus presentation is detected the various LEDs on the front panel of the BBTK will illuminate.





After 30 seconds have elapsed the BBTK will indicate that the capture has completed. The number of line changes or Events will be listed along with a total runtime. Uploading… will be displayed as data is sent to the PC.

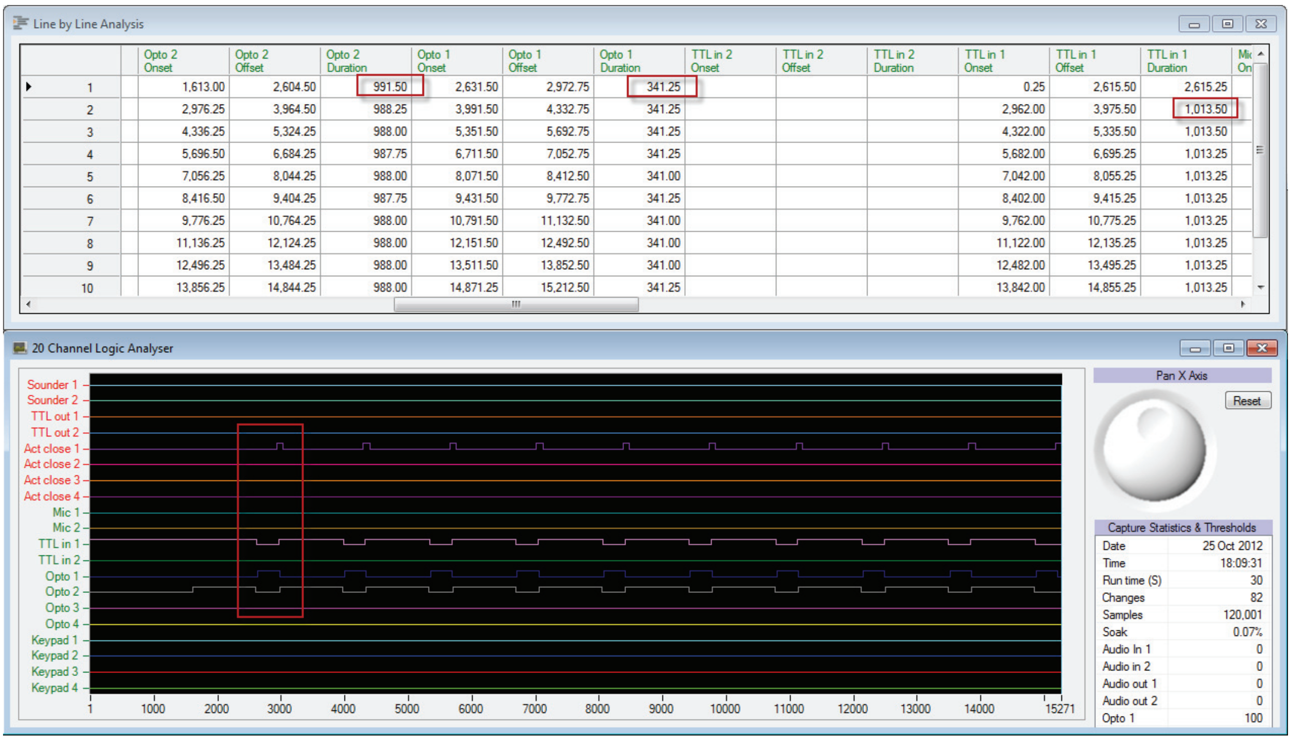


Whilst the data is being uploaded to the PC Software Uploading will be displayed in the Status bar and a progress bar will be displayed.

Once all the data has been uploaded from the BBTK's internal memory the Last Capture Statistics will be displayed. The Start button will be greyed out and the Internal Memory Status LED will go red.

To repeat a capture click Clear BBTK and repeat the previous steps. To analyse any data captured click Done.

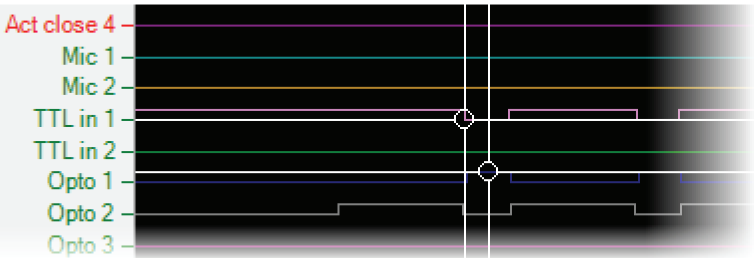
From the resulting Logic Analyser plot shown below we can see that Visual Stimulus presentations were logged as they were presented by the Experiment Generator (Opto 1, blue trace), Response Events were generated as a Stimulus-Response pair from the BBTK (Active Switch Closure 1, purple trace) and the TTL ISI event marker was also recorded (TTL In 1, lilac trace). The fixation point is logged as an Opto 2 event.



If we review the questions posed before we ran the self-validation timing test how do we answer them?

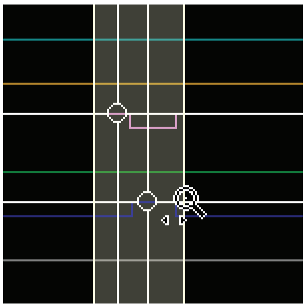
1. Do stimulus bitmaps appear synced with the TTL signal produced by the Experiment Generator and sent to the PCs parallel, or LPT port? This is important if you are trying to sync with external equipment, e.g. EEG machines, fMRI etc. via the TTL signal. If your PC does not have a parallel port you could use a BBTK USB TTL event marking module instead.
2. Do stimulus images accurately terminate when responses are made?
3. Are ISIs 1,000mS as programmed into the Experiment Generator?
4. Are Response Times registered by the Experiment Generator accurate?

Question 1: Do stimulus bitmaps appear synced with the TTL signal? Answer: No.
A cursory examination of the TTL In 1 Duration column of the Line by Line Analysis would suggest that ISIs were not 1,000mS as intended. Instead they seem to be around 1,013mS. This could be an important systematic error if we were using this event marker with other equipment such as EEG machines or fMRI scanners.



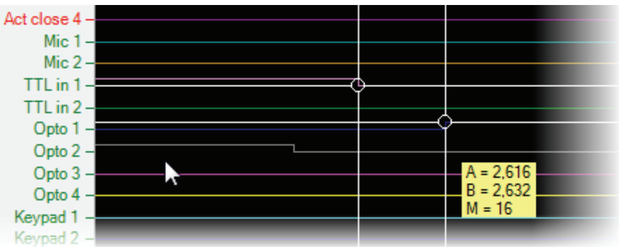
To check this discrepancy more closely we would use the measurement cursors of the Logic Analyser plot. Click on the plot and press M for Measure.

Cursor A and Cursor B will now appear. Drag A over to around the onset of the TTL Event Marker and B over to the onset of the Opto 1 stimulus presentation.



Press + on the keyboard to Zoom In. Click and drag around the cursors to Zoom.

Use +/- next to the back space key on the keyboard. Alternatively right click on the plot and use the context sensitive menus.



After Zooming in and snapping exactly to the Onset of the TTL Event Marker and to the Onset of the Stimulus Presentation detected by Opto 1 we can see that there was a 16mS lag.

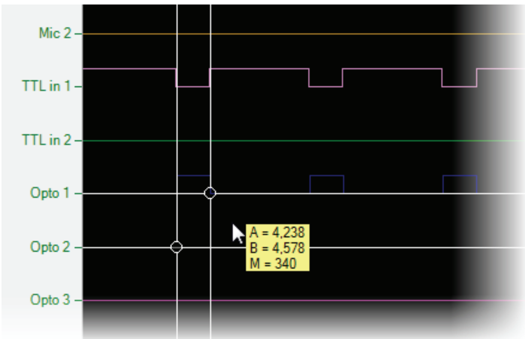
One possible conclusion might be that if the TTL signal was accurate, that the image was displayed 16mS later than it should have been. It is likely that this is due partly to error in the Experiment Generator but can be mainly attributable to the Input Lag of the TFT screen used.

Question 2: Do stimulus images accurately terminate when responses are made? Answer: No.

Line by Line Analysis

	Opto 1 Onset	Opto 1 Offset	Opto 1 Duration	TTL in 2 Onset
1	4,238.00	4,578.25	340.25	
2	5,598.00	5,938.25	340.25	
3	6,957.75	7,298.25	340.50	
4	8,317.75	8,658.25	340.50	
5	9,677.75	10,018.25	340.50	
6	11,037.75	11,378.25	340.50	
7	12,397.75	12,738.00	340.25	
8	13,757.75	14,098.00	340.25	
9	15,117.75	15,458.00	340.25	
10	16,477.75	16,818.00	340.25	

Again a cursory examination of the Opto 1 Duration column of the Line by Line Analysis Spreadsheet would suggest that stimulus images were not terminated at 300mS as each response was made. Their termination point is around 340mS, which is 40mS later than expected.



We could also use the Logic Analyser Measurement Cursors to verify durations. Remember the Logic Analyser rounds up to the nearest whole millisecond.

One possible conclusion might be that the response was not registered in a timely fashion by the Experiment Generator and therefore it could not terminate images at the true reaction time of 300mS. An alternative explanation is that the TFT panels electronics made the stimulus image persist even though the Experiment Generator terminated it.

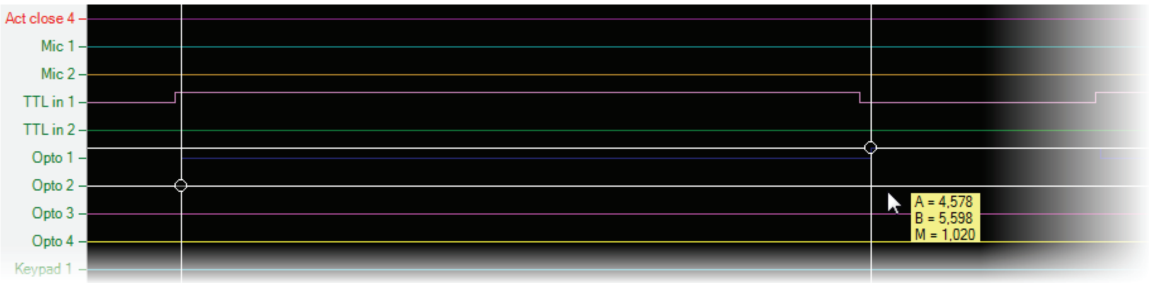
Question 3. Are ISIs 1,000mS as programmed into the Experiment Generator? Answer: No.

	Opto 1 Onset	Opto 1 Offset	Opto 1 Duration	TTL in 2 Onset
	4,238.00	4,578.25	340.25	
	5,598.00	5,938.25	340.25	
	6,957.75	7,298.25	340.50	
	8,317.75	8,658.25	340.50	
	9,677.75	10,018.25	340.50	
	11,037.75	11,378.25	340.50	
	12,397.75	12,738.00	340.25	
	13,757.75	14,098.00	340.25	

We can work out any ISIs on any sensor/line by subtracting the last offset from the next onset and then subtracting the intended ISI from the result. In this case:

5598.00 – 4578.25 = 1019.75
1019.75 – 1000 = **19.75mS ISI**

We can also use the Logic Analyser plot Measurement Cursors to snap to the offset of one event and the onset of the next.



Question 4. Are Response Times registered by the Experiment Generator accurate? Answer: No.

Stimulus.RT
336
336
336
336
336
336
336
336

To evaluate the accuracy of the response time we would need to examine the Response Times recorded by the Experiment Generator. We would then need to subtract the intended RT fed in by the BBTK (300mS). Any difference would be error.

In this case the RT error would be 336 – 300 = **+36mS RT**.

One possible explanation is that the polling or scanning loop on the keyboard took 36mS to check which key had been shorted out by the Active Switch Closure (ASC). Remember ASC simply close the key contacts and don't include any mechanical travel time as that would need to be assessed by the BBTK Robotic Key Actuator (RKA).

Conclusions for this Example

As is the case with many Experiment Generators we have not achieved the levels of accuracy hoped for as compared with a dedicated system like the Black Box ToolKit or even a calibrated paradigm whose accuracy has been tuned using a tool like the BBTK.

In a calibrated paradigm on the same equipment we may choose to make the ISI 980mS in the Experiment Generator so that it is actually 1,000mS as intended. Plus we may choose to subtract 36mS from our response times so that they are equal to the intended RTs. However this would depend on the levels of variance in reality.

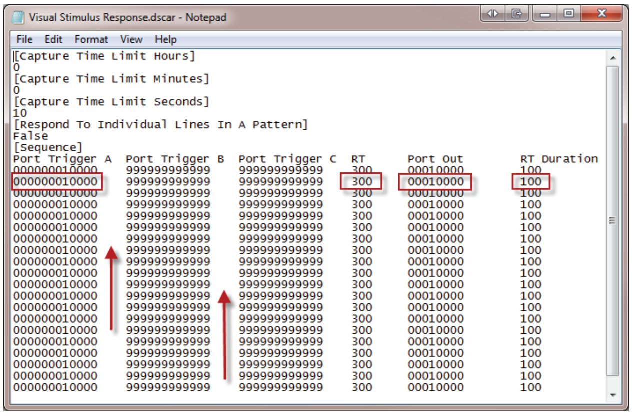
Note the figures in this example have been deliberately kept simple and in your own validation tests you are likely to see much more variance.

12.2 Advanced Use of the Digital Stimulus Capture And Response (DSCAR) Module

The Digital Stimulus Capture And Response (DSCAR) module lets you define sequences of stimuli to respond to and events to generate manually as well as using the wizard. When you define sequences manually this lets you choose a stimulus to respond to, vary the Response Time, the response you generate and the duration of the response event you send to your own hardware all on a trial by trial basis.

By manually constructing your own sequences you can program a more variable schedule. That is, build in human like variability in Response Times. For example, a more variable schedule of events using an Active Switch Closure might be more similar to a human tapping a key.

The easiest way to start defining your own schedules is to create one using the wizard as described earlier, save it and then edit the resulting file in software such as Microsoft Excel. DSCAR files are saved with a ".dscar" file extension and are standard ASCII TAB separated value files.




```
[Capture Time Limit Hours]
0
[Capture Time Limit Minutes]
0
[Capture Time Limit Seconds]
10
[Respond To Individual Lines In A Pattern]
False
[Sequence]
Port Trigger A   Port Trigger B   Port Trigger C   RT    Port Out    RT Duration
000000010000     999999999999     999999999999     300   00010000    100
000000010000     999999999999     999999999999     300   00010000    100
000000010000     999999999999     999999999999     300   00010000    100
000000010000     999999999999     999999999999     300   00010000    100
000000010000     999999999999     999999999999     300   00010000    100
000000010000     999999999999     999999999999     300   00010000    100
000000010000     999999999999     999999999999     300   00010000    100
000000010000     999999999999     999999999999     300   00010000    100
000000010000     999999999999     999999999999     300   00010000    100
000000010000     999999999999     999999999999     300   00010000    100
000000010000     999999999999     999999999999     300   00010000    100
000000010000     999999999999     999999999999     300   00010000    100
000000010000     999999999999     999999999999     300   00010000    100
000000010000     999999999999     999999999999     300   00010000    100
000000010000     999999999999     999999999999     300   00010000    100
000000010000     999999999999     999999999999     300   00010000    100
000000010000     999999999999     999999999999     300   00010000    100
000000010000     999999999999     999999999999     300   00010000    100
000000010000     999999999999     999999999999     300   00010000    100
000000010000     999999999999     999999999999     300   00010000    100
```

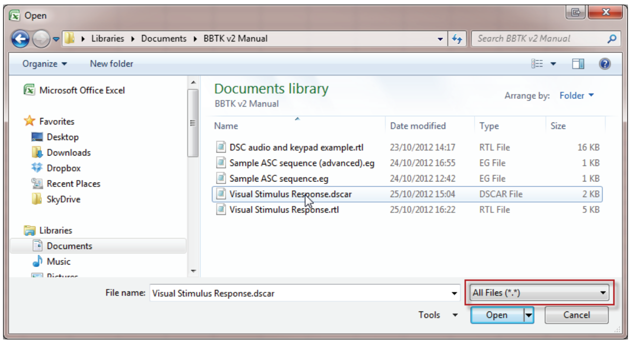
This is the result of saving the sequence described in the example in the previous section when opened in Windows Notepad.

There are three types of stimulus patterns (Triggers A, B, C) that could cause a response. 000000010000 signifies Opto 1 out of the 12 input lines. A series of 9's means don't look for a Trigger B or C.

The RT column is the Response Time in milliseconds after detecting a Trigger Pattern Match on either Trigger A, B or C.

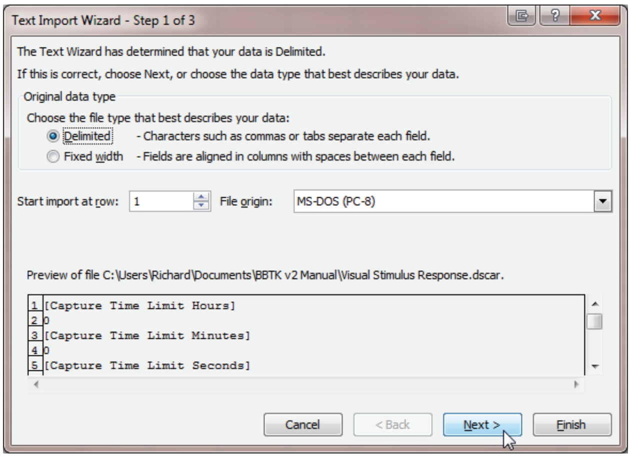
Port Out's are the output lines which responses should be generated on and RT Duration is how long the response event should be generated for in milliseconds.

All values are separated by invisible TAB characters indicated by the red arrows. Any files you create or edit must adhere to this format or they may not work correctly.



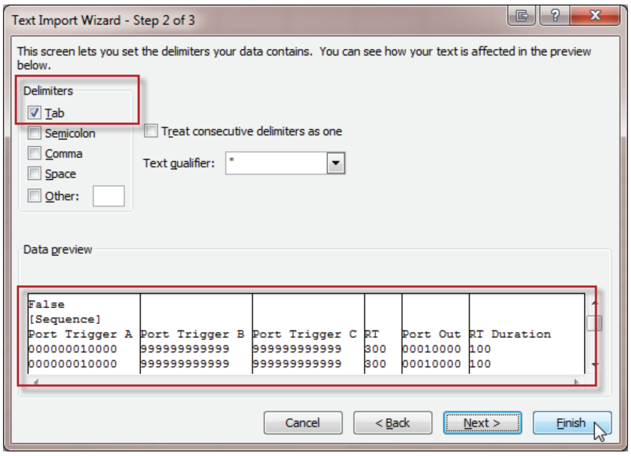
When opening DSCAR files in Microsoft Excel for example ensure that you select the All Files (*.*) filter in the Open dialog box otherwise you won't see the .eg files.

Alternatively you can enter ***.dscar** in the File name box and press return.



The Excel Import Wizard should then start. Ensure the Delimited radio button is selected as we are delimiting columns by TABs.

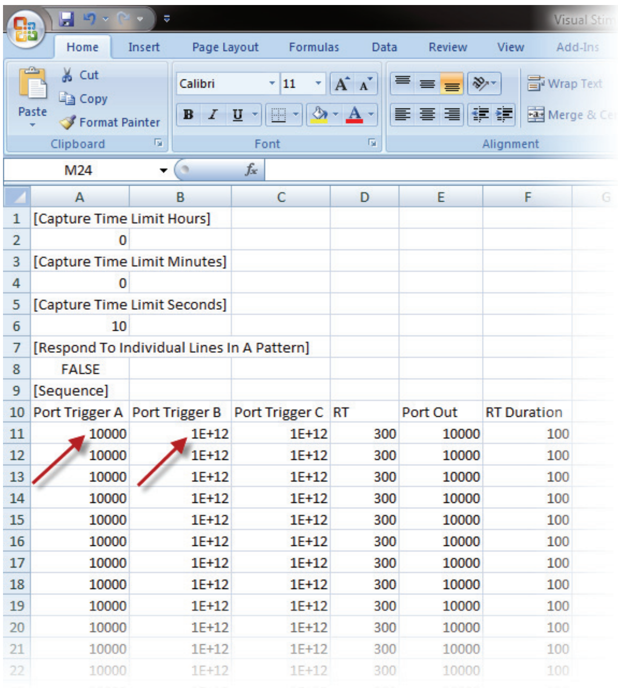
Then click Next.



Excel should automatically identify the file as being TAB separated. If not tick the Tab check box.

You should also see a preview of the three columns which should be split by the invisible TAB character. You may need to scroll down in the Data Preview to see the actual columns.

Usually you can click Finish at this point and the file will be shown in Excel.

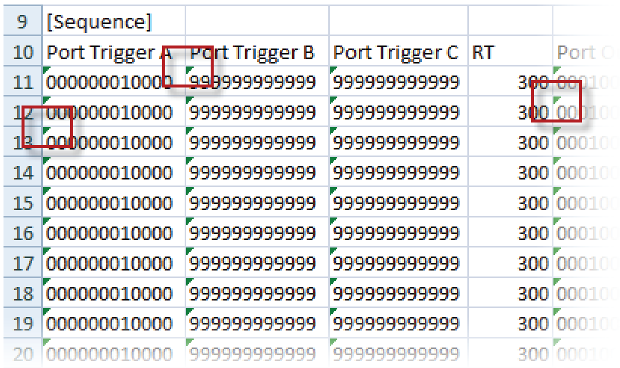


Note however that Excel does not display the Port values correctly. The RT and RT Duration times in mS are displayed correctly though.

You will need to reset the Port Trigger values to their correct format, e.g. 100000 needs to be put back to, 000000010000 in each cell. Do this by prefixing the cell content with a ‘ (apostrophe) and then entering 000000010000. Remember the “1” at position 8 means the BBTK is looking for a stimulus on Opto 1.

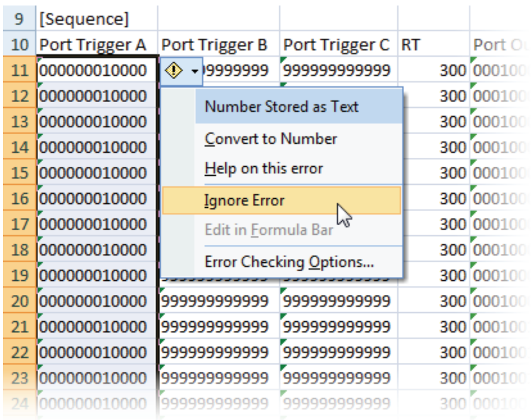
1E+12 is Excel displaying 999999999999 in scientific notation. Change it to ‘999999999999 as described for Trigger values.

Finally change the Port Out values to have leading 0’s, e.g. ‘00010000. “1” at position 4 means ASC 1 is active.

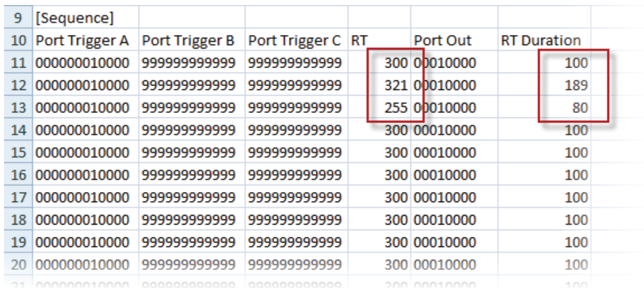


When editing sequences Excel may flag the numbers with a quotation mark in front as a Text As Number error.

Also be aware the Excel my try to automatically increment numbers if you click and drag ranges of cells. So for example the RTs may increment by 1 for each row. To stop this behaviour select two cells and then click and drag of the range you wish to clone.

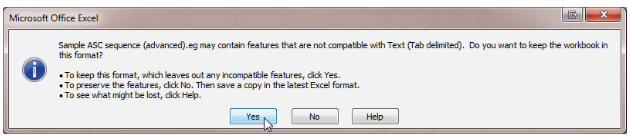


To dismiss the Text As Number warning in Excel highlight all the cells concerned and then click on the Ignore Error drop down.

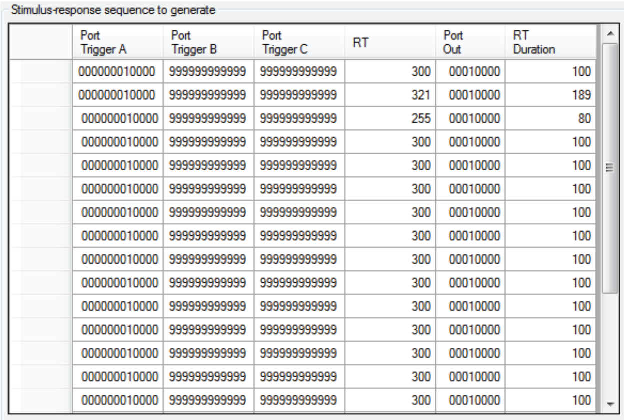


In the example shown I've modified the first RT to be 300mS, the second 321mS, the third 255mS… Durations are 100mS, 189mS and 80mS respectively for the first three responses.

If I wanted I could also change the Port Trigger on each trial, e.g. 000000100000 would respond to a stimulus on Opto 2. In the same way I might alter the Port Out value to 00100000 which would short ASC 2 and respond on a different key. Thus the BBTK could respond to different stimuli with different responses and with different timing characteristics.



Finally click on the Save toolbar icon to save the file. Excel will probably warn you that the file format chosen cannot save all the features that Excel offers. Ignore this information box and click Yes.



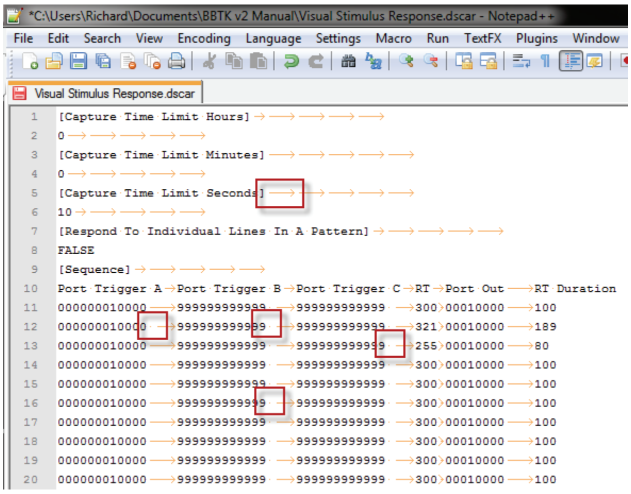
Stimulus-response sequence to generate

Port Trigger A	Port Trigger B	Port Trigger C	RT	Port Out	RT Duration
000000010000	999999999999	999999999999	300	00010000	100
000000010000	999999999999	999999999999	321	00010000	189
000000010000	999999999999	999999999999	255	00010000	80
000000010000	999999999999	999999999999	300	00010000	100
000000010000	999999999999	999999999999	300	00010000	100
000000010000	999999999999	999999999999	300	00010000	100
000000010000	999999999999	999999999999	300	00010000	100
000000010000	999999999999	999999999999	300	00010000	100
000000010000	999999999999	999999999999	300	00010000	100
000000010000	999999999999	999999999999	300	00010000	100
000000010000	999999999999	999999999999	300	00010000	100
000000010000	999999999999	999999999999	300	00010000	100
000000010000	999999999999	999999999999	300	00010000	100
000000010000	999999999999	999999999999	300	00010000	100
000000010000	999999999999	999999999999	300	00010000	100

Close Excel and then load the file into DSCAR by clicking on the Open toolbar button.

Here we can see that the first event we modified in Excel is replicated in the DSCAR spreadsheet ready to be generated.

To run the new sequence as before click on Clear BBTK, Program BBTK and Start.



*C:\Users\Richard\Documents\BBTK v2 Manual\Visual Stimulus Response.dscar - Notepad++

File Edit Search View Encoding Language Settings Macro Run TextFX Plugins Window

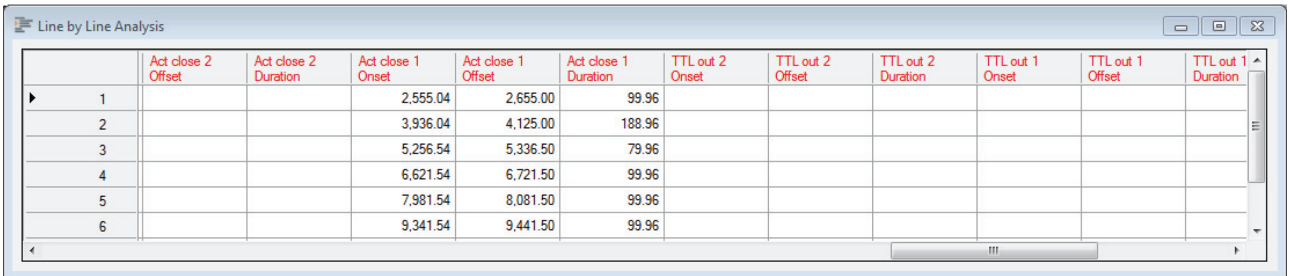
Visual Stimulus Response.dscar

```
[Capture Time Limit Hours]
0
[Capture Time Limit Minutes]
0
[Capture Time Limit Seconds]
10
[Respond To Individual Lines In A Pattern]
FALSE
[Sequence]
Port Trigger A	Port Trigger B	Port Trigger C	RT	Port Out	RT Duration
000000010000	999999999999	999999999999	300	00010000	100
000000010000	999999999999	999999999999	321	00010000	189
000000010000	999999999999	999999999999	255	00010000	80
000000010000	999999999999	999999999999	300	00010000	100
000000010000	999999999999	999999999999	300	00010000	100
000000010000	999999999999	999999999999	300	00010000	100
000000010000	999999999999	999999999999	300	00010000	100
000000010000	999999999999	999999999999	300	00010000	100
000000010000	999999999999	999999999999	300	00010000	100
000000010000	999999999999	999999999999	300	00010000	100
```

If you receive an error message it is probably because Excel has inserted additional blank spaces. Simply open up the file in Notepad and delete the trailing spaces and re-save the file.

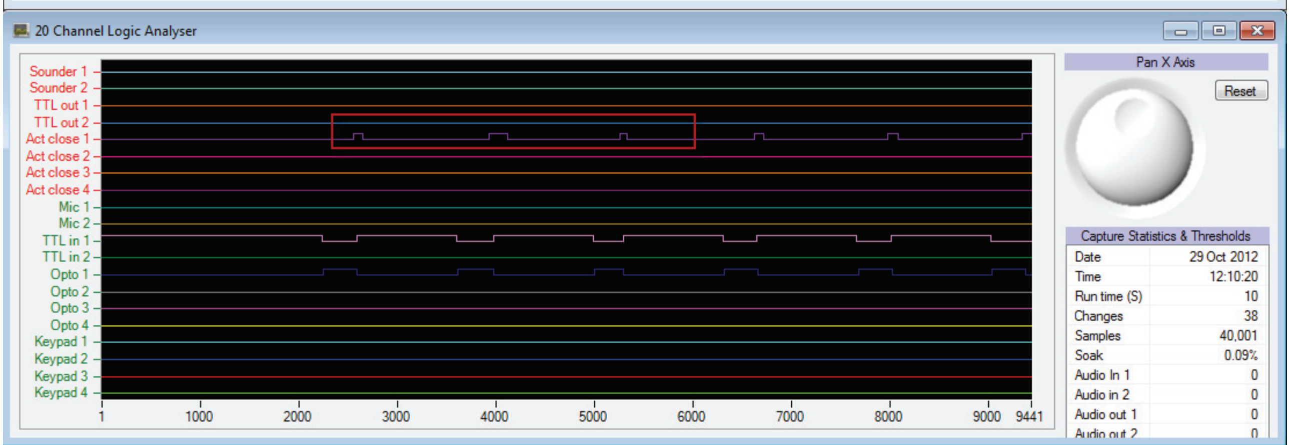
We recommend the Open Source Notepad++ for this task.

When we analyse the resulting data we can see that the three stimulus response pairs we altered are different to the rest of the sequence. We can see that the first duration was 100mS, the second 189mS and the third 80mS as intended.



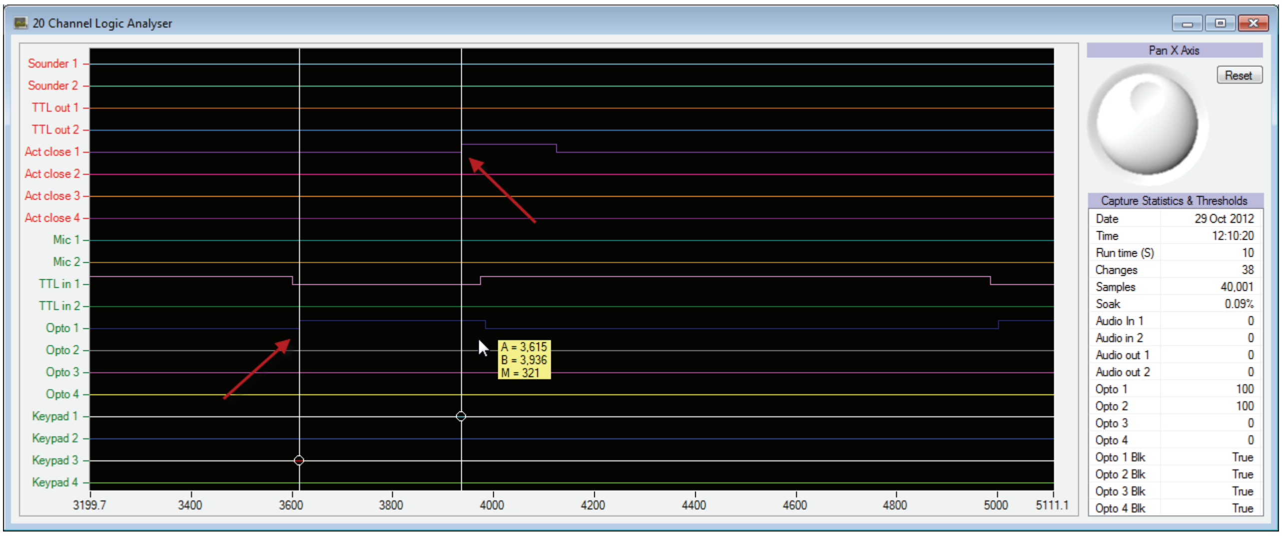
Line by Line Analysis

	Act close 2 Offset	Act close 2 Duration	Act close 1 Onset	Act close 1 Offset	Act close 1 Duration	TTL out 2 Onset	TTL out 2 Offset	TTL out 2 Duration	TTL out 1 Onset	TTL out 1 Offset	TTL out 1 Duration
1			2,555.04	2,655.00	99.96						
2			3,936.04	4,125.00	188.96						
3			5,256.54	5,336.50	79.96						
4			6,621.54	6,721.50	99.96						
5			7,981.54	8,081.50	99.96						
6			9,341.54	9,441.50	99.96						



In terms of Response Time we can either calculate the differences from the spreadsheet or make use of the Measurement Cursors. To measure the difference in milliseconds between the onset of the visual stimulus on Opto 1 and the Response on ASC 1 (indicated by the red arrows) we would press M and drag the two measurement cursors to the relevant onset and offsets. In this case we can see that the BBTK generated the second response at exactly 321mS as intended.

To ensure that you have accurately positioned the measurement cursors you should zoom in around each cursor by pressing + on the keyboard or by right clicking and selecting zoom.



Finally we would compare the Response Times we generated using the BBTK with those recorded by our paradigm under test.

Stimulus.RT
335
359
292
333
333
333

To evaluate the accuracy of the response time we would need to examine the Response Times recorded by the Experiment Generator. We would then need to subtract the intended RT fed in by the BBTK (300mS, 321, 255, 300…). Any difference would be error.

In this case the RT error for response two would be 359 – 321 = **+38mS RT**.

12.3 How Digital Stimulus Capture And Response (DSCAR) Detects a Trigger Stimulus Within a Pattern

DSCAR detects a trigger stimulus in a slightly different way to a human in the respect that it will attempt to look for an exact pattern match in binary across its range of sensors/lines. That is, whether a given sensor is active, i.e. ON, or non active, i.e. OFF.

Exact pattern matching means that if there are other stimuli being detected on other sensors/lines at the same time you are trying to trigger from a specific line the BBTK may not trigger.

Both DSCAR and DSRE detect trigger stimuli within a pattern in the same way.

The easiest way to demonstrate this effect is with some practical examples. If you had two Opto detectors (1 & 2) and you wanted to trigger from Opto 1 the Port Trigger match would be:

000000010000

Where the “1” represents Opto 1 being ON and the other 11 input sensors/lines being OFF.

So when the BBTK detects this pattern it would wait for a predetermined Response Time and then generate a response event, e.g. on ASC 1.

However, if both Optos were active at the same time the actual input pattern across the sensor/input lines would be:

000000110000

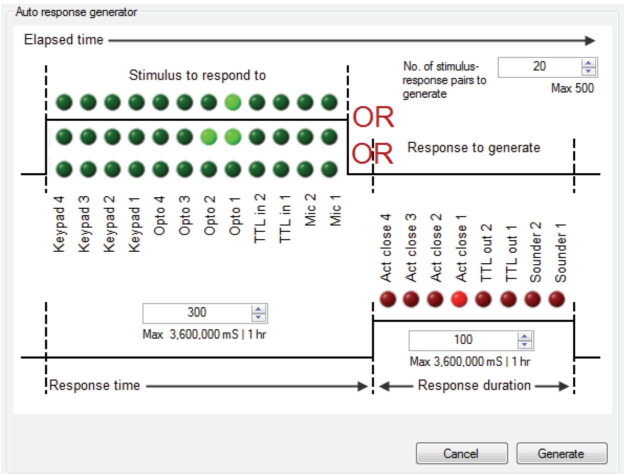
This is not an exact match and so the BBTK would not be triggered to make a response.

In the same way if an audio stimulus was playing and was being captured by BBTK Mic 1, again the input pattern would not match the trigger as this time it would be:

000000010001

There are several solutions to this.

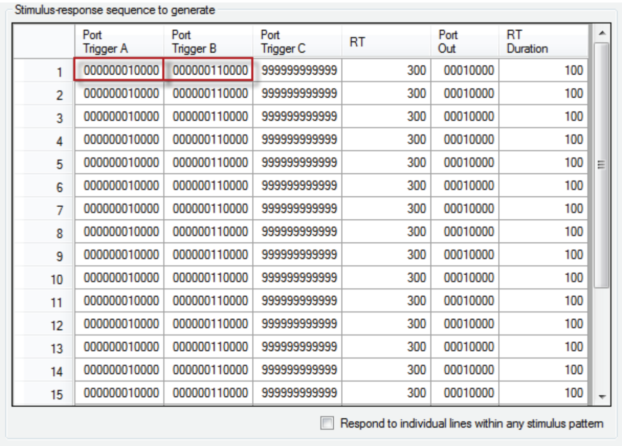
Solution 1: Trigger on More Than One Stimulus Pattern



The Auto Response Generator or wizard is the easiest way to illustrate how to trigger on more than one stimulus pattern.

Here we can see that the stimulus pattern to respond to is either Opto 1 OR Opto 1 AND Opto 2.

Each of the LEDs on one row are effectively AND’d together to form a trigger. Each of the three rows are logically OR’d together. These actually form Port Trigger A, B and C.



	Port Trigger A	Port Trigger B	Port Trigger C	RT	Port Out	RT Duration
1	000000010000	000000110000	999999999999	300	00010000	100
2	000000010000	000000110000	999999999999	300	00010000	100
3	000000010000	000000110000	999999999999	300	00010000	100
4	000000010000	000000110000	999999999999	300	00010000	100
5	000000010000	000000110000	999999999999	300	00010000	100
6	000000010000	000000110000	999999999999	300	00010000	100
7	000000010000	000000110000	999999999999	300	00010000	100
8	000000010000	000000110000	999999999999	300	00010000	100
9	000000010000	000000110000	999999999999	300	00010000	100
10	000000010000	000000110000	999999999999	300	00010000	100
11	000000010000	000000110000	999999999999	300	00010000	100
12	000000010000	000000110000	999999999999	300	00010000	100
13	000000010000	000000110000	999999999999	300	00010000	100
14	000000010000	000000110000	999999999999	300	00010000	100
15	000000010000	000000110000	999999999999	300	00010000	100

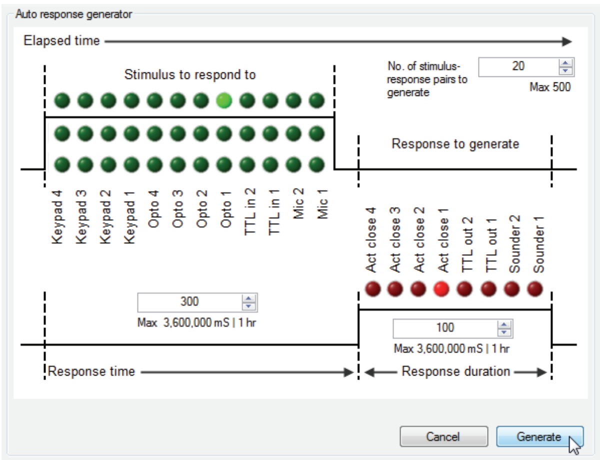
In this scenario so long as Opto 1 and Opto 2 are the **ONLY** sensors/lines active the BBTK will trigger as Opto 1 has been detected. Remember if other sensors are active at exactly the same time it won't trigger as the binary port value will be different.

As can be seen from the Generated spreadsheet two trigger patterns will be looked for by the BBTK and a corresponding response event generated.

Up to three patterns of trigger stimuli can be used but only one response event or pattern can be generated.

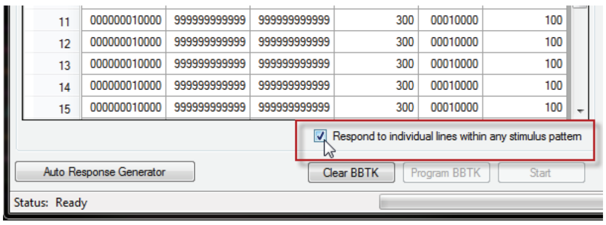
Solution 2: Respond to Individual Lines Within any Stimulus Pattern

As you may have realised you are limited to a restricted set of stimulus patterns that can be OR'd together. Namely three. It may be that you can't adequately describe the stimulus pattern you want to respond to or you may have activity on other sensors/lines that you can't account for or don't want to trigger from. For example, in a cross modal priming paradigm you may have visual and auditory stimuli but only wish to trigger on visual stimulus events on Opto 1 even if a tone is playing at the same time.



Where we want to trigger on one stimulus/line being active and can't be certain of which other sensors/lines may be active we can choose to Respond to individual lines within any stimulus pattern.

To do this we would select the sensor/line we were interested in. In this case Opto 1, select our response, ASC 1 and click Generate.



11	000000010000	999999999999	999999999999	300	00010000	100
12	000000010000	999999999999	999999999999	300	00010000	100
13	000000010000	999999999999	999999999999	300	00010000	100
14	000000010000	999999999999	999999999999	300	00010000	100
15	000000010000	999999999999	999999999999	300	00010000	100

Once the sequence had been generated in the spreadsheet we would tick Respond to individual lines within any stimulus pattern.

So each time Opto 1 detected a stimulus the BBTK would wait 300mS and then generate a response (ASC 1 for 100mS).

You should bear in mind that by ticking this box more than one response can be generated for each stimulus. For example, if the visual stimulus image is displayed for 1,000mS then three responses will be made:

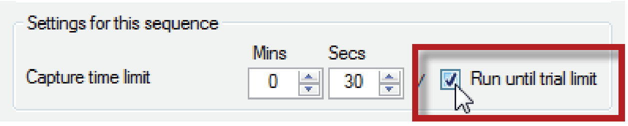
1. 300mS RT + 100mS Duration (RT starts at 300mS after image onset)
2. 300mS RT + 100mS Duration (RT starts at 400mS after image onset)
3. 300mS RT + 100mS Duration (RT starts at 800mS after image onset)

Whereas if this box remains unticked then there has to be an ISI before the triggering mechanism will rearm, e.g. a blank or OFF period where the stimulus image is not displayed. This is typically where a stimulus image terminates up on a response.

All input and output line activity is recorded at all times.

12.4 Capture Until a Specified Number of Trials Have Been Completed

Some paradigms make use of variable trial durations and so it is not always possible to set an end time limit for which the BBTK should respond to stimuli for. If this is the case you have the option to respond to stimuli until either the Capture Time Limit is reached or the number of trials you have programmed is reached.



To stop and upload data after a set number of stimulus-response trials check the Run Until Trial Limit checkbox.

For example if you have setup a 100 trials then 100 responses will be made to the trigger stimulus you have chosen as long as the Run Until Trial limit checkbox is checked. You should ensure that the Capture Time Limit is set for long enough whether this option is checked or not.

If the trial limit is reached the BBTK will stop looking for stimulus triggers, quit early and upload any timing data collected. It will do this as soon as the last response of a trial series is made. Otherwise it will keep producing responses to stimuli until the preset time limit.

13. Generating Events Using Digital Stimulus Response Echo

The Digital Stimulus Response Echo module is very similar to the DSCAR module in that it allows you to generate a series of response events with a known Response Time and duration across a range of modalities triggered by a predefined stimulus pattern.

Up to 12 stimulus input lines can be monitored at any one time using the Professional version of the BBTK* and events on one or more of the 8 output lines can be generated in response.

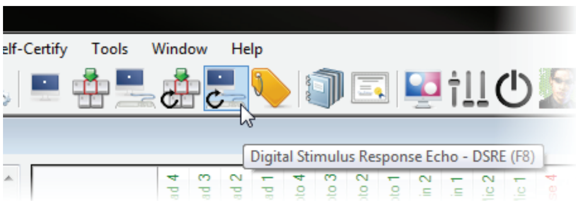
The key differences are that the Response Echo module does not collect any timing data that can be uploaded and analysed by the PC Software; it is not limited to a fixed number of events that it can generate in response to stimuli (it can generate an infinite number of events); and it cannot vary timings on an event by event basis (it can only generate a fixed pattern).

DSRE operates like a like an echo device or a ping test used to check network connectivity on a computer. If it detects a predefined stimulus or stimulus pattern it will make a response. One use for DSRE might be to send a regular series of event markers to an EEG machine or MRI scanner using one of the TTL out lines based on detecting a visual stimulus.

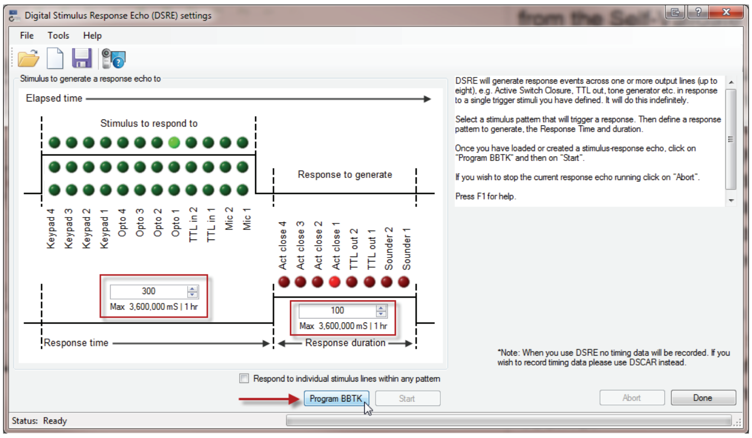
Note that to stop a sequence you will need to click Abort which will reset the BBTK. Thus you are advised to save your Sensor Threshold Settings before you use this module if you have customised them specifically, or reload an existing RTL file and set to those settings.

13.1 How to Respond to an Unlimited Series of Stimuli Using Digital Stimulus Response Echo (DSRE)

Digital Stimulus Response Echo only provides a wizard style interface which automatically generates Response Times and durations for events very simply using a point and click interface.



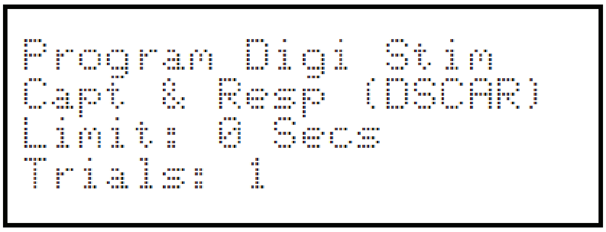
To respond to stimulus events across the 12 input lines begin by starting the Digital Stimulus Response Echo module by clicking on its toolbar button, pressing F8 or from the Self-Validate menu.



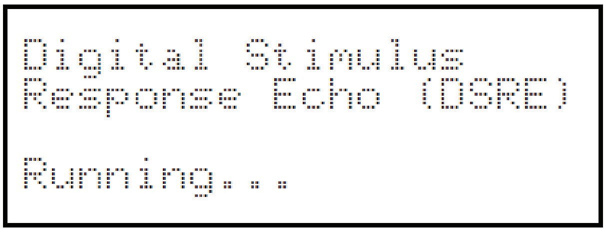
When the DSRE Module starts you will be presented with a graphical representation of what stimuli you wish to respond to, the Response Time, what response event to generate and what duration that event will have.

In the example shown the BBTK will generate an ASC 1 event with a RT of 300mS for a duration of 100mS each time a visual stimulus is detected on Opto 1.

As described in the previous section when using DSCAR you have the option of using AND and OR logic to define stimulus patterns to respond to. If you are unsure if other stimulus events will be detected and an exact pattern match might occur you can tick “Respond to individual lines within any stimulus pattern”. This will trigger a response irrespective of activity on other lines.

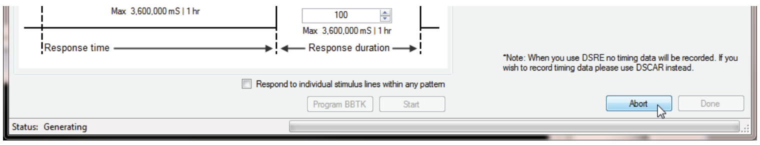


Once you are happy with your sequence click Program BBTK. This will tell the BBTK what events to generate and what the timing characteristics are. The BBTK display will inform you that it is being programmed.

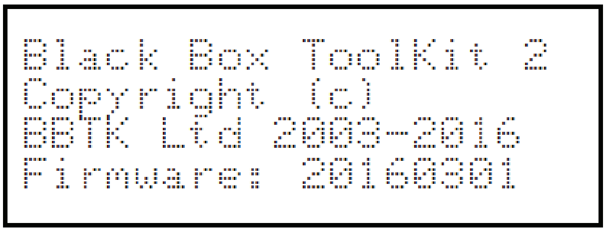


To run the sequence click Start. The BBTK display will change to Running and the PC Software will grey out The Program BBTK and Start button, whilst the Abort button will be enabled. The status bar will change to “Generating”.

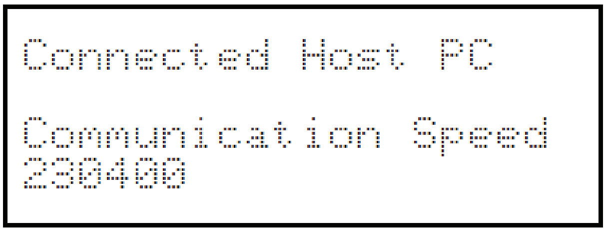
Whilst detecting stimuli and responding to events the LEDs of the lines which are active will illuminate. Here Opto 1 has detected a visual stimuli and a response has been generated on ASC 1.



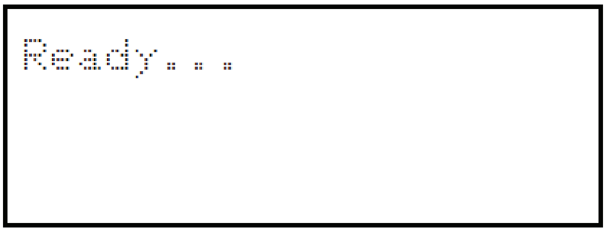
DSRE will run the same sequence of stimulus-response pairs until the BBTK is reset or switched off. To stop the sequence click Abort. This will in effect reset the BBTK.



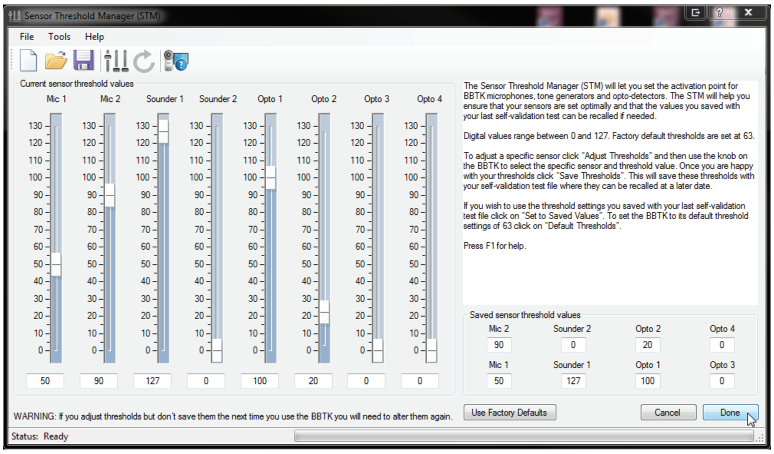
When the BBTK resets it should display a copyright notice along with a firmware version on its LCD screen similar to the one shown.



Next it should attempt to connect to the host PC via the COM/USB port you chose. If successful you should see the Communication Speed displayed in bps. By default this is 230,400 bps but could be slower depending on your Operating System.



Once connected the default is for the BBTK to display “Ready…” indicating it is ready for use.



The PC Software will display the Sensor Threshold Manager. At this point you can choose to load your default values, factory defaults, or choose settings from an open RTL file.

14. Real-Time Event Marking Using the Event Marking (EM) module

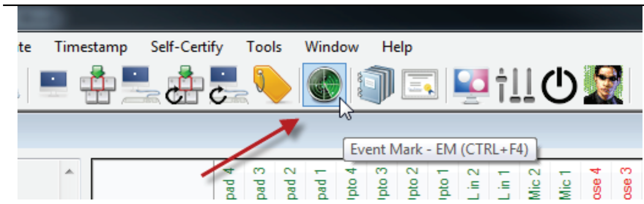
The BBTK enables you to event mark in real-time as events occur on any input lines. On the Elite model this allows event marking of any of the 20 input lines, e.g. opto-detectors, microphones, TTL and TTLe expansion board inputs etc. These inputs can be mapped in real-time to any of the 15 output lines, e.g. sounders, ASC, TTL and TTLe expansion board outputs etc. On the Entry and Pro models the number of lines available for mapping will be less as there are fewer physical input and output options. Currently only eight mappings can be made at once regardless of model.

For example, the standard breakout board and TTLe expansion board can be combined to give a total of nine TTL output event marking lines. These could be paired to input lines representing opto-detectors, microphones, response pad buttons or other external event markers. Temporally yoked inputs are mirrored in terms of onset, duration and offset on their paired output line. In short any input line can be mapped to any output line. The table below details input and output lines that you might make use of on the Elite model*.

Whilst event marking, no timing data is recorded and the BBTK simply acts as an event marking device for use with other equipment. One use might be to TTL event mark the exact timing characteristics of visual and auditory events on an EEG trace for example.

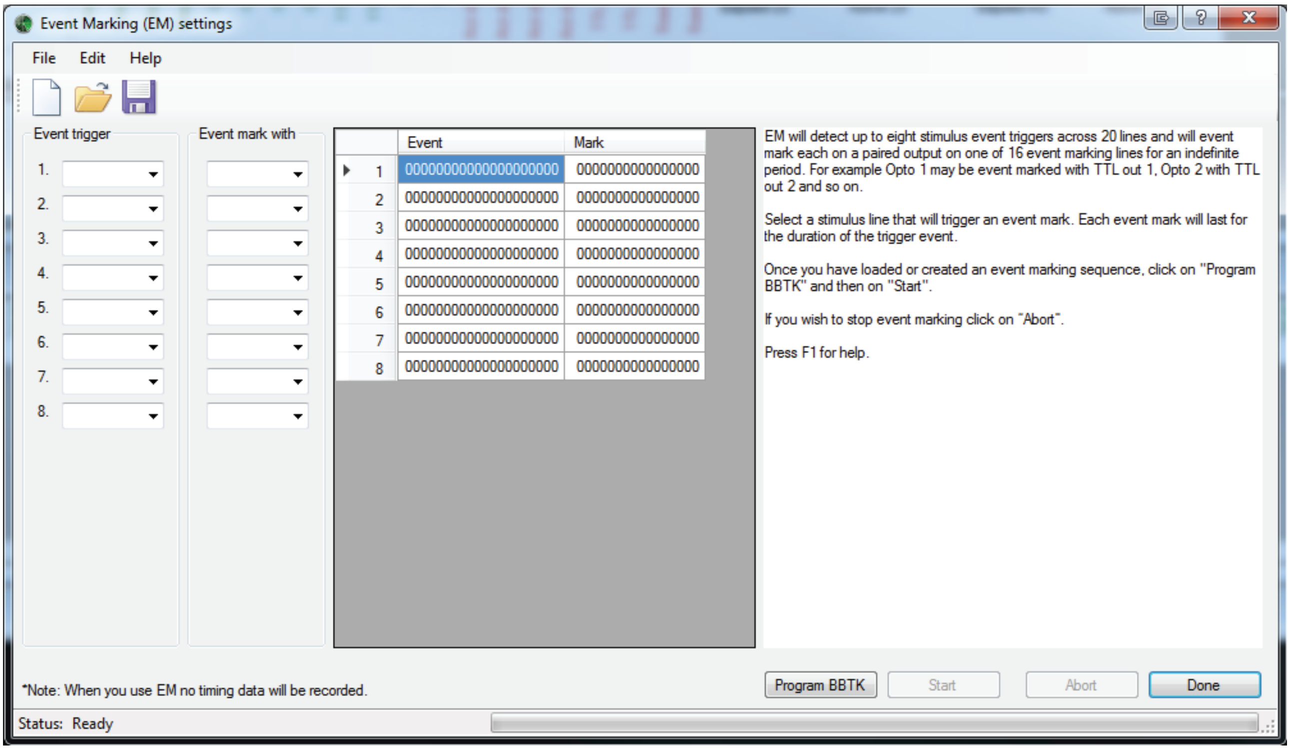
Lines that can trigger an event mark		
Sensor	**No**	**Purpose**
Microphone	2*	Detect audio stimulus presentations from your equipment.
TTL in	2*	Detect TTL (0~5V) digital signals from your equipment, e.g. EEG markers, fMRI etc.
Opto-detector	4*	Detect visual stimuli.
Keypad button	4*	Detect key presses on the 4 button BBTK response pad.
TTLe expansion board	8	Detect TTL (0~5V) digital signals from your equipment, e.g. EEG markers, fMRI etc.

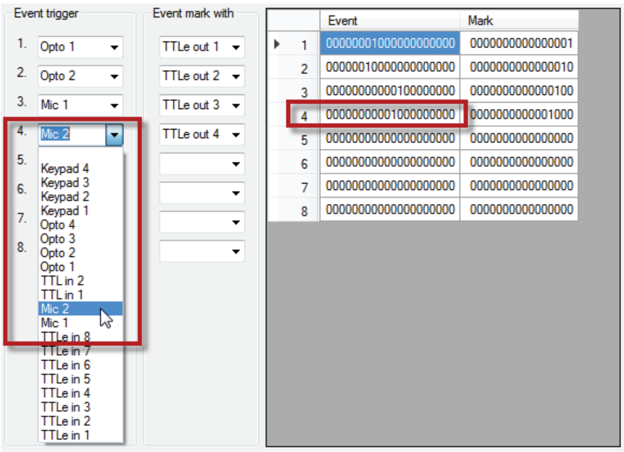
Available lines that can be paired to produce an event mark when triggered		
Output	**No**	**Purpose**
Sounder	2*	Produces a tone that can be used to trigger your own voice keys.
TTL out	2*	Produces TTL (0~5V) digital signals which can be fed into your own equipment, e.g. EEG machines, MRI scanners etc. This interface is also used for the BBTK Robotic Finger.
Active Switch Closure (ASC)	4*	Can be used to close a switch on your own devices to simulate a response, e.g. a key press on a keyboard. In effect the ASC lines are Solid State Relays (SSRs) that short switches out as though a push-to-make event has occurred. For details of how to wire ASC leads to keyboards etc. consult the wiring an ASC section of this guide.
TTLe expansion board	7	Produces TTL (0~5V) digital signals which can be fed into your own equipment, e.g. EEG machines, MRI scanners etc.



To begin event marking start the Event Marking (EM) module by clicking its toolbar button, pressing F12 or select it from Timestamp | Event Mark menu.

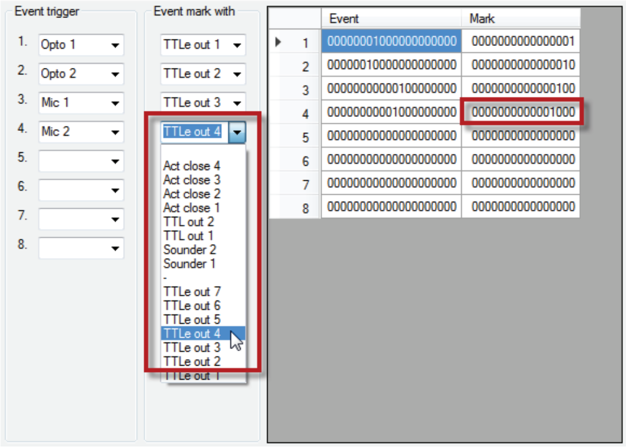
You will then be required to map input triggers to event marking outputs in the settings dialog.





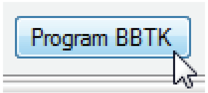
In this example three event triggers have already been mapped to TTLe expansion board outputs.

Finally a fourth event trigger, Mic 2, has been selected and an Event trigger bit pattern constructed.

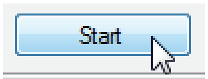


Paired with Mic 2 is the Event Mark TTLe out 4.

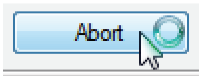
When Mic 2 is active TTLe out 4 will also be active to mirror it as it is now temporally yoked to it.



To tell the BBTK which pairs of inputs and outputs are temporally yoked click on Program BBTK. The BBTK will indicate that the program has been downloaded on its LCD screen.



To start event marking click on Start. When running the BBTK will show that it is in Event Marking mode on its LCD screen.

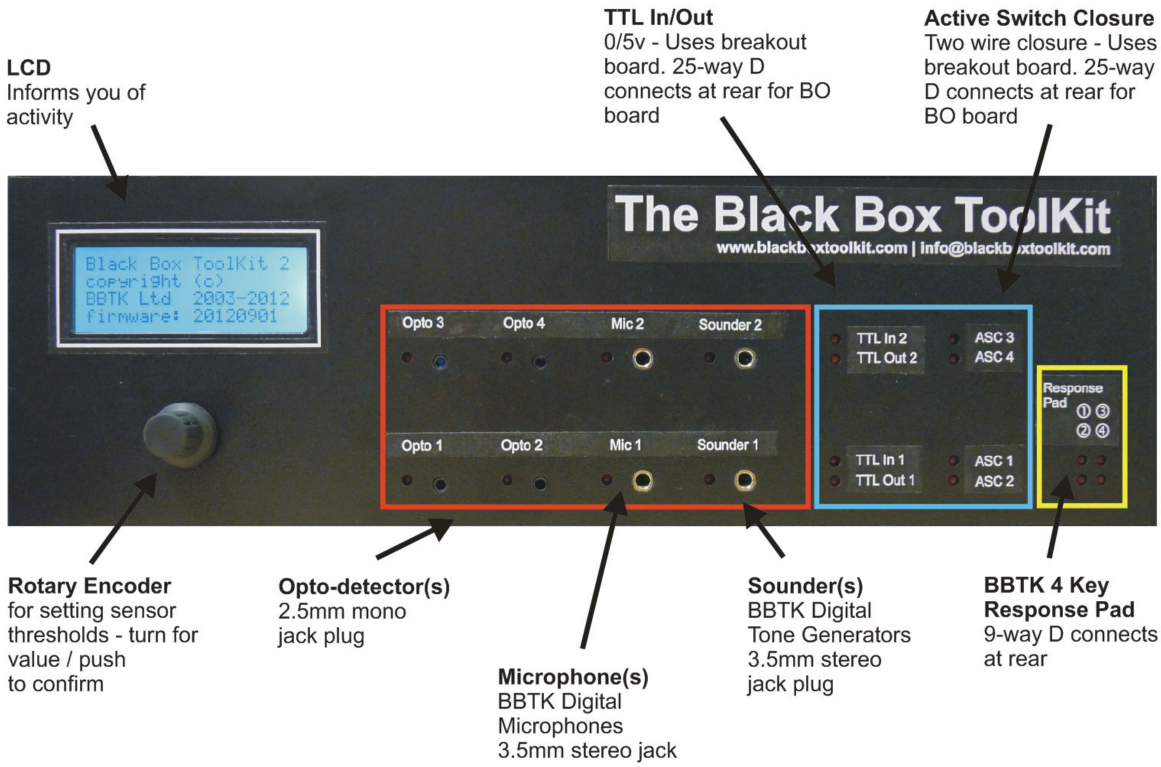


To stop event marking click on Abort. This will in effect reset the BBTK.

Once reset the PC Software will display the Sensor Threshold Manager. At this point you can choose to load your default values, factory defaults, or choose settings from an open RTL file.

15. Overview of Connectivity Options Opto-detectors, Microphones, Sounders, Response Pad, TTL and Active Switch Closure

The Black Box ToolKit offers a total of up to 36 lines on the Elite version. Eight of them can be accessed directly from the front panel via jack plugs (shown in red below).



These eight sensors/lines might be considered as being analogue in the sense that they require you to set a crossing threshold at which point they trigger and produce a digital TTL signal that the BBTK records, e.g. at what volume the mics are triggered or at what brightness the screen needs to be to trigger an opto-detector. As regards the sounders you set the volume or amplitude. Activation thresholds are set using the Sensor Threshold Manager (STM) on the PC together with the Command Knob (which you turn to set the threshold and push to confirm).

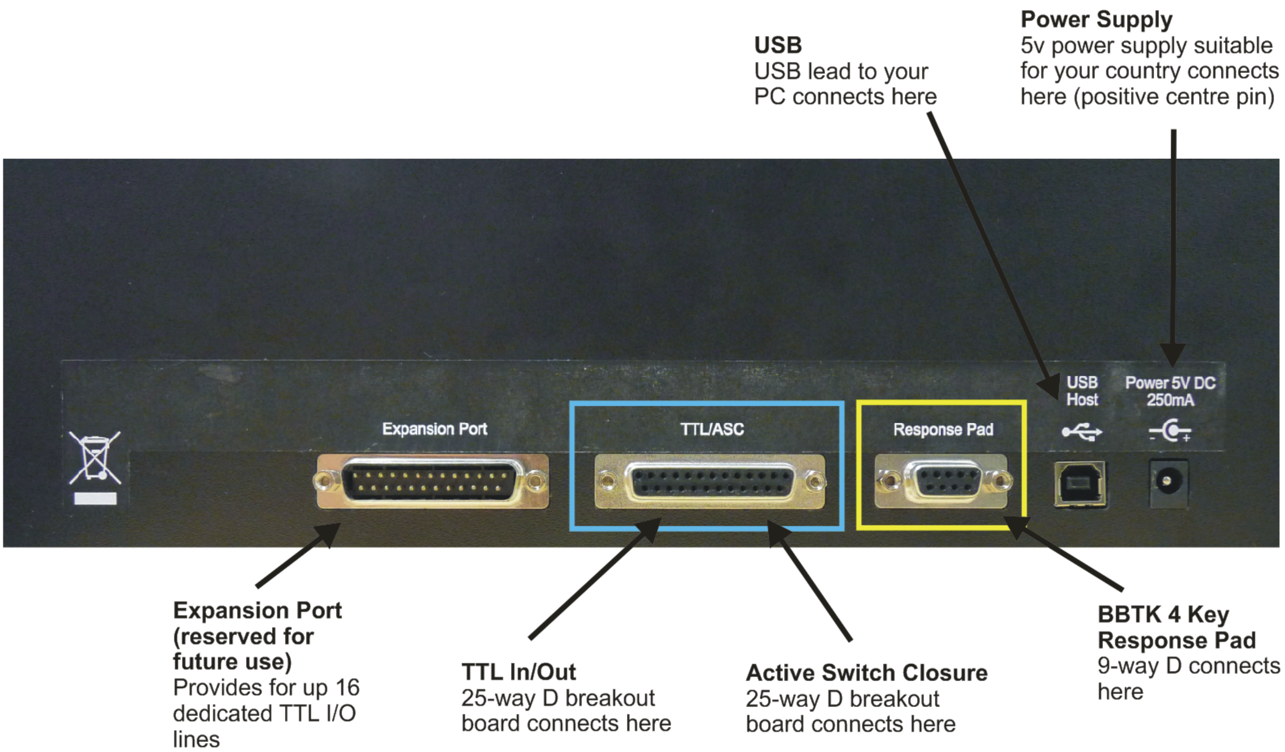
Sensor Type	No	Connector	Purpose
Opto-detectors	4	2.5mm mono jack	Detect onset, offset and duration of visual stimuli presented on your own TFTs, CRTs, Data projectors etc.
BBTK Digital Microphones	2	3.5mm stereo jack	Detect onset, offset and duration of audio events presented on your own speakers, headphones etc.
BBTK Digital Sounders/Tone Generators	2	3.5mm stereo jack	Trigger your own Voice Keys via a tone generated by the BBTK

Next to each sensor/line is a red LED which indicates when it is active.

The remaining 12 standard lines are purely digital in nature, i.e. on or off, +5 or 0 volts for TTL. LED activity indicators are to be found on the front panel for each of these lines.

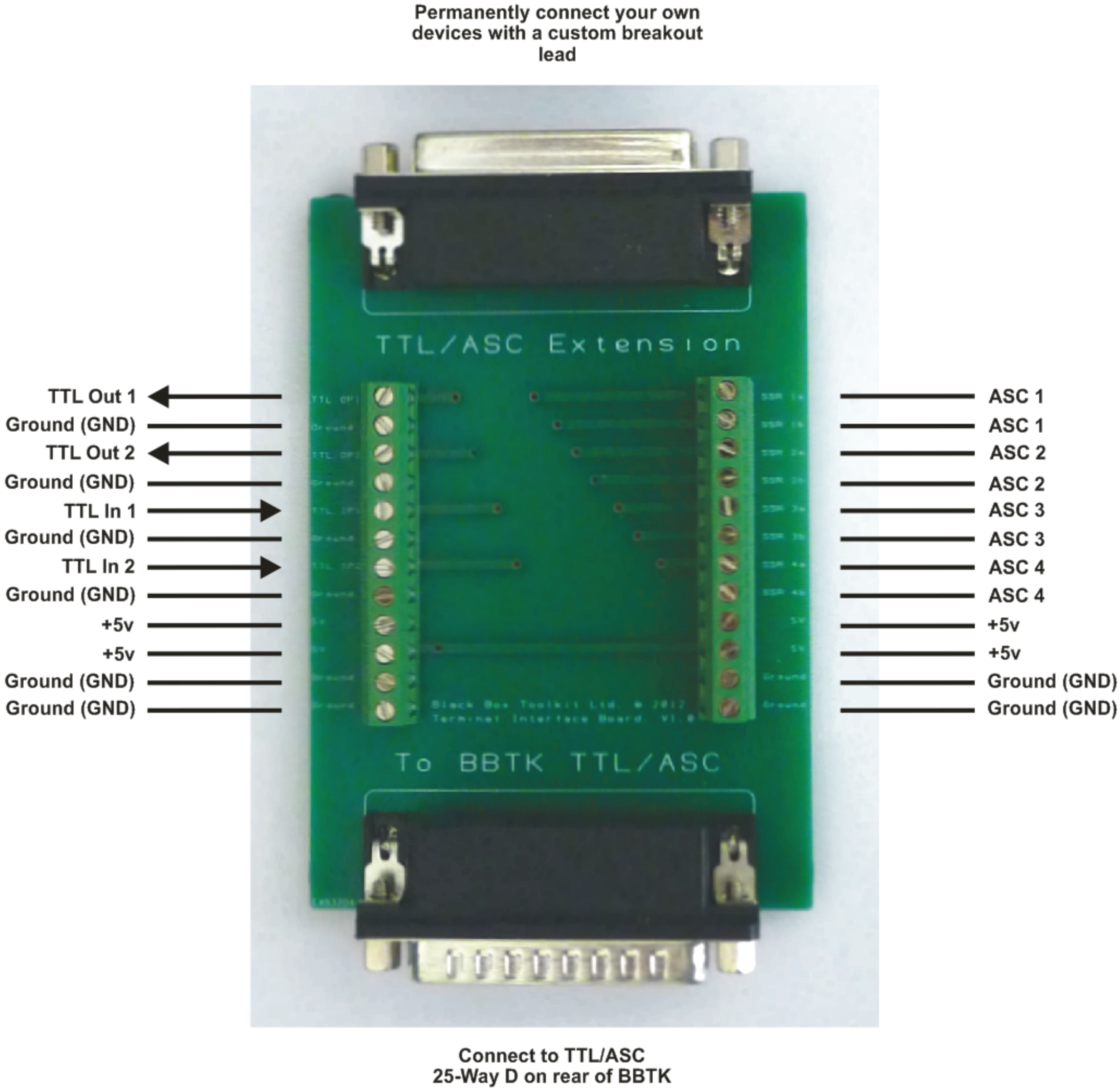
Sensor Type	No	Connector	Purpose
TTL In	2	BBTK Break Out board connected via 25-way D	Detect onset, offset and duration of TTL signals **sent from** your own equipment **in** to the BBTK, e.g. EEG machine event markers, fMRI sync pulses etc.
TTL Out	2	As above	Detect onset, offset and duration of TTL signals **sent to** your own equipment **out** from the BBTK.
Active Switch Closure (ASC) or Solid State Relay (SSR)	4	As above	ASC/SSRs can close keys on your equipment as though you had pressed them. They consist of two wires that are shorted out, or closed, by Solid State Relays in the BBTK.
4 button BBTK response pad	4	9-way D on rear	Works as a standard response pad which can be detected by the BBTK and also trigger your own response devices.

The simplest of these is the 4 button BBTK response pad (optional item). This can be used as an alternative to your own response devices or can be used in conjunction with them and connects to the 9-way D on the rear of the box (shown in yellow).

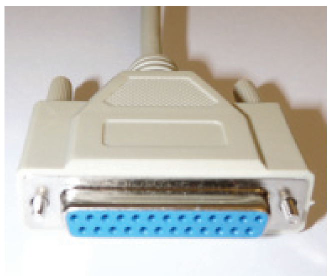


More complex is the TTL/ASC interface which provides a breakout board into which you can wire your own devices. The Breakout Board connects via a 25-way D on the rear (shown in blue).

The BBTK Breakout Board consists of 24 screw terminals that you can wire to. This is not as intimidating as it might first appear and allows for maximum flexibility. It is also much simpler than it looks! An overview of the Breakout Board is shown below. Generally you will have two wires to each of your devices. As different researchers will need cabling of different lengths we have chosen this approach as it offers the most flexibility. If you wish to permanently wire your devices to the BBTK you are advised to make use of a custom made TTL/ASC Extension. To do this you will need a 25-way male D connector which exposes the lines you wish to permanently wire to your own devices.



Connect from Breakout Board extension as a pass through to your own devices



Connects from the Breakout Board to back of BBTK (BBTK terminates in a male D connector)

If you wish to permanently wire your own devices to the BBTK Breakout Board you should use the pin outs below for a male 25-way D connector pass-through or TTL/ASC Extension.

Pin	Description	Pin	Description
1	5V	14	GND
2	TTL OP1	15	GND
3	TTL OP2	16	GND
4	TTL IP1	17	GND
5	TTL IP2	18	NC
6	SSR1a	19	NC
7	SSR1b	20	NC
8	SSR2a	21	NC
9	SSR2b	22	NC
10	SSR3a	23	NC
11	SSR3b	24	GND
12	SSR4a		
13	SSR4b		

Using the Breakout Board itself is straightforward so long as you have a good quality flat-blade screwdriver of the correct size and follow the guidelines below.

Sensor type	Wiring	Usage
TTL Input or Output	1 positive wire and one ground	Wire the positive to positive when going to or from your own equipment, and negative or ground to any of the grounds marked GND. To avoid damage to the BBTK you should not feed in any TTL signals that exceed +5V. Depending on how your TTLs signal an event you may want to invert them either using settings on your hardware or by using a BBTK line inverter (optional item). That is, you may signal an event by sending the TTL signal high or alternatively you my send it low.
Active Switch Closure (ASC)	2 wires	It doesn't matter which way around the wires go as they are simply closed by a Solid State Relay (SSR) when activated by the BBTK. They do not output a voltage nor should you feed any into them. If you wish to trigger a switch down on your equipment using ASC 1 simply wire one side of your switch to ASC1a and the other side of your switch to the second ASC1b terminal. Normally the circuit should be open.

A second 25-way D expansion port allows for a further 16 dedicated TTL lines (8 inputs and 7 outputs). This is an ultra high speed TTL interface that uses its own specialised breakout module. It is ideal for EEG, fMRI event marking and anywhere high speed TTL input or output is needed.

The final connectors on the rear are for power (5V centre pin positive) and for connecting the BBTK to your Host PC via standard USB (A to B cable, A on left and B right in image below).

You are advised not to use cables longer than 5m. They should be high quality and shielded where possible to avoid interference or drop out during data transfer to and from the BBTK to your PC.

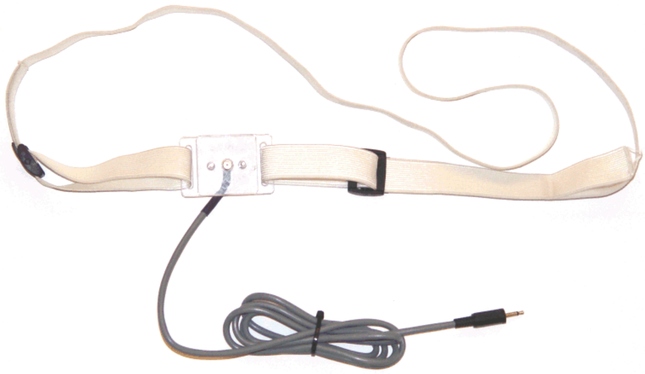
You are strongly advised to use only BBTK supplied USB shielded and choked leads.

Depending on which region you purchased your BBTK in a Power Supply Unit may be included. If so connect the appropriate end to the DC socket on the rear of the BBTK.

If you are using your own localised 5 volt DC power supply the centre pin should be +5V. PSUs rated at higher than 5V should not be used. You are strongly advised to use a rectified or switch mode PSU from a reputable manufacturer and of known quality. The PSU should also be grounded.

Any damage caused by a users own PSU is not be covered by our standard warranty.

15.1 Opto-detectors



The BBTK opto-detectors consist of a photodiode housed in a clear polycarbonate holder and a shielded 2.5mm mono lead. The lead should be plugged into an Opto socket on the front panel of the BBTK. An adjustable elastic strap is provided for you to attach the Opto to your screen. You should ensure that the photodiode lens is kept clean and free from scratches.

Set the sensitivity of each Opto using the Sensor Threshold Manager (STM) once plugged in. You should set the activation threshold so that it triggers reliably when there is a change from black to white on your screen under where the sensor is placed. Activation thresholds can be checked by watching the appropriate LED on the front panel for signs of activity, using the Sensor Check utility or by using the Input Line Check tool.

Care should be taken to set sensitivity thresholds correctly to ensure that Optos trigger as early as possible after the start of an image marker (white block).

Setting thresholds for CRTs
For CRTs the general principle is to set thresholds as low as possible so that the Opto in question just triggers. To ensure you have this set correctly you can usually add +5% to the absolute minimum to ensure you reliably trigger.

Setting thresholds for TFTs
For TFTs generally you should set thresholds as high as possible so that the Opto in question is just not triggering constantly. For example, turn the threshold up until the LED is constantly illuminated by a 100mS flashing block displayed by the BBTK Sensor Check Utility. Then gradually reduce the threshold until the LED flashes in time with the visual display. Usually this will be a one or two percent reduction.

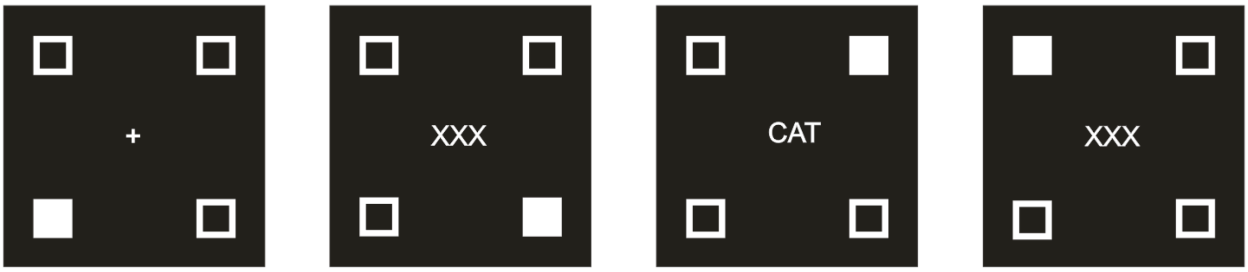
If Opto thresholds are set incorrectly or Optos are physically positioned inappropriately timing is likely to be suboptimal. Depending on your screen you may need to increase its brightness and/or contrast. Where possible you should not alter monitor settings and leave them at levels comfortable for human participants.

Obviously we cannot tell you the exact threshold you need to set as it will vary according to the brightness of each monitor you test. You are therefore advised to install the BBTK Sensor Check utility on the system you will be testing the timing of and use that to help you set the correct thresholds. If you alter the brightness/contrast of the display in question you should set the threshold vales again. Once you are happy with your thresholds you can save them in the Sensor Threshold Manager as the default settings. Alternatively you can reload them from a saved Real Time Log file.

To help the Optos detect the onset of a visual stimulus, image markers should be placed on each of your visual stimuli so that each Opto can detect them. These should be pure white square blocks of around 32x32 pixels (or larger for higher resolution monitors). This is easily accomplished in most image editing software. Where you do not wish the Opto to trigger you should have a black marker of identical size and position or set your experimental background to black by default.

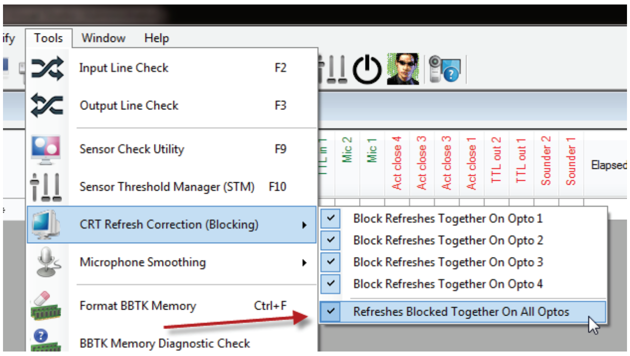
For videos you would superimpose a black block at the same position on every frame and then for the frame(s) you wished to trigger on a white block. For the duration of the frames you were interested in you should ensure the white block is visible at the same position. This enables the BBTK to detect the onset, duration and offset of the frames you are interested in when the video is presented.

For priming studies you may wish to have multiple Opto trigger areas (up to 4 on the Pro and Elite models) so that you can detect each fixation, prime, mask and so on. If you don't want to activate an Opto on a particular prime then you will need to have black event markers at all other Opto locations bar the one waiting to detect a white event marker block as shown below.



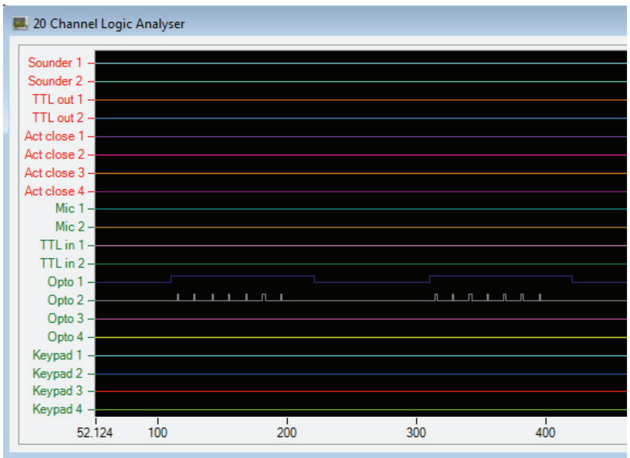
In this example Opto 1 might be fixed bottom left of your screen (fixation), Opto 2 bottom right (mask), Opto 3 top right (prime), Opto 4 top left (mask). Where no Optos should be triggered no event marker should be displayed. Typically this will be where the background is pure black and no event markers are displayed. By using all four Optos you can monitor for the onset, duration and offset of each visual event on fixation frames, primes and masks.

If you wanted to check for TFT monitor input lag you could instruct your experiment generator to send a TTL signal to the BBTK when it thought it was starting to display an image. By subtracting the image onset from the TTL signal onset this gives a measure of the input lag and the inherent delay in your equipment and experiment generator.



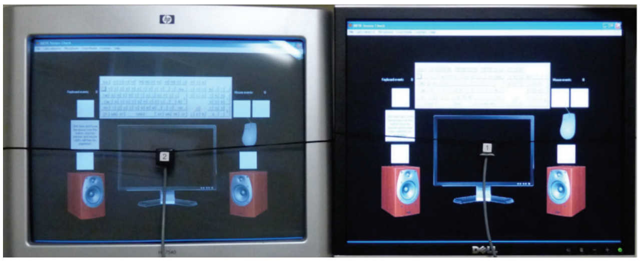
By default all Optos are Refresh Blocked. What this means is that refreshes on a CRT are blocked together so as to appear as one on and one off for a 100mS image for example, rather than 10 periods of on and off activity if running your CRT at 100Hz.

If you choose to turn this feature off you will see every raster scan as it passes under the Opto when using a CRT. For TFT screens it does not matter whether you leave this setting on or off.

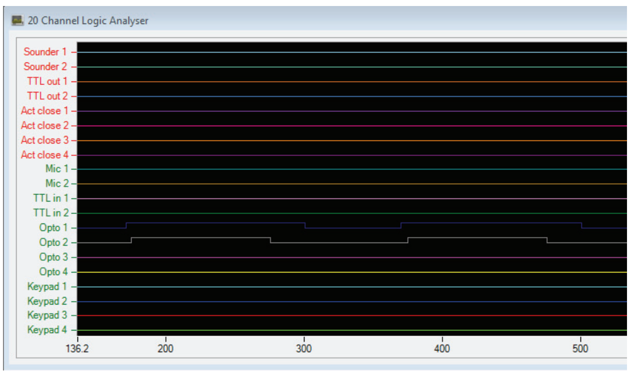


As can be seen in this example Opto 1 is monitoring a TFT screen and Opto 2 is monitoring a CRT but is not refresh blocked. Hence you see each refresh as the raster scan passed under the Opto.

In this case the CRT is refreshing at 75Hz (refresh raster every 13.33mS) and there are 7 refreshes so in theory the image is on for (1000/75) * 7 = 93.33mS. However because the Opto is positioned over only one place on the screen it is typically activated for a 1-2mS depending on the phosphor decay time. This is the width of each short on period or refresh blip.



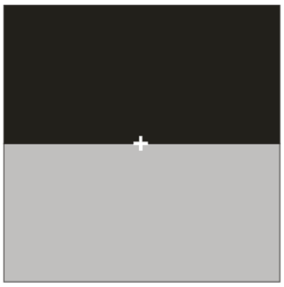
Here we can see the BBTK Sensor Check utility running on one PC but mirrored on a CRT (VGA) and a TFT (DVI). Opto 1 mid screen on TFT on right and Opto 2 mid screen on CRT on left.

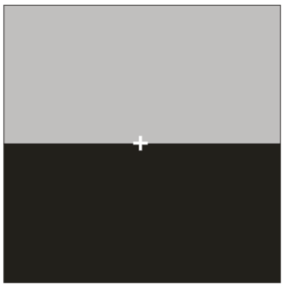


When refresh blocking is turned on we can see that the block starts from the leading edge of the Opto activation point and stops at the offset of the Opto activation point.

For CRT screens ideally you should have one Opto top left of the screen and another bottom right if you are presenting full screen images. Or alternatively have on Opto top left of your image and another bottom right if you are not displaying full screen.

For TFTs this rule does not apply as they have no true raster scan or refresh.





When refresh blocking on CRTs and displaying images full screen and using a single Opto mid screen (+ on the diagram) you need to consider that the image was actually being displayed on the raster before it passed under the Opto, i.e. top of screen to Opto. That is, there was half a frame on the first image. Conversely there was half a frame on the last image as well which needs to be taken account of. So add half a raster scan time to the start and end of the image display times, i.e. 13.33mS/2 = 6.66mS.

This effect can be seen clearly on the Logic Analyser screen grab above where the image onset for the CRT starts a few milliseconds after the one for the TFT on Opto 1.

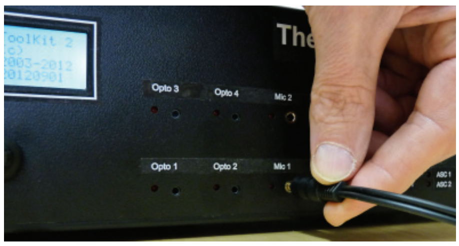
If your images are not displayed full screen you will need to make the appropriate calculations based on the size and position of your images relative to the top left of your CRT and the raster scan time based on the refresh rate.

For TFTs this rule does not apply as they have no raster scan or refresh as such.

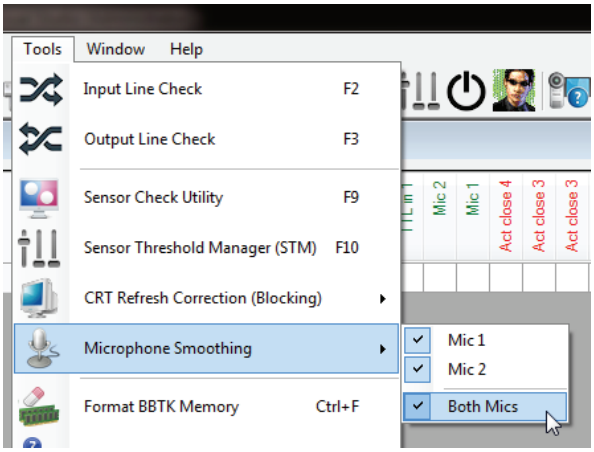
Only BBTK supplied Optos are designed to offer reliable detection of visual stimuli and accurate timing. You should NOT use any other photodiode with the BBTK.

15.2 The BBTK Digital Microphones

The BBTK digital microphones consist of a small enclosure which houses an Electret Mic and a shielded 3.5mm stereo lead. The stereo lead should be plugged into a Mic socket on the front panel of the BBTK.



You should set the sensitivity of the microphone using the Sensor Threshold Manager (STM) once plugged in. Set the activation threshold so that it triggers reliably and doesn't pick up extraneous background noise, e.g. traffic noise. Ideally the Mic should be positioned as closely to your speakers or headphones as possible. Activation thresholds can be checked by watching the appropriate LED on the front panel for signs of activity, using the Sensor Check utility or by using the Input Line Check tool.



By default Mics input is smoothed. As sounds can jitter according to frequency etc. a 20mS smoothing factor is automatically applied. This is a moving window of 20mS that constantly monitors incoming sounds using a dedicated audio processing chip prior to the digital signal being processed by the ARM chip. This helps ensure that the correct duration is recorded and jitter is removed where possible. Smoothing does not affect the onset in anyway. If you turn smoothing off you will simply see more jitter on the audio lines. This works in a similar way to CRT refresh blocking.

Microphone sensitivity thresholds should be set as high as possible to ensure that Mics trigger as early as possible after the start of a sound. If Mic thresholds are set too low or Mics are physically positioned incorrectly relative to your sound producing hardware/speakers timing is likely to be suboptimal.

If you position the Mic too far away from your sound source you will see a delay as the sound waves propagate through the air due to the speed of sound. This will add approximately 1mS per ft (30cm) of distance from the source of the sound.

In addition if the source sound you are using is too loud this can cause the Mic to give false triggers due to saturation. Generally it's best to use a sound level from your own speakers that you would with human participants. That is, it should be as ethologically valid as possible.

Obviously we cannot tell you the exact threshold you need to set as it will vary according to the loudness of each sound you test. You are therefore advised to install the BBTK Sensor Check utility on the system you will be testing the timing of and use that to help you set the correct thresholds. If you alter the volume of the audio in question you should set the threshold values again. Once you are happy with your thresholds you can save them in the Sensor Threshold Manager as the default settings. Alternatively you can reload them from a saved Real Time Log file.

Only BBTK supplied mics are designed to offer reliable detection of audio signals and accurate timing. You should NOT use any other microphone with the BBTK.

15.3 The BBTK Sounders

The BBTK digital Sounders consist of a small enclosure which houses a Piezo Sounder and a shielded 3.5mm stereo lead. The stereo lead should be plugged into a Sounder socket on the front panel of the BBTK.

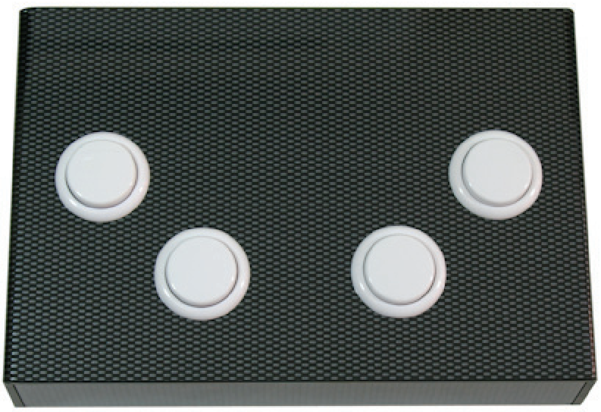
The frequency of the BBTK sounders is factory set at approximately 3.4KHz as this typically gives the best response with voice keys and microphones you might use within your experimental setting.

All the threshold manager allows you to do is set the amplitude, or loudness, of the Sounder. The higher the number/percentage the louder the sounder. When the Sounder is active the LED on the BBTK front panel will be lit.

Note that you can inadvertently trigger the BBTK Mics if they are positioned near the Sounders.

Only BBTK supplied Sounders are designed to offer reliable voice key/microphone triggering and accurate timing. You should NOT use any other Sounder with the BBTK.

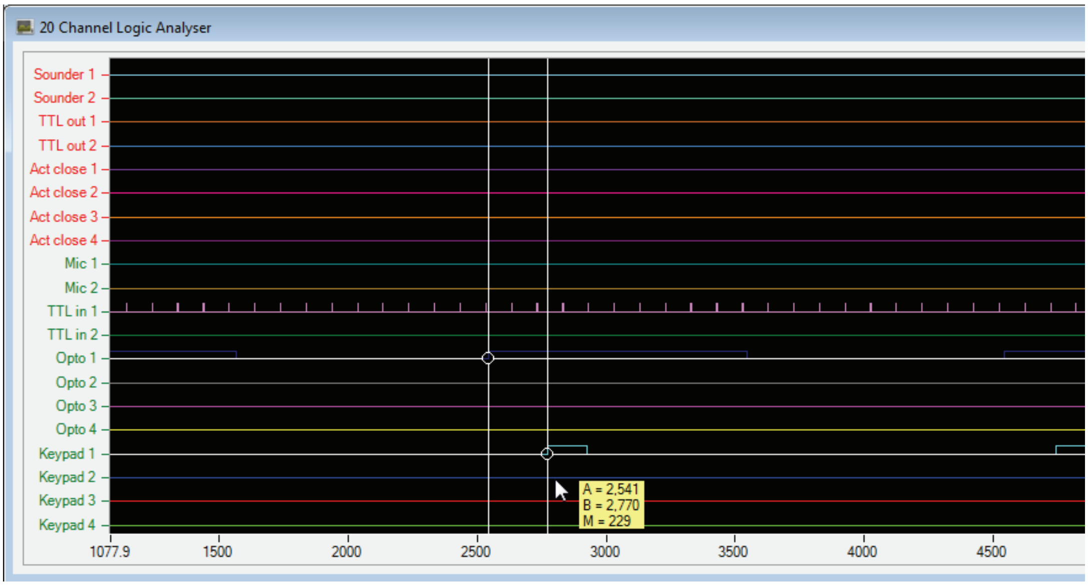
15.4 The BBTK Response Pad



The optional BBTK carbon fibre effect response pad by default houses 4 response buttons. It connects to the rear of the BBTK via a 9-way female D connector (shown in yellow on the main BBTK diagram above).

When used with the Digital Stimulus Capture (DSC) software module of the PC Software this would allow you to record the visual timing characteristics of up to 4 screen regions, the audio characteristics of two audio devices and various TTL signals from your own devices together with the exact time a button was pressed on the BBTK response pad.

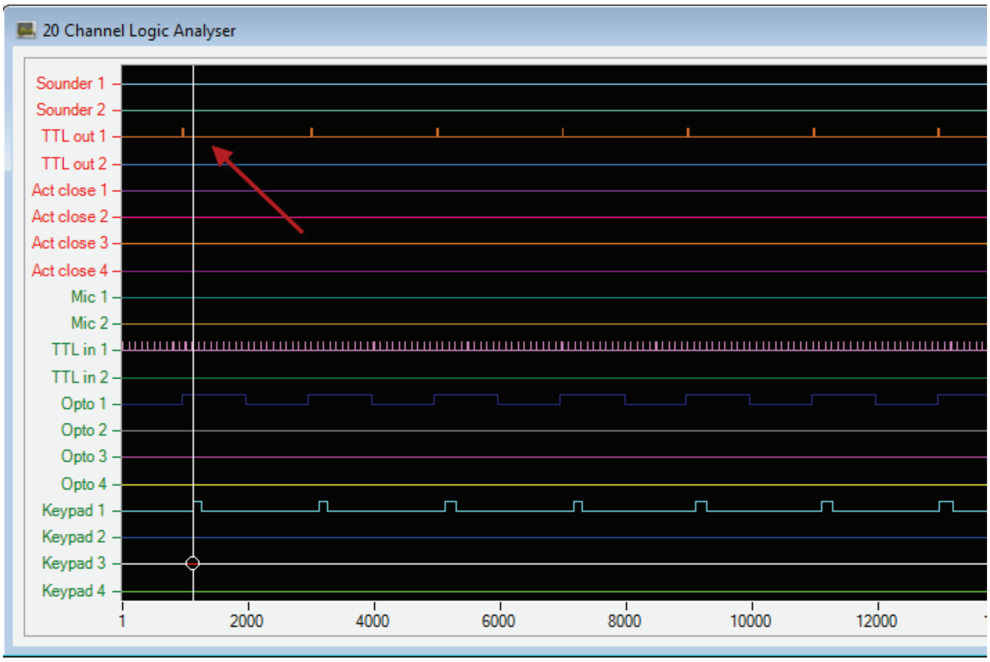
In the DSC example shown below a regular sync pulse from an MRI scanner is being fed into the BBTK via TTL in 1 (purple trace). Opto 1 is placed on the screen of an experiment generator which is producing bitmaps at 1000mS intervals (blue trace). The participant has pressed Key 1 of the BBTK response pad in response to seeing the bitmap. By using the measurement cursors we can read off the RT as 229mS. Alternatively we could copy and paste the Line by Line Analysis spreadsheet into Excel and work out all RTs as a batch. In this example the BBTK has taken over all response timing duties from your own computer.

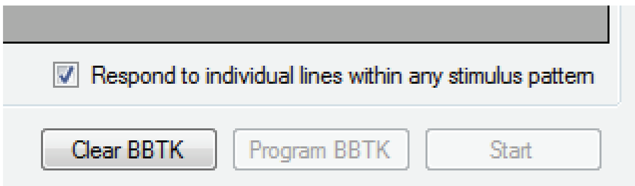


If used with the Digital Stimulus Capture and Response (DSCAR) software module you could monitor the channels outlined above and also generate event markers. For example you could send an event marker to your own device when there was activity on Opto 1. This could allow for TTL event markers to be sent to an EEG machine when a stimulus image appears. All other timing measures would be handled by the BBTK and would be available for later analysis.

If we entered 0 (zero) into the RT of DSCAR when an event was detected on Opto 1 and a TTL out 1 event was generated for 20mS we would see a trace similar to that shown below.

The TTL out 1 signal would occur at exactly the onset of the image and last for 20mS (orange trace). This would then appear on your EEG trace as an event marker. As in the example above all other timings would be handled by the BBTK.





Generally if you made use of DSCAR to generate event markers you would need to tick “Respond to individual lines within any stimulus pattern”. This is to ensure that you send a marker each time there is a trigger even if that trigger occurs at the same time as other events that are being monitored.

Alternatively if you don't need to record timing data but do need to produce accurate event marks for various stimuli types you could make use of the Event Marking (EM) module, e.g. in an EEG study. Using the EM module the BBTK could produce a TTL event mark for a visual stimulus and a separate one for each button press.

If you only required TTL event markers from each response pad button you could simply use the TTL port on the rear of the response pad without using the BBTK at all.

15.5 Advanced use of the Response Pad

The BBTK can act as a partner to your standard experiment generator when used with the BBTK response pad. This allows the BBTK to do the heavy lifting of maintaining timing accuracy (recording timings accurately through external chronometry). Your experiment generator could be programmed to display an image until it receives a response as normal. But in this case rather than a button being pressed on its own response device, a button is pressed on the BBTK response pad instead.

Depending on your specific model of response pad you may have between 1 and 8 buttons, a Voice Key for use with a headset with microphone, 4 Active Switch Closure lines or 8 TTL output lines and a one shot TTL out signal which gives a 50mS pulse when any button is pressed or voice key activated. For more details consult the guide supplied with your response pad.

You have various options for using the BBTK Response Pad with your own experiment generator. These include:

- Using it in standalone USB mode where it plugs into the computer running your experiment and functions as a 1-8 button millisecond accurate response pad that appears as a standard keyboard and sends keystrokes to your experiment generator as though you had pressed a key on a keyboard
- Using it in USB mode with your experiment generator but also connect it to the BBTK. This means that when a button is pressed your experiment generator is sent a keystroke and at the same time the BBTK is sent a button press so that it can show button presses, durations and releases relative to other events. In this scenario the BBTK can also use response pad buttons as triggers to fire other events in its own software. Note that in this mode to maintain backward compatibility the BBTK v2 can only recognise the first 4 buttons
- Using the TTL output socket to send a simple 50mS TTL pulse each time any button is pressed or voice key activated
- Using the BBTK 9-way to provide four TTL lines which mirror each primary button press. Depending on model your response pad may have up to 8 additional TTL output lines
- Using four external high quality push-to-make buttons (But 1~4) rather than the built-in buttons (mono 3.5mm jacks)

15.5.1 Simple Event Marking Using the 2.5mm TTL socket

Each time any of the buttons is pressed a 50mS TTL pulse is sent out through the 2.5mm TTL socket. This uses a stereo connector and flying lead that is provided with the response pad. This 50mS TTL event marking pulse is independent of how the response pad is connected to your own equipment or the BBTK. The 50mS pulse is sent on the leading edge of a button down or voice key activation. Additional button downs may mean that this signal is overlapped.

15.5.2 TTL Event Marking Using the 9-way Female D or BBTK Connection

If you choose not to connect the BBTK response pad directly to the BBTK you can utilise the connection to TTL event mark the four primary buttons on your own equipment, e.g. EEG machines, Eye Trackers etc. Note: Button down TTL durations will be extended by +25mS due to button debouncing (see section on debouncing).

Alternatively you could use the DSCAR or the EM modules to send a TTL signal to your experiment generator, EEG, MRI, eye tracker etc. when a certain key or keys was pressed on the BBTK response pad.

Pin	Description
1	Button 1
2	Button 2
3	Button 3
4	Button 4
5	5V
6	GND
7	GND
8	GND

To wire the response pads TTL output to your own equipments TTL input use the 9-way Female D (labelled BBTK) with the pinouts shown opposite.

15.5.3 TTL Event Marking Using the 9-way Male D TTL Connection

Depending on your model of response pad there may be an 8x TTL Out 9-way Male D. This socket provides a TTL signal for each of response buttons (1-8). Note: Button down TTL durations will be extended by +25mS due to button debouncing (see section on debouncing).

Pin	Description
1	Button 1
2	Button 2
3	Button 3
4	Button 4
5	Button 5
6	Button 6
7	Button 7
8	Button 8
9	GND

To wire the male 9-way D (labelled 8x TTL Out) to your own TTL inputs on your own equipment so that they trigger simultaneously when a BBTK response pad button is pressed use the pinouts shown opposite.

15.5.4 Triggering Your Own Response Devices Buttons Using the 9-way Male D Active Switch Closure (ASC) connection

Depending on your model of response pad you may have a Male D labelled ASC. In which case it is also possible to trigger the buttons of your own devices directly when pressing a button on the BBTK response pad. Effectively this pass through operates as four additional Active Switch Closures.

The ASC socket operates independently of the TTL socket and connection to the BBTK meaning that your own buttons can be triggered whilst simultaneously event marking via TTL.

Pin	Description
1	SSR3a
2	SSR2b
3	SSR2a
4	SSR1b
5	SSR1a
6	SSR3b
7	SSR4a
8	SSR4b
9	NC

To wire the male 9-way D (labelled ASC) to your own response devices so that they trigger simultaneously when a BBTK response pad button is pressed use the pin outs shown.

To interface to your own key you should follow the guide for making ASC connections to keyboards and other response devices.

15.5.5 Button and Voice Key Debouncing

A built in debouncing window means that a button must be cleanly up for 25mS before a button/key up keystroke is sent either as a USB keyboard keystroke or a TTL signal. This means that button down durations will be elongated by +25mS. Response Times (RTs) are unaffected as they are registered on the leading edge of a button down/vocal response. Voice key responses have a debouncing silence window of +200mS meaning durations will be elongated by +200mS.

WARNING: Use of poor quality external buttons or microphone may adversely affect timing accuracy.

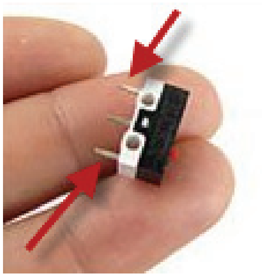
16. How to Make an Active Switch Closure Lead to Trigger Your own Response Device from the BBTK

Often you will want to trigger your own response devices from the BBTK as though a human had pressed a response key for example. This is accomplished by wiring two wires to the back of an individual key on your device. Your key should be Normally Open (NO) and when depressed makes the circuit as a push-to-make contact switch. By wiring a BBTK ASC or Solid State Relay (SSR) wires to each side of the switch we can artificially activate it as though it had been pressed by a human.

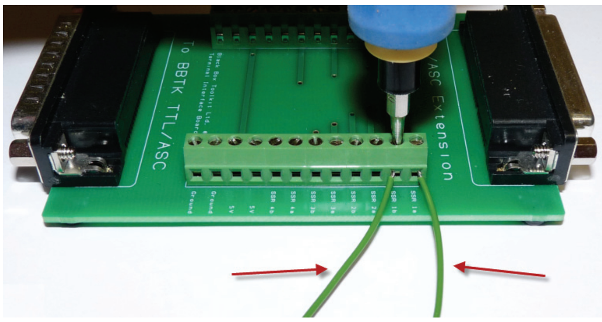
If you don’t feel confident dismantling response devices seek the advice of a qualified technician. Alternatively you might wish to make use of the BBTK Robotic Key Actuator.

NOTE: The following is provided solely for informational purposes and does not constitute a guide which we authorise as being fit for purpose. The Black Box ToolKit Ltd cannot be held responsible for any subsequent data loss or damage to equipment howsoever caused.

16.1 Wiring to a Traditional Micro Switch



If you have a traditional type of mechanical key on a keyboard, response box or mouse for example, wiring an ASC to this is very straightforward as you can normally identify the pins for the micro switch fairly easily as shown. One ASC/SSR wire would go to one pin and one to the other. You should choose as smaller gauge wire as possible to solder to the pins.



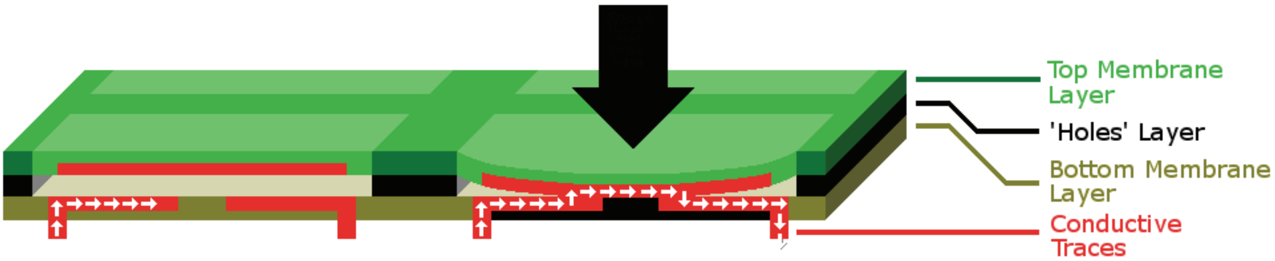
For the BBTK to be able to activate your switch you would simply wire the leads in to a terminal on the breakout board. In this case to SSR1a and SSR1b.

Using DSCAR for example you would then be able to use the BBTK to respond to a visual stimulus on ASC1. It does not matter which way around you connect the wires.

16.2 Wiring to a Membrane Keyboard

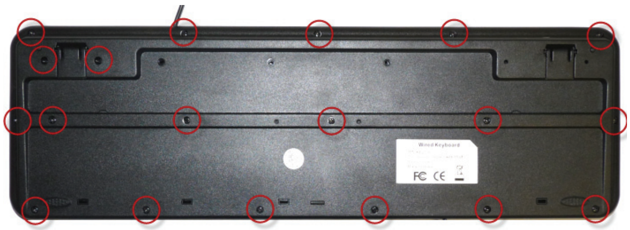
Unfortunately peripherals are now manufactured as cheaply as possible and as a result corners have been cut. Keyboards generally don't contain switches for each key as that would increase costs. Instead they are made up from sheets of plastic membrane onto which a conductive matrix has been etched. Two plastic membrane layers that have conductive traces lay either side of a clear layer that has no conductive traces but instead has a hole cut in it where each key resides. When you press a key you are in effect pressing the two membrane layers together through the hole to complete the circuit. This is a very cheap way to construct a push-to-make switch and replace the traditional micro switch outlined above.

To give keys some spring and tactile feedback a rubber dome is placed above the top membrane layer and under the key. When you press a key the rubber dome, or cup, acts as a damper and springs the key back when released.



In this example we are going to wire an Active Switch Closure to the Space Bar on a cheap membrane keyboard.

Usually you would choose keys that you don't normally use as the key(s) you choose will no longer work when pressed.



Unplug the keyboard from the computer so that there is no power going to it.

The first stage is to flip the keyboard over and remove all the screws.

This can involve removing a larger number of screws!

Carefully remove the rear cover taking care not to disturb any of the rubber cups or accidently press any of the keys on the desk.

Raising the keyboard keys off the desk by chocking with post-it note pads (left and right) helps avoid accidental key presses.

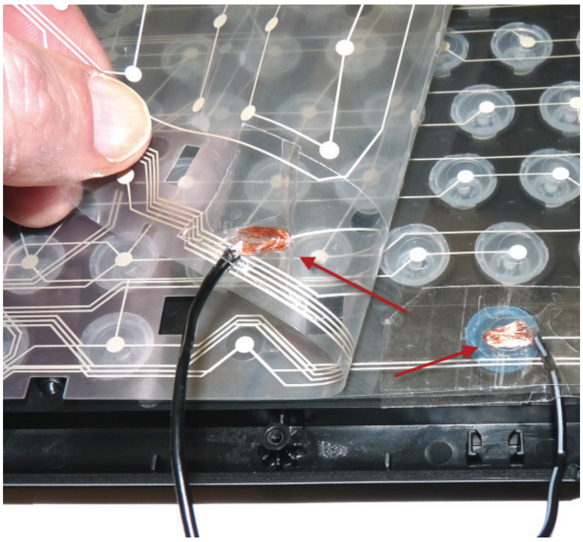
Here you can see the rubber domes, or cups, under each key once the three plastic layers are peeled back.

The keyboard scanning matrix is clearly visible on the top and bottom membrane layers.

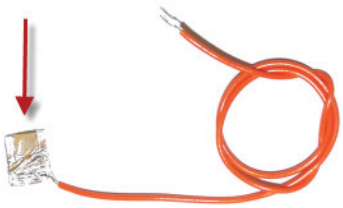
An individual key contact can be seen with a red circle (middle top).

To help prevent the rubber cups being dislodged often its useful to pack the keyboard up using packs of post-it notes.

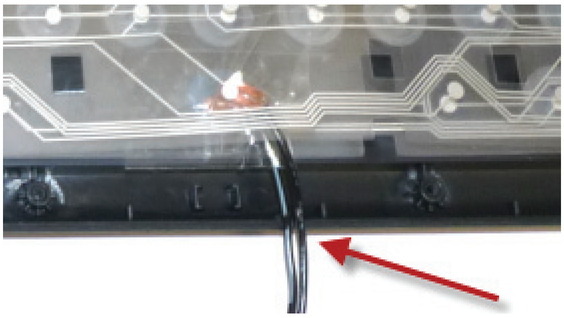
Although slightly difficult to see the red circles show the top and bottom conductive membrane surfaces and the middle “holes” layer sits in between.



Our goal is to attach two splayed wires to the top and bottom conductive traces with clear tape as shown. In this example thicker wires have been used to show how you would accomplish this. The clear tape stops the wires shorting out though the “hole” membrane layer. However this means that the key will no longer work when pressed normally. Hence why it is recommended you use a key(s) that are not normally used, e.g. numeric keypad keys.



The preferred method is to use as thinner gauge multi-strand wire as possible and terminate it in a small pad made of silver conductive foil (cooking foil). The foil is folded around the splayed bare wire. This pad is then clear taped to the conductive area of the membrane.

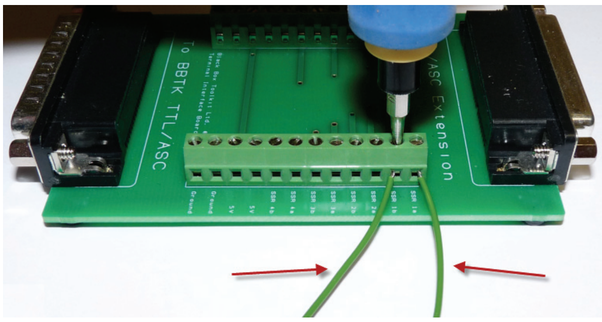


It's often useful to ream or drill a small recess for the wires to exit the keyboard case. Alternatively this can be cut out using sharp craft knife.

Reassembly should be fairly straightforward but take care not to dislodge any rubber cups or misalign the three plastic membranes.

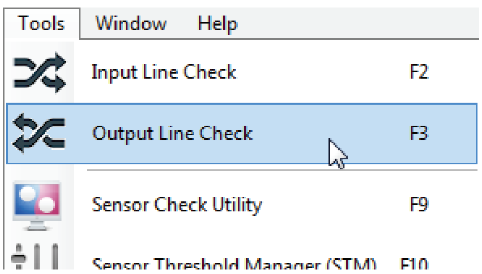
Also ensure that you don't accidently short out any other connectors or keys you were not intending to.

Often it's useful to connect a terminal block or 2.5mm mono socket to the ASC wires.



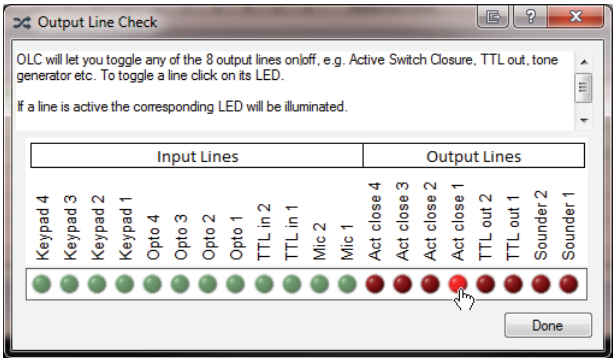
For the BBTK to be able to activate your switch you would simply wire the leads in to a terminal on the breakout board. In this case to SSR1a and SSR1b.

Using DSCAR for example you would then be able to use the BBTK to respond to a visual stimulus on ASC1. It does not matter which way around you connect the wires.



To check your ASC wiring is working as intended you would reconnect the keyboard to the computer you will run your experiment on. All other keys bar the one(s) you wired the pads/ASC leads to should still work when pressed.

Start the Output Line Check under the Tools menu or press F3 in the BBTK PC Software.



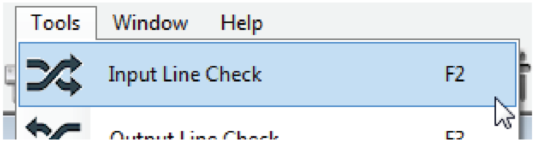
Start a text editor on the computer the keyboard is connected to.

Then press the ASC LED that you wired to the key. The key should then be activated as you toggle the LED on|off as though you where physically pressing the key.

It should also repeat as normal if you leave the LED active.

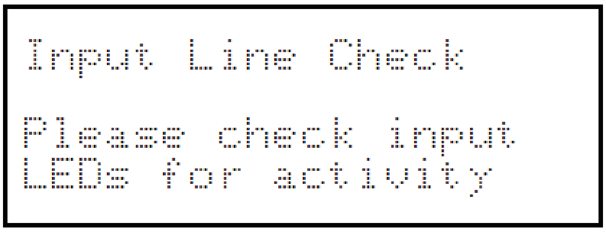
17. Tools & Utilities

17.1 Input and Output Line Check

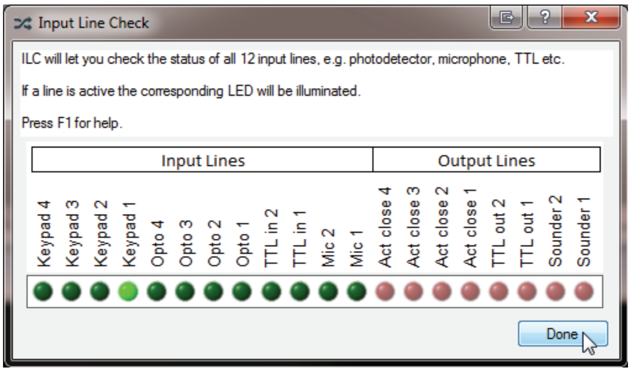


To help you check whether the various input and output lines are working two utilities are provided. They let you monitor input lines live and manually generate outputs on one or more lines. You can use them for checking inputs from Optos, Mics etc.

To start the Input Line Check select Tools | Input Line Check or press F2.



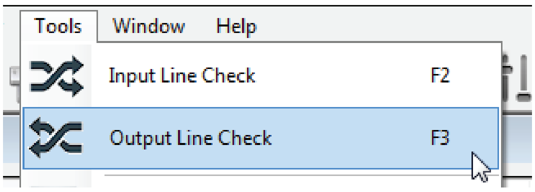
The BBTK will show that the ILC is running.



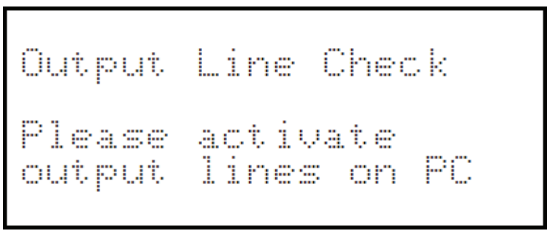
When the ILC starts the standard 12 input lines are represented by green LEDs. When a line is active, e.g. when a key is pressed on the BBTK response pad the corresponding LED will illuminate.

ILC is designed to help you setup your sensors and TTL lines and lets you view their status using the PC Software rather than having to look at the status LEDs on the front of the BBTK. When you click on Done the BBTK will reset.

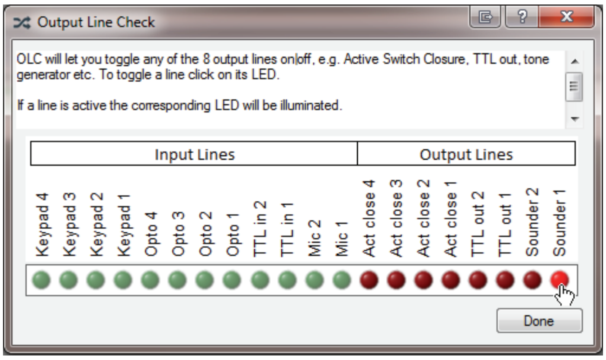
Note this utility is streaming signals live so there may be a noticeable lag.



To manually generate events or signals on one or more lines to test that your own equipment is working select Tools | Output Line Check or press F3.



The BBTK will show that the OLC is running.



Each red LED represents the corresponding output line.

To generate a tone to trigger a voice key for example click on the red Sounder LED. The LED will latch and the Sounder line will go high, the LED will illuminate and a tone will be generated if you have a BBTK Sounder plugged into the BBTK front panel. To turn off the relevant line, or lines, click on the LED again. When you click on Done the BBTK will reset.

Note this utility is streaming signals live so there may be a noticeable lag.

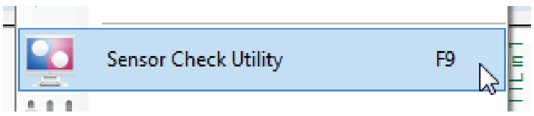
17.2 Sensor Check Utility

The Sensor Check Utility (SCU) is designed to help you check whether the BBTK sensors are operating correctly, e.g. Optos, Mics etc. It can also generate tones to trigger your voice keys and simulate simple experimental paradigms, e.g. cross modal priming. It will also tell you which key on the keyboard has been pressed or which mouse button has been clicked.

It is designed to run on a second PC on which you are running your experiment and it can help you set sensor thresholds using the Sensor Threshold Manager (STM).

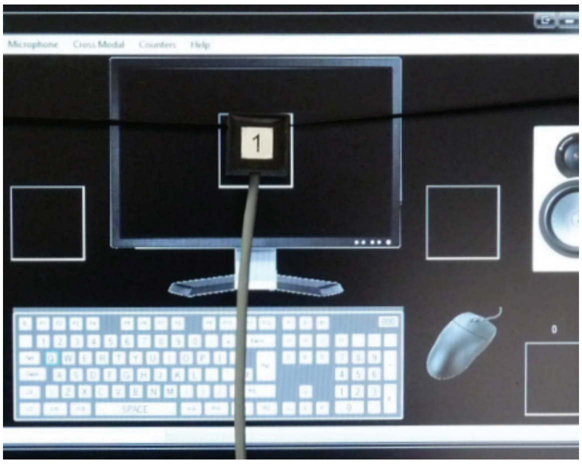
When a keyboard key is pressed or a mouse button is clicked it will helpfully show an event marker on screen. This can be used as an event marker by one of your Opto sensors.

You could use the SCU to simulate a whole experiment. For example you could run DSC or DSCAR and check the timing of visual and auditory presentations by selecting the Cross Modal option from the menu. If you selected DSCAR you could generate responses relative to the onset of either visual or auditory stimuli.



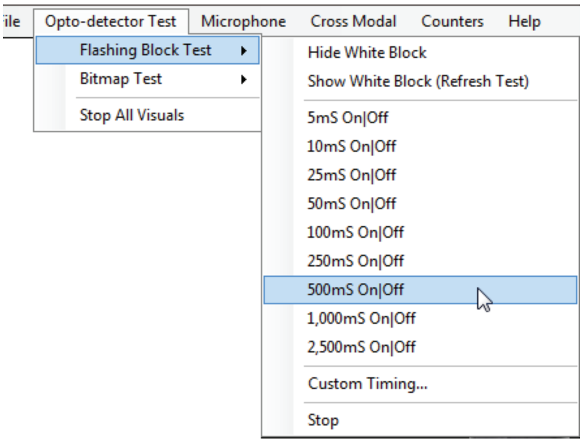
To start the SCU select Tools | Sensor Check Utility or press F9.

When the SCU starts you will be presented with a virtual PC and several Opto event marker areas over which you can place an Opto-detector.



Checking Optos with the SCU

To check your Optos are functioning correctly you could position an Opto mid screen and then select Opto-detector Test from the menu.



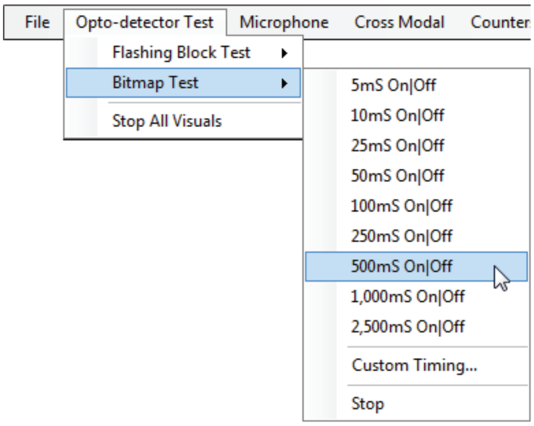
The Flashing Block Test allows you to select a number of timings. Initially you are advised to select a relatively slow duty cycle, e.g. 500mS on|off.

You can then use this regularly flashing block to adjust the sensor thresholds of your Opto as described in the Opto and Sensor Threshold sections of this guide.

Note that the timings of the SCU are unlikely to be accurate. It is purely to help you ensure sensors are working and to set activation thresholds or to check you have correctly constructed stimulus-response sequence in DSCAR.

In all modules you are free to enter your own timings by selecting Custom Timing… from the relevant menu. You can also run more than one test simultaneously should you so wish as the SCU is fully multi-tasking. For example you could run the Flashing Block Test whilst also ping ponging tones between your left and right speakers.

To set thresholds the SCU must be running on the PC you will be evaluating.



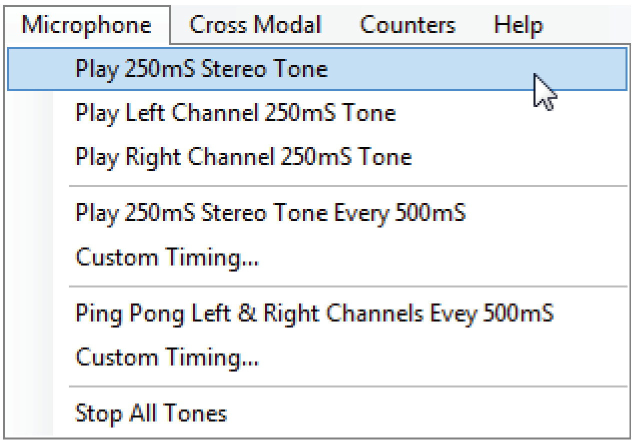
To check more than one opto, e.g. for priming work, you can select the Bitmap Test. This will show two Opto event markers on screen each time a bitmap is displayed.

Two bitmaps will then alternate at the chosen duty cycle.

Two Optos can be positioned over each event marker (left and right white blocks).

You can also place an Opto over the middle Flashing Block Test event marker and run that test at the same time as the Bitmap Test at the same or different duty cycle. To stop activity click Stop or Stop All Visuals.

Note how Opto event markers are structured. When you wish an Opto not to be triggered you should ensure you have a black event marker in place. Where you wish it to be triggered it should be pure white.



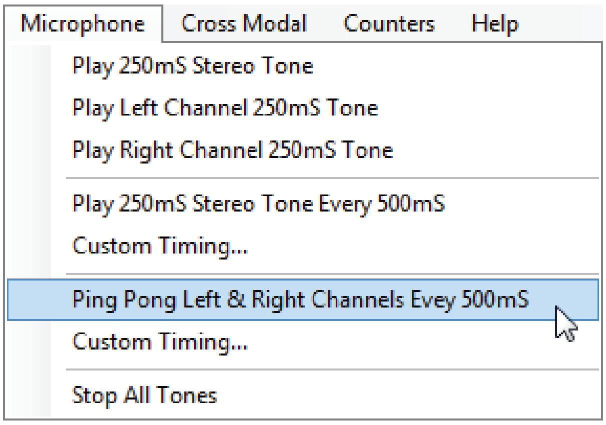
Checking BBTK Digital Mics

You can check the BBTK Mics by selecting Microphone from the menu.

You then have the option of playing either a single 250mS stereo tone, a tone through the left speaker or the right speaker.

For more complex tests you can play a tone every 500mS to help you set Mic activation thresholds. If you select this option the two Opto event markers next to the virtual speakers will turn white when each tone is being played.

This helps you check timing between the Optos and Mics. To stop tones click Stop All Tones.



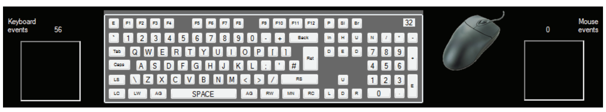
Finally you can choose to ping pong a tone between the left and right speakers at the chosen duty cycle.

When each tone plays the relevant event Opto event marker will turn white for the duration of the tone.

Checking Cross Modal Sensors
Checking your sensors are set correctly for a Cross Modal paradigm can be achieved by selecting Cross Modal from the menu.

You can either choose a 500mS duty cycle or enter your own custom timing.

Bitmaps and tones will cycle at the chosen duty cycle and Opto event markers will be shown as each stimulus is displayed. To end the test click Stop.

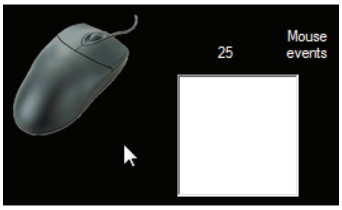


Checking Keyboard and Mouse Responses
A virtual keyboard and mouse are shown along with two Opto event markers which show when a key or button is pressed.

Two sets of counters are also shown which keep a tally of key and button presses.

To check key presses and button down activity the SCU window must have focus. That is, you must have clicked on the title bar if the window was not in focus.

Now when you press a key on the keyboard



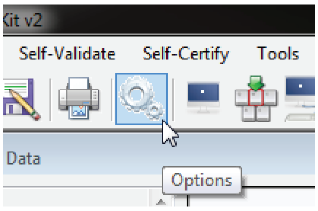
the relevant key will turn green and the Opto event marker will turn white. The key activity counter will increment based on the keyboard key repeat rate set on the system you are working on.

If you want to reset the counters, select Counters | Reset Counters from the menu.

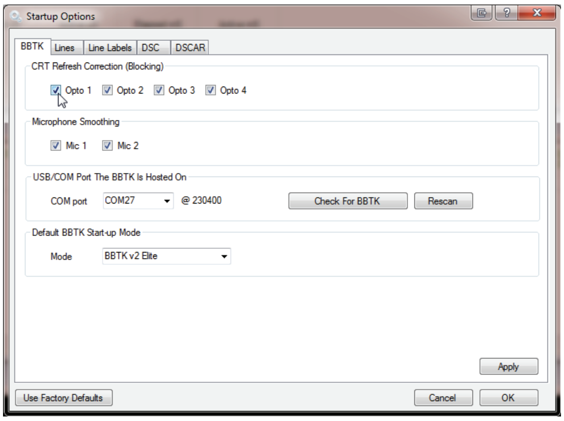
If you wish you can combine any of the options in the SCU to check complex sensor and response setups. For example, you could use the Flashing Bitmap Test alongside playing a 250mS tone every 500mS whilst making keyboard responses. When each event occurred the relevant Opto event marker would also be displayed.

To illustrate why getting accurate timing can be so difficult try running the Cross Modal test and pressing multiple keys on the keyboard as rapidly as possible. You should be able to notice that timing begins to drift noticeably!

17.3 Setting Default Options

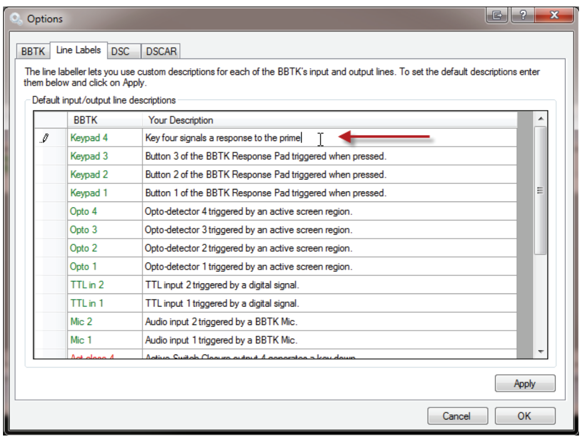


The BBTK allows you to set various options to be the default each time you use it. These can set from the Tools | Options menu or by clicking on the Options toolbar icon.



To set default CRT Refresh Correction (Blocking) for each Opto check or uncheck the relevant Opto in the options dialog.

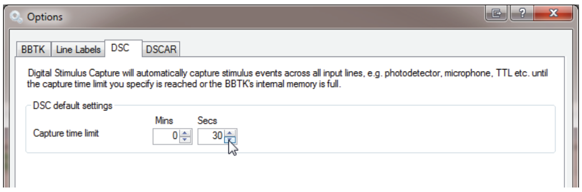
When you are happy with your choices click on Apply.



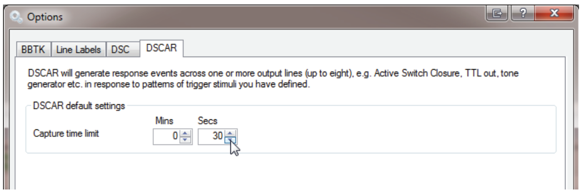
To modify the default line label descriptions move to the Line Labels tab then click on the description you want to change.

Change as many descriptions as you need to and then click on Apply to save them as the default. You cannot edit the line name.

These new line labels will then be used as the default and saved with each new Real Time Log File, be shown in reports and shown online in a repository.



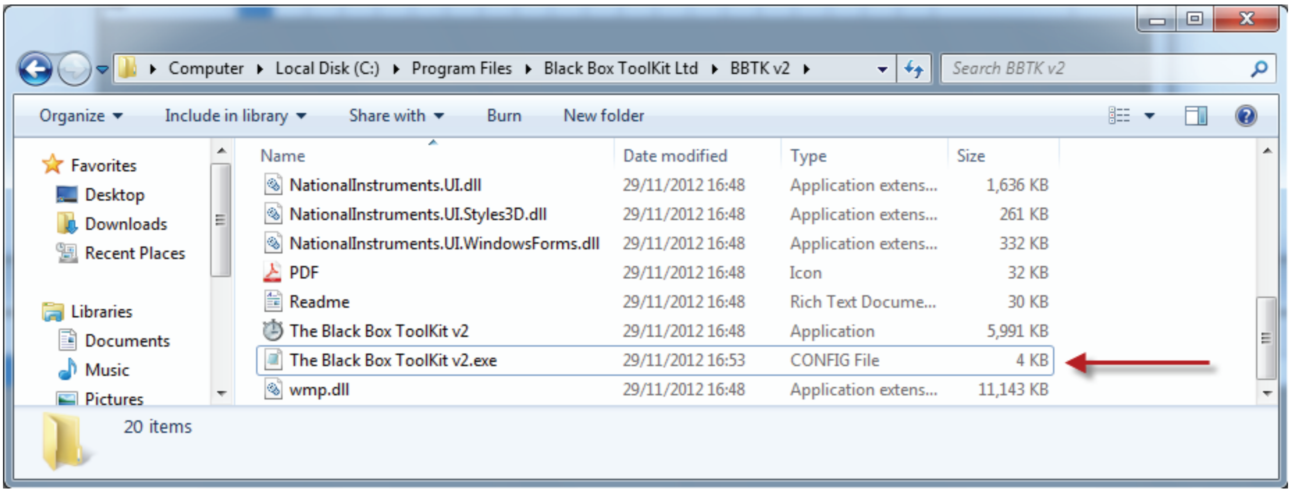
To modify the default DSC capture time move to the DSC tab, alter the capture limit and then click on Apply to save as the default.



To modify the default DSCAR capture time move to the DSCAR tab, alter the capture limit and then click on Apply to save as the default.

17.4 Where are Configuration Options Stored?

All configuration options and default sensor activation threshold values are stored in a single XML file in the root of the folder where the BBTK PC Software is installed. The actual file is called, "The Black Box ToolKit v2.exe.config" and appears as a CONFIG file in Explorer.



You can edit it using any XML editor (or in Windows Notepad). However you are advised not to edit it directly and instead make changes using the PC Software, e.g. changing default line descriptions or setting default sensor threshold values etc.

To edit the file you will need administrator rights to the local PC. To make editing simpler you are advised to copy the XML Config file to another folder (other than Program Files) make the changes and then copy it back.

If you make a mistake and edit the wrong section this may cause the PC Software to crash or behave unpredictably.

Before making any changes you are advised to make a backup copy.


```xml
<?xml version="1.0"?>
<configuration>
  <startup>
    <supportedRuntime version="v4.0" sku=".NETFramework,Version=v4.0" />
  </startup>
  <appSettings file="">
      <add key="BBTKUser" value="IT Support" />
      <add key="BBTKOrg" value="The Black Box ToolKit Ltd" />
      <add key="BBTKSerial" value="AAAAA-BBBBB-CCCCC-DDDDD-EEEEE" />
      <add key="BBTKUpdateServer" value="www.blackboxtoolkit.com" />
      <add key="StartupMode" value="BBTKv2ELITE" />
      <add key="BBTKSerialPort" value="COM27" />
      <add key="BBTKBaudRate" value="230400" />
      <add key="Opto1RefreshBlock" value="1" />
      <add key="Opto2RefreshBlock" value="1" />
      <add key="Opto3RefreshBlock" value="1" />
      <add key="Opto4RefreshBlock" value="1" />
      <add key="AudioIn1Smoothing" value="1" />
      <add key="AudioIn2Smoothing" value="1" />
      <add key="STMAudioIn1" value="63" />
      <add key="STMAudioIn2" value="63" />
      <add key="STMAudioOut1" value="63" />
      <add key="STMAudioOut2" value="63" />
      <add key="STMOpto1" value="63" />
      <add key="STMOpto2" value="63" />
      <add key="STMOpto3" value="63" />
      <add key="STMOpto4" value="63" />
      <add key="DSCTimeLimit" value="30" />
      <add key="DSCARTimeLimit" value="30" />
      <add key="ScopeLine20" value="Sounder 1" />
      <add key="ScopeLine19" value="Sounder 2" />
      <add key="ScopeLine18" value="TTL out 1" />
      <add key="ScopeLine17" value="TTL out 2" />
      <add key="ScopeLine16" value="Act close 1" />
      <add key="ScopeLine15" value="Act close 2" />
      <add key="ScopeLine14" value="Act close 3" />
      <add key="ScopeLine13" value="Act close 4" />
      <add key="ScopeLine12" value="Mic 1" />
      <add key="ScopeLine11" value="Mic 2" />
      <add key="ScopeLine10" value="TTL in 1" />
      <add key="ScopeLine9" value="TTL in 2" />
      <add key="ScopeLine8" value="Opto 1" />
      <add key="ScopeLine7" value="Opto 2" />
      <add key="ScopeLine6" value="Opto 3" />
      <add key="ScopeLine5" value="Opto 4" />
      <add key="ScopeLine4" value="Keypad 1" />
      <add key="ScopeLine3" value="Keypad 2" />
      <add key="ScopeLine2" value="Keypad 3" />
      <add key="ScopeLine1" value="Keypad 4" />
```

The various entries should be fairly self-explanatory. Each setting is stored as a key and value pair. You should only ever edit the value within the “” (quotation) marks.

You should not edit key names.

If you made an error when entering your user name, organisation or serial number during the setup you can correct it here. Your serial number is important as it helps you check for updates and is needed to access technical support.

The update server URL should not be changed as this enables you to automatically check for updates to the PC Software or ARM firmware.

The serial port value tells the BBTK which serial port to use. That is, which serial port emulated over USB. The baud rate refers to how fast that port operates. If you have transmission issues you may need to lower that here and match this value in the BBTK.ini file stored with the BBTK firmware on the BBTK flash drive letter.

Default time limits are set in seconds for the various modules described by the key.

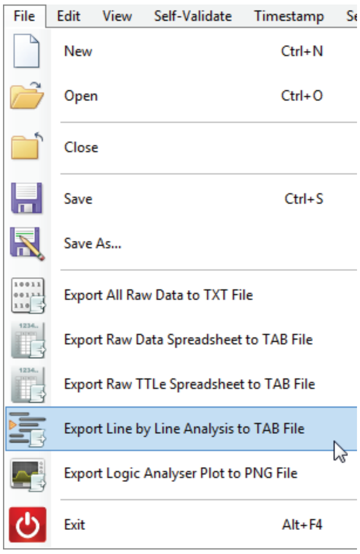
Whether CRTs are Refresh Corrected (Blocked) are set by a “1” for true and a “0” for false.

Any entries starting with STM are sensor threshold default values (0-127).

Default line descriptions are ordered by the line key with the actual description as the value. Do not edit keys as they will not make the line names change.

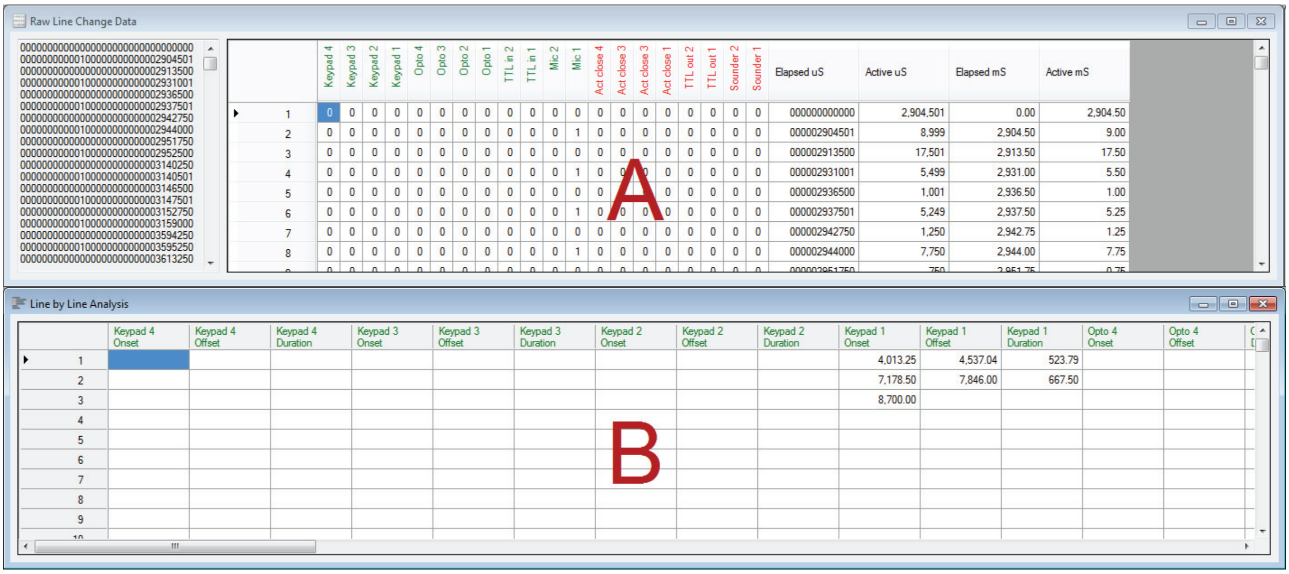
Entries not described above are generally to do with internal house keeping and the Microsoft .NET framework.

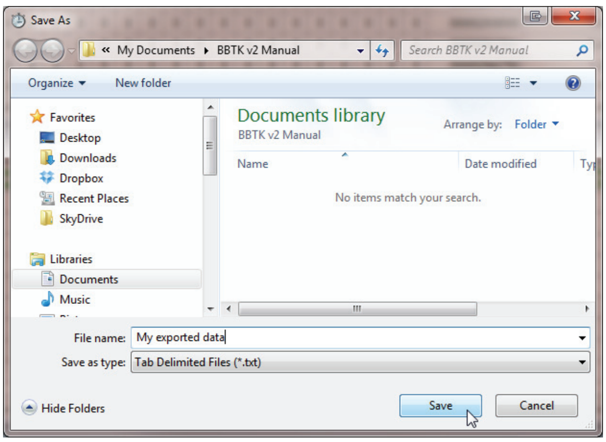
18. Exporting Data



You can export both spreadsheet views into standard TAB delimited files so that you may analyse the data further in Microsoft Excel or SPSS for example.

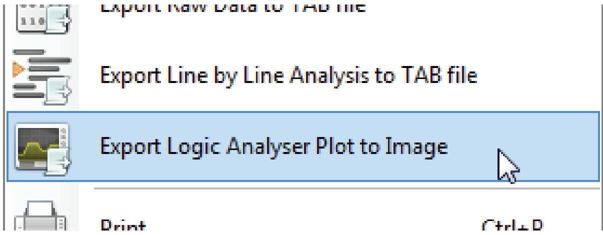
The first spreadsheet you can export is the Raw Line Change Data (A) and the second the Line by Line Analysis (B)





When you choose to export data from the File menu you will be prompted to choose a folder and appropriate file name.

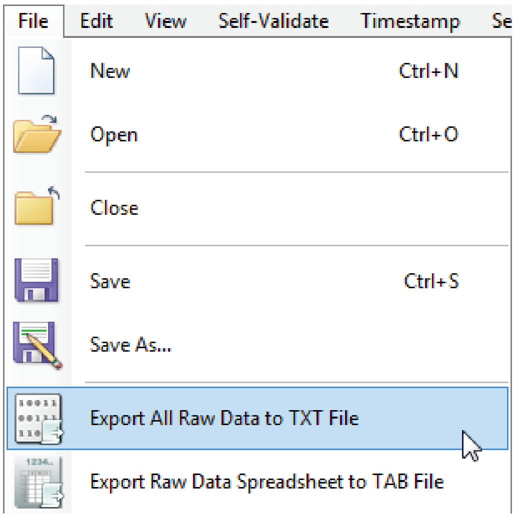
Once saved you can load the data into any software that supports TAB delimited files and enable you to view data in a spreadsheet style view.



If you wish you can also export the current Logic Analyser view to a PNG file (Portable Network Graphic).

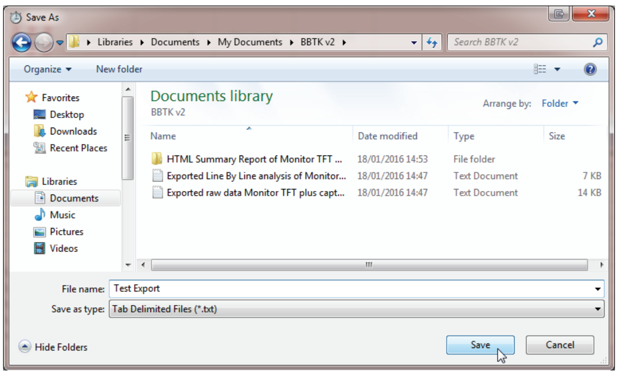
In addition to exporting you also have the option of Copy and Pasting data or graphics into your preferred application. You can either do this under the Edit menu or by pressing CTRL+C when you have highlighted the spreadsheet range you are interested in.

18.1 Hand Analysing Data in Excel

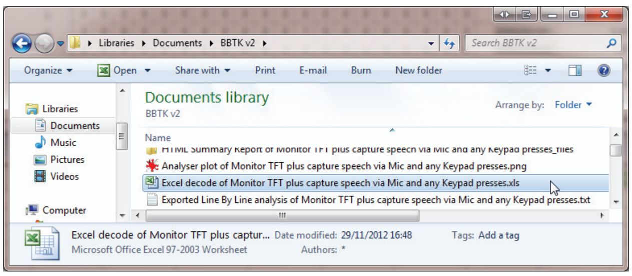


If you are developing your own software analysis tools to work with the raw BBTK data we have provided a Microsoft Excel spreadsheet template to help decode the raw data.

To hand analyse data you will need to select Export All Raw Data to TXT File from the File menu.

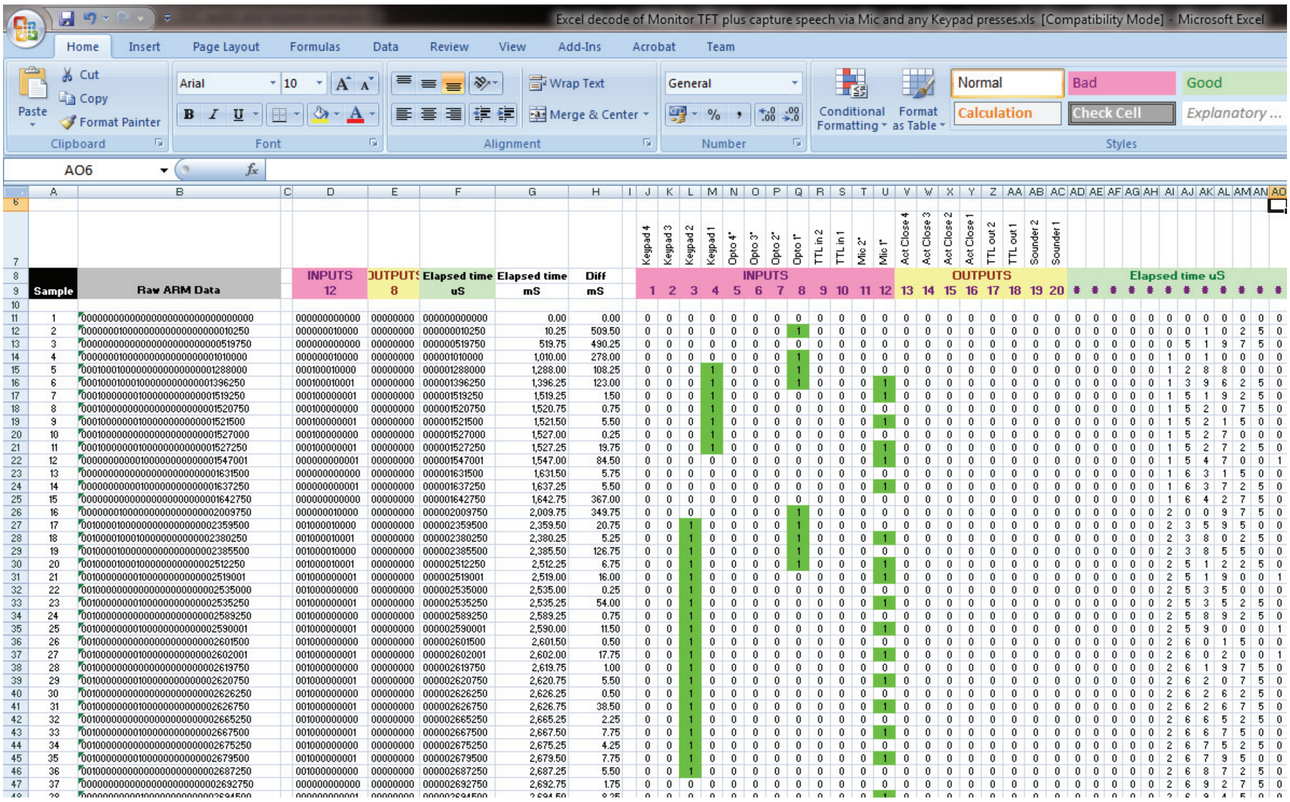


Enter a filename where the exported data will be stored and click on Save.



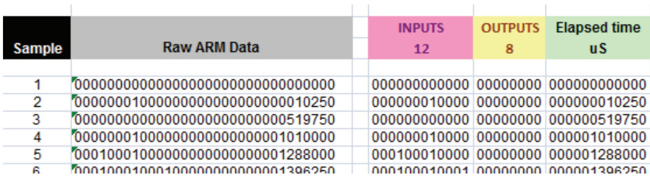
Next start Microsoft Excel and open the template we have provided in your Document Library:

"Excel decode of Monitor TFT plus capture speech via Mic and any Keypad presses.xls"



This example file automatically decodes the raw ARM line change data into a graphical representation as shown.

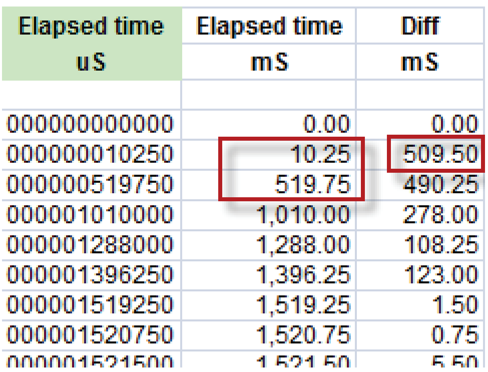
If you paste your own raw data over the top it will be decoded in a similar way. To do this open your exported text file in an ASCII text editor, e.g. Notepad, select all the exported data (CTRL+A) and then copy (CTRL+C) and paste it (CTRL+V) into the Raw ARM Data column in the sample template. Ensure that all example data has been overwritten.



Sample	Raw ARM Data	INPUTS 12	OUTPUTS 8	Elapsed time uS
1	00000000000000000000000000000000	000000000000	00000000	000000000000
2	00000001000000000000000000010250	000000010000	00000000	000000010250
3	00000000000000000000000000519750	000000000000	00000000	000000519750
4	00000001000000000000000001010000	000000010000	00000000	000001010000
5	00010001000000000000000001288000	000100010000	00000000	000001288000

Line change data is split by Sample into the binary input port value and the output port value.

Next the time in Microseconds (uS or millionths of a second) is shown. 1,000 Microseconds = 1 Millisecond.



Elapsed time uS	Elapsed time mS	Diff mS
000000000000	0.00	0.00
000000010250	10.25	509.50
000000519750	519.75	490.25
000001010000	1,010.00	278.00
000001288000	1,288.00	108.25
000001396250	1,396.25	123.00
000001519250	1,519.25	1.50
000001520750	1,520.75	0.75

Next the elapsed timestamp in milliseconds (mS) is computed.

Finally by looking at two adjacent line changes and working out the difference a Diff in milliseconds is computed.

Keypad 4	Keypad 3	Keypad 2	Keypad 1	Opto 4*	Opto 3*	Opto 2*	Opto 1*	TTL in 2	TTL in 1	Mic 2*	Mic 1*	Act Close 4	Act Close 3	Act Close 2	Act Close 1	TTL out 2	TTL out 1	Sounder 2	Sounder 1
INPUTS												OUTPUTS							
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0
0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0

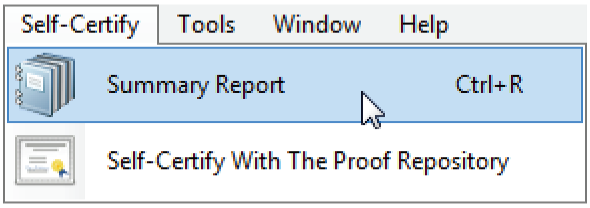
By parsing line change values and applying conditional colour formatting where individual lines are active they are colour coded in green.

If you were to rotate this view to the horizontal this is very similar to the Logic Analyser plot conceptually.

WARNING: You should note that we cannot be held responsible for any errors which you may introduce by analysing your own data. This spreadsheet template is provided "as is" and is intended purely for informational purposes.

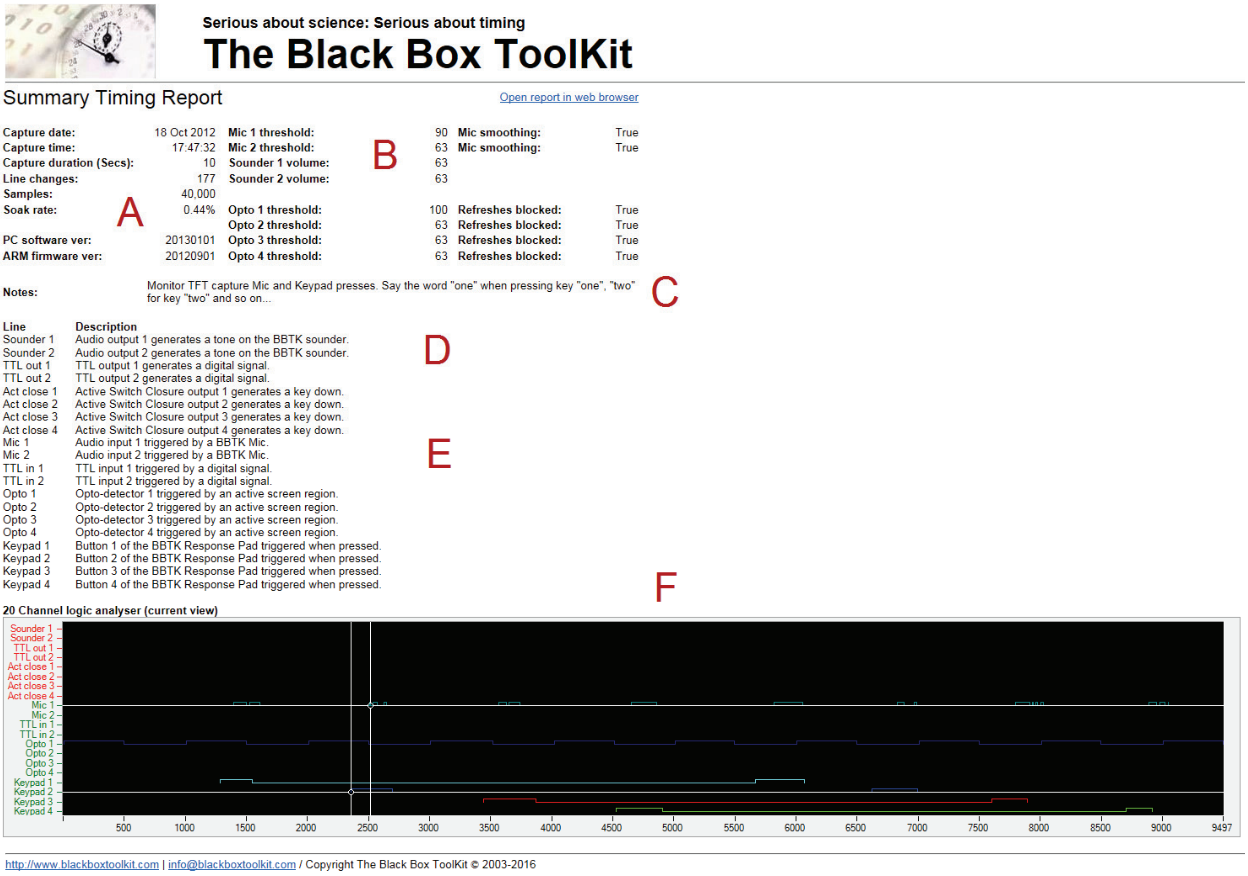
NOTE: If CRT refresh blocking and audio smoothing were turned on when the original raw data was captured you will need to subtract 20mS from the line duration where a stimulus was active, e.g. where an image was displayed on a monitor or audio detected.

19. Producing Summary Timing Reports



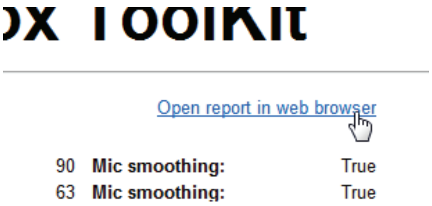
The PC Software allows you to produce Summary Timing Reports from any Real Time Log file.

To produce a report select Summary Report from the Self-Certify menu, press CTRL+R or click on the toolbar button.

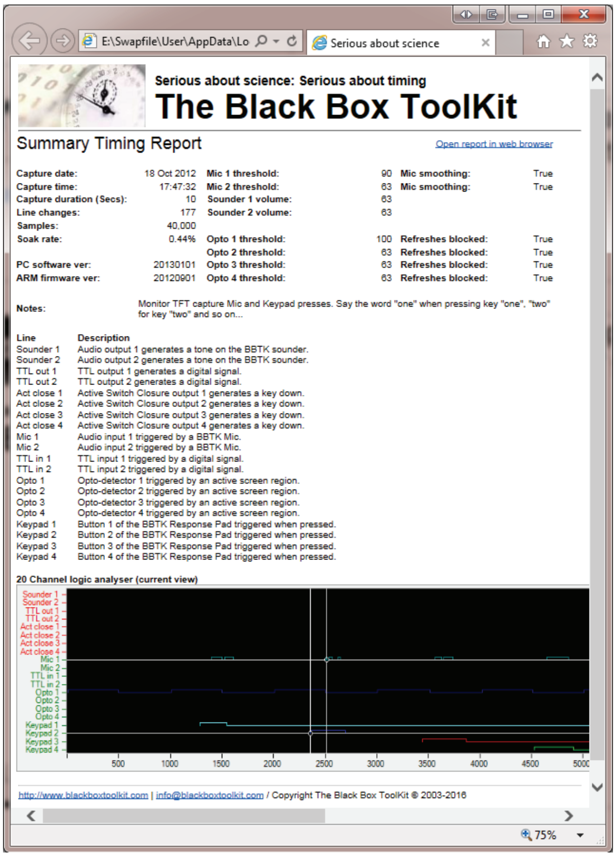


Summary Timing Reports detail:

A. When the self-validation run took place, what the duration was, how many line changes were detected, the number of samples and the soak rate (a measure of load). The version numbers for the PC Software and ARM firmware are also shown.
B. Each sensor activation threshold is shown together with details on CRT Refresh Blocking.
C. Any textual notes you made in the notes window will be shown here.
D. User defined line labels for the standard 8 output lines are shown next to the relevant line name.
E. User defined line labels for the standard 12 input lines are shown next to the relevant line name.
F. The current Logic Analyser plot view is shown at the bottom of the report.



If you wish you can open the report in a web browser by clicking on the link.



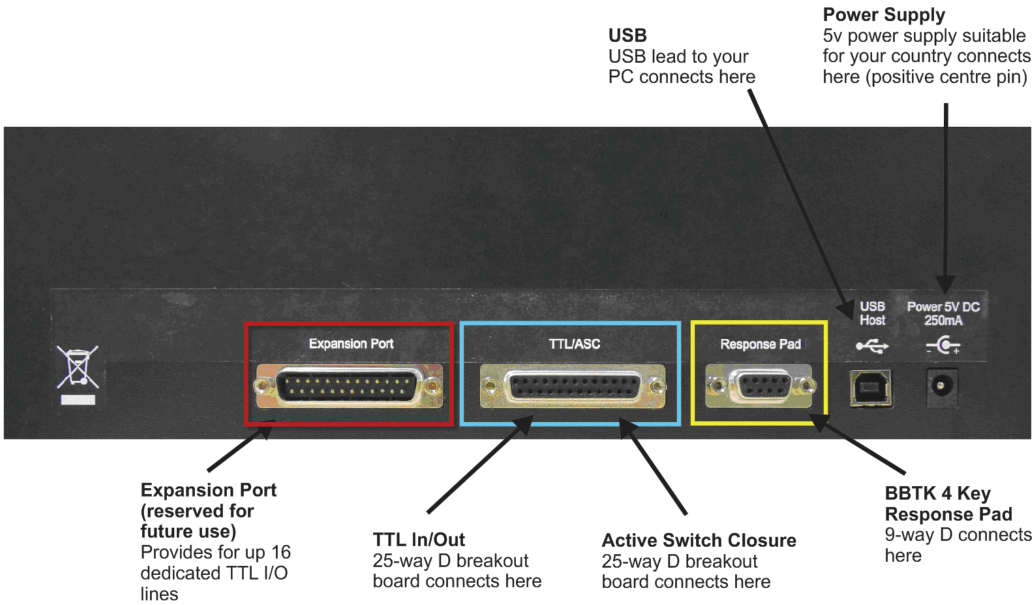
This gives you the opportunity to save the report as a single MHT file (MIME HTML).

20. Using the 16 Channel TTLe Expansion Board

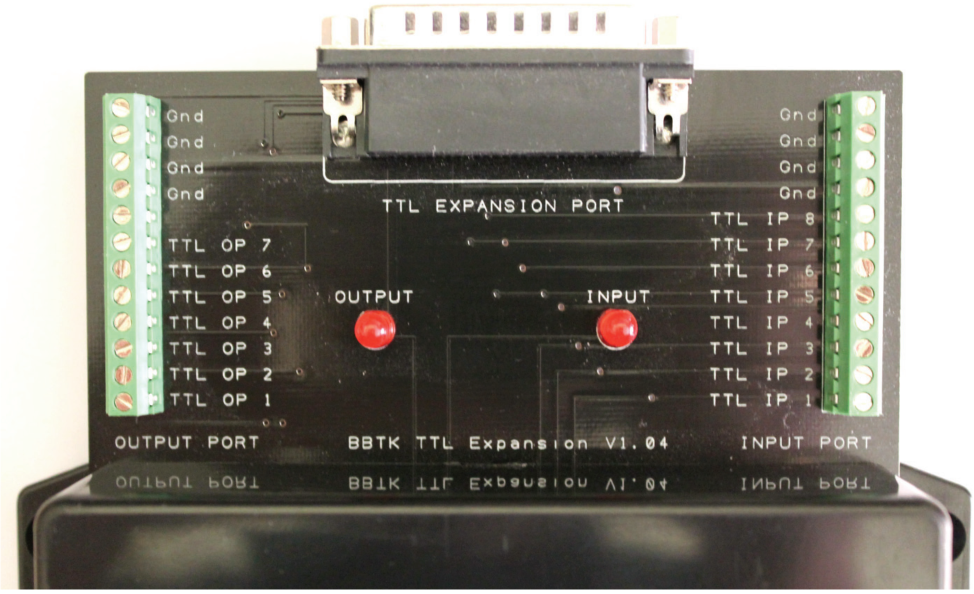
20.1 What is the TTLe Expansion Board?

The 16 Channel TTLe Expansion board offers additional multipurpose TTL I/O lines that can be used with any equipment that supports standard 0~5V TTL signals, e.g. EEG, fMRI, parallel ports or digital I/O cards. Specifically it offers 8 TTL input lines and 7 TTL output lines (plus one direction line). It ships as standard with BBTK Elite models and can be purchased as an add-on for Entry and Pro models.

It can be used at the same time as the standard BBTK breakout board TTLs to offer a total of 10 TTL input lines and nine TTL output lines. Together with the other sensors such as opto-detectors, microphones etc. this gives a total of 36 lines or channels. It works seamlessly with all the standard software modules such as DSC, EG, DSCAR and can also be used for event marking stimuli and responses in the Event Marking (EM) module.



The TTLe Expansion Board connects to the BBTK using the rear left hand Expansion Port (shown in red) and a 25-way cable.



TTL output lines from your equipment should be connected to the screw terminals on the right of the expansion board labelled INPUT PORT (+0~5V). If you wish to feed signals into your equipment you should connect input lines to the left of the expansion board labelled OUTPUT PORT (+0~5V). If you have an input or output ground from your equipment you should connect it to a Gnd terminal. Input or output activity is indicated by the two LEDs labelled INPUT and OUTPUT.

For a more permanent wiring solution you have the option of constructing a custom cable that connects to the TTL EXPANSION PORT 25-way D.

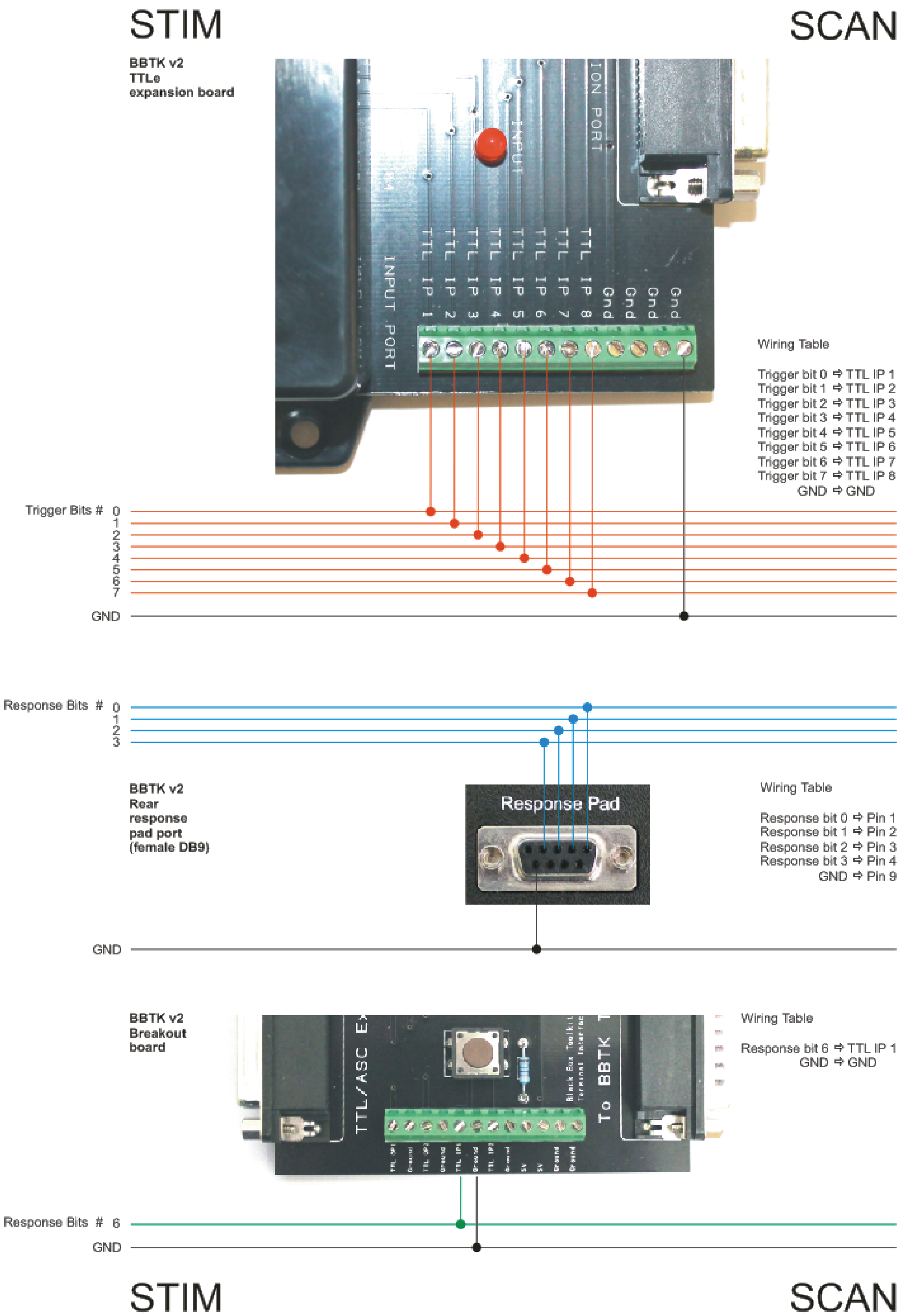
NOTE: Please note you should not plug one of your existing equipments cables into this port as the pin outs are different. The Black Box ToolKit Ltd cannot be held responsible for any loss or damage howsoever caused. This documentation is provided solely for informational purposes and does not constitute a guide which we authorise as being fit for purpose.

TTL EXPANSION PORT 25-way D pinouts

Pin	Description	Pin	Description
1	TTL IP 1	14	TTL OP 1
2	TTL IP 2	15	TTL OP 2
3	TTL IP 3	16	TTL OP 3
4	TTL IP 4	17	TTL OP 4
5	TTL IP 5	18	TTL OP 5
6	TTL IP 6	19	TTL OP 6
7	TTL IP 7	20	TTL OP 7
8	TTL IP 8	21	GND
9	GND	22	GND
10	GND	23	GND
11	GND	24	GND
12	GND	25	GND
13	GND		

20.2 An Example Using the 16 Channel TTLe Expansion Board in EEG

A common use for the TTLe expansion is to provide additional I/O lines in EEG settings. In the example shown below eight event marking lines are being monitored along with four response pad lines and one sync line.



21. Self-Validating Stimulus Onsets and Durations with Elite Digital Stimulus Capture (DSC)

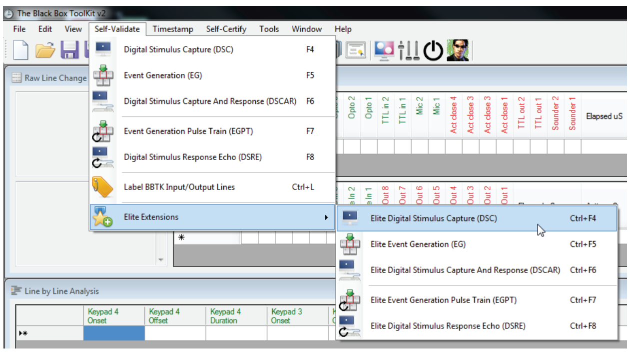
The Elite Digital Stimulus Capture (DSC) module allows you to self-validate the onset, duration and offsets of any of your stimulus materials across a range of modalities. Up to 20 stimulus input lines can be captured at any one time using the Elite version of the BBTK* together with the TTLe expansion board.

Standard sensors and input lines together with the TTLe expansion board cover:

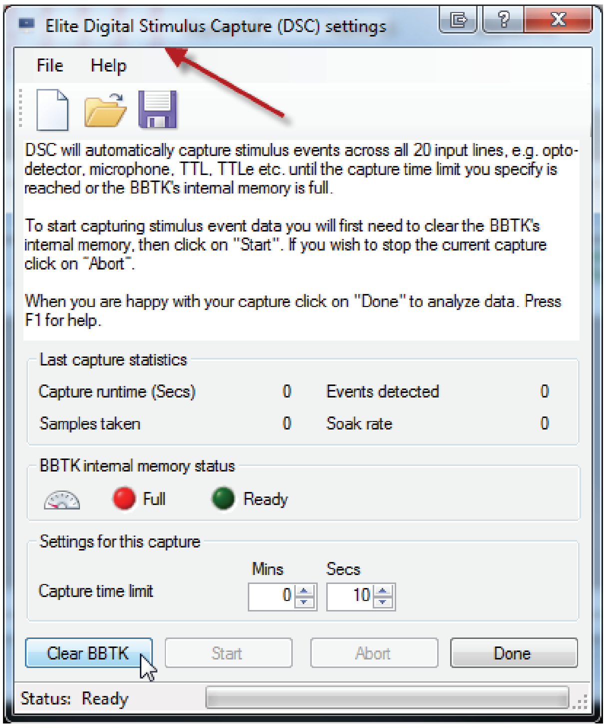
Sensor	No of sensors	Purpose
Microphone	2*	Detect audio stimulus presentations from your equipment.
TTL in	2*	Detect TTL (0~5V) digital signals from your equipment, e.g. EEG markers, fMRI etc.
Opto-detector	4*	Detect visual stimuli.
Keypad button	4*	Detect key presses on the 4 button BBTK response pad.
TTLe expansion board	8	Detect TTL (0~5V) digital signals from your equipment, e.g. EEG markers, fMRI etc.

In principle each sensor, or line, operates in the same way. Each sensor detects an onset when triggered when an activation threshold is crossed (for more details see the section of this guide which covers the Sensor Threshold Manager). In the case of the TTL lines and the keypad buttons these thresholds cannot be set and are simply digital events, i.e. on or off or key down or up.

The Elite version of DSC works in the same way as the standard Entry and Pro version but with access to an additional set of TTL Lines. You are advised to familiarise yourself with Section 6 of this manual before you begin as this covers the DSC module in more depth.



To capture any events across the 20 input lines begin by starting the Elite DSC module by selecting Elite Digital Stimulus Capture (DSC) from the Elite Extensions submenu under Self-Validate or by pressing CTRL+F4.



Ensure that you are running the Elite version of DSC by checking that Elite is shown in the title bar.

You will need to clear the BBTK memory as normal and then enter the capture time limit.

Here events on any of the sensors and lines will be captured for 10 seconds.

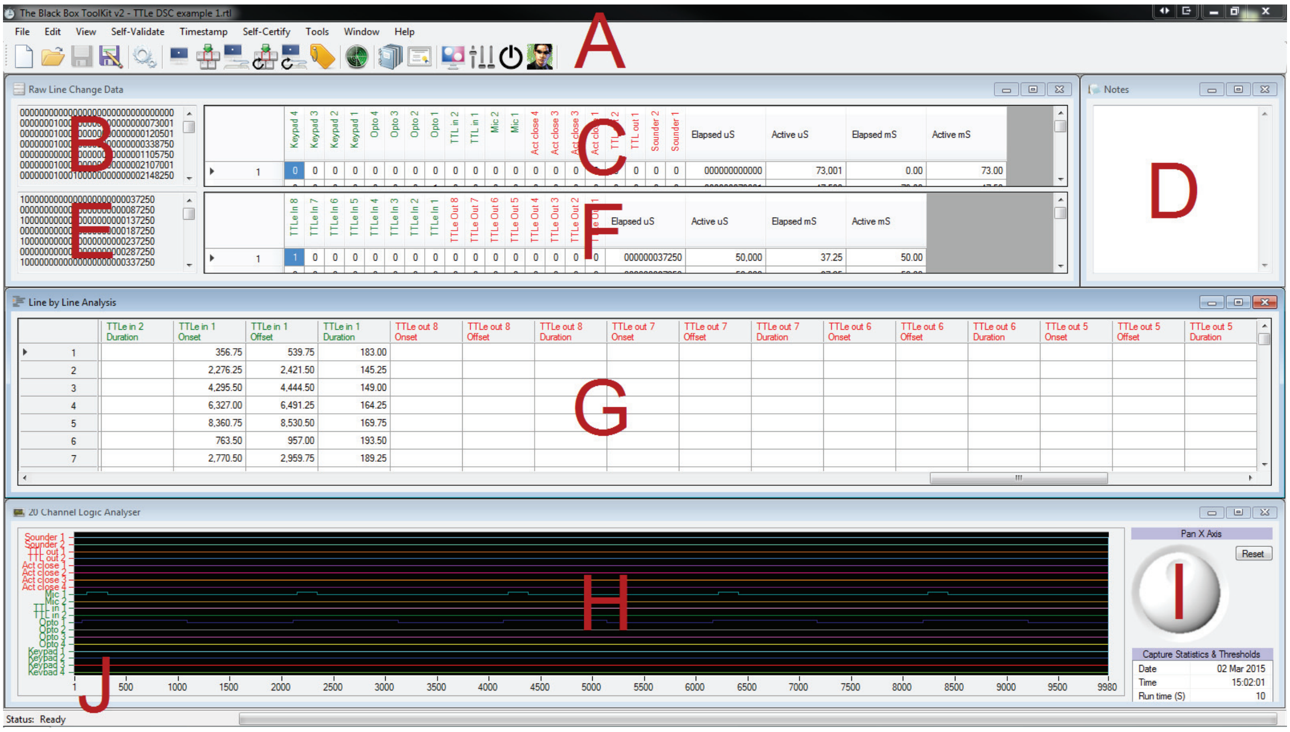
Click Start to begin recording stimulus activity.

After 10 seconds have elapsed the BBTK will indicate that the capture has completed. The number of line changes or Events will be listed along with a total runtime. Uploading… will be displayed as data is sent to the PC. To analyse any data captured click Done.

22. Analysing Captured Timing Data with the Logic Analyser when using the 16 Channel TTLe Expansion Board

22.1 Key Parts of the Interface

The Elite version of the BBTK v2 PC Software is slightly different to the Entry and Pro in that it displays the additional 16 TTLe expansion board lines. To do this the Raw Line Change Data window is split into two covering the standard lines (B&C) and the TTLe lines (E&F). Depending on your version of the PC software you may not have raw text windows B&E. In addition to the additional data displays the Line by Line Analysis spreadsheet contains additional columns that show the onset, offset and duration of each event on the TTLe lines (G).



A Shows the menu bar and standard toolbar buttons. If you look at the menu items or hover over a toolbar button a shortcut key will be shown, e.g. CTRL+R for a summary report.

B Shows the raw standard lines capture data that is uploaded by the BBTK's ARM CPU after a capture (depending on your version of the PC software).

C Shows the status of each line each time there was a change on any of the 20 standard BBTK lines (12 input sensors and 8 outputs). Elapsed time and durations are shown in uS (microseconds or millionths of a second) and mS (milliseconds or thousandths of a second).

D Shows a simple notepad that can be used to make notes that are saved with the Real Time Log (RTL) file.

E Shows the raw TTLe lines capture data that is uploaded by the BBTK's ARM CPU after a capture (depending on your version of the PC software).

F Shows the status of each line each time there was a change on any of the 16 BBTK TTLe lines (8 inputs and 8 outputs). Elapsed time and durations are shown in uS (microseconds or millionths of a second) and mS (milliseconds or thousandths of a second).

G Shows the processed raw data. It shows the onset, offset and duration in mS (milliseconds) of each line. Note that a single sensor on period may appear as multiple line changes in C & F as other lines go on and off. Only in D can you get a clearer picture of what happened.

H Shows a Logic Analyser plot of the captured data (digital on and offs).

Note the Logic Analyser plot is only accurate to 1mS, whereas G is accurate to hundredths of a millisecond, i.e. two decimal places.

I Shows summary Capture Statistics & Thresholds. This provides details on capture date, time, runtime, number of line changes or events, samples taken, soak rate, sensor thresholds and whether the opto-detectors blocked together individual refreshes on a CRT.

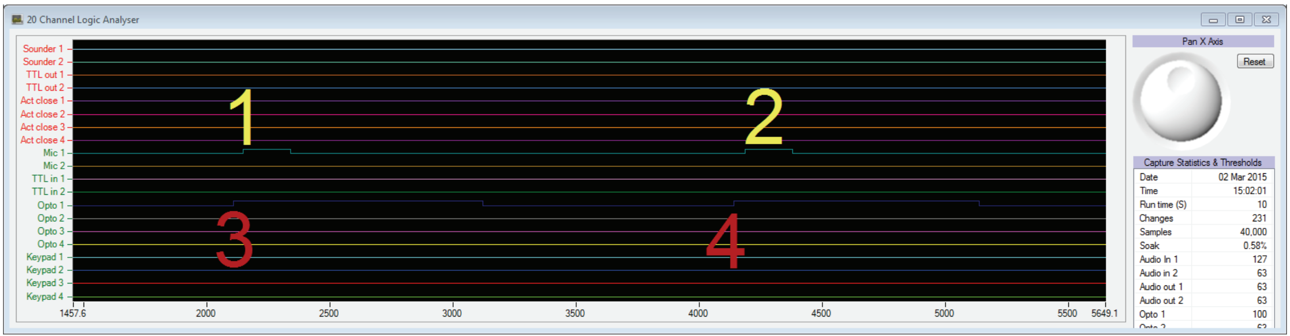
J Shows the status bar and progress indicator. For example, when longer captures are plotted on the Logic Analyser this will show which lines are being analysed.

22.2 Checking a Reaction Time Paradigm using the 16 Channel TTLe Expansion Board

Usually when checking your timing the first place to start is the 20 Channel Logic Analyser. This shows input lines/sensors in green, output or generation lines in red against a time base in mS (milliseconds). Each line is shown in a different colour to help differentiate between them.

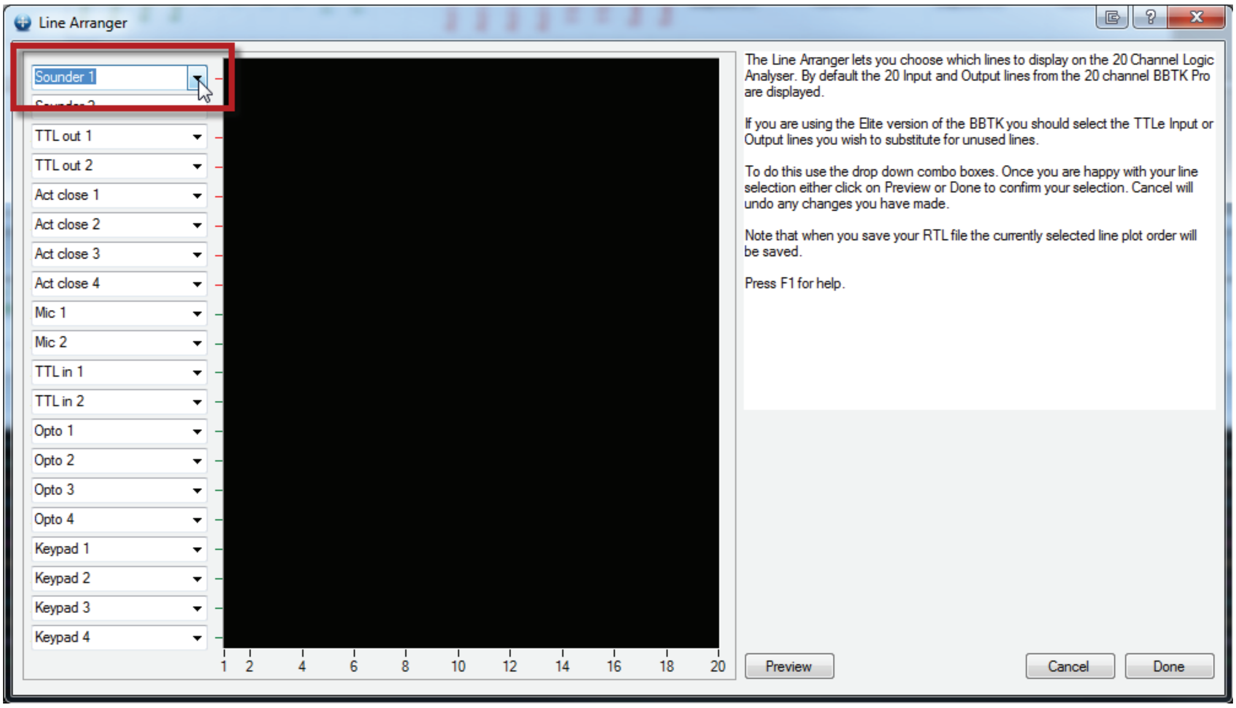
In the example shown below the participants task was to respond to a visual and auditory event when they occurred together. In this scenario one line on the TTLe expansion board accepted a TTL sync signal from either an MRI scanner or EEG machine and another accepted a response as a TTL button press.

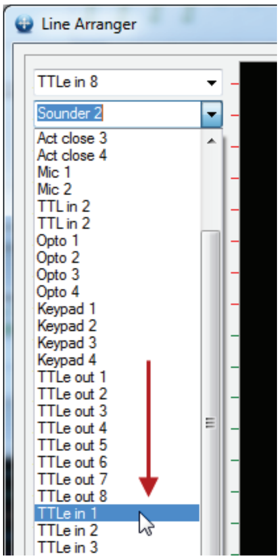
By default the Logic Analyser only displays the BBTK's 20 standard lines, i.e. microphones, opto-detectors etc. as shown below.



1 Shows the onset and duration of the first audio event (a 250mS tone).
2 Shows the onset and duration of a second audio event (another 250mS tone).
3 Shows the onset and duration of the visual stimulus (1,000mS)
4 Shows the onset and duration of a second visual stimulus (1,000mS)

Although we can see two trials on the Logical Analyser (1/3 and 2/4) we cannot see the other two TTLe lines representing the sync pulse and the response to when the participant thought the audio and visual stimulus were aligned. To display these additional lines you need to double click on the plot, or Y axis, to show the Line Arranger. The Line Arranger enables you to pick which of the BBTK's 36 lines to display on the 20 channel plot.

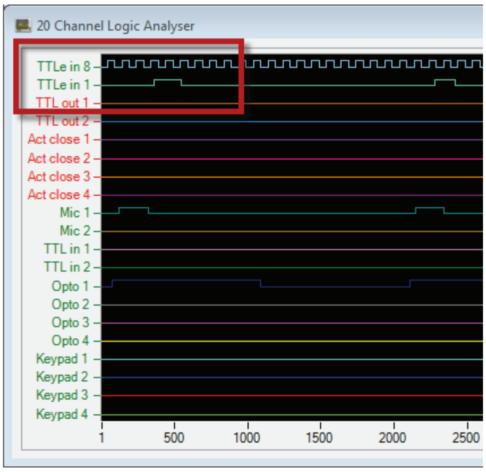




Typically you would select unused sensors, or lines, and substitute them for the ones you are interested in. In this case select TTLe In 8 (the sync pulse) and TTLe In 1 (the TTL response button) to replace Sounder 1 & 2 which are not being used.

To do this click on the drop down combo and select the lines to replace those shown at that position on the Logic Analyser currently.

To accept the changes click on Done. If you want to preview how they would look click on Apply.



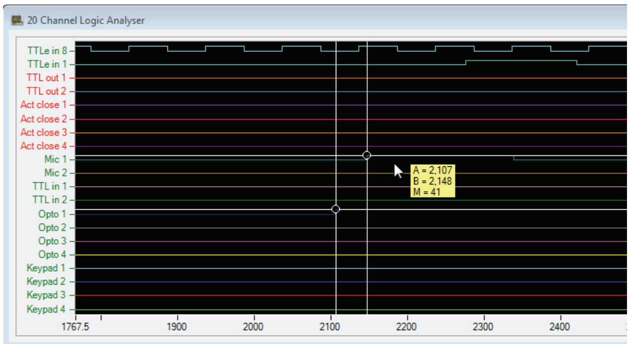
Here we can see on the Y axis that Sounder 1 & 2 have been swapped for the sync pulse (TTLe 8) and TTL response button (TTLe 1).

The regular sync pulse is clearly visible as TTLe in 8.

Note how both TTLe in lines are displayed in a green font as both are input lines (outputs are displayed in red).

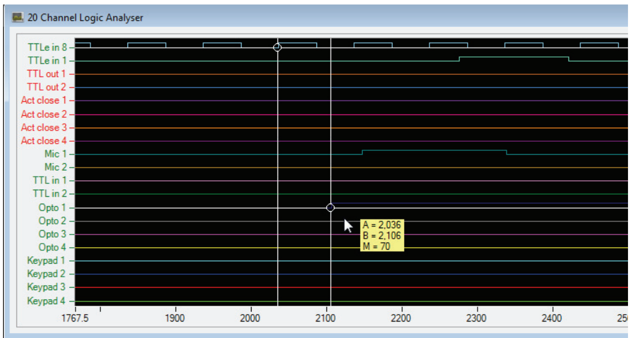
In a perfect world both the BBTK and the commercial Experiment Generator, or STIM in the case of EEG and fMRI, would record exactly the same time. However this is unlikely to be the case as the commercial Experiment Generator will be running on a second PC and will suffer from imperfect timing.

You are advised to familiarise yourself with Section 7 of this manual before you begin as this covers analysing timing data in more depth.

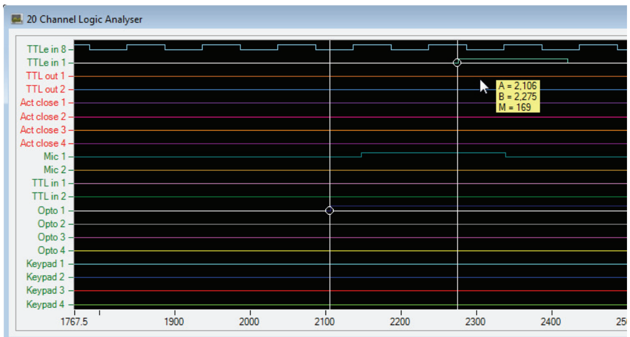


Now that we can see all the lines we might begin by checking whether the visual and audio stimulus onsets are perfectly aligned?

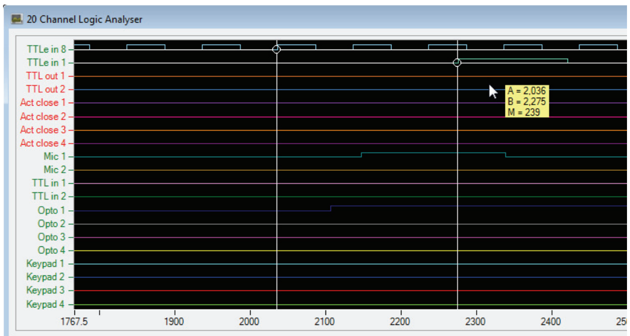
To do this press M on the keyboard and drag the two measurement cursors to align with the onsets of the lines you are interested in and then read off the alignment error (M). In this case they are out of sync by 41mS.



Next we could check the sync pulse to visual stimulus error by snapping to the leading edge of the sync pulse and then to the onset of the visual event. In this example the error is 70mS.



The actual real world RT could be checked by measuring the time between the onsets of the visual stimulus as measured by the opto-detector to the onset of the TTL response button on TTLe in 1. In this example the real RT is 169mS. It is highly likely that the experiment generator, or STIM, being used would have recorded a different RT due to hardware and software lags.



Finally we could check what RT we would estimate the experiment generator, or STIM, would have recorded if recording from the sync pulse the visual and auditory stimuli should have been aligned with. In this example the RT should have been 239mS. Again it is highly likely that the experiment generator, or STIM, being used would have recorded a different RT due to hardware and software lags.

23. Generating Events Using Elite Event Generation (EG)

The Elite Event Generation (EG) module allows you to generate a series of events with a known onset, offset and duration across a range of modalities. Events on one or more of the 15 output lines can be generated using the Elite version of the BBTK* together with the TTLe expansion board.

Standard modalities and output lines together with the TTLe expansion board cover:

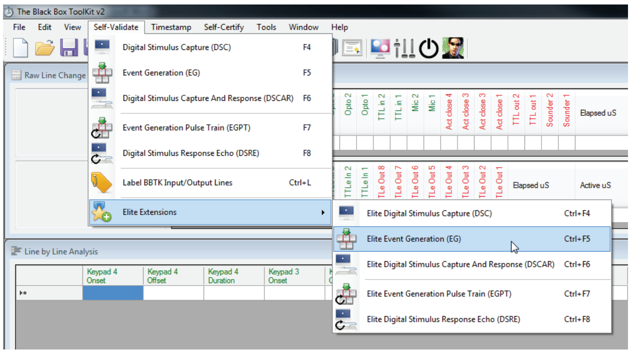
Sensor	No	Purpose
Sounder	2*	Produces a tone that can be used to trigger your own voice keys.
TTL out	2*	Produces TTL (0~5V) digital signals which can be fed into your own equipment, e.g. EEG machines, MRI scanners etc. This interface is also used for the BBTK Robotic Finger.
Active Switch Closure (ASC)	4*	Can be used to close a switch on your own devices to simulate a response, e.g. a key press on a keyboard. In effect the ASC lines are Solid State Relays (SSRs) that short switches out as though a push-to-make event has occurred. For details of how to wire ASC leads to keyboards etc. consult the wiring an ASC section of this guide.
TTLe expansion board	7	Produces TTL (0~5V) digital signals which can be fed into your own equipment, e.g. EEG machines, MRI scanners etc.

In principle each operates in the same way in that you choose the line, or lines, you wish to activate an output on. The BBTK doesn't differentiate how the lines work, as it assumes all operate in a digital way. For example, as far as the BBTK is concerned a Sounder, or Tone Generator, has the same properties as a TTL out line.

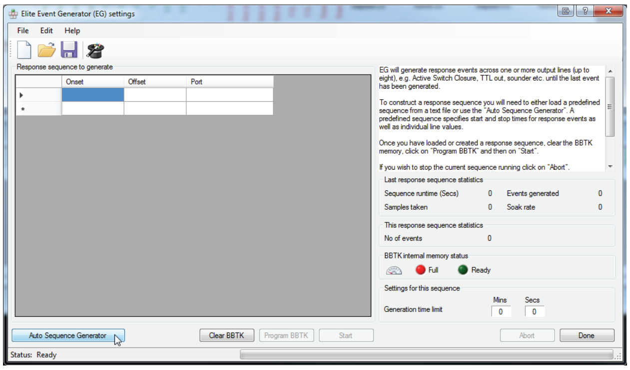
The Elite version of EG works in the same way as the standard Entry and Pro version but with access to an additional set of TTL Lines. You are advised to familiarise yourself with Section 9 of this manual before you begin as this covers the EG module in more depth.

23.1 How to Generate Events Using the Wizard

Initially we would advise that you make use of the wizard style interface to help you generate events. This automatically generates onsets, offsets and durations for events very simply using a point and click interface.

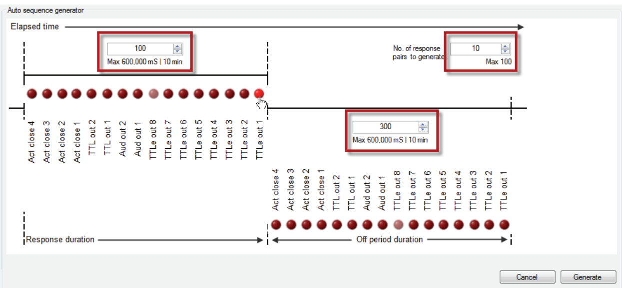


To generate events across the 15 output lines begin by starting the Elite EG module by selecting Elite Event Generation (EG) from the Elite Extensions submenu under Self-Validate or by pressing CTRL+F5.



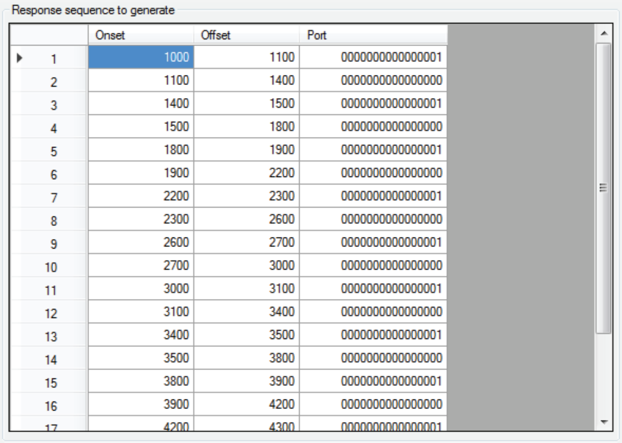
When the Elite EG Module starts you will be presented with a spreadsheet view which has columns for Onsets, Offsets and a Port value. Onset and Offset are times in milliseconds since the start of the run and Port is a binary pattern indicating which lines should be on or off.

Click on Auto Sequence Generator to activate the Wizard.



The spreadsheet will be replaced by a graphical representation of the events you intend to generate and their timing characteristics. The graphic represents elapsed time, On events and Off events along with times for each (red boxes).

In the example shown the BBTK will generate a TTL signal on the TTLe expansion port on TTLe out 1 for 100mS and have on off period where nothing happens for 300mS. It will generate 10 On events to give a sequence of 20 events. Finally click on Generate to fill in the spreadsheet.



Response sequence to generate

	Onset	Offset	Port
1	1000	1100	0000000000000001
2	1100	1400	0000000000000000
3	1400	1500	0000000000000001
4	1500	1800	0000000000000000
5	1800	1900	0000000000000001
6	1900	2200	0000000000000000
7	2200	2300	0000000000000001
8	2300	2600	0000000000000000
9	2600	2700	0000000000000001
10	2700	3000	0000000000000000
11	3000	3100	0000000000000001
12	3100	3400	0000000000000000
13	3400	3500	0000000000000001
14	3500	3800	0000000000000000
15	3800	3900	0000000000000001
16	3900	4200	0000000000000000
17	4200	4300	0000000000000001

Each row in the spreadsheet is a single On or Off event. Events automatically start after 1 Second. So the Port value of "0000000000000001" is generated at 1,000mS through 1,100mS for event 1, then event 2 takes over and is generated between 1,100mS and 1,400mS. A port value of "0000000000000000" means all lines are cleared.

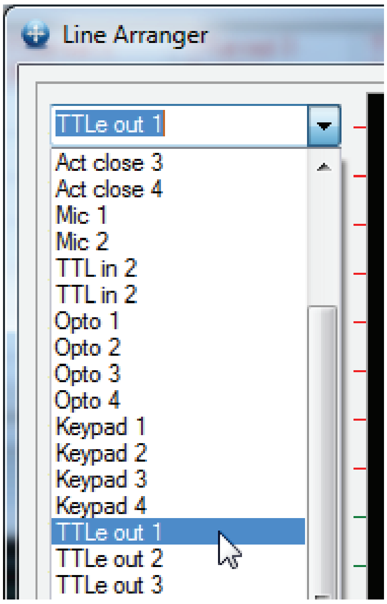
So from the spreadsheet we can see that regular events will be generated for 100mS (on) and 300mS (off) one after another. If you want to save this sequence click on the Save toolbar button.

The status panel will show the number of events to generate together with how long it will take to generate the complete sequence.

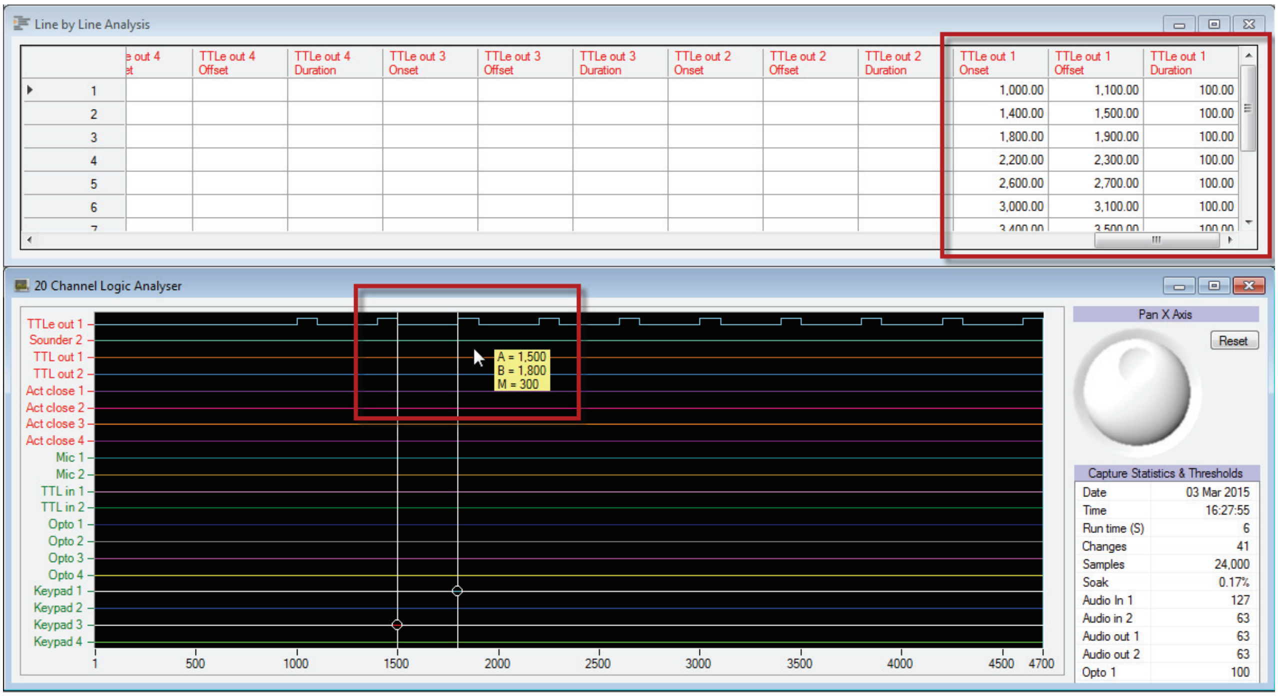
You will need to clear the BBTK memory as normal and then click Start to begin generating the sequence. Whilst generating events the LED of the lines which are active will illuminate when an On event occurs. In the case of the TTLe expansion board the single OUTPUT LED will illuminate.

After the time limit has elapsed the BBTK will indicate that the capture has completed. The number of line changes or Events will be listed along with the total runtime. Uploading… will be displayed as data is sent to the PC. To analyse any data captured click Done.

The Logic Analyser will only display events being generated on any of the output lines indicated in red on the column headers and on the Y-axis of the plot. In the Line by Line Analysis spreadsheet we can see that 10 On events were recorded that lasted for exactly 100mS as intended. In the Logic Analyser plot we can see that Inter Stimulus Intervals were 300mS as intended, i.e. the Off periods.



Remember that to display the TTLe out 1 line on the Logic Analyser you will need to choose it in the Line Arranger by double clicking on the plot, or Y axis, and swap it for another unused line, e.g. Sounder 1 in this case.



For more advanced use of the Elite EG module you are advised to consult section 9.2 which covers the EG module in more depth.

24. Generating Events Using Elite Event Generation Pulse Train (EGPT)

The Elite Event Generation Pulse Train (EGPT) module is very similar to the Elite Event Generation (EG) module in that it allows you to generate a series of events with a known onset, offset and duration across a range of modalities. Events on one or more of the 15 output lines can be generated using the Elite version of the BBTK* together with the TTLe expansion board.

The key differences are that the Pulse Train module does not collect any timing data that can be uploaded and analysed by the PC Software; it is not limited to a fixed number of events that it can generate (it can generate an infinite number of events); and it cannot vary timings on an event by event basis (it can only generate a fixed pattern).

Elite EGPT operates like a standard bench Function Generator that generates square waves at a known frequency across up to 15 channels. One use for EGPT might be to send a regular series of event markers to an EEG machine or fMRI scanner using one of the TTLe out lines. However you can make use of any of the output lines either individually or simultaneously should you wish.

Note that to stop a sequence you will need to click Abort which will reset the BBTK. Thus you are advised to save your Sensor Threshold Settings before you use this module if you have customised them specifically, or reload an existing RTL file and set to those settings.

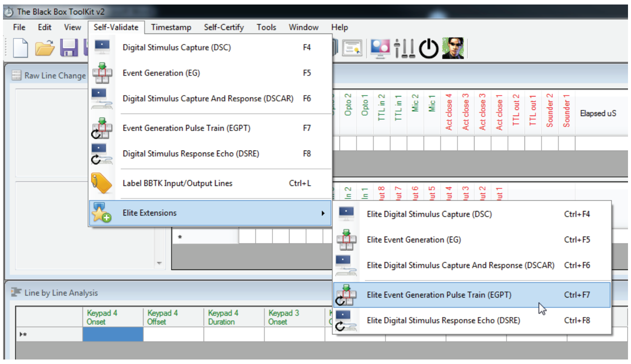
Standard modalities and output lines together with the TTLe expansion board cover:

Sensor	No	Purpose
Sounder	2*	Produces a tone that can be used to trigger your own voice keys.
TTL out	2*	Produces TTL (0~5V) digital signals which can be fed into your own equipment, e.g. EEG machines, MRI scanners etc. This interface is also used for the BBTK Robotic Finger.
Active Switch Closure (ASC)	4*	Can be used to close a switch on your own devices to simulate a response, e.g. a key press on a keyboard. In effect the ASC lines are Solid State Relays (SSRs) that short switches out as though a push-to-make event has occurred. For details of how to wire ASC leads to keyboards etc. consult the wiring an ASC section of this guide.
TTLe expansion board	7	Produces TTL (0~5V) digital signals which can be fed into your own equipment, e.g. EEG machines, MRI scanners etc.

In principle each line operates in the same way in that you choose the line, or lines, you wish to activate an output on. The BBTK doesn't differentiate how the lines work, as it assumes all operate in a digital way. For example, as far as the BBTK is concerned a Sounder, or Tone Generator, has the same properties as a TTL out line.

24.1 How to Generate an Unlimited Series of Events Using the Wizard

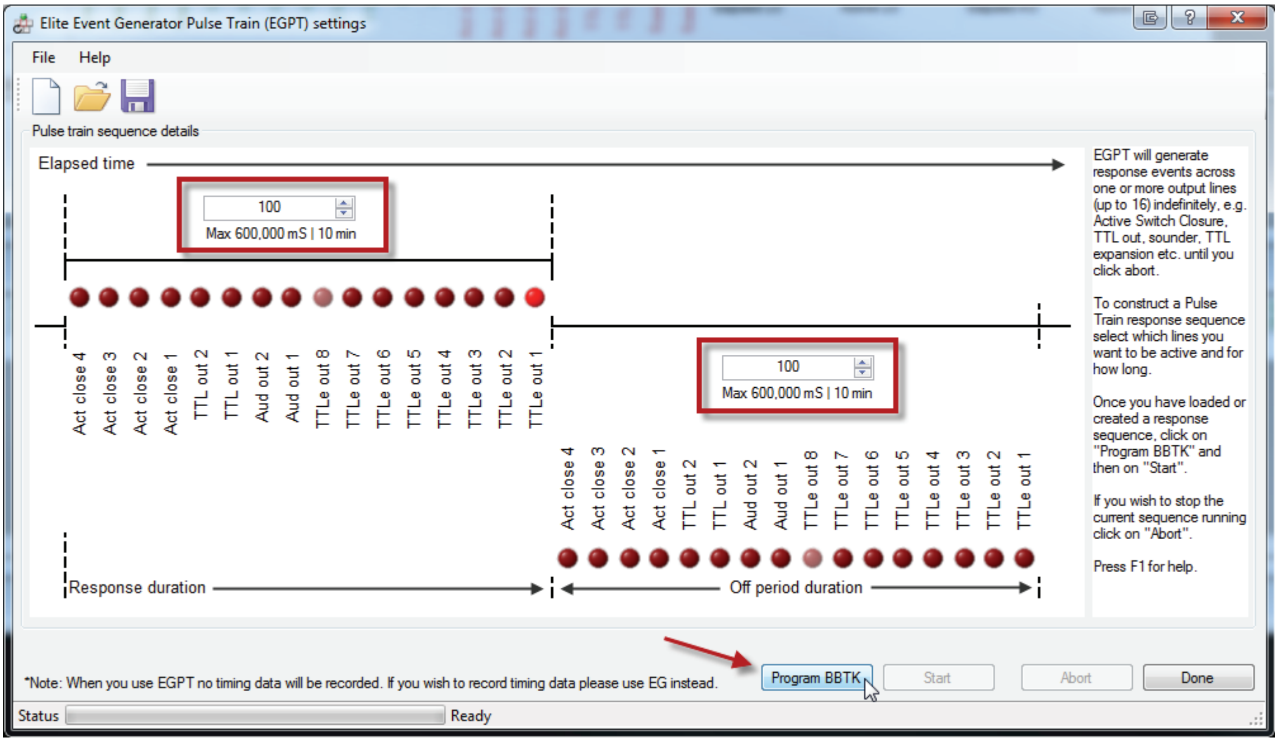
Elite EGPT provides a wizard style interface which automatically generates onsets, offsets and durations for events very simply using a point and click interface.



To generate events across the 15 output lines begin by starting the Elite Event Generator Pulse Train (EGPT) module from the Elite Extensions submenu under Self-Validate or by pressing CTRL+F7.

When the Elite EGPT Module starts you will be presented with a graphical representation of the events you intend to generate and their timing characteristics. The graphic represents elapsed time, On events and Off events along with times for each (red boxes).

In the example shown the BBTK will generate a TTL signal on the TTLe expansion port on TTLe out 1 for 100mS and have on off period where nothing happens for 100mS.



Once you are happy with your sequence click Program BBTK. This will tell the BBTK what events to generate and what their timing characteristics are.

To run the sequence click Start. Whilst generating events the LED of the lines which are active will illuminate when an On event occurs. In the case of the TTLe expansion board the single OUTPUT LED will illuminate.

To stop the sequence click Abort. This will in effect reset the BBTK.

Once reset the PC Software will display the Sensor Threshold Manager. At this point you can choose to load your default values, factory defaults, or choose settings from an open RTL file.

25. Self-Validating Stimulus-Response Paradigms with Elite Digital Stimulus Capture And Response (DSCAR)

The Elite Digital Stimulus Capture And Response (DSCAR) module allows you to self-validate the onset, duration and offsets of any of your stimulus materials across a range of modalities. Up to 20 stimulus input lines can be monitored at any one time using the Elite version of the BBTK*. In addition it allows you to simulate human or machine responses with known timing characteristics in response to a stimulus event or pattern of events across a range of modalities. Events on one or more of the 15 output lines can be generated using the Elite version of the BBTK*.

DSCAR is the cornerstone of the BBTK as it allows you to self-validate a complete experiment in terms of presentation, synchronisation and response timing accuracy. This allows you to compare the timing characteristics of your paradigm against what really happened and to track down and eliminate sources of error. This is the key principle of self-validation and later the self-certification of your published articles and data. Think of DSCAR as a combination of the DSC and EG modules.

Standard sensors and input lines together with the TTLe expansion board cover:

Sensor	No of sensors	Purpose
Microphone	2*	Detect audio stimulus presentations from your equipment.
TTL in	2*	Detect TTL (0~5V) digital signals from your equipment, e.g. EEG markers, fMRI etc.
Opto-detector	4*	Detect visual stimuli.
Keypad button	4*	Detect key presses on the 4 button BBTK response pad.
TTLe expansion board	8*	Detect TTL (0~5V) digital signals from your equipment, e.g. EEG markers, fMRI etc.

Standard modalities and output lines together with the TTLe expansion board cover:

Sensor	No	Purpose
Sounder	2*	Produces a tone that can be used to trigger your own voice keys.
TTL out	2*	Produces TTL (0~5V) digital signals which can be fed into your own equipment, e.g. EEG machines, MRI scanners etc. This interface is also used for the BBTK Robotic Finger.
Active Switch Closure (ASC)	4*	Can be used to close a switch on your own devices to simulate a response, e.g. a key press on a keyboard. In effect the ASC lines are Solid State Relays (SSRs) that short switches out as though a push-to-make event has occurred. For details of how to wire ASC leads to keyboards etc. consult the wiring an ASC section of this guide.
TTLe expansion board	7*	Produces TTL (0~5V) digital signals which can be fed into your own equipment, e.g. EEG machines, MRI scanners etc.

So for example we can instruct DSCAR to look for a visual presentation on Opto 1, wait 300mS and hold down a response key for 100mS. By monitoring all 20 input modalities, or lines, we can log any stimulus event including the visual presentation.

In addition to holding down a response key using an ASC line we could also event mark the same response using one of the TTLe expansion boards output lines so that it could appear on an EEG trace for example. If there was a regular sync pulse we would also be able to monitor this on a TTLe input line.

We could check any onset, offset and duration. By generating a response at a known Response Time after the onset of a visual stimulus we can be certain that we have given whatever paradigm we were testing consistent RTs. For example, it might be a commercial Experiment Generator presenting a simple visual Stimulus-Response paradigm or a more complex EEG based experiment as in the example below. To check RTs we would simply compare the results it recorded against what RTs Elite DSCAR generated, i.e. 300mS. Any difference from 300mS would be due to error. Obviously this error resides somewhere within the whole paradigm and needs to be investigated further.

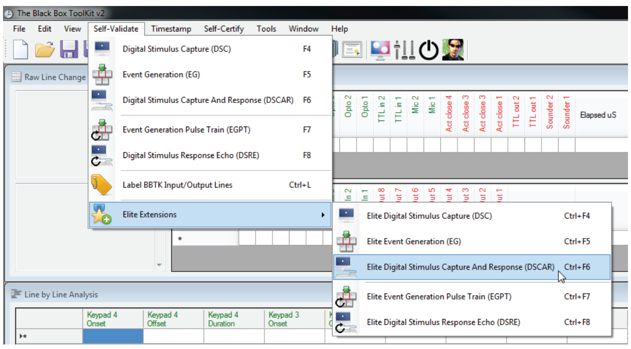
Summary of example paradigm

- Present Visual Stimulus for 1000mS
- Opto-detector 1 placed over the screen region where a white marker block is superimposed over the stimulus image (black screen background)
- Active Switch Closure 1 (ASC 1) lead wired into space bar of keyboard of experiment generator
- ASC response made by the BBTK 300mS RT after the onset of the visual stimulus
- ASC response duration, or key down, lasting for 100mS
- Temporally yoked TTLe event marker wired to EEG machine from TTLe out 1
- Sync pulse from EEG machine wired to TTLe in 8

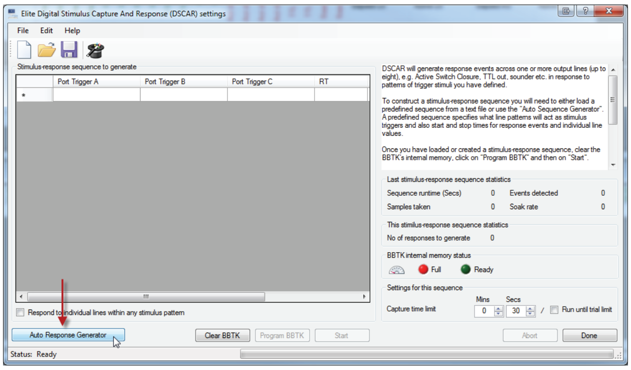
25.1 How to Detect Stimuli and Generate Response Events Using the Wizard

Initially we would advise that you make use of the wizard style interface to help you detect stimuli and generate response events using Elite DSCAR. This automatically helps you select which stimulus events trigger response events very simply using a point and click interface.

The Elite version of DSCAR works in the same way as the standard Entry and Pro version but with access to an additional set of TTL Lines. You are advised to familiarise yourself with Section 11 of this manual before you begin as this covers the DSCAR module in more depth.



To capture and respond to events begin by starting the Elite DSCAR module by selecting Elite Digital Stimulus And Response (DSCAR) from the Elite Extensions submenu under Self-Validate or by pressing CTRL+F6.

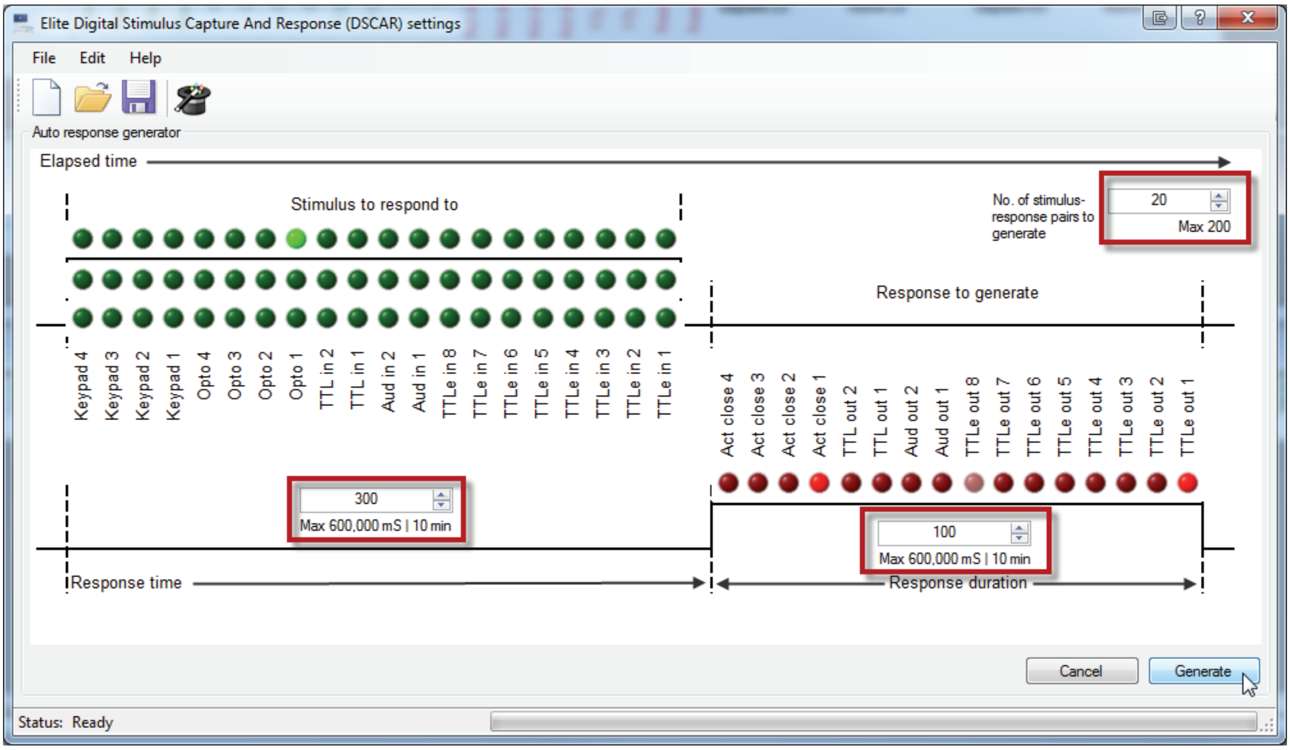


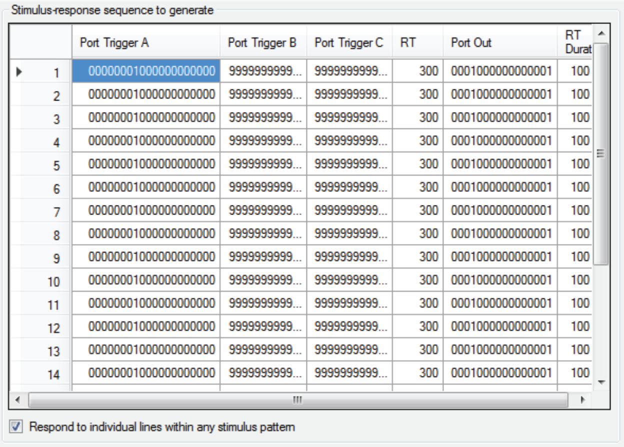
When the Elite DSCAR Module starts you will be presented with a spreadsheet view which has columns for up to 3 trigger stimuli (Port Triggers), a RT, Port Out (events to generate) and a RT duration (how long the response event is active). RT and RT duration are times in milliseconds. Port is a binary pattern indicating which lines should be on or off.

Click on Auto Response Generator to activate the Wizard.

The spreadsheet will be replaced by a graphical representation of the trigger stimuli you wish to respond to and the response events you intend to generate (red boxes).

In the example shown the BBTK will generate an Active Switch Closure (key press) with an RT of 300mS after detecting a visual stimulus on Opto 1 (the stimulus bitmap). The response event (holding a key down) will last for 100mS. Up to 20 stimulus-response pairs will be looked for. Finally click on Generate to fill in the spreadsheet.





Stimulus-response sequence to generate

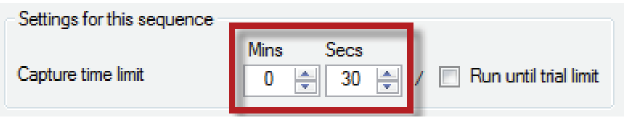
	Port Trigger A	Port Trigger B	Port Trigger C	RT	Port Out	RT Durat
1	00000001000000000000	9999999999...	9999999999...	300	0001000000000001	100
2	00000001000000000000	9999999999...	9999999999...	300	0001000000000001	100
3	00000001000000000000	9999999999...	9999999999...	300	0001000000000001	100
4	00000001000000000000	9999999999...	9999999999...	300	0001000000000001	100
5	00000001000000000000	9999999999...	9999999999...	300	0001000000000001	100
6	00000001000000000000	9999999999...	9999999999...	300	0001000000000001	100
7	00000001000000000000	9999999999...	9999999999...	300	0001000000000001	100
8	00000001000000000000	9999999999...	9999999999...	300	0001000000000001	100
9	00000001000000000000	9999999999...	9999999999...	300	0001000000000001	100
10	00000001000000000000	9999999999...	9999999999...	300	0001000000000001	100
11	00000001000000000000	9999999999...	9999999999...	300	0001000000000001	100
12	00000001000000000000	9999999999...	9999999999...	300	0001000000000001	100
13	00000001000000000000	9999999999...	9999999999...	300	0001000000000001	100
14	00000001000000000000	9999999999...	9999999999...	300	0001000000000001	100

Respond to individual lines within any stimulus pattern

Each row in the spreadsheet is a single Stimulus-Response pair. So for example Port Trigger A “00000001000000000000” means that if Opto 1 detects a stimulus, wait for 300mS (RT) and then generate a Port Out “0001000000000001” response event (ASC key press and TTLe out 1) for 100mS.

So from the spreadsheet we can see that responses will be generated each time a stimulus image is detected. The 20 possible S-R pairings will be worked through in sequence as each is triggered. Port values of “99999999999999999999” means don’t look for a second or third stimulus type.

In this example as there is a regular sync signal coming from the EEG machine so we have ticked Respond to individual lines within any stimulus pattern. This is done as otherwise there may not be a single Opto-detector event. Logically there may be a sync signal on TTLe in 8 that slightly overlaps the Opto event and therefore this won’t be an exact trigger pattern match and so a response won’t be made by the BBTK at the correct time. This overcomes the issue of potentially overlapping events regardless of which line they overlap on.



Before you can begin you will need clear the BBTK memory by clicking Clear BBTK. Once the memory has been cleared set the Capture Time Limit. In this case the sequence will run for 30 seconds.

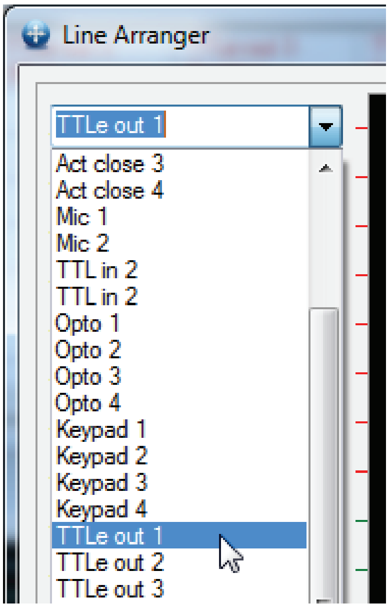
When the BBTK internal memory has been cleared the status LED will go green and the Program BBTK button will be enabled. Click the Program BBTK button to load the sequence to be generated.

The Start button will now be enabled in the PC Software ready for you to tell the BBTK to start looking for stimulus images to trigger its responses.

Start the paradigm on the PC running the Experiment Generator.

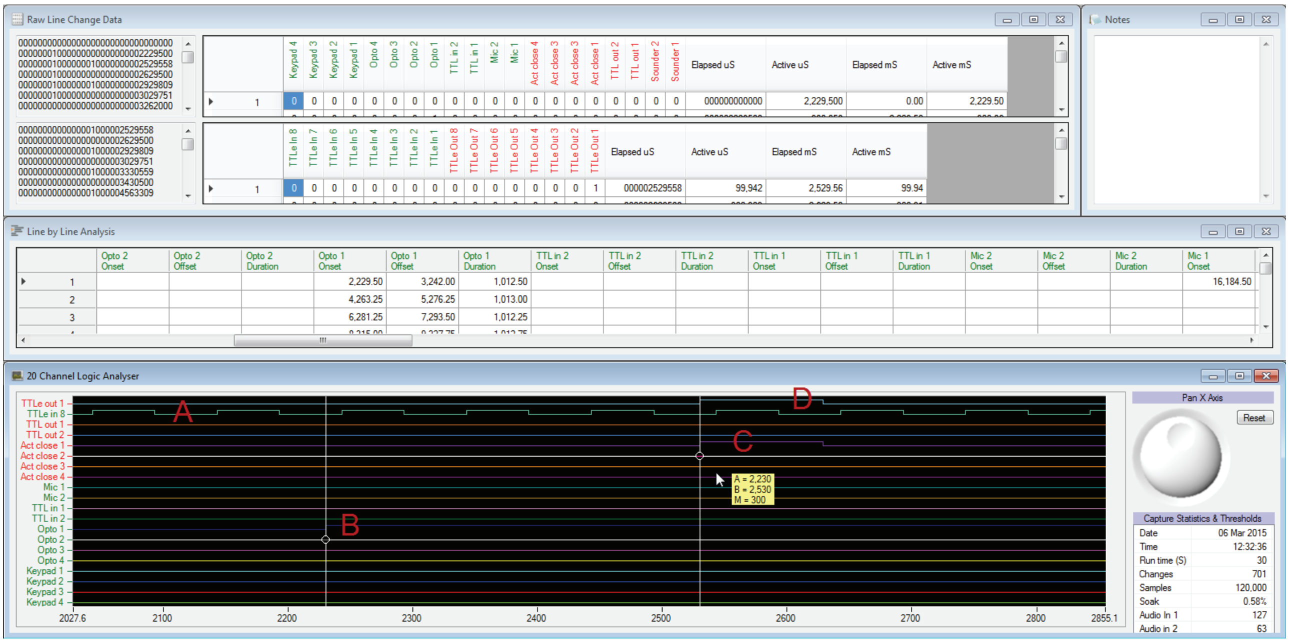
Ensure that no BBTK sensors are triggering and then click Start on Elite DSCAR.

As each stimulus presentation is detected the various LEDs on the front panel of the BBTK will illuminate. After 30 seconds have elapsed the BBTK will indicate that the capture has completed. The number of line changes or Events will be listed along with a total runtime. Uploading… will be displayed as data is sent to the PC.



Remember that to display the two TTLe expansion board input and output lines you will need to use the Line Arranger. Do this by double clicking on the plot, or Y axis, and swap them for other unused lines, e.g. Sounder 1 in this case.

From the resulting Logic Analyser plot shown below we can see that Visual Stimulus presentations were logged as they were presented by the Experiment Generator (Opto 1, blue trace B), Response Events were generated as a Stimulus-Response pair from the BBTK (Active Switch Closure 1, purple trace C) and the yoked TTLe out 1 event marker was also recorded as being sent (D). The sync pulse from the EEG machine can be seen on TTLe in 8 (A).



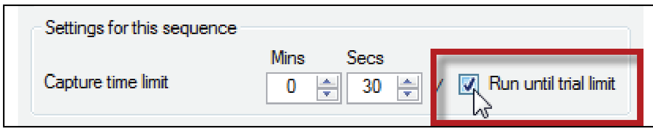
The tooltip pop-up shows that Elite DSCAR responded with a press of the space bar via ASC 1 (C) with an RT of 300mS as intended. Simultaneously a TTL event marker was sent on TTLe out 1 (D). By comparing the RT of 300mS against what was recorded by the experiment generator makes it possible to determine presentation and response timing errors. The EEG trace can also be examined to check for where the event marker from the BBTK is shown relative to the real world onset of the visual stimulus.

The experiment generator itself would also be likely to produce a TTL event mark on the EEG trace indicating when it thought it displayed the stimulus image. If this was the case it would have been advisable to T into that TTL lead and take a signal from it to feed into either one of the standard TTL in lines, e.g. TTL in 1/2 or one of the TTLe in expansion board lines.

This would be useful as if the experiment generator was waiting for a sync pulse to align its visual presentation this would tell us how accurately that was done.

25.2 Capture Until a specified Number of Trials Have Been Completed

Some paradigms make use of variable trial durations and so it is not always possible to set an end time limit for which the BBTK should respond to stimuli for. If this is the case you have the option to respond to stimuli until either the Capture Time Limit is reached or the number of trials you have programmed is reached.



To stop and upload data after a set number of stimulus-response trials check the Run Until Trial Limit checkbox.

For example if you have setup a 100 trials then 100 responses will be made to the trigger stimulus you have chosen as long as the Run Until Trial limit checkbox is checked. You should ensure that the Capture Time Limit is set for long enough whether this option is checked or not.

If the trial limit is reached the BBTK will stop looking for stimulus triggers, quit early and upload any timing data collected. It will do this as soon as the last response of a trial series is made.

26. Generating Events Using Elite Digital Stimulus Response Echo

The Elite Digital Stimulus Response Echo module is very similar to the Elite DSCAR module in that it allows you to generate a series of response events with a known Response Time and duration across a range of modalities triggered by a predefined stimulus pattern.

Up to 20 stimulus input lines can be monitored at any one time using the Elite version of the BBTK* and events on one or more of the 15 output lines can be generated in response.

The key differences are that the Elite Response Echo module does not collect any timing data that can be uploaded and analysed by the PC Software; it is not limited to a fixed number of events that it can generate in response to stimuli (it can generate an infinite number of events); and it cannot vary timings on an event by event basis (it can only generate a fixed pattern).

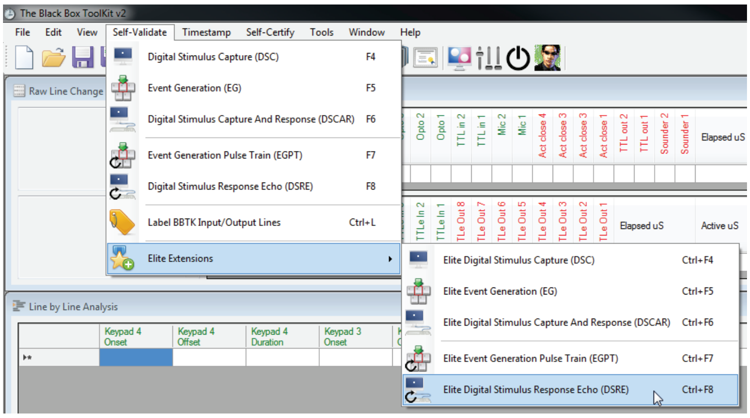
Elite DSRE operates like an echo device or a ping test used to check network connectivity on a computer. If it detects a predefined stimulus or stimulus pattern it will make a response. One use for Elite DSRE might be to send a regular series of event markers to an EEG machine or MRI scanner using one of the TTLe expansion board TTL out lines based on detecting a visual stimulus.

Note that to stop a sequence you will need to click Abort which will reset the BBTK. Thus you are advised to save your Sensor Threshold Settings before you use this module if you have customised them specifically, or reload an existing RTL file and set to those settings.

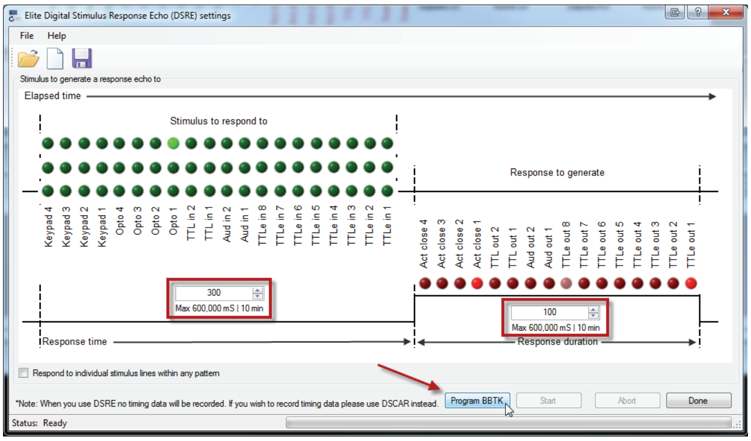
26.1 How to Respond to an Unlimited Series of Stimuli Using Elite Digital Stimulus Response Echo (DSRE)

Elite Digital Stimulus Response Echo only provides a wizard style interface which automatically generates Response Times and durations for events very simply using a point and click interface.

The Elite version of DSRE works in the same way as the standard Entry and Pro version but with access to an additional set of TTL Lines. You are advised to familiarise yourself with Section 12 of this manual before you begin as this covers the DSRE module in more depth.



To respond to stimulus events across the 20 input lines begin by starting the Elite Digital Stimulus Response Echo module by selecting Elite Digital Stimulus Response Echo (DSRE) from the Elite Extensions submenu under Self-Validate or by pressing CTRL+F8.



When the Elite DSRE Module starts you will be presented with a graphical representation of what stimuli you wish to respond to, the Response Time, what response event to generate and what duration that event will have.

In the example shown the BBTK will generate an Active Switch Closure (Act Close 1) and a TTLe out 1 event with a RT of 300mS for a duration of 100mS each time a visual stimulus is detected on Opto 1.

As described in the previous section when using DSCAR you have the option of using AND and OR logic to define stimulus patterns to respond to. If you are unsure if other stimulus events will be detected and an exact pattern match might occur you can tick “Respond to Individual Lines Within any Stimulus Pattern”. This will trigger a response irrespective of activity on other lines.

Once you are happy with your sequence click Program BBTK. This will tell the BBTK what events to generate and what the timing characteristics are. The BBTK display will inform you that it is being programmed.

To run the sequence click Start. The BBTK display will change to Running and the PC Software will grey out The Program BBTK and Start button, whilst the Abort button will be enabled. The status bar will change to “Generating”.

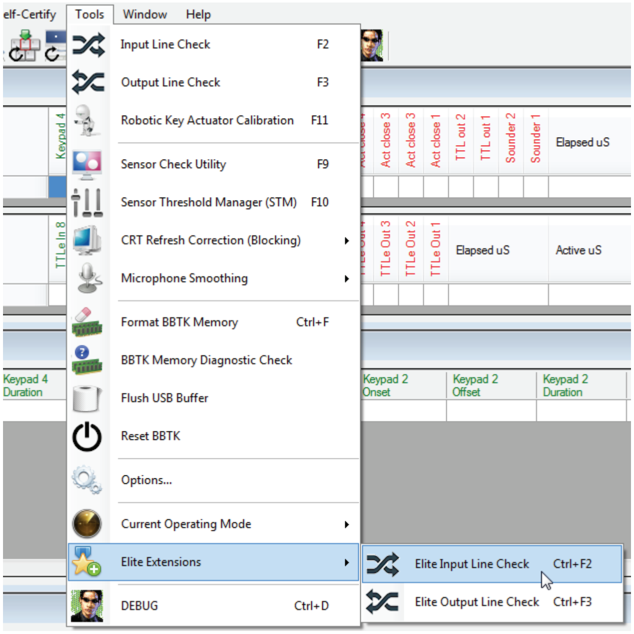
Whilst generating events the LED of the lines which are active will illuminate when an On event occurs. In the case of the TTLe expansion board the single OUTPUT LED will illuminate.

DSRE will run the same sequence of stimulus-response pairs until the BBTK is reset or switched off. To stop the sequence click Abort. This will in effect reset the BBTK.

Once reset the PC Software will display the Sensor Threshold Manager. At this point you can choose to load your default values, factory defaults, or choose settings from an open RTL file.

27. Elite Tools & Utilities

27.1 Elite Input and Output Line Check



To help you check whether the various TTLe expansion board input and output lines are working two utilities are provided. They let you monitor input lines live and manually generate outputs on one or more lines. You can use them for checking inputs from Optos, Mics etc. together with the TTLe lines.

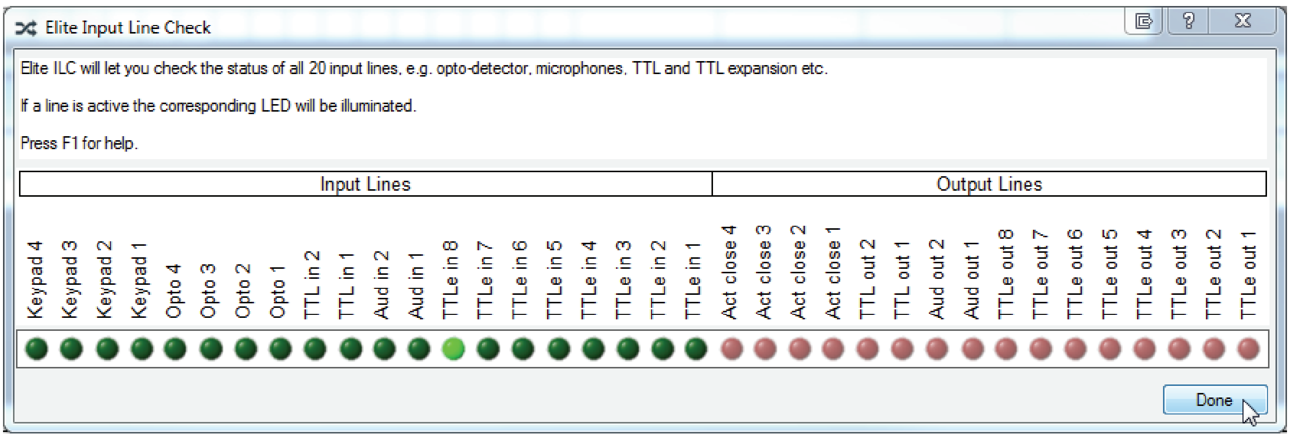
To start the Input Line Check select Tools | Elite Extensions | Elite Input Line Check or press CTRL + F2.

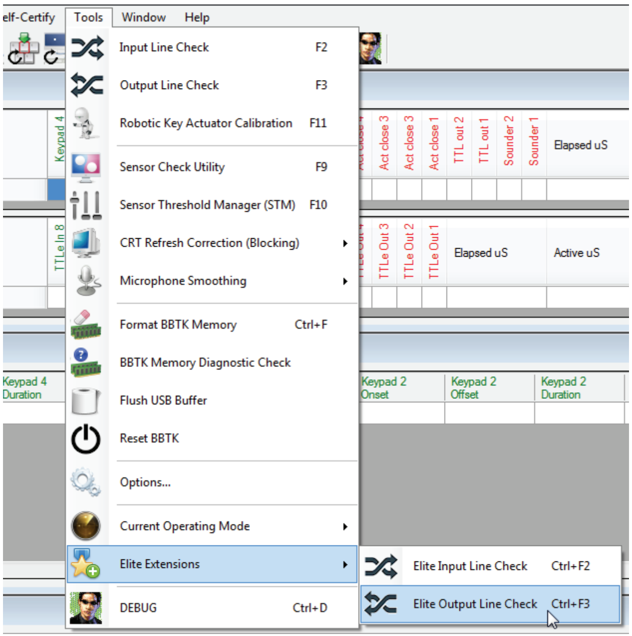
The BBTK will show that the ILC is running.

When the Elite ILC starts the 20 input lines are represented by green LEDs (12 standard input lines and 8 TTLe input lines). When a line is active, i.e. when a TTLe input line goes high the corresponding LED will illuminate. In the example below a +5V TTL signal has been fed into TTLe in 8.

ILC is designed to help you setup your sensors and TTL lines and lets you view status using the PC Software rather than having to look at the status LEDs on the front of the BBTK. When you click on Done the BBTK will reset.

Note this utility is streaming signals live via the USB port and so there may be a noticeable lag.





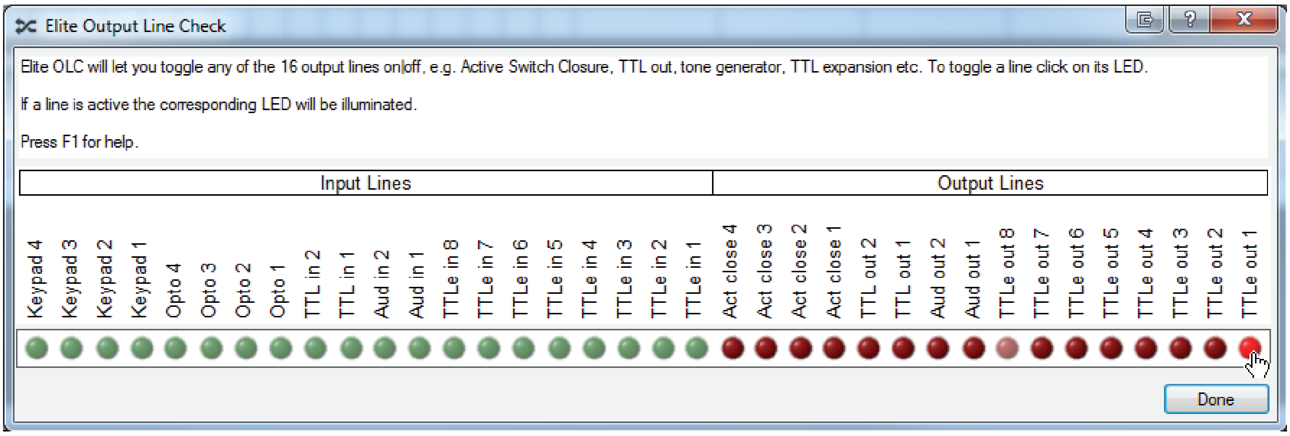
To manually generate events or signals on one or more lines to test that your own equipment is working select Tools | Elite Extensions | Elite Output Line Check or press CTRL+F3.

The BBTK will show that the OLC is running.

Each red LED represents the corresponding output line.

To send a TTLe expansion board output line high (+5V) click on the red LED. In this example TTLe out 1 will go high and latch high. To turn the relevant line, or lines, off click on the LED again. When you click on Done the BBTK will reset.

Note this utility is streaming signals live via the USB port and so there may be a noticeable lag.



28. Troubleshooting

28.1 Rebooting the BBTK

Occasionally you may need to reboot your Black Box ToolKit when a reset is ineffective. The basic procedure for rebooting is:

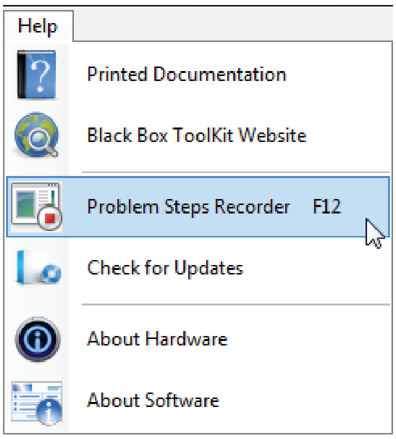
1. Unplug the USB lead from your host PC
2. Remove the power adapter from the BBTK or turn it off at the mains supply
3. Wait 5 seconds
4. Reapply power so that the Copyright and firmware version are shown on the LCD screen
5. Plug the USB lead back into your PC

Depending on the cause of the issue you may need to reset the BBTK using the reset button on the PC Software toolbar to reconnect with the BBTK.

If you continue to have problems connecting quit the PC Software, carry out steps 1 though 5 and then restart the PC Software on your host PC.

28.2 Problem Steps Recorder

If you are running the PC Software on Windows Vista, Windows 7, 8, 8.1 or 10 then you can make use of the Microsoft Problem Steps Recorder to help us troubleshoot problems and produce a fix. The PSR automatically records everything you do in a series of screen grabs and narrative text. This is stored as a compressed HTML file (MHT) and compressed (zipped) ready to be emailed to us. Unfortunately Microsoft does not produce a version of PSR for Windows XP.



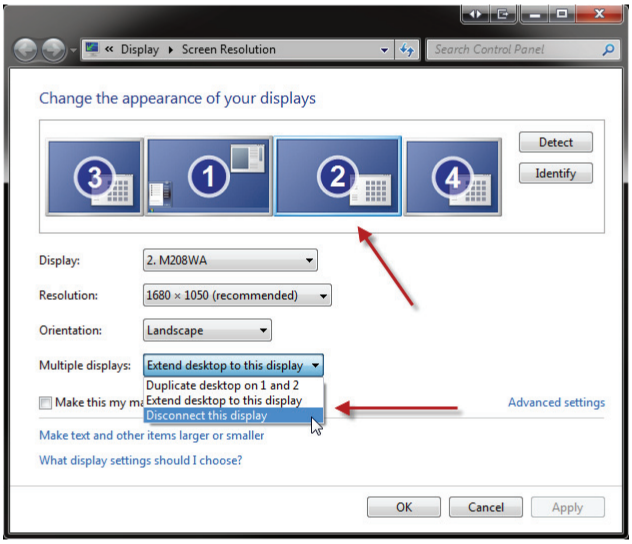
From the Help menu start the Problem Steps Recorder.

You should aim to faithfully recreate what caused your issue. Contact us on our support email address below for advice before sending us your PSR recording as it may be too large to email.

support@blackboxtoolkit.com

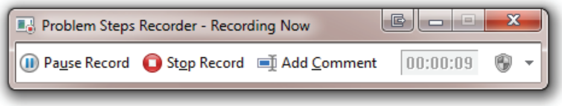
It's often useful to think about exactly what steps you need to recreate before you begin.

Once you start PSR a recording toolbar will appear. To start to record click Start Record or press Alt+A.



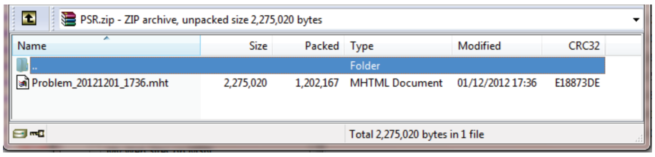
When recording you are advised not to have any personal information that could be captured and ensure you only click on the BBTK PC Software and repeat the exact steps that caused you to have an issue.

To save screen grabbing all of your monitors you are strongly advised to disable all monitors other than your primary display. If you have a multiple monitor setup it's best to make sure that the PSR Toolbar is on the same monitor as the BBTK PC Software, i.e. your primary monitor.



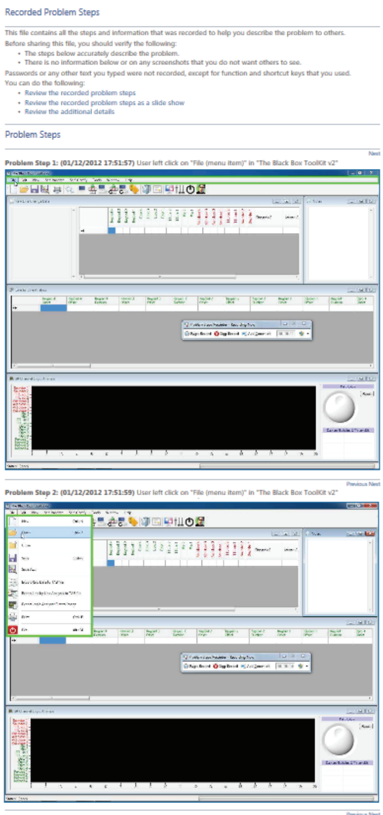
When you start to record your actions the toolbar will change.

To stop recording click Stop record or press ALT+O.



When you click on Stop or close the PSR you will be prompted where to save the resulting Zip file to your hard drive.

If you have software that can open a Zip file installed on your PC you can open it up and look inside.



A screen grab of each interaction you had will be shown as a series of steps.

For example if you click on a menu it will be screen grabbed and a narrative piece of text produced. All interactions will be timed and dated.

By recording the exact series of steps it helps you describe the issue you are having more easily.

PSR logs help us to fix issues as rapidly as possible as it helps us recreate the issue in the exact same manner you did.

If you had an issue when working with a particular file you should also be prepared to send us that to aid diagnosis.

Recording Session: 01/12/2012 17:51:56 - 17:52:08

Problem Steps: 5, Missed Steps: 0, Other Errors: 0

Operating System: 7601.17592.x86fre.win7sp1_gdr.110408-1631 6.1.1.0.2.48

Problem Step 1: User left click on "File (menu item)" in "The Black Box ToolKit v2"
Program: The Black Box ToolKit v2, 1.3.0.0, The Black Box ToolKit Ltd, THE BLACK BOX TOOLKIT V2.EXE, THE BLACK BOX TOOLKIT V2.EXE
UI Elements: File, MenuStrip, MenuStrip, WindowsForms10.Window.8.app.0.2bf8098_r13_ad1, The Black Box ToolKit v2, WindowsForms10.Window.8.app.0.2bf8098_r13_ad1

Problem Step 2: User left click on "File (menu item)" in "The Black Box ToolKit v2"
Program: The Black Box ToolKit v2, 1.3.0.0, The Black Box ToolKit Ltd, THE BLACK BOX TOOLKIT V2.EXE, THE BLACK BOX TOOLKIT V2.EXE
UI Elements: File, MenuStrip, MenuStrip, WindowsForms10.Window.8.app.0.2bf8098_r13_ad1, The Black Box ToolKit v2, WindowsForms10.Window.8.app.0.2bf8098_r13_ad1

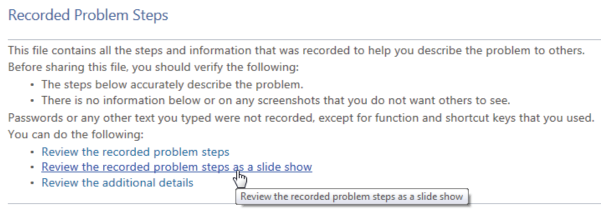
Problem Step 3: User left click on "Open (menu item)"
Program: The Black Box ToolKit v2, 1.3.0.0, The Black Box ToolKit Ltd, THE BLACK BOX TOOLKIT V2.EXE, THE BLACK BOX TOOLKIT V2.EXE
UI Elements: Open, File, MenuStrip, MenuStrip, The Black Box ToolKit v2, WindowsForms10.Window.20808.app.0.2bf8098_r13_ad1

Problem Step 4: User left double click on "Name (editable text)" in "Open"
Program: The Black Box ToolKit v2, 1.3.0.0, The Black Box ToolKit Ltd, THE BLACK BOX TOOLKIT V2.EXE, THE BLACK BOX TOOLKIT V2.EXE
UI Elements: Name, BBTK v2, Items View, DirectUIHWND, ShellView, SHELLDLL_DefView, CtrlNotifySink, DirectUIHWND, DUIViewWndClassName, Open, #32770

A textual Additional Details section will be shown at the bottom of the sequence of screen grabs.

This shows additional technical details of what was recorded.

You can also replay the sequence of actions as a slide show. Screen grabs are played back at the same speed they were recorded.



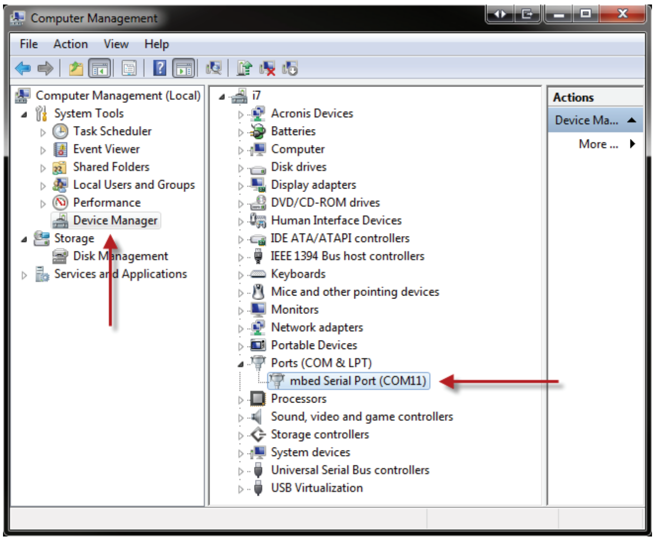
In short a PSR helps you to help us.

Contact us on our support email address below for advice before sending us your PSR recording as it may be too large to email.

support@blackboxtoolkit.com

28.3 Changing the Virtual Serial Port Manually and Reducing Transmission Speed

The BBTK is controlled by sending serial commands over a USB connection from the PC Software. The serial port driver you install when you first setup the BBTK creates a virtual COM port. For the BBTK to know which virtual port to use there needs to be an entry in the BBTK.ini on the BBTK flash drive letter and also a matching entry in the XML file that holds the default settings for the PC Software. Occasionally Windows can become “confused” as to which serial port it uses for a given USB device, e.g. if you plug the BBTK into different ports each time you use it.



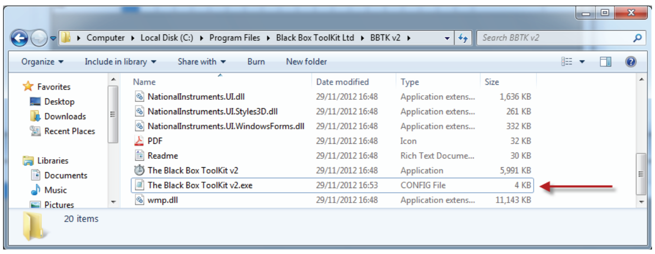
Changing COM Ports

To change the virtual COM port used manually you first need to work out where the BBTK is connected.

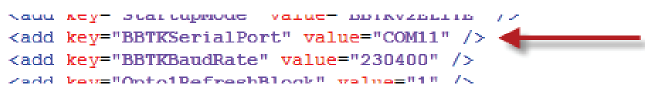
Plug the BBTK into your normal USB port and then open the Device Manager in Windows.

Control Panel\System and Security\Administrative Tools\Computer Management

Expand the Device Manager entry and then the Ports (COM & LPT) and look for an “mbed Serial Port” hive. In this example the BBTK is connected to **COM11**.



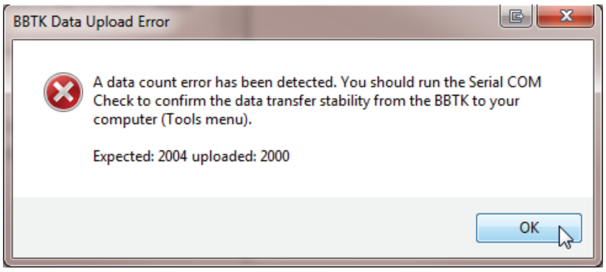
Next you should locate the BBTK PC Software configuration file (The Black Box ToolKit v2.exe.config) and open it in an XML editor or in Notepad. For more information see the “Where are Configuration Options Stored?” section of this guide.

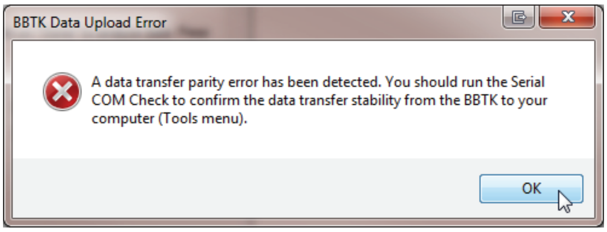


Locate the key that sets the serial port and enter the same COM port as shown in the Device Manager.

Save the file and then reboot the BBTK by unplugging both the USB and power supply. Then power back on, wait a few seconds and then reconnect the USB. Restart the PC Software. After a few seconds the PC Software should connect to the BBTK.

If you have more than one BBTK you will need to ensure you switch to the correct one in Tools | Options. Alternatively you can install the PC Software twice into two different folders. This will allow you to have two separate XML configuration files and therefore multiple COM ports.





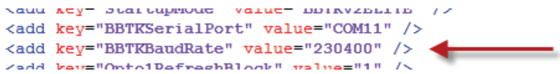
Reducing Transmission Speed

Depending on the speed of the PC you are running the PC Software on you may need to reduce the speed of the virtual serial port as it may not be able to cope reliably with high speed transmission. If your PC can't cope you will normally receive a message from the BBTK PC Software as each data upload from the ARM is verified.

The default transmission speed is:

230400 bps

But you can choose any standard serial transmission speed you wish.

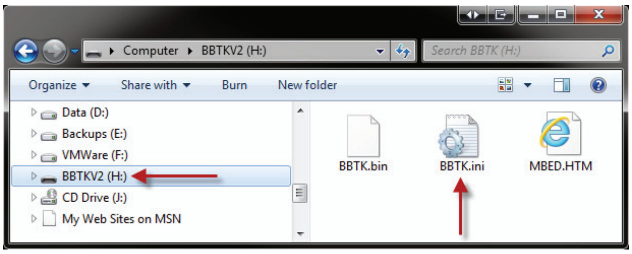


To do this edit the XML configuration file as described above. Locate the BBTKBaudRate key and edit the value to a lower standard serial speed. This tells the PC Software what the transmission speed is.

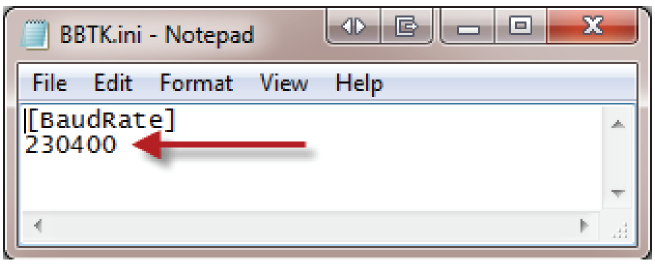
9600
19200
38400
57600
115200
230400
460800
921600

A list of standard supported serial transmission speeds is shown opposite.

The slower the speed you choose the longer it will take to upload data from the BBTK to the PC Software. This does not affect timing accuracy as that is independent of upload speed.



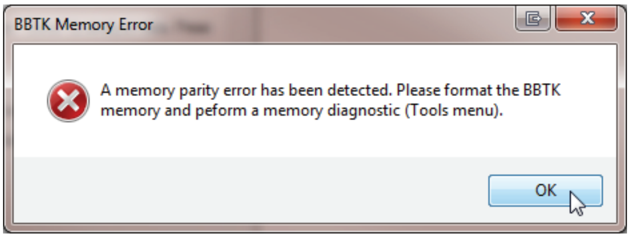
To complete the process you need to tell the ARM chip in the BBTK what transmission speed to send data back to the PC Software at. To do this edit the BBTK.ini file on the BBTK flash drive in Notepad or other text editor.



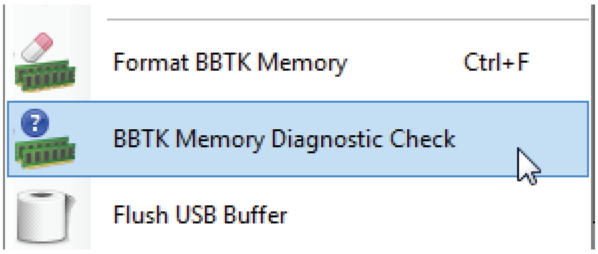
Edit the BaudRate entry to match that you chose for the PC Software. Remember to save the file and then reboot the BBTK as described above.

If you continue to have transmission speed issues reduce the speed in both configuration files until you achieve stability.

28.4 Carrying Out a BBTK Memory Diagnostic Check

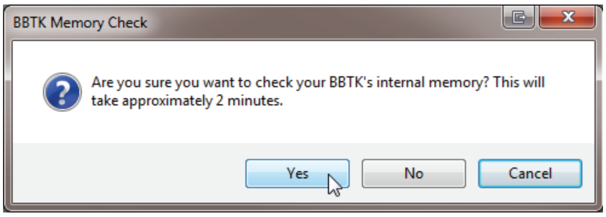


Your BBTK contains an 8MB (64Mbit) memory chip to store timing data which is separate to the memory on the ARM chip and the 2MB flash drive which contains the firmware etc. This is good for at least 100,000 erase/program cycles and has a 20 year data retention life.

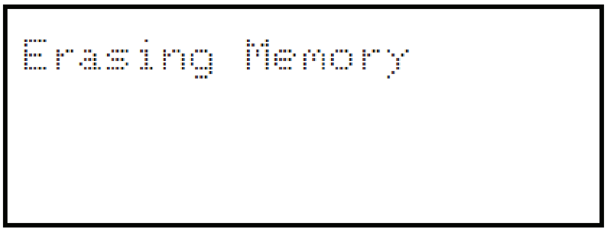


If you receive a BBTK Memory Error message you are advised to run a full memory diagnostic.

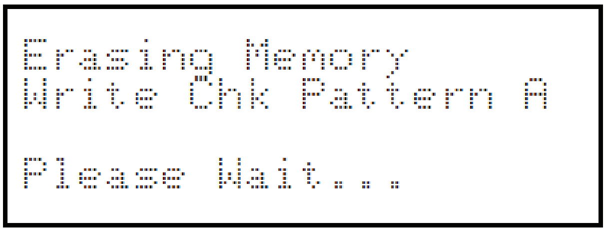
To carry out a memory check, select “BBTK Memory Diagnostic Check” from the Tools menu.



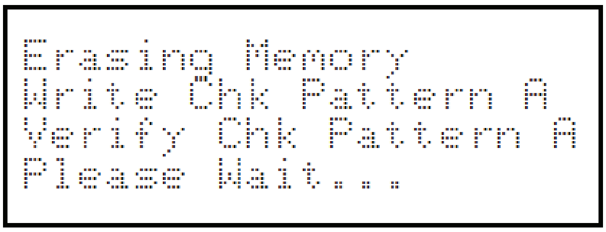
Note that a full memory check will take around 2 minutes as 64,000,000 memory cells will be erased, written to and read from.



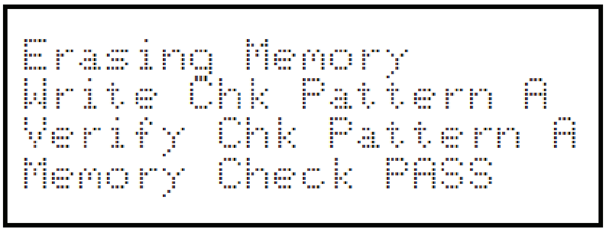
First every sector of the memory chip will be erased.



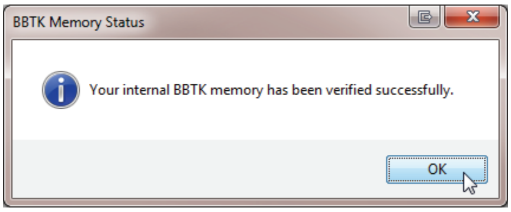
A check character will then be randomly generated by the PC Software and sent to the BBTK. This character will be written to every memory cell.



Every memory cell will be read in sequence to ensure that it matches the check character.



Finally you will be told whether the memory check has passed the test.



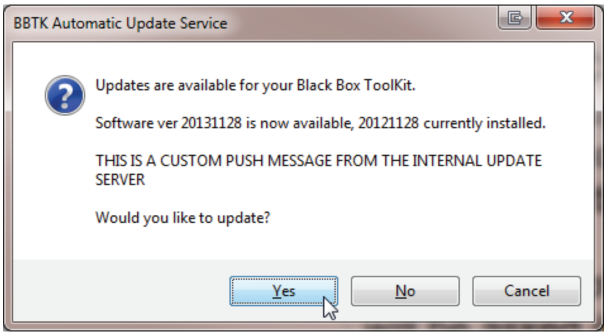
A dialog box will also appear in the PC Software to inform you as to the result of the test.

If your BBTK memory fails the test you are advised to run the test a further couple of times.

Should your BBTK consistently fail the memory check you should contact us for advice. Unfortunately this is not a user replaceable part as it is intended to last for the life of your unit. If your BBTK is still within its standard warranty period you will need to ship it back to us for a replacement memory chip to be fitted.

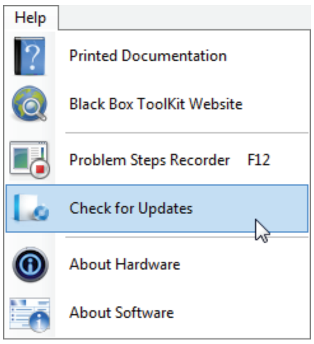
28.5 PC Software and ARM Firmware Update Checks

By default the BBTK PC Software will check for updates once each time you start it.

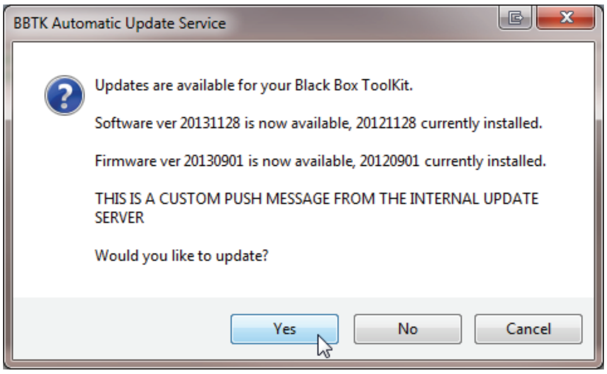


The BBTK PC Software is programmed to automatically check for an update 30 seconds after start up depending on whether you are connected to the internet.

If there is a software update available you will be asked if you wish to visit the relevant support pages of our website. It is important you have correctly entered your serial number as this helps us provide the correct versions of the PC Software and ARM firmware for you.



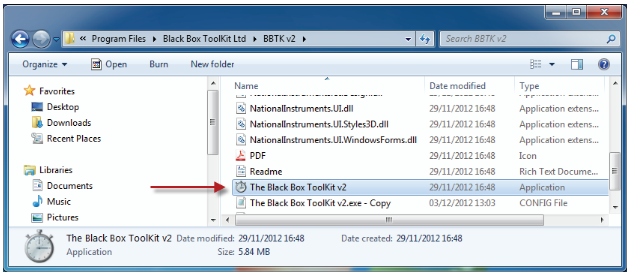
To check the firmware version you will need to carry out a manual update check. This will check both whether there is a newer version of the PC Software and/or ARM firmware.



When you carry out a manual update check if there is a newer version of the ARM firmware you will be informed.

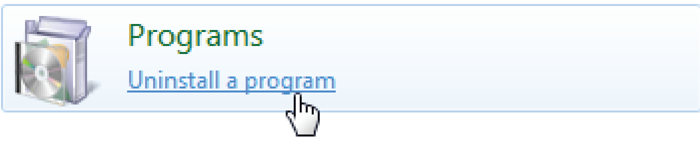
You should download a complete package which includes both the PC Software and matching ARM firmware.

28.6 Updating PC Software

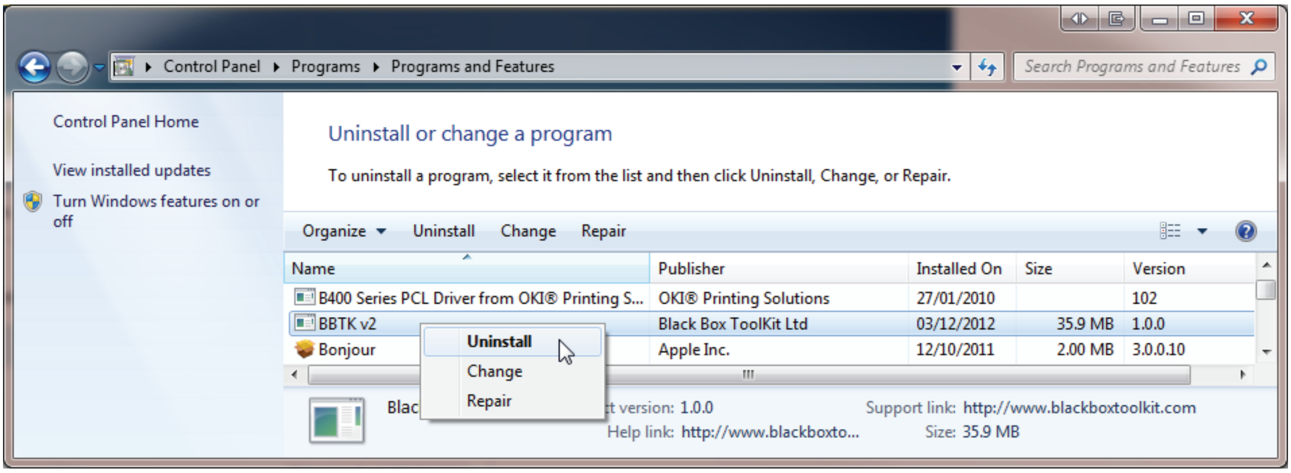


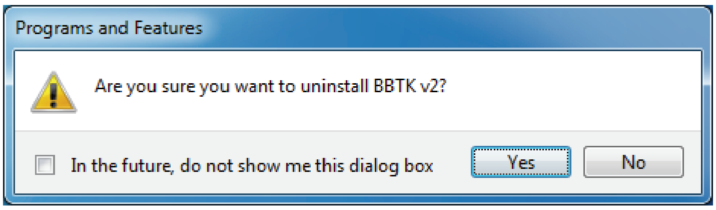
For reference you are advised to make a backup copy of your XML Config file detailed in the, "Where are Configuration Options Stored?" section of this guide.

All your default threshold settings, line labels and other details are stored in this file.

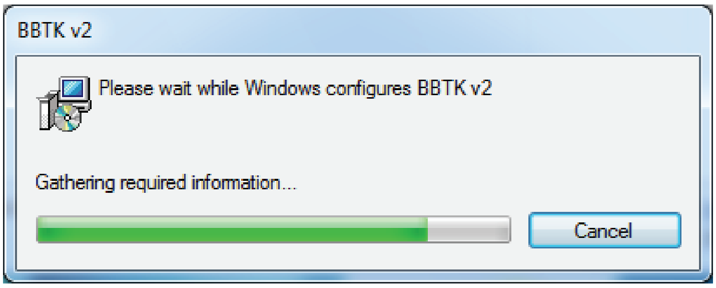


In the control panel you should click on the Uninstall a program link





Next choose the BBTK v2, right click and select Uninstall. The Uninstall process will now begin. If prompted click on Yes.

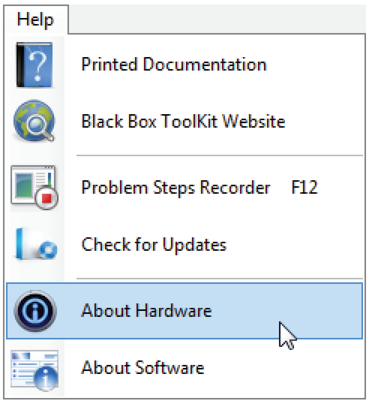


The BBTK PC Software will then be uninstalled.

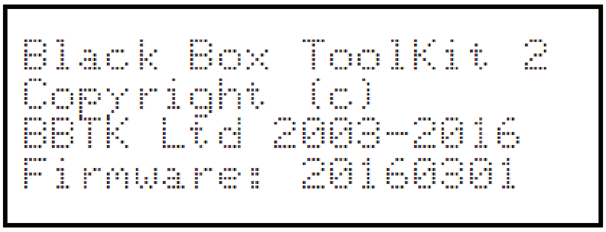
To update your PC Software to the latest version simply reinstall as per the, “Installing the Black Box ToolKit PC Software” section of this guide.

You should not need to reinstall any drivers unless explicitly told to do so in the instructions that come with the specific update. Simply update the PC Software by uninstalling and reinstalling it.

28.7 Updating Firmware

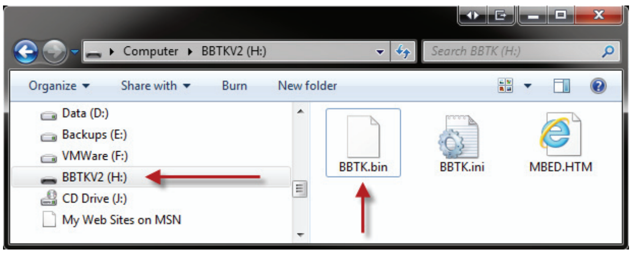


To determine which firmware you have select Help | About Hardware.



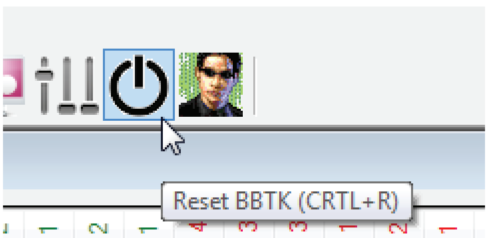
You are advised to make a note of the firmware version. The firmware date is in the following format:

YYYY MM DD



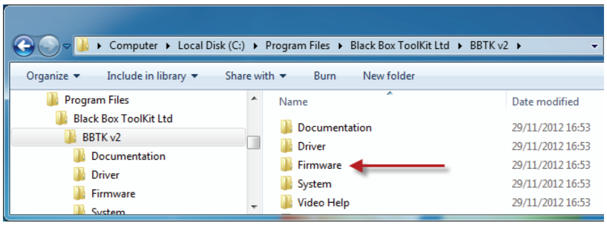
Updating the ARM firmware is incredibly easy. Locate the flash drive letter which contains the BBTK.bin firmware file.

Download a later firmware file from the BBTK website and simply copy it over to replace the existing one. You are advised to keep a copy of your original.



To run the new firmware simply reset the BBTK using the Reset BBTK toolbar button.

Alternatively power cycle the BBTK by removing USB lead, then the power lead. Wait 5 seconds, reapply the power and then reconnect the USB lead.



A copy of the firmware your BBTK PC Software shipped with is included within the firmware folder should you need to recover it.

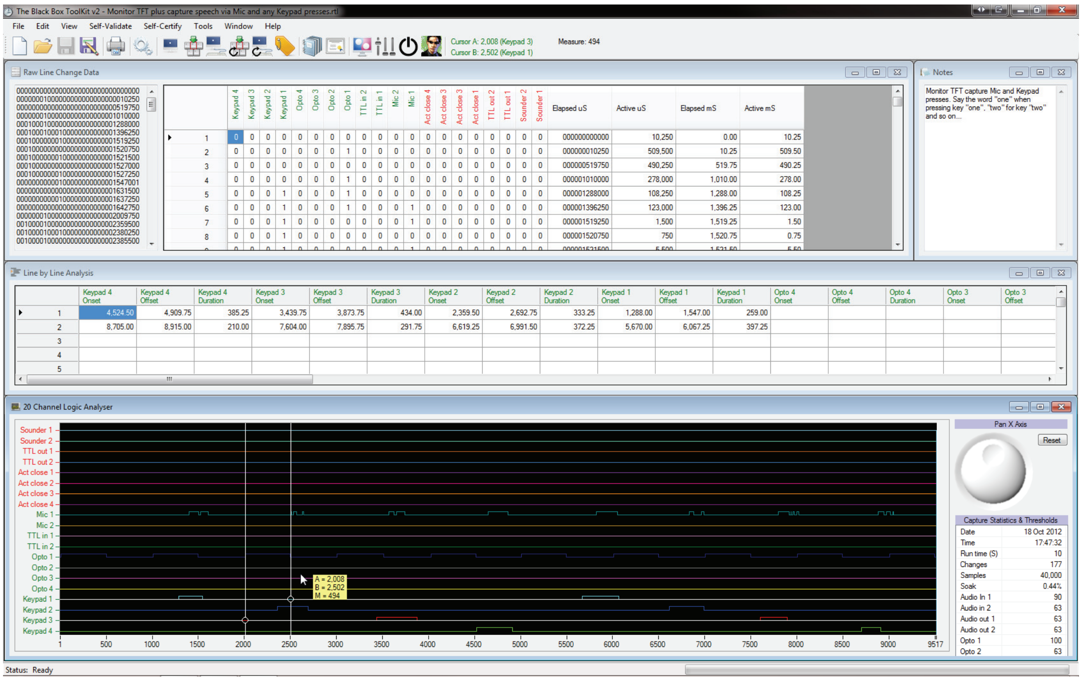
29. Technical Specifications

29.1 Hardware Specifications

- NXP LPC1768 running at 96MHz
- ARM Cortex-M3 32 bit processor (ARMv7-M architecture)
- 3.3Vdc Abracon Corporation CMOS SMD Crystal Clock Oscillator
- Internal timestamps stored with µS precision (accuracy to millionths of a second)
- 64MBit internal memory (8MB RAM) for storing samples (max 262,144 line changes)
- RFI coated ABS plastic or metal enclosure
- Line change detection and time stamping (only stores changes, e.g. a bitmap on an opto-detector is 2 line changes regardless of duration. That is, on and off)
- 2MB flash drive (BBTK appears as a drive letter under Windows/OS X for easy firmware updates - copy a single firmware file across and reset. No need to flash firmware!)
- LCD status screen (20x4 lines)
- Rotary encoder for setting sensor activation thresholds - turn and press to confirm (all thresholds stored and recalled digitally)
- USB connection to host PC for sequence programming and uploading and analysis of timing data
- Once programmed fully autonomous and unaffected by anything you do on the host PC
- Can be used with low powered netbooks
- Fully documented API for controlling the BBTK from your own software (uses serial commands over USB virtual COM port)
- Powered by 5V Switch Mode PSU (suitable for worldwide use)
- Each of the 20 standard lines has it's own activity LED on the front panel
- Opto and Mic smoothing built-in and controllable via GUI (block CRT refreshes together for ease of analysis)
- Up to 36 input and output lines across a range of sensors (Elite model)
    - 4x opto-detectors (front panel)
    - 2x TTL input lines (uses breakout board via 25-way D on rear)
    - 2x TTL output lines (uses breakout board via 25-way D on rear)
    - 4x Active Switch Closures using Solid State Relays (uses breakout board via 25-way D on rear)
    - 2x BBTK digital microphones (front panel)
    - 2x BBTK digital sounders (front panel)
    - 4 key BBTK response pad connector (9-way D on rear)
    - 16 additional TTL input/output lines using rear 25-way expansion port

29.2 Software Specifications

The BBTK version 2 comes complete with a redesigned and fully integrated control and analysis application written in the Microsoft .NET 4 framework for the Windows Presentation Foundation (WPF). It supports Microsoft Windows XP SP3, Vista SP2, 7 SP1, 8, 8.1 and 10 natively. It also supports VMWare/Parallels on Mac OS X and Linux so long as a virtual serial/COM port can be used.



- Integrated 4 Window MDI interface (raw line change data, notepad, line-by-line analysis spreadsheet and 20 channel logic analyser)
- Easy to use clear well designed interface based on customer feedback and field trials
- Latest WPF and interface design
- Colour coded spreadsheets and logic analyser
- Ability to name your own line labels
- Make notes describing your paradigm (up to 64k)
- Wizards for constructing stimulus-response sequences
- Save programs generated by the wizards for reuse or modification
- Easy to use timing cursors
- Timing tooltips shown when analysing data
- Capture statistics stored with each capture
- Digital sensor activation thresholds stored with each capture
- Highlight timing data in spreadsheets from the logic analyser by pressing H
- Save spreadsheets so you can load them in Excel
- Copy data or logic analyser plots for pasting into Word
- Produce summary reports in HTML (includes logic analyser plots etc)
- Video based help system (never look at a printed manual again!)
- High quality printed manual for reference purposes
- Automatic update notifications of the latest BBTK ARM firmware and PC Software
- Clear and easy to understand file formats (fully documented)
- Integrates with the hardware for setting sensor activation thresholds. Turn the knob on the BBTK and the thresholds alters sliders shown in the PC Software
- Global settings stored in a readable XML file
- Supports the Windows Problem Steps Recorder (PSR) for enhanced troubleshooting
- Internationalisation supported by Windows regional options

30. Timing Specifications

30.1 Digital Stimulus Capture And Response (DSCAR) module timing characteristics

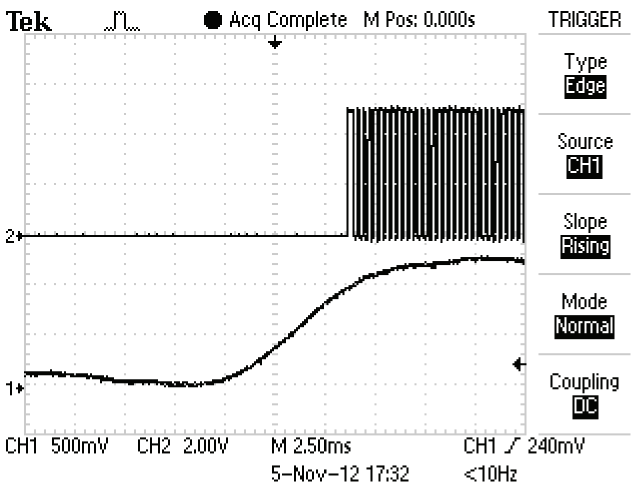
Various validation timing tests have been carried out at all stages of development. Initially these have focused on the Digital Stimulus Capture And Response (DSCAR) module of the BBTK and associated ARM firmware. Timing measures presented are round trip times. That is, the time taken to detect a stimulus and generate a response to it. It should be noted that timings are affected by how appropriately sensor activation thresholds are set and the quality of the equipment presenting the stimulus.

Description	Nominal accuracy
BBTK keypad key down event to generation of a tone using BBTK Sounder	<100µS
Tone duration accuracy of a BBTK Sounder	<80µS
Electrical signal of BBTK sounder to output of audio smoothing PIC (leading edge of a sound detected)	<159µS
Mic smoothing error on sound duration (20mS smoothing on trailing edge)	<500µS
Frequency of BBTK Sounders	3.4KHz +/- 1%

Opto-detector (TFT - 17" AG Neovo S-17A @ 75Hz) to BBTK Sounder (see note 1) - target RT 5mS	<600µS
Opto-detector (CRT - 17" HP 7540 @ 60Hz) to BBTK Sounder (see note 2) - target RT 5mS	<600µS

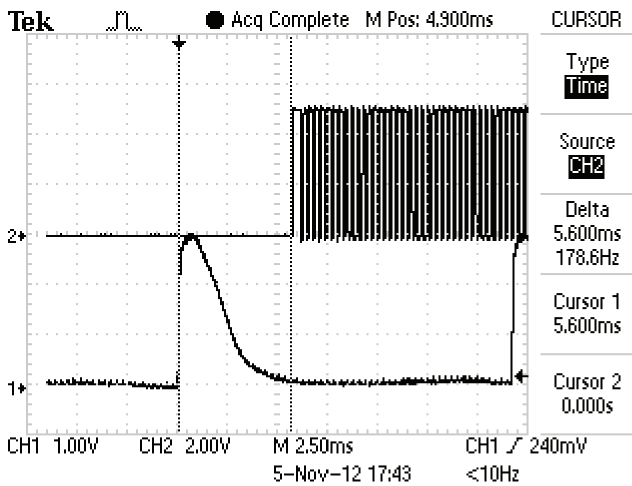
BBTK keypad key down event to Active Switch Closure	<400µS
TTL signal in to Active Switch Closure	<120µS
TTL signal in to TTL signal out	<40µS

Note 1



The warm-up curve (channel 1) for the TFT chosen is longer than for a CRT shown right. Sounder output channel 2. RT target 5mS

Note 2



Warm-up curve (channel 1) is faster for the CRT chosen. Sounder output channel 2. RT target 5mS

30.2 Digital Stimulus Capture (DSC) module timing characteristics

Description	Nominal accuracy
100mS duty cycle TTL signal fed into the BBTK	<1µS

30.3 Event Generation (EG) module timing characteristics

Description	Nominal accuracy
100mS duty cycle TTL signal generated by the BBTK	<1µS

