Measuring Leakage Current with 400e SMU

Application Notes

Version 1.0, 10-2013

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Section 1: Overview

This application notes discusses how to reduce test time during leakage current measurement at power supply pin of a device-under-test (DUT), where large value of capacitor is normally present to supply required instantaneous current.

This application notes assumes users possess a fair knowledge of the usage of 400e SMU.

Section 2: Measuring Leakage Current

Power supply pin normally takes large amount of current during normal operation. High current range of SMU is therefore selected. However, it is more accurate to use smaller current range for leakage current measurement. The problems of using smaller current range when huge capacitor is present are:

1. If current range of SMU is small, it takes very long time to fully charge up the capacitor before leakage current of the DUT can be measured. For example, if current range is 1uA, and the capacitor is 10uF, then the estimated time required to fully charge up the capacitor if supply voltage is 3V is 30s. This is ridiculously long for testing.

2. Slight voltage variation across a huge capacitor will easily cause micro-amps of charging or discharging of current to flow, and it takes a long time for this current to settle down before stable measurement can be performed.

There are 2 ways of performing fast leakage current measurement:

1. Insert a low on-resistance (R_{on}) FET switch in series with the capacitor at power supply pin.
    a. Disconnect the capacitor during leakage current test, then use small current range to measure the leakage current of the DUT.
    b. Reconnect the capacitor once leakage current is measured, then change to higher current range for remaining tests. Using high current range such as 1A will normally fully charge up the capacitor in split of miliseconds.

2. If it is not possible to insert such FET switch at power supply pin, do the following:
    a. Use high current range to pre-charge the capacitor, in case the capacitor is still empty such as upon power-up.
    b. Insert a small delay to ensure the capacitor is fully charged up. Estimation can be made using following methods:
        i. Apply formula dt = C*dv/i, where
            1. C = Capacitance
            2. dv = Change of voltage at power supply pin
            3. i = Current compliance
        ii. After applying the supply voltage, measure the voltage and current for few hundred milliseconds, at 1ms interval. Then plot the voltage and current curves in Microsoft Excel, and observe the settling time.

iii. Use oscilloscope to observe the waveform at power supply pin.

c. Once capacitor is fully charged up, change the current range to the desired range for leakage current measurement. When this happens, voltage at power supply pin will sag a little and it takes some time to fully charge up the capacitor again. The time it takes to fully charge up the capacitor again depends on the current range selected. Use methods described in b(ii) and b(iii) to estimate the delay required.

d. When voltage reaches steady state (capacitor is fully charged up), freeze the control loop of the SMU by setting `AemDCPwr_ConfigureOutputEnabled` to `false`. This prevents the current fluctuation caused by any slight voltage fluctuation at the power supply pin due to the presence of the capacitor.

e. Perform leakage current measurement. Apply higher NPLC if necessary.

f. Un-freeze the SMu control loop by setting `AemDCPwr_ConfigureOutputEnabled` to `true`.

g. Change the current range to the original value.

h. An example code is shown below.

```
ViReal64 vRb[1000], volRead;
ViReal64 iRb[1000], curRead;

ViReal64 vrng, irng_charge, irng_meas;
vrng = 10; irng_charge = 10e-3; irng_meas = 10e-3;

status = AemDCPwr_ConfigureSamplingTime(vi,ch,100e-6,AEMDCPWR_CONST_SECONDS);
status = AemDCPwr_ConfigureOutputTransient(vi, ch, AEMDCPWR_CONST_TRANSIENT_NORMAL);
status = AemDCPwr_ConfigureSense(vi, ch, AEMDCPWR_CONST_REMOTE);

//precharged capacitor with large current range - in case capacitor is empty (as in
during power up)
status = AemDCPwr_ConfigureCurrentLimitAndRange(vi, ch, 0,
0.99*irng_charge,irng_charge);
status = AemDCPwr_ConfigureVoltageLevelAndRange(vi,ch,0,vrng);
usleep(1000);
status = AemDCPwr_ConfigureVoltageLevelAndRange(vi,ch,0.34*vrng,vrng);

//loop measurements for voltage and current - with 1ms delay for each loop -
for (i=0;i<1000;i++){
	status = AemDCPwr_Measure(vi,ch,AEMDCPWR_CONST_MEASUREVOLTAGE,&vRb[i]);
	status = AemDCPwr_Measure(vi,ch,AEMDCPWR_CONST_MEASURECURRENT,&iRb[i]);

	if (i==20){
		//Change to Measure range
		status = AemDCPwr_ConfigureCurrentLimitAndRange(vi, ch, 0,
		0.9*irng_meas,irng_meas);
	}
	if (i==50){
		//Freeze control loop
		status = AemDCPwr_ConfigureOutputEnabled(vi,ch,false);
	}
	usleep(1000);
}
```

```
//run debug mode & add breakpoint here  - plot line graph of voltage and current to
observe for settling time
//back to normal conditions
status = AemDCPwr_ConfigureOutputEnabled(vi,ch,true);  //un-freeze control loop
status = AemDCPwr_ConfigureCurrentLimitAndRange(vi, ch, 0,
0.9*irng_charge,irng_charge);
status = AemDCPwr_ConfigureVoltageLevelAndRange(vi,ch,0,vrng);
```

Section 3: Revision History

1.0	OCT 2013	INITIAL RELEASE