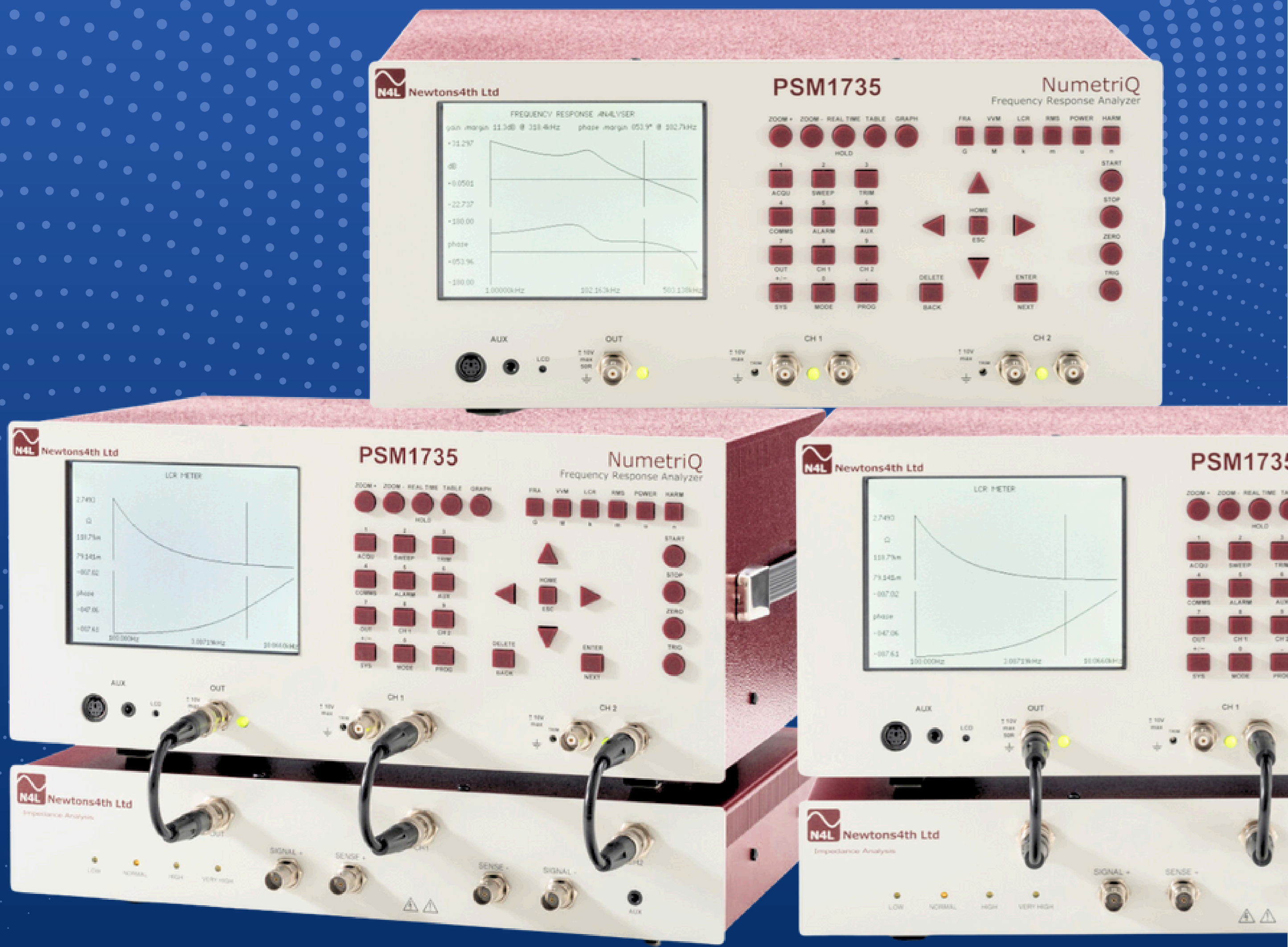
Application Notes

Amplifier Frequency Response Testing

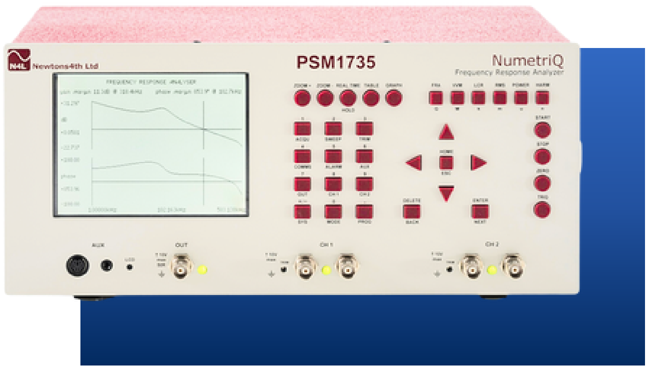


Introduction

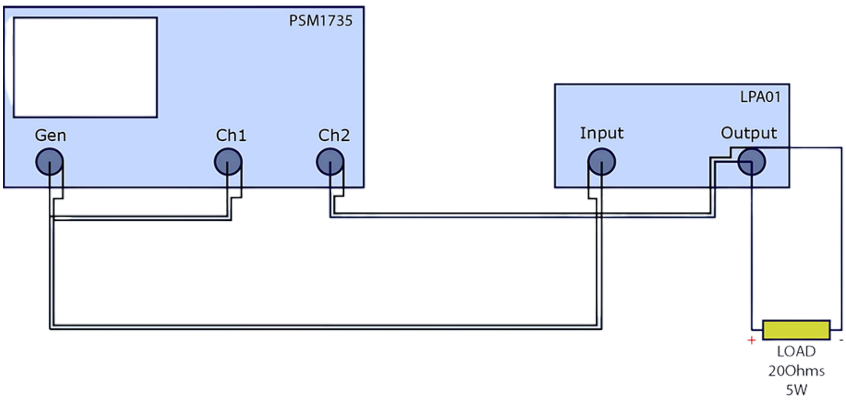
Amplifier frequency response testing is an important performance characteristic to be determined during amplifier design and development. This application note utilises a PSM1735 (35MHz bandwidth Frequency Response Analyzer) to determine the frequency response of a power amplifier up to 10MHz. To ensure the PSM1735's generated signal level does not fall away at higher frequencies it was decided to set the generator to 0.7Vrms and the "TRIM" feature was used to ensure that the output of the generator was 0.7Vrms at all frequency points. To test the amplifier in a realistic operating mode, a 5W 20 Ohm load was utilised. This will result in a current of 350mArms with the 7Vrms output voltage (Amplifier was set to x10 gain).

Features of PSM1735

Basic Accuracy	0.01dB
Phase Accuracy	**0.02°**
Frequency Range	**10uHz ~ 35MHz**
Generator	**10Vpk Grounded**
Input	**Single Ended Grounded and Balanced Differential**
Display	**320×240 Mono LCD Graphic**

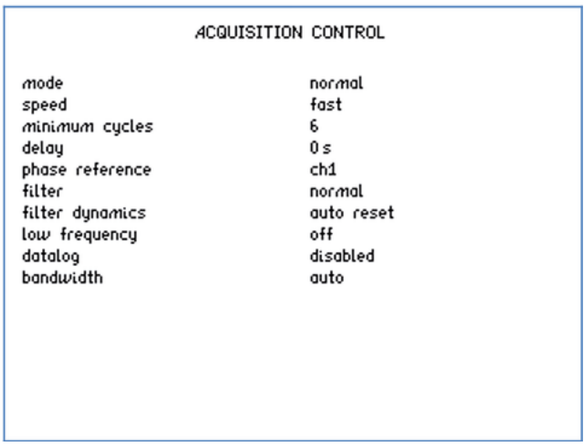


Test Setup

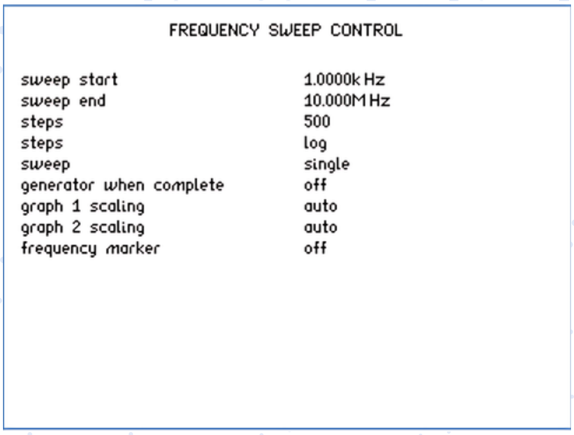


The image illustrates how to connect the PSM1735 and the Test Amplifier with a load of 20 Ohms so this test can be performed under realistic operating conditions. An open circuit test would not be realistic since no current would flow.

Once the instrumentation has been connected as above, next we need to ensure the instrument is set up correctly. The following screenshots describe the setup procedure.



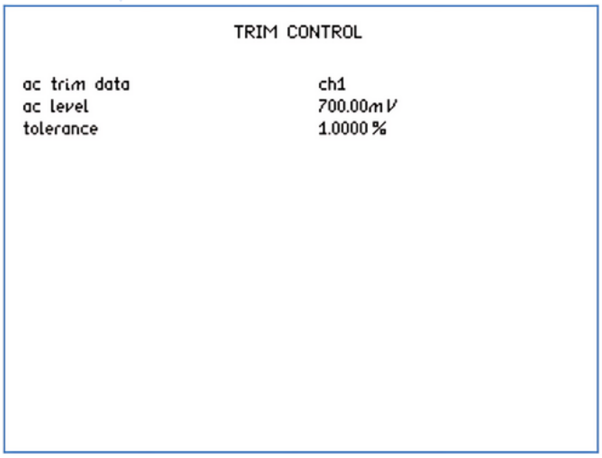
In the ACQU menu the following settings were made; Speed was set to fast and "Minimum cycles" was set to 6. The instrument will repeat the measurement 6 times in this case and take the average of the 6 results.



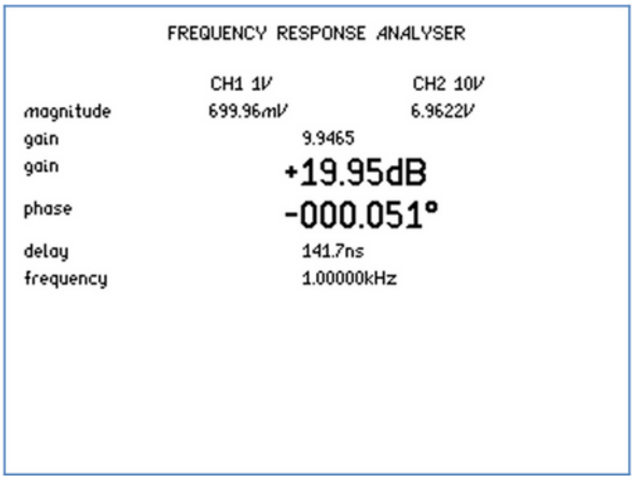
In the SWEEP menu, the sweep start was set to 1 KHz and the sweep end was set to 10MHz. The instrument will sweep between these two frequencies, from low to high.

The step count was set to 500, this represents how many points there are along the X-axis (frequency) of the graph once the results have been plotted.

The trim was set to 700mV on CH1 to ensure that the input signal to the amplifier was maintained at the same level throughout the test. The tolerance was set to 1% to ensure the voltage was within 1% of the specified value.



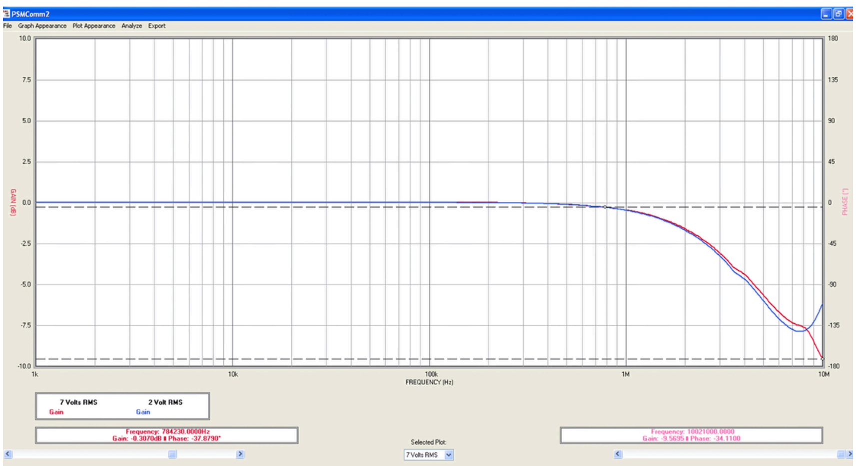
Once the settings had been setup there was a nominal gain of +20dB, this is because the gain was set to x10.



By pressing the ZERO button the right-hand side of the instrument, the gain of +20 was set to be read as our 0dB reference point.

Using PSMComm2 (N4L Bode plotting software) the PSM1735 was remotely controlled and the first sweep at 7Vrms output was performed. A screenshot of PSMComm2 software is shown below; in the screenshot we have plotted two sweeps. One at 7Vrms and another at 2Vrms, this

the software's ability to compare numerous plots.



The performance was very flat to the specified bandwidth of the amplifier (1MHz), the 3dB point was at around 3MHz. Throughout the whole frequency response test the output wave form was monitored and remained sinusoidal with little distortion.

Application Notes

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Hall Sensor Calibration
&
Current Shunt Calibration

Introduction

An Automatic Current Shunt Tester (AHST) is a testing setup to check the calibration and performance of Current Sensors. AHST is a combination of Hardware modules and software modules.

- Calibrated Standard Current Shunts are available as per rating up to 10,000 Amp & More as per requirement.
- DC Power Supply rating can be chosen as per test requirement.

Solution available from Low Current Values to High Current Values Up to 10000Amp or more.

- 6 1/2 Digit Precision Multimeter to measure Standard Shunts Value & Tested Shunts Value.

LEM Zero Flux High Precision Current Transducers

IT65-S *	→ 85Apk 60Arms/DC
IN100-S	→ 100Arms/DC / 150Apk
IT200-S	→ 200ADC / pk 141Arms
IN200-S	→ 200Arms / DC 300Apk
IT205-S *	→ 283Apk 200Arms/DC
IT400-S	→ 400ADC / pk 282Arms
IN400-S	→ 400Arms/DC 600Apk
IT405-S *	→ 566Apk 400Arms/DC
IN500-S	→ 500Arms/DC / 800Apk
IT600-S	→ 600ADC / pk 425Arms
IT700-S	→ 700ADC / pk 495Arms
IT1000-S	→ 1000ADC / pk 707Arms
IT605-S *	→ 849Apk 600Arms/DC
ITN600-S	→ 600ADC / pk 424Arms
ITN900-S	→ 900ADC / pk 636Arms
ITN1000-S	→ 1000ADC / pk 707Arms
IN1000-S	→ 1500Apk 1000Arms/DC
IN1200-S	→ 1500Apk 1200Arms/DC
IN2000-S	→ 3000Apk 2000Arms/dc
LF510-S	→ 500Arms 0.6% AC+DC
LF1010-S	→ 1000Arms 0.4% AC+DC

Danisense High Precision Current Transducers

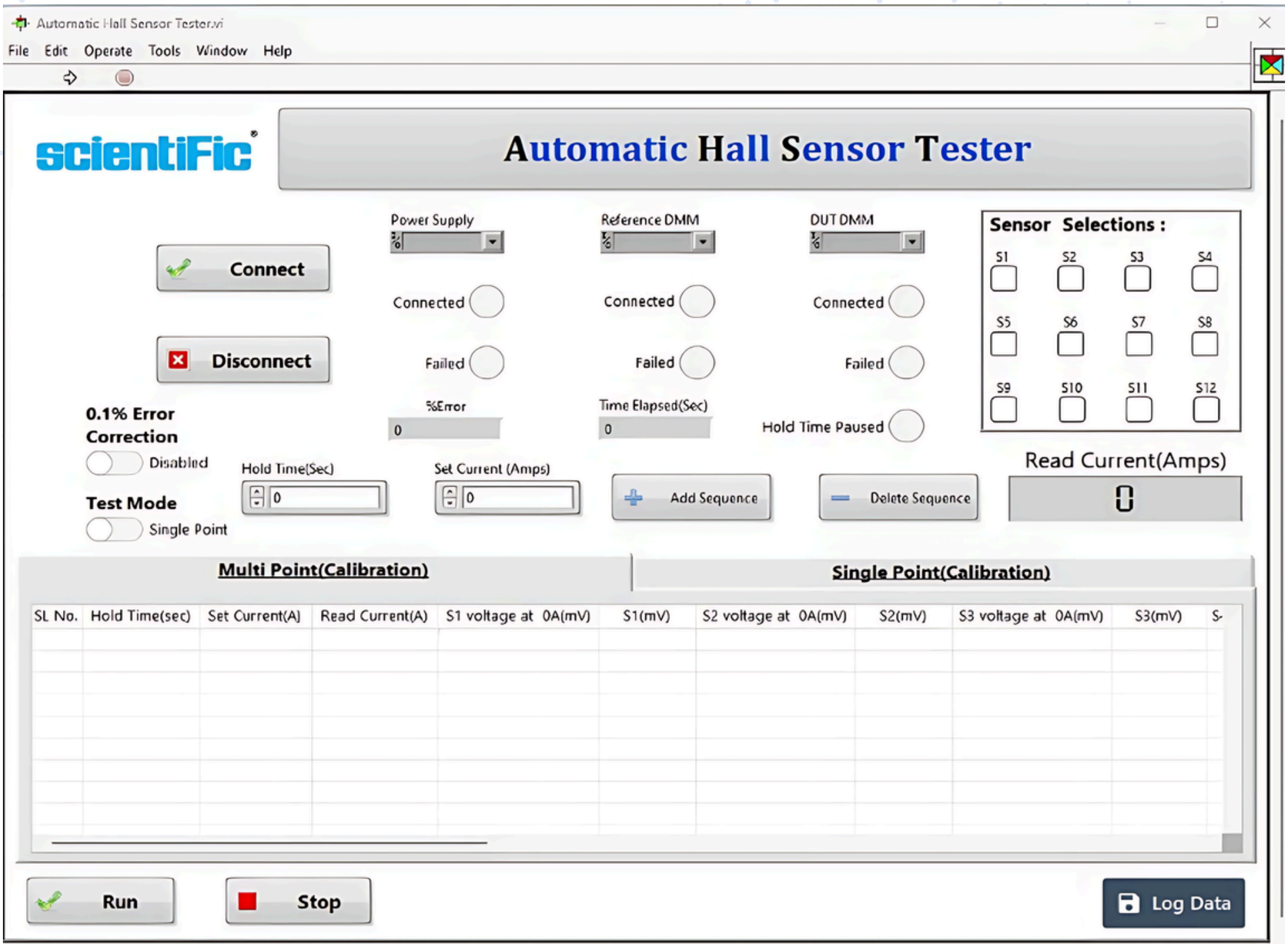
DS50ID	→ 50Arms + 75Apk/DC Freq Bandwidth (±3dB) <1MHz
DS200ID	→ 200Arms + 300Apk/DC Freq Bandwidth (±3dB) <1MHz
DS300ID	→ 300Arms +5005Apk/DC Freq Bandwidth (±3dB) <1MHz
DS400ID	→ 400Arms + 600Apk/DC Freq Bandwidth (±3dB) <300kHz
DS600ID	→ 600Arms + 1000Apk/DC Freq Bandwidth (±3dB) <500kHz
DM1200ID	→ 1200Arms + 1500Apk/DC Freq Bandwidth (±3dB) <300Hz
DL2000ID	→ 2000Arms + 3000Apk/DC Freq Bandwidth (±3dB) <300kHz

High Frequency Rogowski Current Transducers

WR5000	1A -> 5000Arms	WR5000
WR10000	2A -> 10000Arms	WR10000

Software

The test setup comes with software that controls and supervise the overall test procedure and collects data from the instruments and also have a feature to log the collected data. The GUI is shown in the figure below.



The GUI can conduct a test in two modes, viz. Single Point(Calibration) mode and Multi Point(Calibration) mode. Each of these modes can further be operated with or without "0.1% Error Correction".

The GUI have the capacity to conduct test on a maximum of twelve (12) current sensors simultaneously. The current sensor outputs are connected to the scanner card attached to the Reference DMM. While conducting a test, a particular channel selection of the scanner card can be done using the "Sensor Selections" in the GUI, which in turn starts to measure the particular current Sensor output connected to that particular channel of the scanner card. The GUI also have indicators of communication connection status, "%Error", "Time Elapsed" & continuous "Read Current" indicators.

Application Notes

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Double Pulse Test

Introduction

The standard test method for measuring switching parameters and evaluating the dynamic behavior of Si, SiC, and GaN MOSFETs and IGBTs is the double pulse Test (DPT). Double pulse testing can be used to measure energy loss during device turn-on and turn-off, as well as reverse recovery parameters.

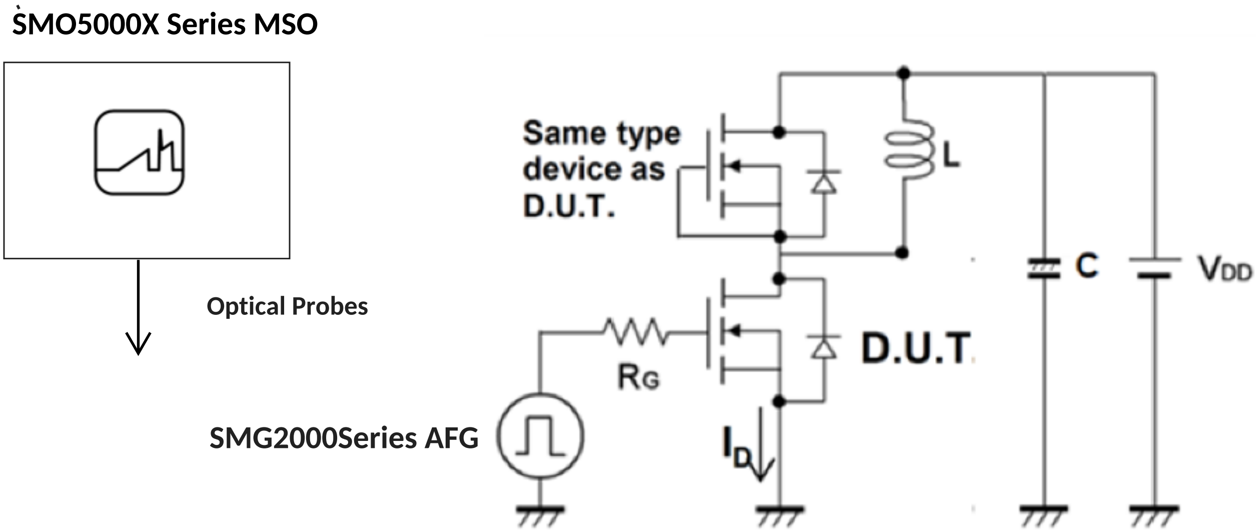
Application Details

Double pulse test is performed using two devices. One device is the device under test (DUT) and the second device is typically the same type of device as the DUT. Note the inductive load on the “high” side device. The Inductor is used to replicate circuit conditions that you may have in a converter design. The instruments used are a Scientific power supply or SMU to supply the voltage, an arbitrary function generator (AFG) to output pulses that trigger the gate of the MOSFET to turn it on to start conduction of the current, and an Scientific oscilloscope & Optical Differential Probes to measure the resulting waveforms.

Generate Gate Drive Signals for a Double Pulse Test

The easiest way to generate the gate drive signals to perform a double pulse test is to use an arbitrary waveform generator (AFG). An AFG may be used to generate the gate drive signal to perform a double pulse test. The Scientific SMG2000Series AGF has a built-in pulse test generator to create the pulses with varying pulse widths.

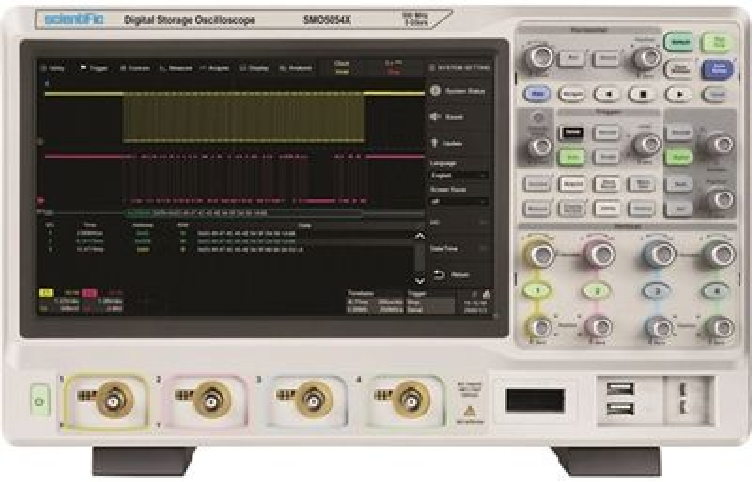
SMG2122 AFG



Double pulse test circuit.

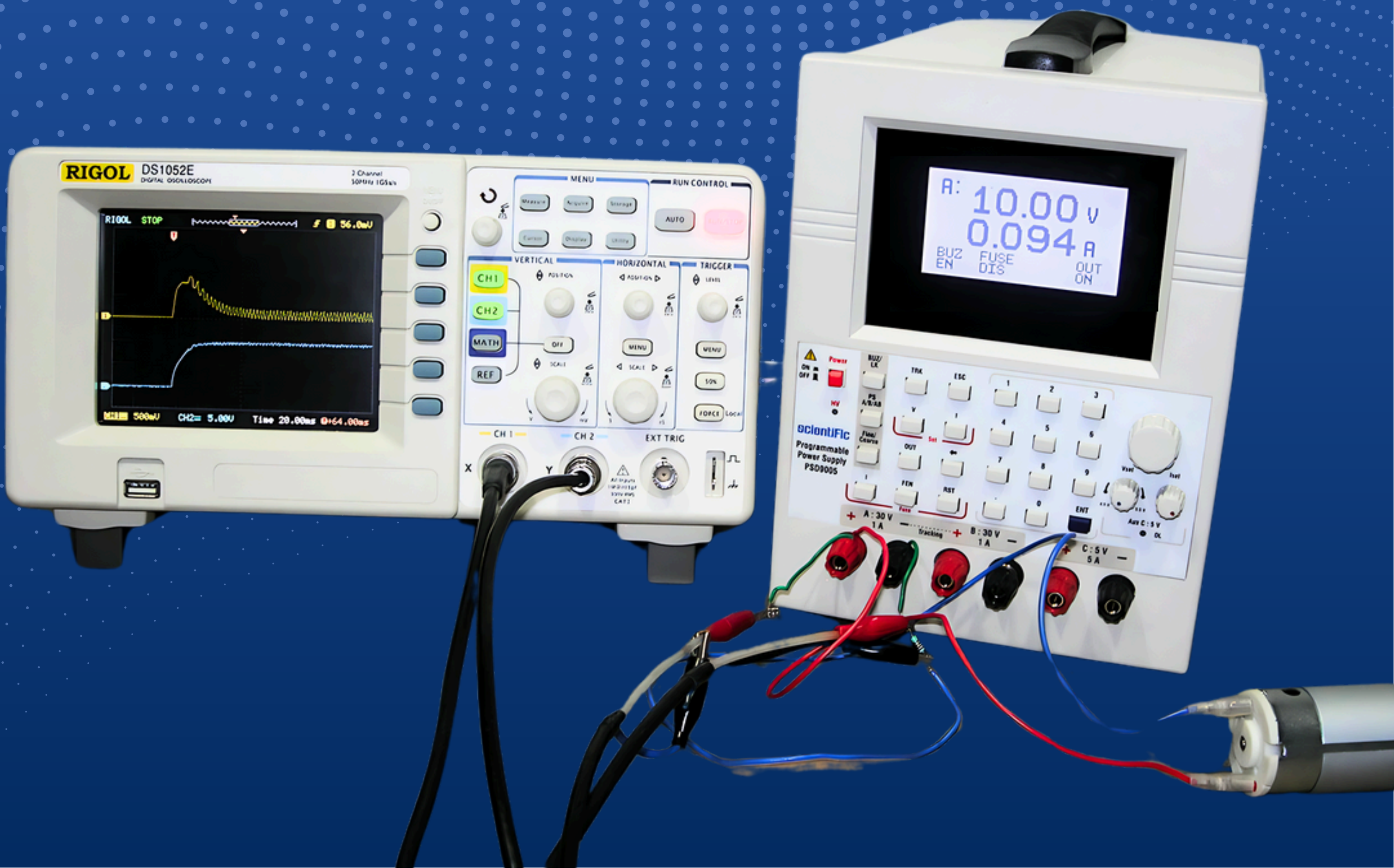
How to Measure Turn-on and Turn-off Timing and Energy Losses

Scientifc oscilloscope and Optical Differential Probes is a great tool for capturing the double pulse waveforms so you may obtain the turn-on and turn-off times parameters of your device.



Application Notes
02/09/13

PSD9005 for DC Motor Testing Application



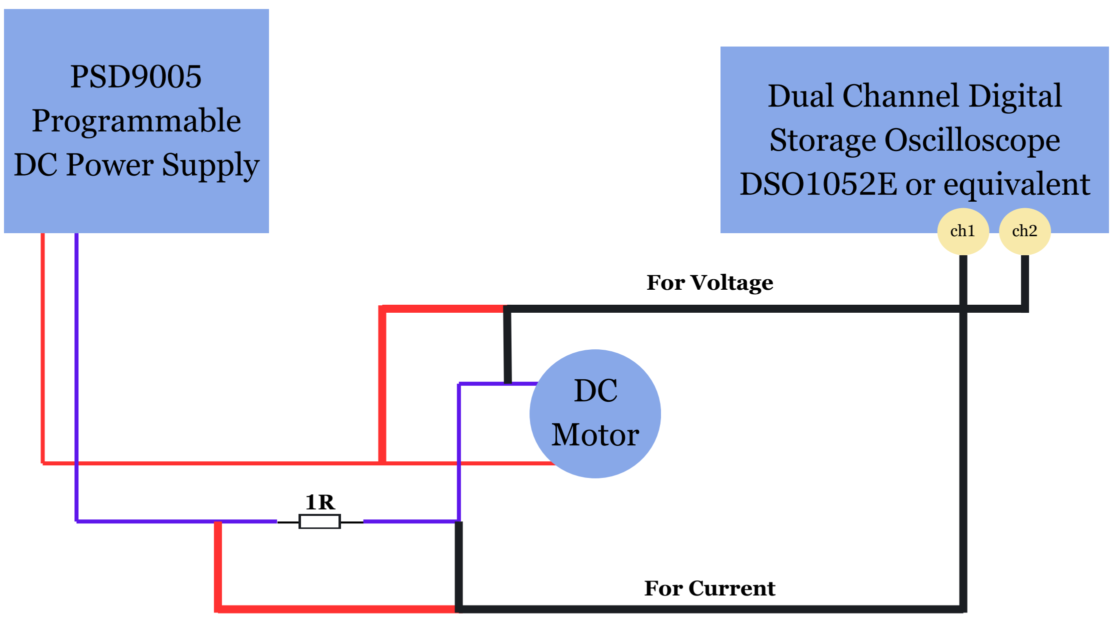
Requirements

1. PSD9005 Programmable DC Power Supply.
2. Connection cable for DC motor
3. Dual Channel Digital Storage Oscilloscope DSO1052E or equivalent.
4. Connected probes e.g. BNC to Crocodile Probes – 2 Nos
5. Resistance – MFR 1 Ω, ¼ W
6. DUT – DC Motor (12 V)

Introduction

PSD9005 is a Programmable Dual DC Power Supply, which delivers fully programmable 2 x 0 to 30 V at 1 A and auxiliary 5 V at 5 A. One of its applications demands a small 12 Volts DC motor to be tested at different voltages 6 V, 9 V, 10 V, 12 V, and 13.5 V. As per the test requirements, we can set output voltages & current limits for DC motor testing applications. Our object is to analyze the voltage & current waveforms. With the PSD9005 in this testing, we can use features like protecting the DC Motor from overloading and measuring load current with high resolution. The use of an electronic fuse lets us overload protection against excess current. It can also be used in automatic testing.

Connection Diagram



To display voltage waveform on DSO, connect the probe across the DC motor as shown above. To display the current waveform on DSO, we can use the current probe of appropriate rating. In case of current probe is not available, with a very small error introduced we can insert a series resistor of very low value, say 1 ohm. When the DC motor current flows through the sense resistor, a proportional voltage and shape will develop across it, which is connected to the second channel of DSO.

Since,

$$\mathbf{V = I * R \quad R = 1\ ohm ;}$$

so,

$$\mathbf{I = V / 1\ ohm = V\ Amp}$$

The current waveform in this connection will be inverted as the reference ground is taken and the DC motor negative terminal. To view the correct current waveform, the signal applied to channel 2 is set to Inverted.

- Set the PSD9005 DC output to 6.00 Volts, and current to 4 to 5 times the normal DC motor current. So that the current demand from the DC motor on switch ON can be supplied. The DUT motor takes approximately 100 mA load current. So set the Iset of PSD9005 to say 1 Amps.
- Set the DSO in Single shot mode, with Y attenuator Ch 1 to 200 mV/div; Ch 2 to 5 V/div, time base to 20 ms/div.
- Switch ON the output "OUT", and the DC output will appear across the DC motor, PSD9005 display will show the current flowing, which is 0.094 A for the DUT connected.

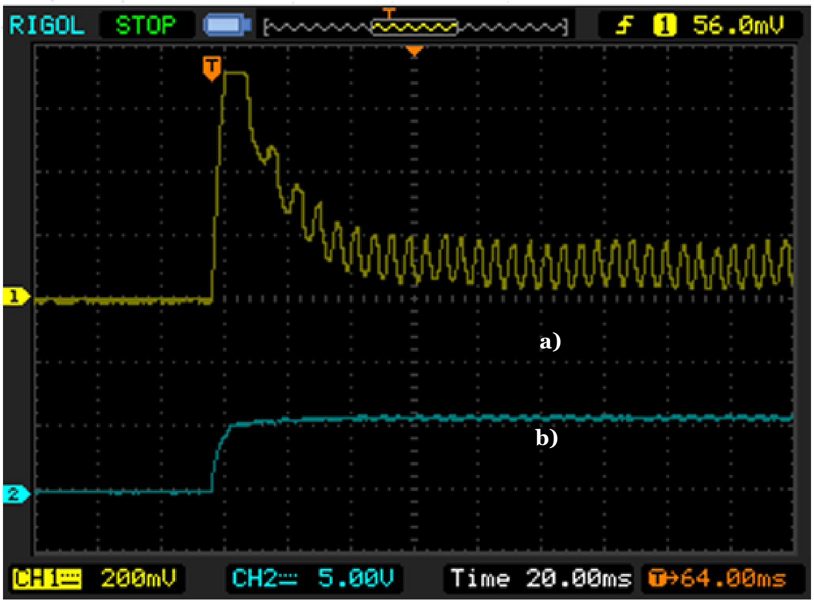


Fig 1 a) Current waveform
b) Voltage waveform

- DSO will record the waveform as shown in Fig -1. You will see, there is a surge in current when the power supply is connected, which gets stabilized after sometime. Since the DC motor connected is Brush type and hence the high frequency sine wave is visible over the load current. The maximum current peak is approx. 720 mA .

- Switch OFF the power supply, and set the DC output voltage to 9.00 V.
- Set the DSO Ch 2 attenuator to 500 mV/div and reset the Single shot.
- Switch ON the DC output of the power supply, you will get the waveforms as shown below in Fig-2.

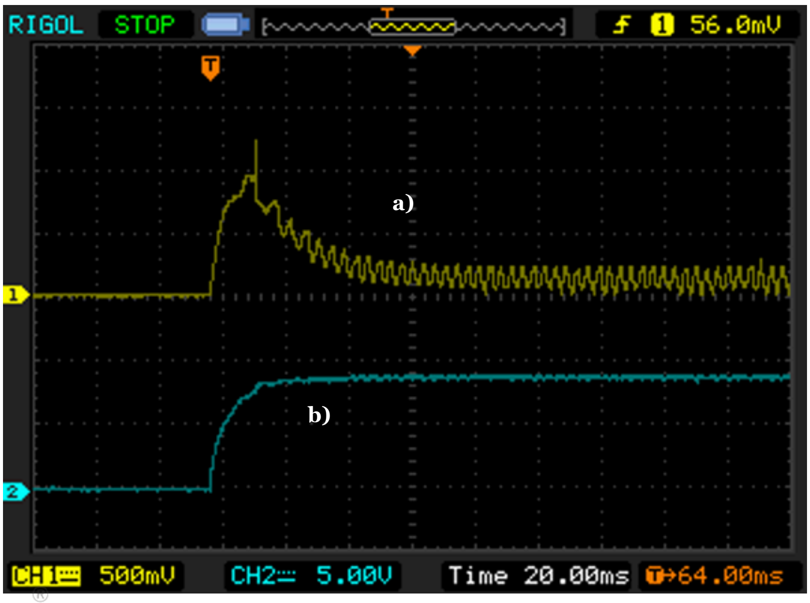


Fig 2 a) Current waveform
b) Voltage waveform

- Power Supply shows load current 0.096 A.
- From the waveform , we can see the change in load current behavior when the voltage applied to DC motor changes.
- Similarly set the DC outputs to 10.00 V and 12.00 V, the respective load currents read by power supply unit is 0.094 A and 0.098 A. The captured waveforms are shown in Fig 3 & 4.

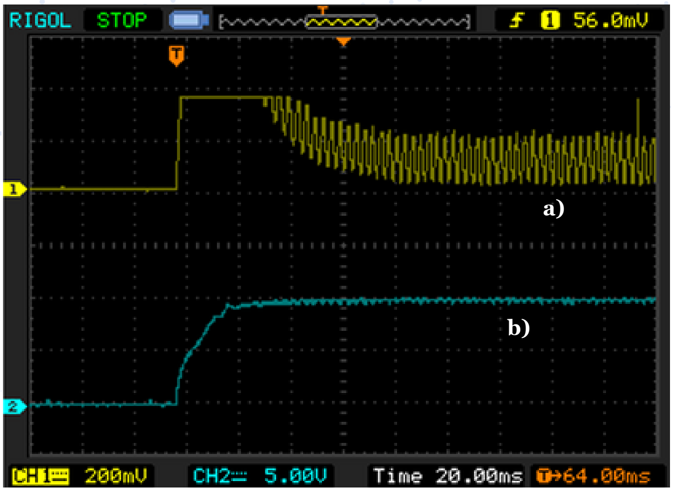


Fig 3 a) Current waveform
b) Voltage waveform

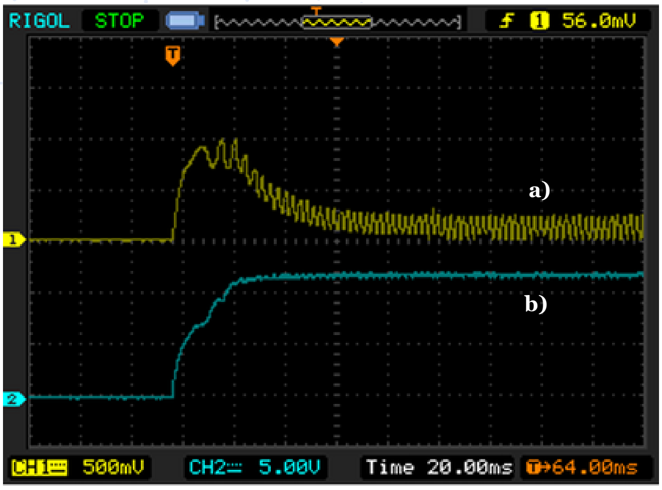


Fig 4 a) Current waveform
b) Voltage waveform

Application Notes

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PWM Motor Drive Ramp Testing with the PPA45/5500 Power Analyzers

Introduction

Ramp testing of PWM/Inverter Motor drives is a demanding application for any power analyzer, however the PPA4500 and PPA5500 series of power analyzers are ideally suited to such an application. They both feature very high speed FPGA architecture, excellent common mode rejection, sophisticated parallel filtering and frequency tracking algorithms which provide true wideband measurements of dynamically changing loads. This application note will discuss how to set up the power analyzer for a ramp test of a PWM motor drive in which both the load and the fundamental/motor frequency is expected to rapidly change.


Features	PPA4500	PPA5500
V, A rdg Error	0.03%	0.01%
Power rdg Error	0.04%	0.02%

Setting Up the PPA

We must first enter "PWM Motor Drive Mode" which is found in the "APP" menu.

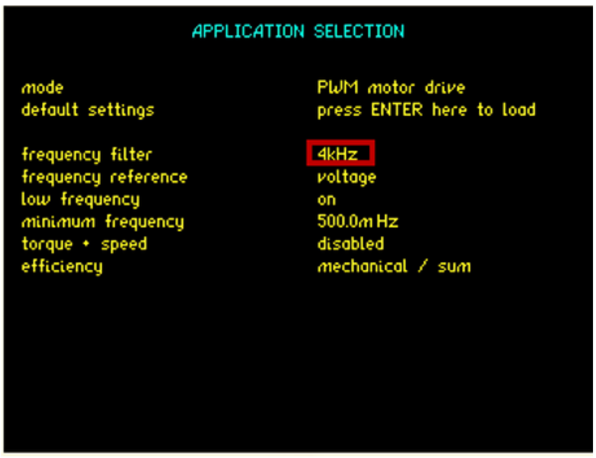


Fig 1

The most influential setting here is the "frequency filter", this is a parallel digital filter intended to filter out the switching/carrier frequency of the inverter drive for frequency detection ONLY. It is important to remember that the data used for power analysis is not filtered and you will always obtain wideband power measurements, it is often overlooked that many power analysers on the market filter such data resulting in incorrect measurements, particularly the Voltage RMS parameter with often significant wideband content as a result of the switching edges.

The frequency at which this filter is set is very important, the principle to use when setting this parameter is to use a filter that is slightly higher in frequency than the maximum motor frequency and lower than the switching/carrier frequency.

Example filter selections are illustrated in the table below;

Max Motor/Fundamental Freq	Switching Freq	Filter Selection
100Hz	5kHz	250Hz
1kHz	25kHz	4kHz

Speed

As we intend to perform a very fast measurement we have the option to carry out "cycle-by-cycle" analysis, this is essentially the ability to output the RMS value on a cycle-by-cycle basis which requires the analyzer to output data after every cycle. We will set the instrument in "Very Fast" mode, very fast mode will provide a minimum window size of 1/80s which will clearly provide cycle-by-cycle analysis up to 80Hz.

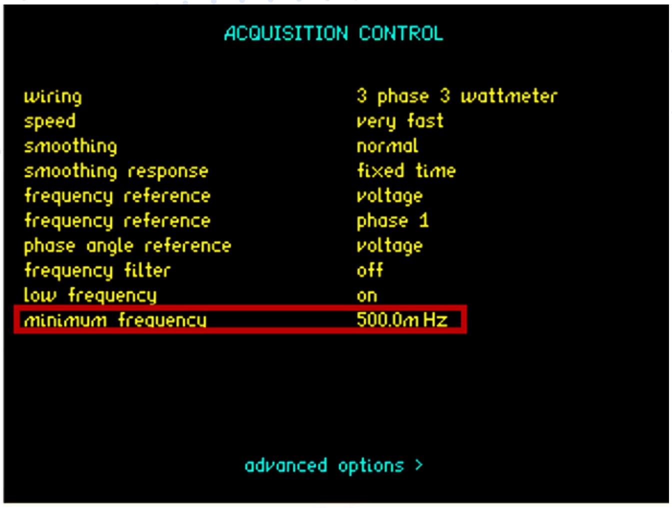


Fig 2

When cycle-by-cycle analysis of higher fundamental frequencies than the 80Hz possible in very fast mode is required, it is recommended to use a speed setting of "window" and then select the window size as required (minimum 2ms direct to internal RAM/ minimum 5ms direct to Software).

Note that low frequency mode is set to ON, this mode provides a very useful feature.

Low frequency mode ensures that as the fundamental frequency time period becomes longer (as frequency decreases) the window will automatically extend down to the frequency specified in the PWM Application/Acquisition menu as the minimum frequency.

Advanced Acquisition

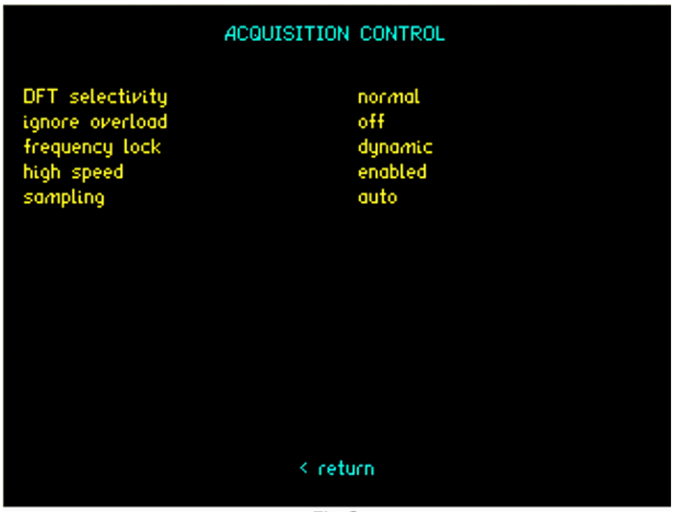


Fig 3

If we press the Right keypad arrow whilst in the Acquisition menu, we enter Acquisition-Advanced settings. We know that the fundamental/motor frequency will be rapidly changing therefore it is recommended to set frequency lock as Dynamic and high-speed mode to Enabled.

Note: High Speed mode disables some of the parameters computed in "normal mode", the instrument will now compute Vrms, Irms, Watts RMS for Channel 1, 2 and 3.

Ranging

As the load will by dynamic and we wish to analyse the device on a cycle by cycle basis we should set the ranging to manual and set the range to a level at which we know the load will not exceed during the test.

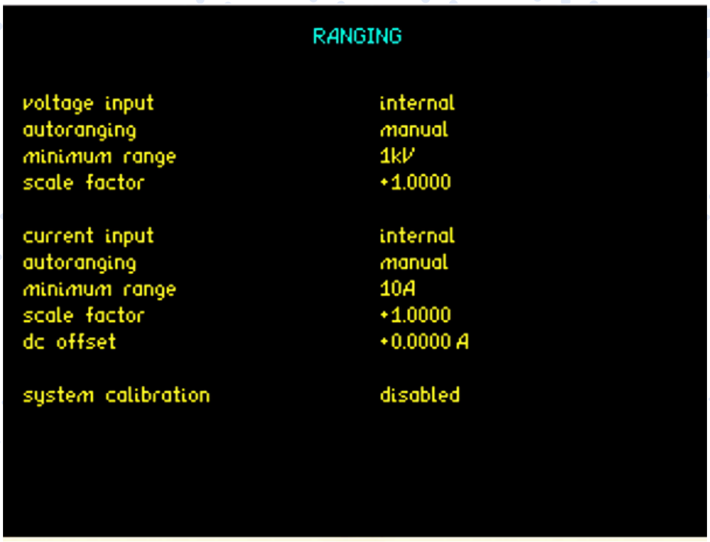


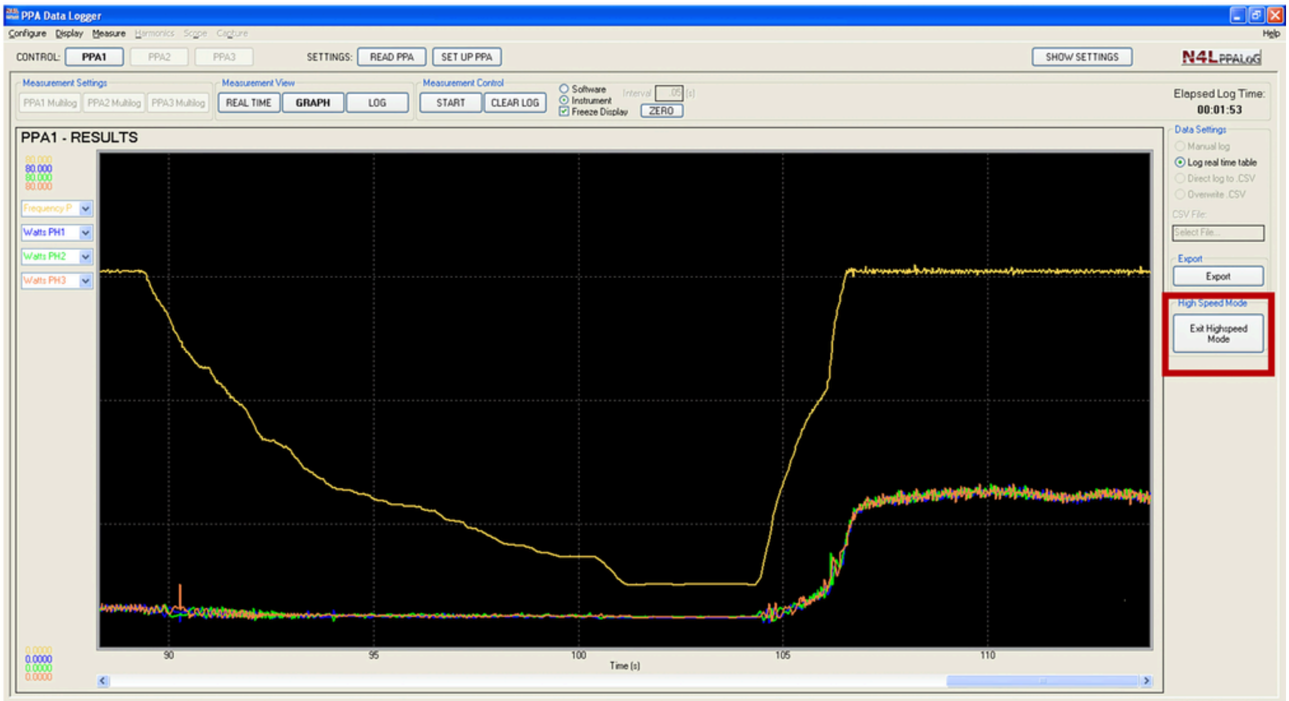
Fig 4

Note: Setting the range to manual and accidentally exceeding this range level will NOT cause any damage to the PPA Voltage/Current inputs providing the Voltage/Current level does not exceed the maximum current for the particular model of PPA used. This is a result of the sophisticated "single shunt - single attenuator" design developed by N4L.

Example limits are as follows for the PPA45/5530:

Model	Voltage Limit	Current
PPA45/5530 Standard Current	1000Vrms/3000Vpk	30Arms/300Apk
PPA45/5530 Low Current	1000Vrms/3000Vpk	10Arms/30Apk
PPA45/5530 High Current	1000Vrms/3000Vpk	50Arms/1000Apk

Analysis



Using PPALoG, free software available via the N4L website, high-speed mode is enabled and the PPA Datalogger was started.

The figure illustrates the speed at which the PPA45/5500 combined with N4L software is able to synchronise with a rapidly changing fundamental frequency whilst simultaneously analysing the Voltage, Current and Power.

In line with N4L's philosophy of true real-time no-gap analysis, this mode is no different and the measurement is taken with no gap.

At 15:50:17 the load on the motor was removed, during ramp-up at 15:50:32 the load increased, an Excel graphical plot (fig 6) is also shown below.

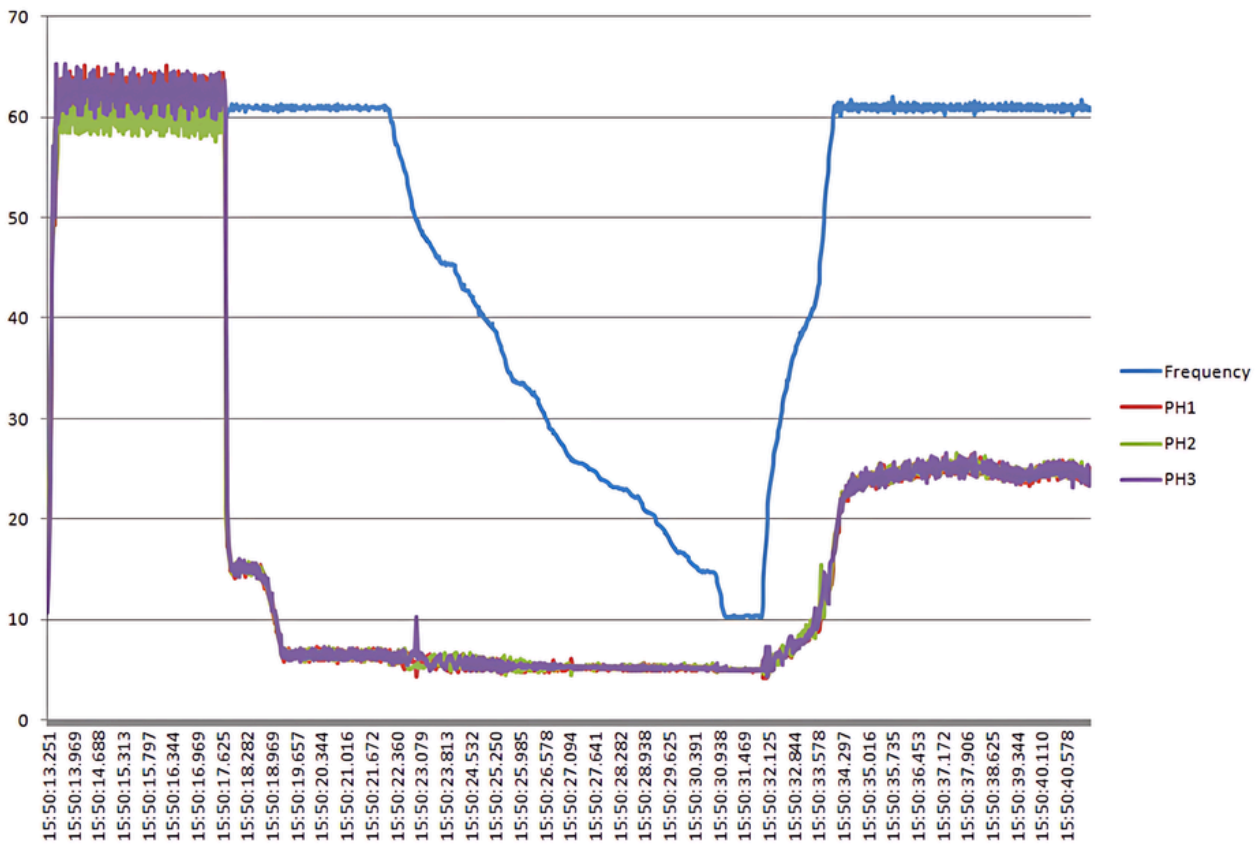


Fig 6