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14585A S/W and N6781A Source-Measure Module Demonstrations Using the Pulsed Load Demo ET

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1.0 INTRODUCTION

3G and emerging 4G broadband mobile wireless devices and their components have high power consumption during active video and data transmission operation, leading to short battery operating time. Tools for measuring and optimizing their current drain are of key importance during their development. The Agilent 14585B DC Power Analyzer software in combination with Agilent N6781A 2-Quadrant Source Measure Modules is a useful tool for measuring and optimizing current drain and valuable complement to RF test platforms for 3- and 4G wireless device development work.

Up to 4 N6781A modules can be installed in a host N6705B DC Power Analyzer mainframe. The 14585B software can in turn control and monitor up to 4 mainframes / 16 DC power outputs. While the N6705B can be directly used as a stand-alone solution for this testing, the 14585B provides many useful enhancements to make for an even more capable solution for battery current drain and analysis.

This manual guides the user through several exercises illustrating the significance of the unique features of new solution and the value they bring to the customers' applications.

1.1 **Hardware requirements**

- One (1) N6781A and one (1) low voltage, low power module (N676x, N673x, 4x, 5x or 6x). Two modules are needed for N6781A ammeter mode and multi-channel mode demonstrations. One more low voltage module is needed for powering the pulsed demo load unit if there is no dedicated AC to DC adapter for this purpose.
- One (1) N6705B DC Power Analyzer mainframe
- One (1) Pulsed demo load ET (NPN-2100) with one (1) power cable assembly (2 needed for multi-channel demonstrations) and DC power cable (when powered by another N67xx module in the N6705B) or an AC to 9 VDC adapter
- One (1) PC or lap top and LAN interface cable with 14585A Power Analyzer and supporting software installed

1.2 Software requirements

- 14585B Power Analyzer Software, version A.0x.xx (a software license installed in N6705B mainframe is needed for it to interface to the N6705B)
- Agilent I/O Libraries Suite 15.5 (CD ROM P/N xxxxx-xxxxx)
- Visual Studio.Net 2003, version x.xx (?), or newer (?)

1.3 Firmware requirements

- N6705B: Mainframe firmware revision C.0x.xx (?) or later

2.0 CONTENTS

3.0 PULSED DEMO LOAD MODULE DESCRIPTION

Referring to the block diagram in figure 1, a two-speed multi-vibrator drives one switched resistor load directly, and two one-shot pulse circuits which in turn drive two more switched resistor loads. In addition to these pulsing loads there are two fixed resistor loads. The multi-vibrator and one-shots are separately powered so only the load resistors draw current from the N6781A modules being demonstrated. Various combinations and settings of these loads provide dynamic current drain waveforms ranging from micro-amps to amps, simulating pulsed talk- and standby-mode current drains drawn by a typical mobile wireless device. The 4, 40, 80, and 40k ohm values were selected to provide "even" current values with 4 volts applied, while giving ample headroom to exceed this with up to 6 V applied (6781A 6V, 3A output) to more accurately simulate actual DUT currents. This provides a controlled load that considerably eases the task of demonstrating the N6781A Source-Measure Module and 14585A Power Analyzer Software compared to setting up and operating an actual mobile wireless device. The demo load module's inputs can be easily used as multiple, separate loads for demonstrating multi-channel test applications, using multiple N6700 series modules for power and measurement. Expect accuracies of 3% on load level and 10% on pulse timing for this demo load.

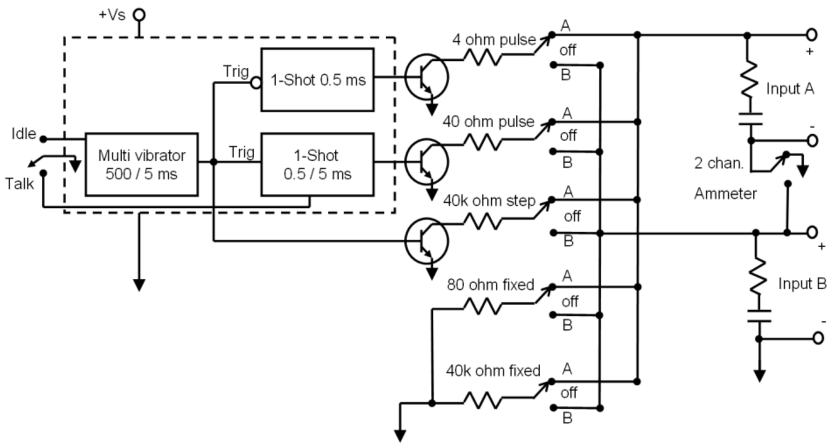

Figure 1: NPN-21900 Pulsed Demo Load ET Module Block Diagram

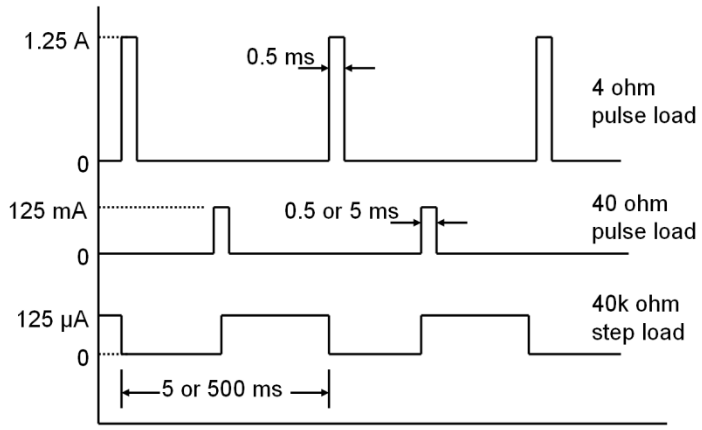

Figure 2: Pulsed Demo Load Module Current Drain Waveforms with 5 VDC Applied

4.0 TALK-MODE CURRENT DRAIN EMULATION

A reasonable approximation of a GSM mobile phone talk-mode current drain can be created by paralleling the 4 ohm pulse load, the 40 ohm pulse load, and the 80 ohm fixed load. The period is to be set to 5 msec. When 5 VDC is applied by the 6781A module, a 62.5 mA baseline current is drawn with alternating 1.25 A and 125 mA, 0.5 msec wide transmit and receive pulses occurring every 5 msec, on top of the 64.1 mA. Average current is 200 mA (62.5 mA + (10% * 125 mA) + (10% * 1,250 mA)).

5.0 STANDBY OR IDLE MODE CURRENT DRAIN EMULATION

A reasonable approximation of a mobile phone idle mode current (GSM or CDMA) can be created by paralleling the 40 ohm pulse load, the 40k ohm step load and 40k ohm fixed load together. The period is to be set to 500 msec. When 5 VDC is applied by the 6781A module, a 125 µA baseline current and incremental 125 µA step and 125 mA, 5 msec wide receive pulse currents on top of the baseline. Average current is 1.4375 mA (0.125 mA + (0.125 mA * 50%) + (125 mA * 1%)).

A further complicating factor about idle mode current drain is an actual mobile device periodically becomes active and transmits in order to register with a base station. Standard tests for idle mode current drain run at least 44 minutes in order to include these registration activities. This also means the current measurement system needs to be able to measure up to 2.5 amps even though the overall average is only a few milliamps of current.

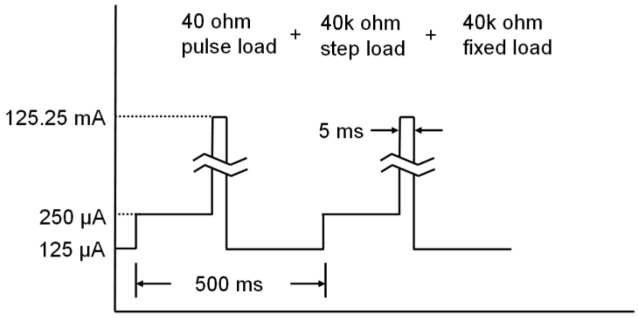

Figure 3: Standby Current Drain Emulation

6.0 FIXED- VS. SEAMLESS-MEASUREMENT RANGING DEMONSTRATION

Refer to Figure 4 for the following set up:

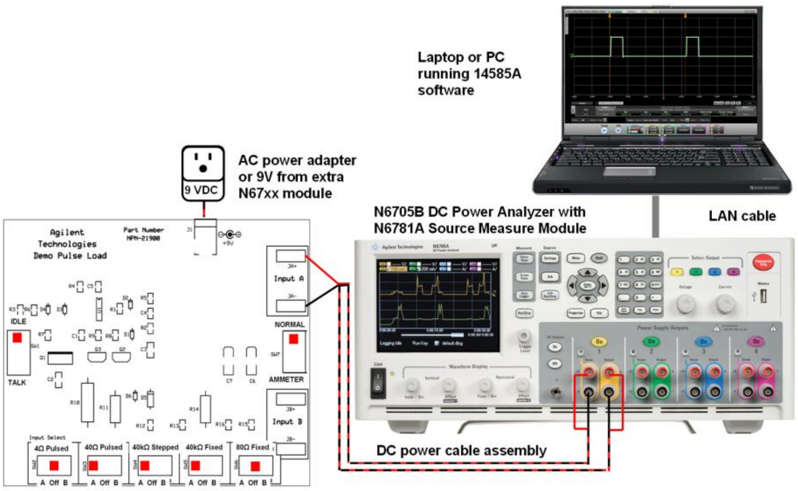

Figure 4: Set Up for Demonstrating the N6781A's Fixed vs. Seamless-Measurement Ranging

Connect up the N6705A DC Power Analyzer mainframe, containing the N6781A 2-Quadrant Source-Measure Module to the demo pulse load ET, using the twin twisted pair cable assembly provided. The pulse demo load includes an R-C compensation network across it's input to assure a stable output on the N6781A when being used in its high bandwidth setting (note; there is usually there is enough capacitance in a customer's DUT that an external one is not needed). Connect to the 40KΩ fixed, the 40KΩ stepped, and the 40Ω pulsed loads, and set switch to "idle" to simulate standby current drain.

Connect up the AC adapter to provide power to the demo pulse load ET. Set up the demo pulse load ET as described in section 5 for idle mode current drain emulation.

If demonstrating by using the 14585A Power Analyzer software, interface the N6705B DC Power Analyzer to the PC or laptop using a LAN cable. The rest of the procedure is primarily using the 14585A software however it is just as practical to perform this demonstration directly from the N6705A's front panel and display. Once everything is connected, power up the equipment.

Establish a LAN interface connection to the N6705B by selecting "A Connect" in the Instruments box at the bottom of the 14585A interface. Select the active N6705B that is available and then depress the "configure" button at the bottom to establish a connection. Note, the 14585A software can interface with up to four N6705B mainframes.

Access the N6705A's V/I source settings and advanced source settings screens through the Instrument Control tab on the left hand side of the 14585A interface. Make the following selections:

- Voltage Range: 6.12 V
- + Current Limit: 3.06 A
- Voltage: 5V
- Compensation setting: High-3 (7 to 150 µF load capacitance)
- Voltage Sensing: 4-wire

Enable the output. The N6705A meter display should read 5 V (<+/- 4mV). With the demo pulse load ET connected and powered some current drain should be indicated.

Fixed Range Measurement Exercise

Select the14585A software's scope operating mode for this testing. Make the following waveform acquisition parameter settings in the 14585A interface:

- Select Output 1 current to be displayed.
- Set vertical amp/div to 50 mA/d
- Set horizontal time/div for 200 ms/div
- Set acquisition buffer size to "auto" (optimizes sampling speed & resolution)
- De-select (turn off) any other Output voltage and current waveform acquisitions
- Through the "Ranges…" button, on the lower right side, set the measurement range setting for Output 1 voltage and current to "20 Volts" and "3 Amps"
- Select triggered measurement and channel 1 current as trigger source
- Set trigger level to 0.05 A and trigger for positive slope

Depress the Scope Run button. The 14585A should acquire and display a current waveform like that shown in Figure 5. Note, the measurement system will continually re-acquire new measurements until the Scope Run button is depressed again. **Leave it continually running for the rest of the demo.**

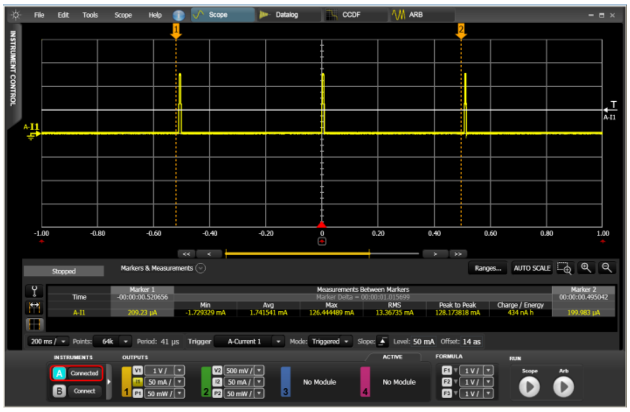

Figure 5: 14585A Pulsed Current Drain Waveform Acquisition

Turn on the measurement markers as shown in figure 5. Place them on 1 or 2 waveform periods. Make note of the calculated measurements for average current (~ 1.5 mA) and period time (~ 0.5s).

Now change the time scale to 2 ms/d and place the measurement markers to select just the pulse plateau portion <u>within</u> the vertical sides of the pulse, as shown in figure 6. Again note reading for pulse plateau average and peak to peak currents. (Note, peak to peak is about 500 µA)

Figure 6: 14585A Determining Pulse Plateau Values Using Markers

Now adjust the time scale back to 200 ms/d and place the measurement markers to select a small portion of the valley between the pulses, as shown in figure 7. Make note of the DC & p-p values.

Figure 7: 14585A Determining Pulse Valley Values Using Markers

Expand the amplitude by decreasing the vertical scale setting down to 200 µA/d, as shown in figure 8. The peak to peak current noise at the pulse valley is the same as at the pulse plateau (~ 500 µA p-p) when in fixed range measurement.

Figure 8: Expanding the Pulse Valley Amplitude

Seamless-Ranging Measurement Exercise

Make the following single change: Through the “Ranges…” button, set the measurement range for Output 1 current to “Auto” **(Most effectively demonstrated when actively measuring!)**

Now when making the measurements for the pulse valley, take note of the difference compared to the fixed measurement range values. The expanded pulse valley waveform should now appear as shown in Figure 9. The 125 µA step current is now easily observed and measured as the 6781A’s measurement system has seamlessly ranged to the most ideal range for the amplitude of that portion of the waveform. Make note of DC average (~125 uA) and peak to peak (~ 20 µA p-p) values are now for the pulse valley area. The DC offset error has now dropped from 200 uA in the 3 amp range down to just 75 nA by auto-ranging down to the 1 mA range for the pulse valley and similarly the noise floor dropped from 500 µApp down to ~20 µApp (a 25X reduction).

Figure 9: Expanding the Pulse Valley Amplitude, Seamless Ranging Measurement Turned On

7.0 FIXED- VS. SEAMLESS-MEASUREMENT RANGING DISCUSSION

There are two aspects to be considered here when attempting to make accurate measurements on very dynamic current drain waveforms having high peak pulses and low valley and DC average values, such as the ones being measured here; and that is the DC accuracy and AC noise floor.

DC Accuracy, Conventional Fixed Range Measurement

A good, conventional fixed range current measurement instrument provides 0.05 to 0.1% reading error plus 0.05 to 0.1% offset error of the range when making DC measurements. Due to the offset error, this falls short of the accuracy needed when trying to measure idle currents and other, similar low duty cycle, high peak pulsed standby and sleep mode currents. Minimizing this idle mode current drain in order to optimize battery run-time is critically important to wireless mobile device developers. To illustrate, the idle current described in section 5 has an overall average current of 1.4375 mA and the average of the valley current is only 0.1875 mA. However, peak pulse currents from over 100 mA, and as high as ampere levels during a registration, dictates using a 3 amp measurement range. Even though the accuracy of the N6781A's 3 amp measurement range is excellent; having 0.025% reading error plus 0.3 mA offset error it is clearly evident it is inadequate for this scenario as offset error yields the following:

- Idle current measurement error (%) = (0.025% + (0.3 mA/**1. 4375 mA**) * 100%) = 20.9%
- Valley current measurement error (%) = (0.025% + (0.3 mA/**0.1875 mA**) * 100%) = 159%

This fundamental issue with offset error leads device developers to resort to tricks and other means to gain better insight here, usually having other significant downsides.

DC Accuracy, N6781A Seamless Ranging Measurement

After setting the N6781A's measurement range from "3A fixed" to "auto" and repeated making the pulsed current waveform acquisition shown in Figure 8 we found we are now able to accurately observe and measure the low level currents in the valley portion of the waveform, while at the same time still measure the pulse peak currents, all in one acquisition. This is a major advance in measurement capabilities that has been a problem until now. The N6781A is able to seamless transition through its upper three measurement ranges which are as follows:

3A: 0.025% reading + 0.3 mA	100 mA: 0.025% reading + 5 µA	1 mA: 0.025% reading + 75 nA

With ranging the offset error is no longer limited by the highest range used. Instead the offset error is the sum of the offset errors weighted by the percent of time spent in that respective range. The idle current measurement errors now become:

- Idle current offset error (mA) = 0.3 mA * 0.01 + 0.000075 mA * 0.99 = 0.00307425 mA
- Idle current measurement error (%) = (0.025% + (0.00307425 mA/1. 4375 mA) * 100%) = 0.239%
- Idle valley current measurement error (%) = (0.025% + (75 nA / 0.1875 mA)*100%) = 0.065%

This is almost two orders of magnitude (40 dB) improvement over fixed ranging for the overall idle current measurement and whopping 2,446 times (~65 dB) improvement for the idle valley current measurement! It would require nearly 8 decades or 25 bits of measurement accuracy in a fixed range measurement system to get this kind of measurement performance!

AC Noise Floor and Waveform Digitization

As shown in Figures 4 through 8, the N6781A not only provides accurate DC measurements, but it digitizes the dynamic current drain waveform at up to 200k Sa/s rate, providing considerable insight for correlating current drain as it relates to specific DUT activities. It is readily seen comparing Figures 7 and 8 that the seamless measurement ranging provides similar benefit to dynamic waveform resolution at low levels as it does for DC offset measurement error. At the same time several factors influence the ability to accurately digitize the current waveform.

The dominant source of current noise measured results from the AC impedance the load / DUT presents to the N6781A output's voltage noise, so keeping the DUT and fixture capacitance as small as what only is needed minimizes the current noise floor and maximizes the dynamic measurement range.

For this demonstration the peak to peak noise current on the 3 amp measurement range was 500 µApp (250 µA pk), which is 81.6 dB of dynamic measurement range. Changes made in the N6781A's current measurement system based on the range it is in dynamically reduces the noise floor. **As seen in Figure 8 the peak to peak noise is now only ~20 µApp, extending the dynamic measurement range by 28 dB, for effectively an impressive total of 109.6 dB of dynamic measurement range being realized for this example shown!**

8.0 SOURCE VOLTAGE TRANSIENT DROP DEMONSTRATION

N6781A Fast Transient Response Demonstration

The N6781A is a fast transient response DC source and is able to maintain a stable voltage with minimum transient voltage drop for fast pulsing loads such as wireless mobile devices.

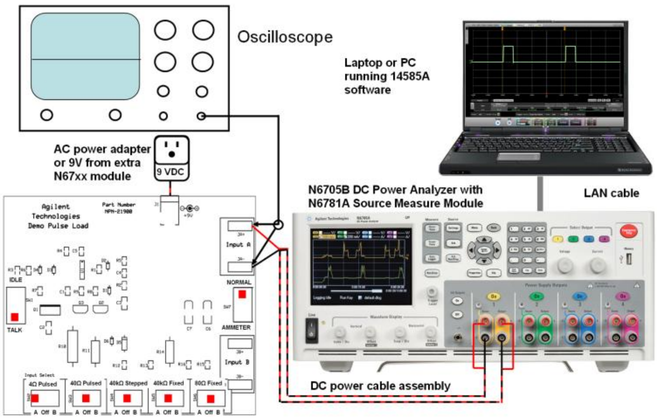

Figure 10: N6781A Transient Voltage Drop Performance Test Setup

The set up for measuring transient voltage drop performance is virtually the same as in section 6. The main differences are the 4 ohm pulse load input of the demo load is being used, set to the higher rate "talk" mode position, and an oscilloscope is connected up to measure the transient voltage drop. The 4 ohm pulse load has a 10 µs rise and fall time, consistent with the N6781A's specified performance. **(If no oscilloscope is available the N6781A's voltage readback can be used, but has a bit more attenuation due to bandwidth limitations, when compared to the oscilloscope.)**

- Use N6781A source settings as per section 6
- Set the N6781A voltage to 4V
- Set the N6781A current measurement ranging to "3A fixed"
- Set the 14585A s/w to display 500 mA/d as the pulse plateau amplitude is about 1 A (@ 4V)
- Set the 14585A s/w to display 10 to 20 µs/d
- Set the oscilloscope to display 50 mV/d and 10 to 20 µs/d
- Set the oscilloscope trigger to negative edge triggered, -20 mV level
- Enable the N6781A output
- Make note of the transient voltage drop magnitude and recovery time
- Change the N6781A current measurement ranging to "Auto"
- Again make note of the transient voltage drop magnitude and recovery time

The transient voltage drop performance should be similar to that shown in figure 11 (green=current, yellow= volts). Note that here a current probe had been used to capture the current drain pulse on the oscilloscope. The 14585A software will serve that function in this lab

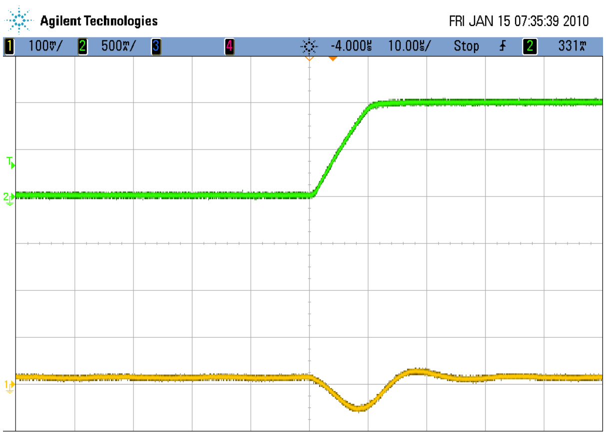

Figure 11: N6781A Transient Voltage Transient Drop Performance
(Demonstrate both with auto-ranging measurement on and off.)

DC Source with General Performance Transient Response, Comparative Demonstration
Providing there is a suitable DC source (N673x, 4x, 5x, or 6x), it can be connected up in place of the N6781A as in the previous demonstration, and its transient response measured for comparative purposes. Due to its slower response performance, the following setting changes are recommended:

- Set the 14585A s/w to display 100 µs/d
- Set the oscilloscope to display 500 mV/d and 100 µs/d (roughly 10X greater)
- Set the oscilloscope trigger to negative edge triggered, -40 mV level

The comparative results are shown in Figure 12:

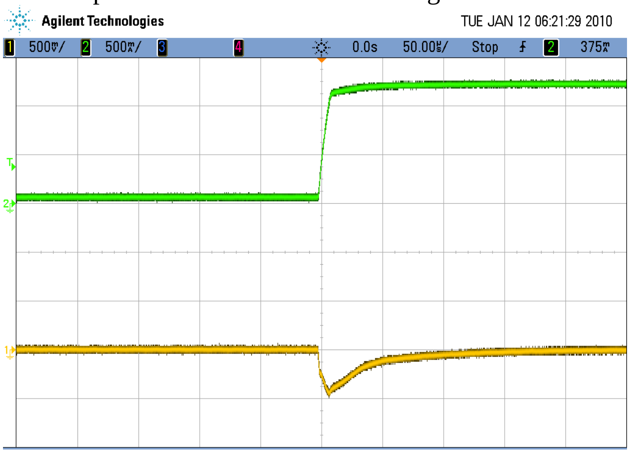

Figure 12: N6762A General Transient Performance Comparative results

9.0 SOURCE VOLTAGE TRANSIENT DROP DISCUSSION

The N6781A transient voltage drop should be around 50 mV and recovery to within 20 mV is (specified to be) under 20 µs, which is shown that it easily meets by the measurements just taken. Small transient voltage drop and fast recovery time are important characteristics for a “battery emulator” type of DC source being used to power mobile wireless devices and the components within them (like the RF PA) that draw fast, high peak pulsed currents. This is in comparison to a DC source having general transient response performance as shown in Figure 12; the transient drop magnitude and recovery time is on the order of magnitude greater on both aspects. Such general transient response performance impacts the performance of the DUT.

Whether the N6781A is set to a fixed measurement range or to auto ranging measurement, it has the same transient voltage drop performance. The current sourcing and measurement are very much decoupled in the N6781A. “Competing” SMU type of DC sources have problems when their output current exceeds their measurement current range, leading to output voltage glitching, current limiting, and other problems, and in some cases causing damage to voltage-sensitive DUTs.

10.0 BATTERY RUN-DOWN / ZERO-BURDEN SHUNT DEMONSTRATION

The N6781A can alternately be configured and used as a combination zero-burden (zero-ohm) ammeter and independent voltmeter to measure an actual battery run-down current and voltage when the battery is being used to power a DUT, as well as be used to measure DUT sub-circuit currents and voltages.

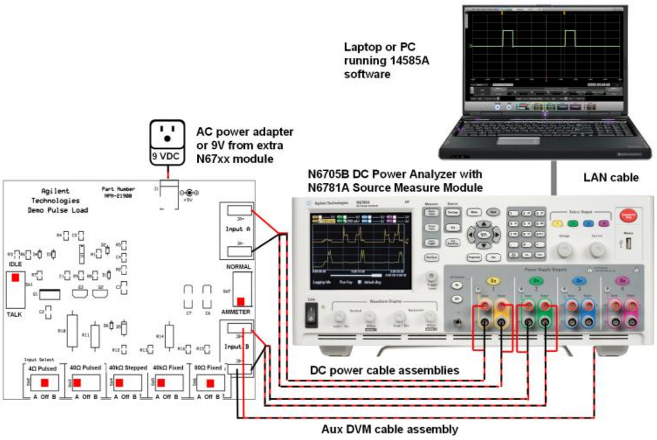

Figure 13: Battery run-down / zero-burden shunt demonstration setup

An N6781A in channel 1 is connected in series with the "battery" (output 2), as shown in figure 13, serving as a zero-ohm (zero-burden) ammeter. Note that it is ground reference side, which is generally preferred but not absolutely required. Using the supplied cable assembly, connect the N6781A output 1 auxiliary DVM input across the demo pulse load as shown. Through either the 14585A software or N6705B front panel, in the source settings, set the output 1 N6781A to the following:

- Select emulating: "Current Measure Only", which has the following presets:
    - Voltage Priority
    - Voltage Range: 6.12 V
    - Current Limit: 3A
    - Output Voltage: 0 V
- In the advanced source settings make the following selections:
    - Compensation setting: Fast-3 (7 to 150 µF load capacitance)
    - Voltage Sensing: 4-wire
- Select Properties; under Output 1-Meter Properties make the following selections:
    - Meter Ranges: Select "Auto"
    - Voltage Measurement Input: Select Aux Voltage
- Key points on N6781A set up:
    - With the N6781A programmed to zero volts it becomes a zero-burden (zero ohm) shunt.
    - The N6781A features an uncommitted digitizing DVM input for measuring auxiliary voltages; in this case, for measuring the voltage of the battery furnishing the energy during a battery run-down test.

For demonstration purposes output 2 serves as the "battery". Ideally a second N6781A module can be used as the battery emulator, even programming output resistance. Alternately other, general purpose modules can be used, having comparable voltage and current limit levels, and include a large bypass capacitor (2,000 to 4,000 uF) at end of its cable to improve voltage stability powering the DUT. Alternately, an actual battery can be used if desired!
Either by using the 14585A software or N6705B front panel, set output 2 to the following:

- In the advanced source settings; Voltage sensing: 4-wire
- If an N6781A module:
    - Voltage Range: 6.12 V
    - Current Range: 3.12A
    - Compensation setting: Fast-3 (7 to 150 µF load capacitance)
- Set voltage limit to 5 V
- Set current limit to 3 A
- Output enabled

Following is a suggested example of a short demonstration of various activities being captured by the data logging. Feel free to further improvise as you see fit. Select data logging mode of operation for the 14585B software and make the following selections:

- Data log duration: ~ 1.5 minutes
- Data log period: 0.2 millisecond
- Select Channel 1 voltage & set to: 5V/d
- Select Channel 1 current & set to: 100 mA/d
- De-select any other inputs
- Set Time axis to: 10 sec/d

Start the data log:

- After ~20 seconds switch demo load to “talk” to show change in load pulse rate being logged.
- After ~20 seconds change channel 2 output voltage to 4 volts to show change in “battery” voltage being logged.
    - Key point: Output 1 DVM is logging DUT voltage, not its output voltage
    - Key point: Source voltages can be changed during data logging
- After ~20 seconds switch demo load back to “idle”
- Let the logging end. Disable output 2 DC source to turn off power

The end data log result should look similar to Figure 14:

Figure 14: 14585A Zero-burden ammeter logging exercise result

11.0 BATTERY RUN-DOWN / ZERO-BURDEN SHUNT DEMONSTRATION / DISCUSSION

Now that the logging is finished, share the following post-test details:

- Select the 2nd section of the data log capturing “talk” mode rate current drain. Expand the time scale to 5 ms/d
    - Key point: Even in data log mode it is possible to capture high speed details of a fast pulse rate signal like GSM in talk mode.
        - One can log at up to 10 kSA/s to the 14585A (it is an external application)
        - It is possible to log to the N6705A’s internal drive (or a high speed USB stick plugged into the N6705A) at up to 50 kSA/s if greater detail is needed

Figure 15: Data log details for talk mode

- Set horizontal time scale back to 10s/d. Turn on output 1 power trace and set to 500mW/d. Turn on and place markers on the start and end of the second section of data for talk mode drain.
    - Key point: Logging mode easily captures and accurately calculates current, voltage, watts, amp hours (coulombs) and watt hours for determining energy and power consumption and efficiency for analyzing optimizing battery run-down time.

Figure 16: Power trace and vertical markers turned on

- Select a section of the idle mode current. Expand the time scale to 50ms/d. Place markers between, but not including, two idle current pulses. Expand vertical scale to 100 µA/d. Show how uA-level the "off" mode current is accurately captured between the A-level pulses. Make note of average value and peak to peak value.
    - Key point: The integration taking place in data log mode can be used to one's advantage in further reducing the noise floor of the current measurement. The digitizer itself continuously samples at 200,000 kSA/s. These samples are average by the data log period, in this case 0.1 ms (2,000 samples are being averaged!). Note how much further the peak to peak noise floor has been reduced (from ~20 µA p-p as seen in section 6, figure 9, using scope mode), down to 3.5 µA p-p here. Data log integration is effectively a user-programmable low pass filter.

Figure 17: Looking a µA-level sleep current signal between pulses in data log mode

- <u>Closing Key Point:</u> With the N6781A's output set to zero volts and connected in series with the battery and DUT, it becomes a true zero-burden, zero-ohm shunt / ammeter, neither contributing to, or like a resistor shunt, subtracting from the battery's voltage. Even more, it is able to seamlessly measure from µA levels to A levels accurately. This dynamic range is not even achievable with a resistor shunt, regardless of how much voltage drop there is on it.

12.0 MULTI-CHANNEL DEMONSTRATION

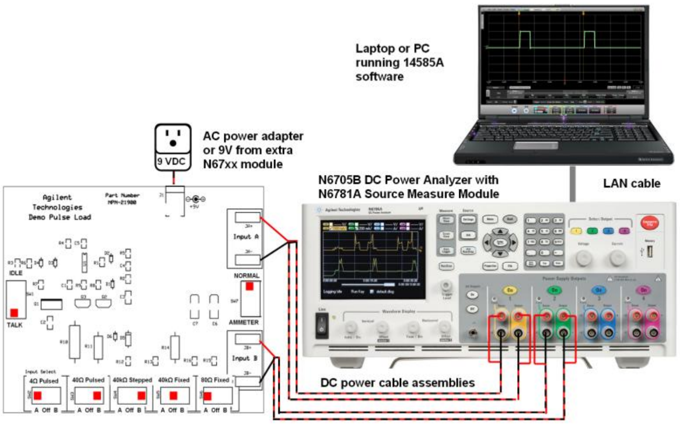

Figure 14: Multi-channel demonstration setup

To demonstrate the multi-channel capabilities of the 14585B SW (& N6705B DC Power Analyzer) the demo pulse load ET can be used as a 2 channel load to draw pulsed current from multiple DC sources installed in the N6705B.

Connect the demo pulsed load ET to the N6705B as shown in Figure 14. Set the output 1 N6781A as described in section 6. For reference, access the N6705B's source settings and advanced source settings screens through the Instrument Control tab on the left hand side of the 14585A interface. Make the following N6781A selections:

- Under sourcing menu, emulating: "2 Quadrant Power Supply"
  - Voltage Range: 6.12 V
  - Current Range: 3.12A
  - Set voltage limit to 5 V
  - Set current limit to 3 A
  - Set output resistance to 0.2 ohms
  - Under advanced source settings:
    - Compensation setting: Fast-3 (7 to 150 µF load capacitance)
    - Voltage Sensing: 4-wire
- Select Properties; under Output 1-Meter Properties:
  - Meter Ranges: Select "Auto"
  - Voltage Measurement Input: Select Output Voltage (should be this by default)

If output 2 is an N6781A module, set it up as per output 1. If output 2 is a more general purpose power supply module, set it up to provide comparable output voltage and current.

Following is a suggested example of a short demonstration of various activities being captured by the data logging. Feel free to further improvise as you see fit. Select data logging mode of operation for the 14585B software and make the following selections:

- Data log duration: ~ 1.5 minutes
- Data log period: 0.4 millisecond
- Channel 1 voltage: 5V/d
- Channel 1 current: 500 mA/d
- Channel 2 voltage: 5 V/d
- Channel 2 current: 50 mA/d
- Time axis: 10 sec/d

Start the data log:

- After ~20 seconds switch demo load to "idle" to show change in load pulse rate being logged.
- After ~20 seconds change channel 1 output voltage to 4 volts to show change in voltage being logged.
  - Key point: Source voltages can be changed during data logging
- After ~20 seconds change channel 2 output voltage to 4 volts to show change in voltage being logged.
  - Key point: Source voltages can be changed during data logging.
- Let data logging end. Disable DC source outputs to turn off power

Figure 15: A Multi-channel Data log example

13.0 MULTI-CHANNEL DISCUSSION

Many of the attributes and key points for data logging during multi-channel operation are the same as shown in data logging for battery run down demonstration.

The key thing about multi-channel operation is it gives users the ability to control and log current and voltage on up to 16 outputs with just one instance of the 14585B software running. The 14585B will interface with up to 4 N6705B DC Power Analyzer mainframes, each holding up to 4 DC power source modules. This is useful for applications including:

- Running long term tests on multiple devices at once for greater test throughput when needing to characterize a larger population of DUTs.
- Running side-by-side tests on devices all under the same condition to help determine if behavior issues are with the device or with the stimulus.
- Logging on multiple channels to correlate current drains and applied voltages of sub-circuits against applied stimulus and against overall current drain, in effort to analyze and optimize overall current drain of a device.

14.0 PULSED CURRENT LOAD DEMONSTRATION

The N678xA modules have fast current priority mode response, making them excellent as either a dynamic current source or dynamic current load. Pulsed and constant current loading is a key part of Power Management IC (PMIC) testing. This section describes how to demonstrate the N6781A as a pulsed load.

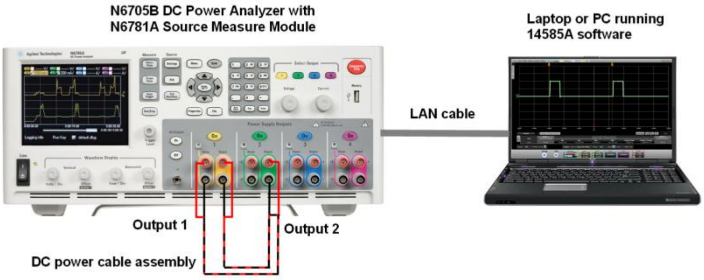

Figure 16: N6781A Pulsed Current Load Demonstration

On the N6705B connect the output 1 to output 2 using the 4-wire sense power cable, as shown in Figure 16. Output 1 is the N6781A module acting as a current load and Output 2 is a general purpose module serving as a voltage source being loaded by the N6781A. The pulse parameters are such that they approximate a GSM transmit mode current drain.

Set up Output 1:

- In source settings menu select CC Load emulation mode from the pull down menu. It pre-configures the N6781A with:

    - Current priority
    - 3 amp current range and 6 volt voltage limit
    - -0.5 ma current (minimum loading starting point)
- In advanced source settings select “High 3 for (7-150 uF)” output voltage bandwidth setting
- Enable the output

Set up the ARB. When using the 14585A software:
- Select the ARB screen
- Select I-1 (output 1 current). It will have “fixed DC” initially.
- Select “512-point sequence” at the top and then select “add” in the middle. I-1 will change to “sequence”
- Select “pulse” from the pre-configured waveforms
- Set the following waveform parameters:
    - Start amplitude: -0.05A (negative current = current sinking)
    - End amplitude: -1.3 A
    - Delay: 0
    - Pulse Time: 0.00058 sec
    - End Time: 0.00406 sec
- Select done, once entered set sequence repeat to “continuous”

When using the N6705B mainframe directly to set up the ARB make sure the 14585A software is not running. There will be conflicts otherwise. Do as outlined above for creating the ARB using the N6705A, selecting “ARB” and then “Properties” buttons on the front panel.

Set up Output 2:
- From the Source Settings screen set the output to source 5 Volts and 2 Amps
- In the advanced setting screen select “Local” sensing
- Enable the output

At this point, before running the ARB, in meter view, Output 1 should read “5 V, -0.5 mA, CC” while Output 2 should read “5 V, 0.5 mA, CV”

Go to the 14585A scope screen and set up the parameters as follows:
- Set time to “2 ms/div”
- Set points to “auto”
- Set trigger to “A-Current 1”
- Set mode to “triggered”
- Set slope to negative edge
- Set trigger level to -0.2 amps

Start the ARB by pressing the “ARB” run button. If the meter view is displayed Output 1 will read “5 V, about -200 mA, CC” while Output 2 should read “5 V, about 200 mA, CV”. The current reading meter will be a little jumpy because it is a pulsing current.

Start the scope measurement by pressing the “Scope” run button. You should see a waveform capture like that shown in Figure 17.

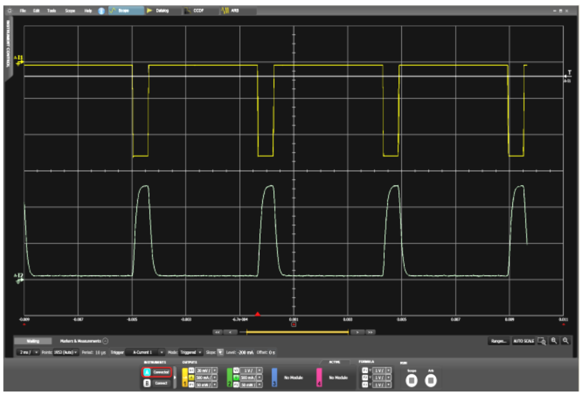

Figure 17: N6781A Pulsed Current Load Operation, Waveform Capture

15.0 PULSED CURRENT LOAD DISCUSSION

As demonstrated, the N6781A is an excellent, fast, current load well suited for dynamically loading outputs of voltage regulators on PMICs for testing purposes. If checked with an oscilloscope and wideband current probe the 10-90% slew rate is better than ~3 microseconds regardless of current step size (PRELIMINARY, slew rate specs need to be finalized!). One can not only create simple pulsed loads as shown, but, as seen in the 14585A ARB set up screen, there are numerous options for generating a variety of complex waveforms

- 512 point variable dwell ARB generation for data efficiency
- 64 K point constant dwell ARB generation for higher resolution when needed
- 14 pre-defined ARB waveforms
- Formulas for creating complex ARB waveforms
- Ability to tie waveform segments together for creating complex ARB sequences
- Ability to import ARB data files, say if you recorded the current drain of a device and wanted to play it back with a load, eliminating the need to use the device itself
- ARB sequence repeat from 1 to 1,000, or continuous.

Also, as can readily be seen in the scope capture in Figure 17, the new N6781A has much greater measurement bandwidth than previous DC power modules available for the N6705B.

16.0 APPENDIX A; NPN-21900 DEMO PULSE LOAD ET SCHEMATIC