TERIDIAN SEMICONDUCTOR CORP.

71M6511/71M6511H Energy Meter IC

AN_651X_006 | **Application Note**

JULY 2005

Current Shunt Meter Interface Using the TERIDIAN 71M6511

The 71M6511/6511H Demo Board is designed to use all combinations of sensors, i.e. current transformer (CT), current shunt/CT or single shunt resistor. The Demo Code is designed to support all operating modes. **The Demo Board is normally shipped in CT configuration.**

With a few quick modifications, the 71M6511/6511H Demo Board can be adapted to operation with a current shunt/CT or Single Shunt combination.

Safety Precautions

In shunt configuration, the whole Demo Board will be at line voltage! Touching the board or any components must be avoided!

It is highly recommended to isolate Demo Board and Debug Board (when used) by removing the jumpers on JP2 and JP3 and by providing separate power supplies for the Demo Board and Debug Board !

Wiring for Shunt Resistors

Figure 1 shows the general topology of the current shunt sensor operation. The voltage drop across the shunt resistor is fed into the IA input of the 71M6511/6511H device, with V3P3 being the reference. The voltage at the shunt is divided by the resistor divider R1/R2 (see Figure 1) associated with the voltage input and supplied to the VA input of the chip. The power to the 6511 chip is generated by attenuating the voltage between NEUTRAL and LINE through a network consisting of resistors, capacitors and diodes.

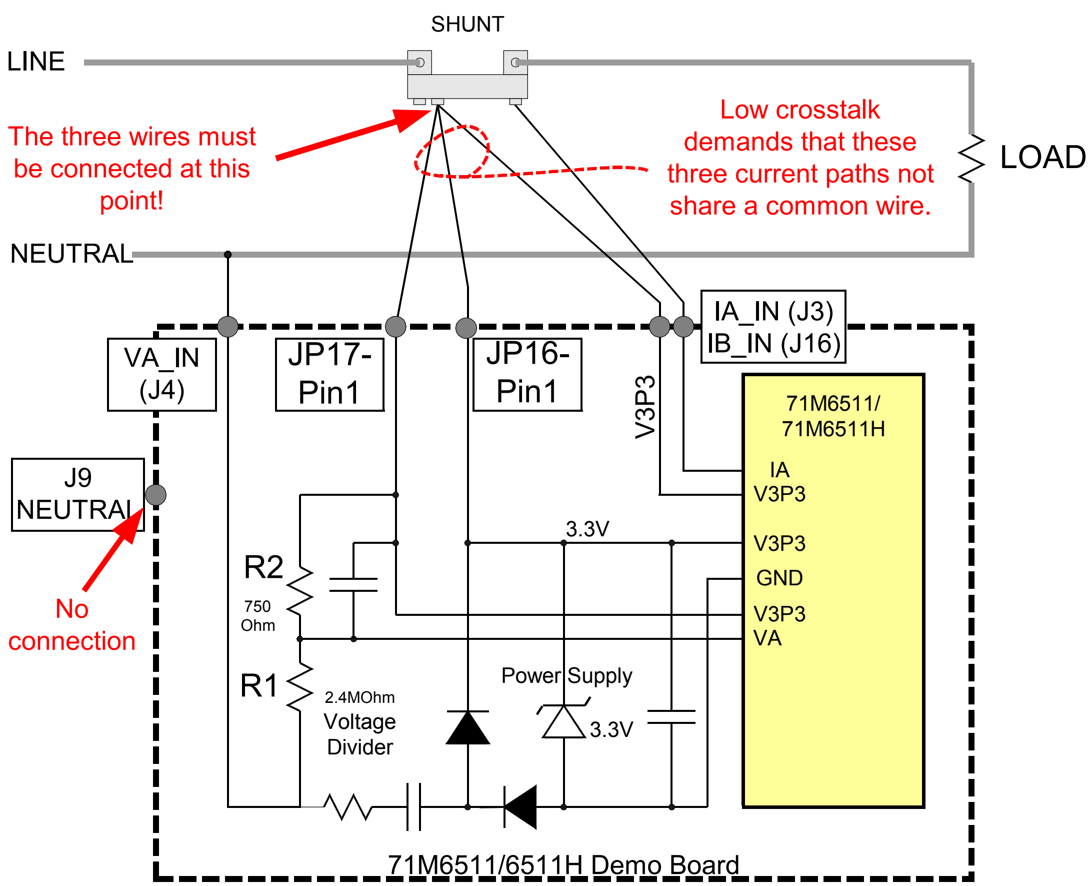


Figure 3. Wiring for Current Shunt Operation Mode

Figure 2 shows the connections required at the shunt resistor itself. It is important that three separate wires for V3P3 are attached at the shunt resistor and are routed to the 6511 Board separately, as shown in Figure 2.

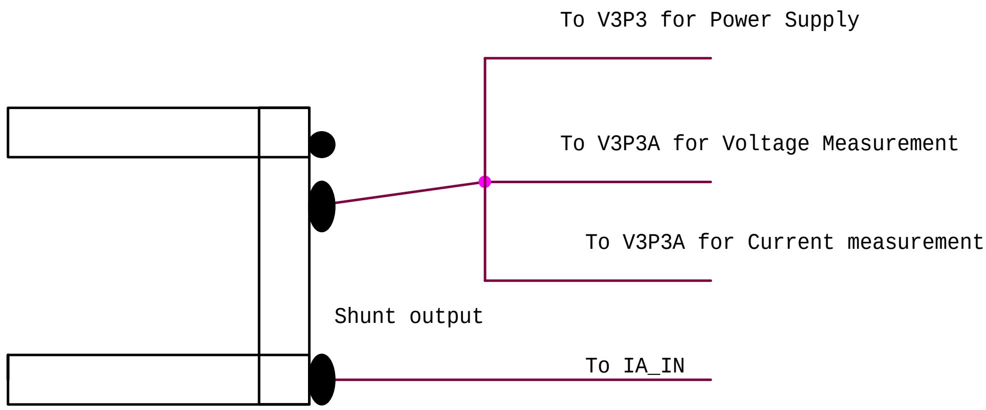


Figure 2: Typical shunt connections

Figure 3 shows the top-level view of a two-layer 6511 Demo Board connected to a shunt resistor. As can be seen in Figure 3, the nets V3P3, V3P3J2, and V3P3_JUMPER are all connected at the shunt resistor.

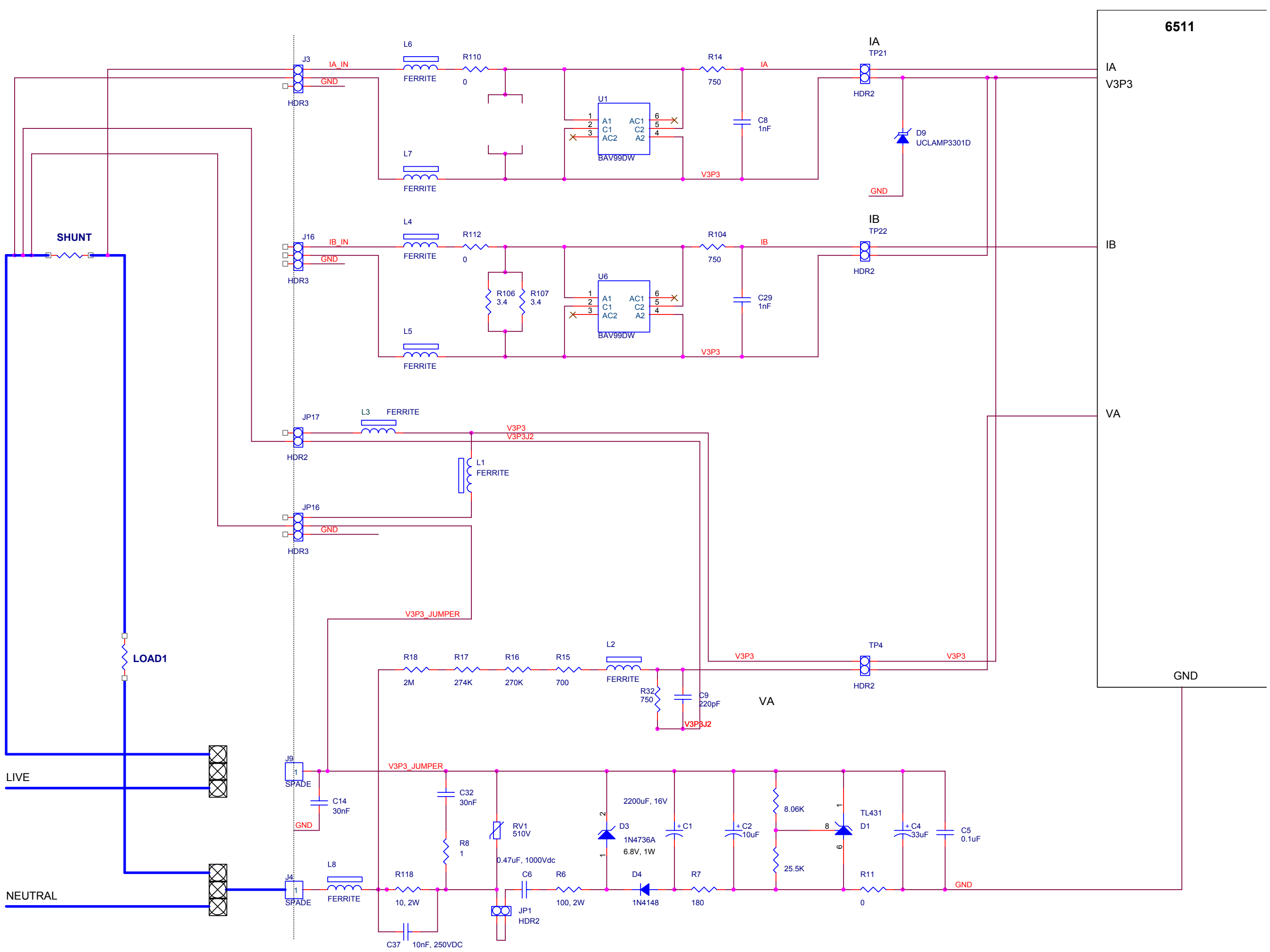


Figure 3: Top-level view of shunt connections

Current Shunt Input Schematic

Figure 4 shows an example for implementing a current shunt input on the TERIDIAN 71M6511 Demo Board.

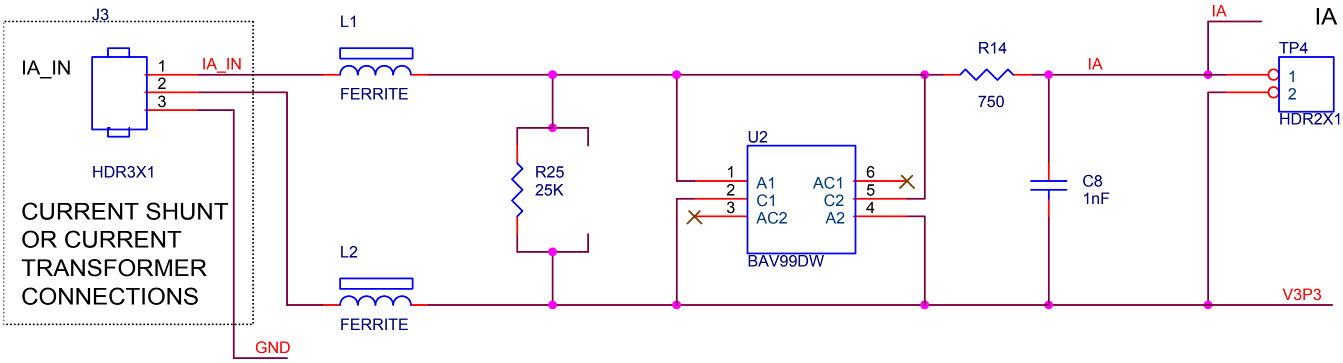


Figure 4: Current Shunts input signal conditioning circuit

Key EMI/EMC precautions for the input signal conditioning circuit (not available on the original Demo Board) are:

a. L1 and L2 are Ferrite beads that provide 600Ω impedance for signals above 100MHz. (TERIDIAN MMZ2012S601A).
b. The combination of R14 and C8 provides a low-pass filter with cutoff frequency of around 212kHz.
c. The V3P3 trace connecting to the input signal conditioning circuit should be wide.
d. The J3 connector has a three-input pin provision to accommodate for the connection of a shield for the Shunt cable. The shield may be connected to the digital ground to prevent high frequency noise entering through the Shunt metal plate.
e. In environments with high electromagnetic radiation, R25 can be used at 25kΩ to prevent spurious measurements.
f. Unused current inputs should be properly terminated or shorted.

It is important to note that the routing of the input sensing traces for reference V3P3 to the voltage and shunt inputs is very critical. The circuit shown in Figure 1 provides the necessary information for routing the V3P3 net:

Software Adjustjments

The ADC in the 71M6511/6511H chip is operating in 22-bit resolution mode. This means that both the control registers *CFIR* and *MUX_DIV* are set to 1.

Required modifications to the 71M6511 Demo Board for Current Shunt Sensor Connections:

The Demo board has provisions to incorporate the changes as pictured in Figure 1.

In order to operate the 71M6511/6511H Demo Board with a current shunt sensor, the following measures must be taken:

a. Remove the jumpers on JP16 and JP17.

b. Remove R24 and R25 if IA_IN is the input channel for the current shunt or remove R106 and R107 if IB_IN is the input channel for the current shunt.

c. The Neutral line must be connected to J4

d. The wires from the shunt resistor must be connected to contacts 1 and 2 on J3 if IA_IN is the input channel or contacts 1 and 2 on J16 for IB_IN.

e. Connect Pin1 of JP16 (pin closest to the regulator output, power supply pin) and pin 1 of JP17 (resistor divider output) together at the shunt, V3P3 terminal as shown in Fig 1.

f. Through the serial terminal, the Demo Program can be set to run in current shunt mode. This is done by issuing the commands **`>]IOSHUNT=15`** if IA_IN is connected to the shunt or **`>]I1SHUNT=15`** for IB_IN connected to the shunt. This will cause the Demo Program to select the proper input channels and to apply the gain of 8 to the shunt input channel from the ADC output before processing for power measurement.

CAUTION

Note: While connecting Neutral to VA_IN (J4), care should be taken to prevent shorting between LINE and NEUTRAL. Also note that no connection is required at J9 (NEUTRAL) since the LINE voltage from the shunt resistor becomes the reference for measurement.

Meter Performance with Shunt Connected

A Demo Board was used for testing the meter performance with Shunt resistor, using 71M6511 Demo Code revision 3.04. Meter accuracy or performance was verified for several test conditions by varying the input current gain and by using both internal and external power supply. Since the signals obtained from the Shunt resistor are small, it is better to integrate the inputs for a longer time (20 seconds) in order to ensure repeatability. Results are listed for 8x gain (Shunt_on), 1x gain (Shunt_off) and for operation with the internal power supply of the Demo Board (int_power). The results for internal supply were obtained with 1x gain (Shunt_off).

Measurement results are shown in Table 1 and Figure 5.

						Test Results		
step	element	volt	amp	phase_angle	freq	Shunt_on	Shunt_off	Int_power
1	S	240	10	0	50	-0.0939	-0.1248	-0.1452
2	S	240	5	0	50	-0.0894	-0.1233	-0.1478
3	S	240	3	0	50	-0.1054	-0.1261	-0.1439
4	S	240	1	0	50	-0.0627	-0.1201	-0.1156
5	S	240	0.3	0	50	0.0002	-0.0697	-0.134
6	S	240	0.1	0	50	-0.1944	-0.1505	-0.0176
7	S	240	0.06	0	50	0.0407	-0.1743	0.1042

Table 1: Shunt Measurement Results

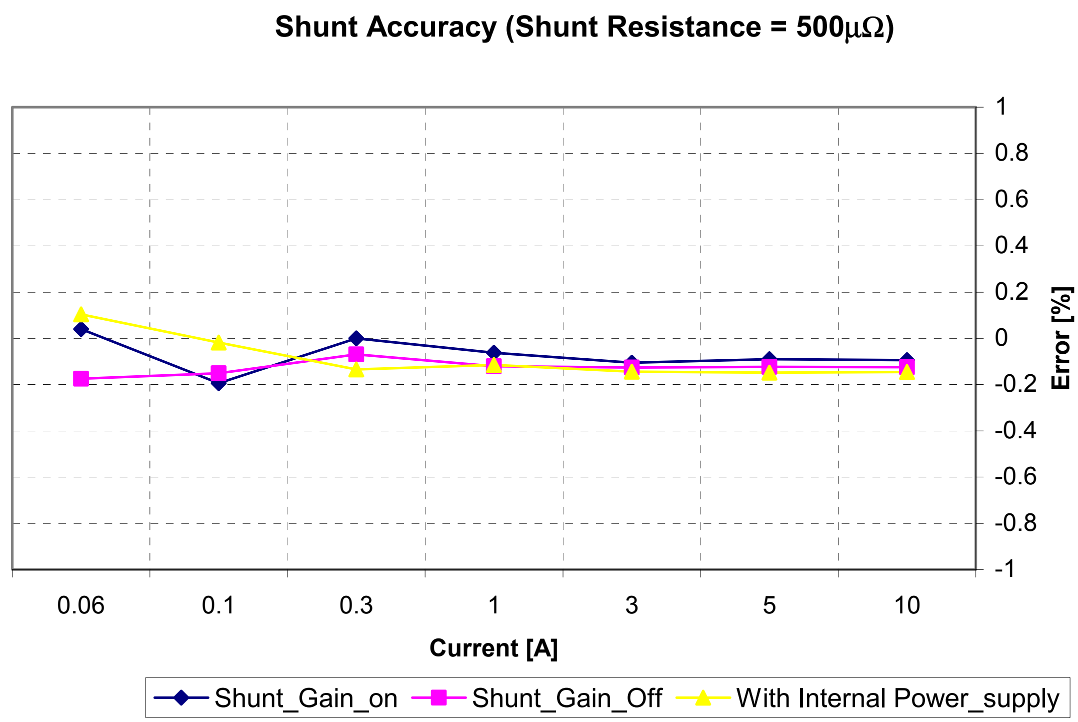


Figure 5: Shunt measurement results

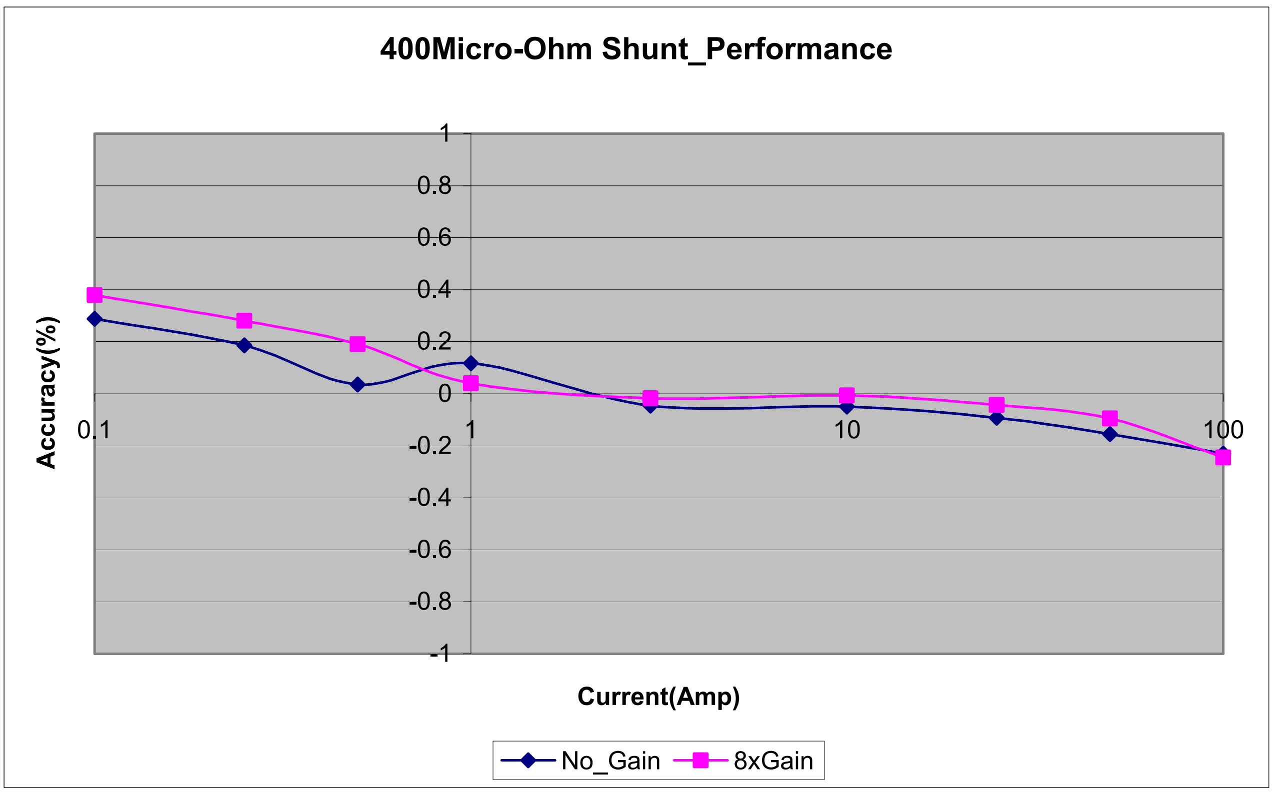
Measurement Results with Various Shunt Resistors:

400µΩ Shunt Performance

TERIDIAN 71M6511 B03 Demo Board accuracy was tested with a 400 µΩ Shunt. The shunt resistor was connected to the 71M6511 demo board as per the instructions provided in this application note.

The measured data and performance curve are given below:

step	volt	amp	revs	freq	No_gain	with 8x gain
2	240	100	100	60	-0.23	-0.2453
3	240	50	50	60	-0.1547	-0.0949
4	240	25	25	60	-0.0917	-0.043
5	240	10	10	60	-0.0491	-0.0066
6	240	3	3	60	-0.0459	-0.0178
7	240	1	1	60	0.1166	0.0409
8	240	0.5	1	60	0.0355	0.1906
9	240	0.25	1	60	0.1862	0.2799
10	240	0.1	1	60	0.2876	0.3789

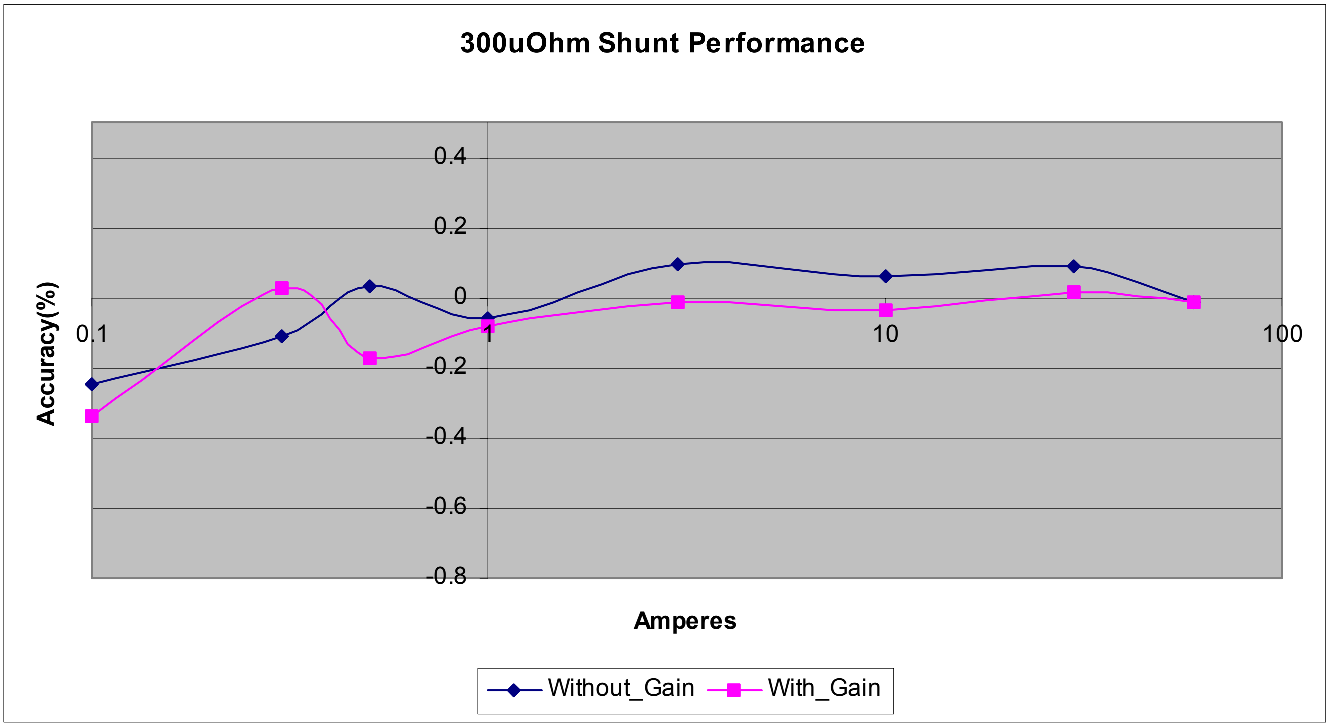


300µΩ Shunt Performance

TERIDIAN 71M6511 B03 Demo Board accuracy was tested with a 300µΩ shunt. The shunt resistor was connected to the 71M6511 demo board as per the instructions provided in this application note.

The measured data and performance curve are given below:

Step	Volt	Amp	NoGain	8xGain
1	240	60	-0.0128	-0.0128
2	240	30	0.09	0.0141
3	240	10	0.0617	-0.0341
4	240	3	0.0938	-0.016
5	240	1	-0.0615	-0.083
6	240	0.5	0.0303	-0.1756
7	240	0.3	-0.1086	0.0294
8	240	0.1	-0.2453	-0.3387



180µΩ Shunt performance

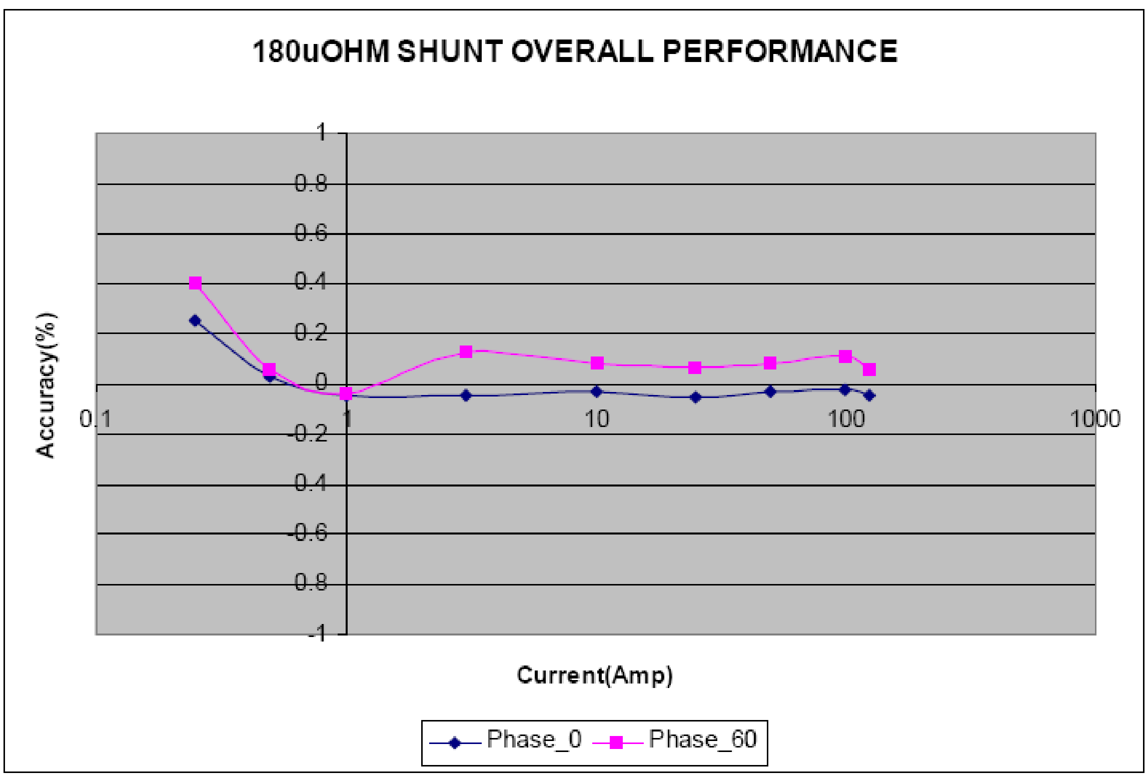
A 180µΩ shunt resistor was connected to the 71M6511 Demo Board as per the instructions provided in this application note. The following parameters were used:

- PHADJ_A = -1850
- QUANT = +1200 (CE QUANT variable)
- WRATE = 7933 for kh = 1.0Wh/pulse
- IMAX = 10420 (set for 1042A)

The theoretical computation based on 180µΩ provides only 950A. However, when measuring the shunt resistor, the resistance appeared 10% lower than specified, which is 168µΩ.

The measured data and performance curve are given below.

step	volt	amp	Phase_0	Phase_60
1	240	125	-0.0479	0.0628
2	240	100	-0.0232	0.1123
3	240	50	-0.0332	0.08
4	240	25	-0.0511	0.067
5	240	10	-0.0335	0.0857
6	240	3	-0.0453	0.1298
7	240	1	-0.0466	-0.0358
8	240	0.5	0.029	0.0634
9	240	0.25	0.2532	0.4062



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