Application Brief 1

Welcome to this Cleverscope Application Brief

This application brief gives you two examples of how Cleverscopes are being used. May be some food for thought here!

We let you know about our update release policy. Remember that you can get the updates direct from www.cleverscope.com/download.
Standard updates are free!

Application Brief 1

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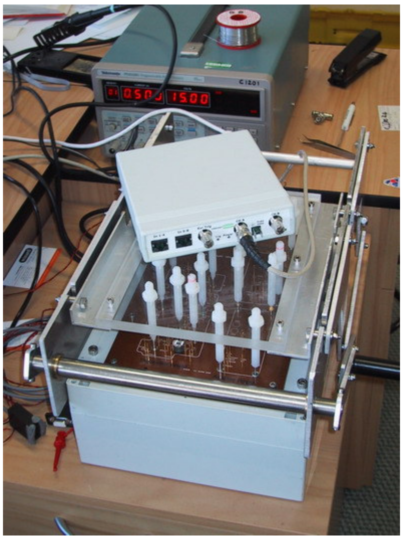
Applications

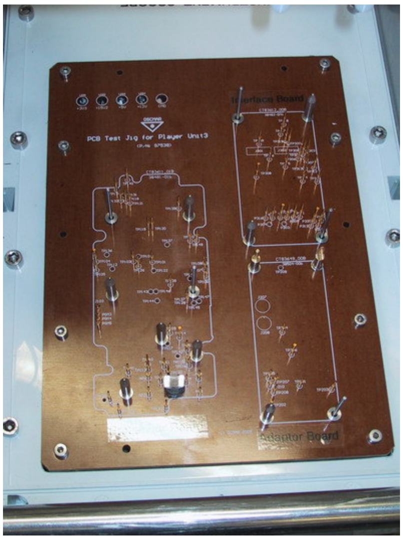
Automated Test Equipment (ATE)

Automated Test Equipment (ATE) is used to automate the process of validating an assembled Printed Circuit Board, or a finished item. In either case test stimulus are presented to the unit under test, and output signals are measured and validated. ATE offers significant cost benefit in production throughput, process quality, and assurance that a complete test sequence has been carried out and passed where production runs are greater than 50 units or so.

ATE usually comprises a programmable power supply, a signal source, a matrix switch and a signal measurement unit. Usually these are controlled by a PC running a programmed test sequence. Results may be stored to disk or printed for quality assurance purposes.



Here is a triple PCB test jig, using a Cleverscope and programmable Power Supply to carry out all test functions. In this example the Cleverscope is externally connected to allow re-use.



This is the pin jig that probes each important node on the PCB. The PCB is livened up, and test signals applied with the response measured using the Cleverscope.

The matrix switch relays can be seen in this interior view of the jig, in the upper printed circuit board. The lower printed circuit board contains the matrix switch controller, and SPI bus communications controller used to communicate with the PCB under test.

Cleverscope offers several benefits over conventional oscilloscope or plug-in cards when used in ATE systems. These are:

- Low cost compared to conventional oscilloscopes or plug-in acquisition cards.
- Includes a signal source (sine, square, triangle or DC level) and 11 measurement inputs – 8 digital, 1 external trigger and 2 analog inputs. For smaller systems one Cleverscope can do all the stimulus and measurement.
- Small size compared with standard oscilloscopes saves room in the test enclosure.
- Fast response time (typically 20 msec) to an instrument state change. Many common oscilloscopes can take several seconds to fully change state. State changes are needed when changing ranges or timescales, or changing from time to frequency measurements.
- Does not need to be mounted on a bussed backplane, or in a PC, which saves sunk cost when designing the ATE module. The module need be connected to the PC only when it is needed, allowing one PC to be shared between several ATE modules, which are taken off the shelf only at production time.
- Large internal memory allows comprehensive testing of long time sequences such as serial data, I^2C or SPI transactions, encoded laser or IR pulses, RF baseband data transmissions or power up sequences.

We offer a Labview vi driver for people to implement ATE systems. Labview is well suited to this kind of development.

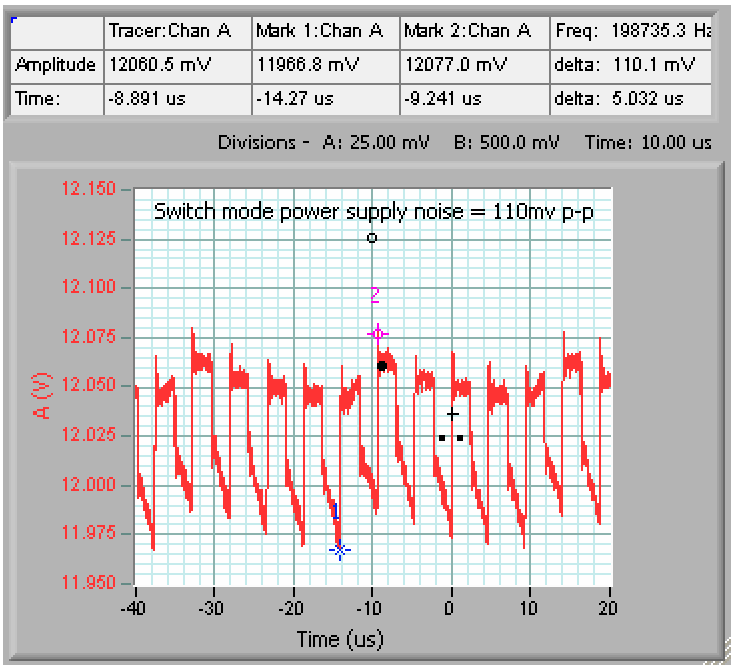
Power Supply Noise Analysis

Many modern systems, such as Cell Phones, PDA's and MP3 players use switch mode power supplies to maximize battery life. This kind of supply uses a switch controlled inductance to manage power flow into a smoothing capacitor. They are very efficient because the switch is either on or off; losses are only significant during the switch transition. However the transition generates noise. Two types of noise are usually present in a printed circuit board – harmonic noise dependant on the switch frequency, and wide band noise resulting from the transition impulse response. The noise may be transferred to other components in the system via conduction (down PCB tracks for example) or radiation (components or tracks act as antennas to transmit and receive the noise). The noise has several detrimental effects:

- Power supply conducted noise can increase the noise level in any analog signals used in the system (eg RF or baseband signal, or the audio signal in an MP3 player, or the signal being digitised in a cell phone). The noise level increases because the Power Supply Rejection Ratio (PSRR) of most op-amps decreases with frequency. At high frequencies the power supply noise adds to the signal.
- Power supply conducted noise increases jitter in time based systems (such as Cell Phones, systems including an ADC, or real time clock). The jitter increases because the power supply noise is added to the logic threshold voltage. As the threshold voltage moves up and down the switch transition point varies in time – leading to jitter.
- Power supply radiated noise can mix directly with the signal, decreasing the signal to noise ratio.
- Power supply noise decreases the probability of meeting EMC requirements. Many products require EMC certification (eg CE mark or meeting IEC or Mil-std specifications). EMC standard tests measure both conducted and emitted noise.

A spectrum analyser is an essential tool in finding and reducing the effects of power supply noise.

As an example here is the output of a commercial 12VDC plug-pack power supply. The plug-pack has a universal 90-260VAC input, and uses a switch mode supply to achieve this wide range.



Cleverscope offers several benefits over conventional oscilloscopes when doing power supply noise analysis. These are:

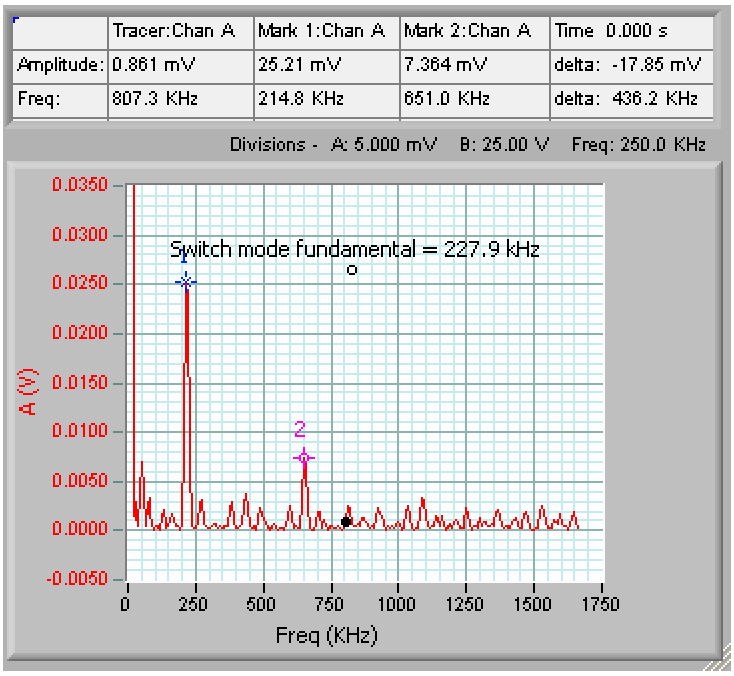
- Simple copy and paste of displayed waveforms or spectra into a document. Add a brief description of what was seen and later comparison with results obtained after modification is easy.
- The scale and offset system means you can look at the detail stacked on top of a DC level. The full 10 bit A/D dynamic range is applied to the vertical window on display. For example in the 12V plug-pack output, the 10 bit A/D range covers the voltage range 11.95 – 12.15V. The resolution is 0.2 mV (200mV/1000).

  For typical conventional PC scopes without offsetting a +/- 12V range would be have to be used. These scopes have 8 bit resolution, resulting in a voltage resolution of 94 mV (24000mV/256). Some scopes offer 12 bit mode, without offset, and give a resolution of 5.9 mV (24000 mV/4096).

  In either case the offset method allows detail between 30 and 470 times finer to be examined. Further a very popular brand of benchtop scope offers only a +/- 2V offsetting range, which means that most power supplies cannot be examined in detail.

  In some situations AC coupling can be used to improve resolution, but the DC information is lost (and in many cases it is useful to be able to see later what the DC level was – for example 12.025V in the example). Further the information you may want to look at might not be at the AC zero voltage (for example the switching output in a switchmode power supply might oscillate between +0V and +Vin. You cannot examine either +0.5V or +Vin, because the AC zero is at Vin/2).

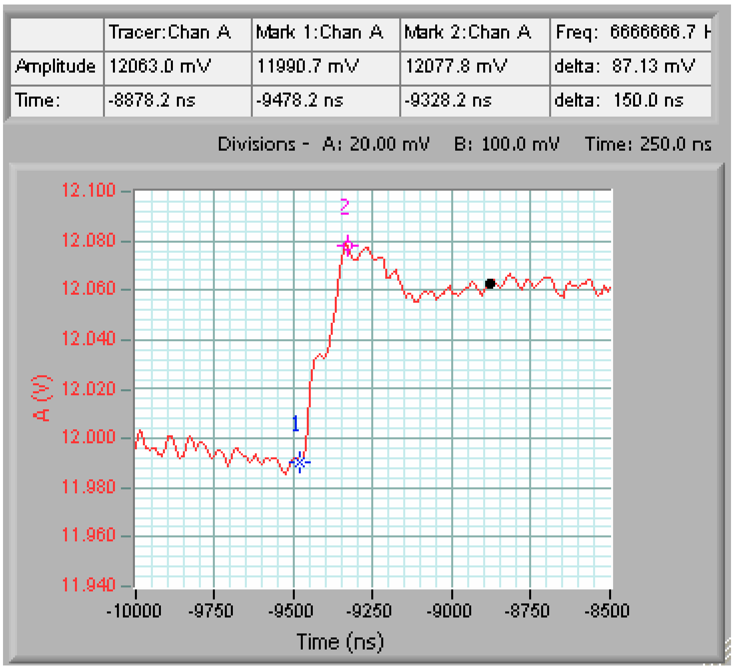
The spectrum of the power supply signal is shown below. We have chosen the voltage mode of display (rather than dB) to show the actual noise level, and to highlight the fundamental and 3rd harmonic. The switch fundamental frequency is 227.9 kHz.



Using this knowledge we can go looking for the switchmode signature in the equipment powered by the plugpack, and minimize it, even though other signals may be present.

Other methods of measuring the effects of power supply noise can also be done: conducted noise can be measured using a high bandwidth current probe around the equipment power supply lead. Radiated noise can be measured using suitable EMC antennas. If you'd like help with this please contact us.

Finally it is often useful to check that the slew rate of any voltage edges is as designed, and that there is no ringing or oscillation. Here we examine one edge in detail:



- Many modern switch modes operate in the 200 kHz – 2 Mhz range. We can expect harmonics out to the 11th harmonic, or 22 MHz with a 2Mhz switch mode. Cleverscope samples at 100 MSa/s, giving you an instantaneous spectral display of 50 Mhz bandwidth. This is more than sufficient to find the spectral signature of high frequency switchers in your circuitry, or via an antenna, radiated from the PCB or associated wiring.
- In most situations Cleverscope will maintain a time resolution of 10ns when sampling the switch mode power supply. This means that after you have captured a sample waveform, you can examine it in detail. As an example you may wish to check on the rise and fall times- low EMC emission design usually control the slew rate. You can verify the correct slew rate, and check for ringing and oscillation. Most standard oscilloscopes do not have this kind of resolution, and find it difficult to select a particular edge from a collection of edges and show the detail.

In the example a controlled slew rate power supply has been used. The total slew time is 150 ns. There is a small amount of ringing following the upward step, but it is not significant. Notice the small oscillation (its about 17 MHz, and 5 mV in amplitude).

Calibration

Calibration is important to get maximum accuracy in the Cleverscope. Accuracy is derived as follows:

1. The yearly calibration process calibrates the internal reference to 1 part in 2000. Our standard (external) calibration source has an accuracy of +/-0.02%. So total accuracy of the internal reference is known to +/- 0.07% at calibration time.
2. The internal calibration procedure calibrates each gain setting with an accuracy of +/- 1 part in 400. This is an accuracy of +/- 0.25%.
3. The internal reference has a temperature drift of +/- 15 ppm. Assuming a 20 degree temperature shift worst case, this is +/- 300 ppm or +/- 0.03%.
4. The A/D is 10 bits and is mapped across the displayed vertical range, with a maximum overlap of 20%. There are 26 ranges, each 0.8 of the amplitude of the previous range, and we map the display to the range that just covers it. So we assume at worst case that 80% of the A/D dynamic range is mapped across the vertical amplitude displayed. With a 10 bit A/D, this gives us 800 displayed counts.
5. When making a measurement, we assume, for the standard case, that the displayed waveform is using 40% of the display window. Thus for the standard case the waveform may contain 320 counts. Therefore the error is +/- 1 part in 320, or 0.3%.
6. We calibrate the offset system from end to end (ie -maximum value to + maximum value), and then interpolate in between. A 10 bit D/A is used to generate the offset voltage. The error is therefore +/ 2 parts in 1000, or +/- 0.2%.

To summarize, our overall accuracy is
= +/- [0.07 + 0.25 + 0.03 + 0.3 + 0.2]%
= +/- 0.85%.

The specified data sheet is therefore conservative.

Update Release Policy

Cleverscope is a work in progress. The Cleverscope system has been structured from the ground up to be re-configurable. A large Field Programmable Gate Array (FPGA) contains all the logic needed to power the acquisition unit. This logic includes a soft processor, which is loaded each time the acquisition unit powers up. The processor runs the firmware application that provides communication over the USB, and manages signal acquisition, triggering and signal generation. Using the USB we can update the FPGA design and the processor firmware in the field. You will find the latest binary file (which contains both the FPGA design, and the processor firmware) at www.cleverscope.com/download/ along with a loader.

Our policy is to add functionality as our user base grows, responding to requests from you the user. You can request changes in two ways – by sending us an email at support@cleverscope.com or you can jot down your request in the forum. You'll find the forum at http://www.cleverscope.com/forum/. It's easy to join, and free. You'll find four areas in the forum – **Communications between members**, **Using Cleverscope**, **Training** and **Cleverscope Wish List**. Making your requests on the forum means that other people can add feedback and add insight from their experience. We will be maintaining the wish list as a separate web page fairly soon, with ticks as we knock off each item. We welcome your contribution!

The FPGA used in Cleverscope gives us flexibility you won't find in a normal scope. In the long run we plan to allow users to make plug-ins which can be loaded into the FPGA to carry out purpose specific manipulation of the acquired signals. Example plug-ins might include specialist signal processing (such as filters, correlators or FFT's) or protocol analysers.

For the moment, the FPGA means that we can respond to users to implement functions that many people want, and then disseminate them via our website.

The FPGA gives us considerable resources, including:

- A 32 bit processor with 42 DMIPS throughput.
- 16 Mbyte of RAM (shared between acquired samples, and processor program memory)
- Enough logic resources to do some serious number crunching!