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Application Note

MSM8974 Software Power Monitor Tool

80-NA437-16 Rev. A

July 25, 2012

Submit technical questions at:
https://support.cdmatech.com

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U.S.A.

Revision history

Revision	Date	Description
A	July 2012	Initial release

1 Introduction

1.1 Purpose

This application note provides a description of the Software Power Monitor (SPM) tool. The SPM tool assesses the impact on power to the power monitoring device environment after software has been added or changed (device driver, applications, or other). The user of the SPM application would typically compare new results for power measurement points to known results before the changed software was applied to the target device environment. The SPM application allows any noticeable power differences for these power measurement points to be observed.

This application note describes the SPM basic specifications, block diagram, application, and the Web-based Qualcomm Embedded Power Monitor (WQEPM) software tool.

1.2 Scope

This document is for engineers or software developers who want to monitor the power usage of one or more measurement points in a target device. Normally, this occurs after written device drivers or applications have been written to run in the target device, and the power usage needs to be assessed. Users are expected to be familiar with the target device and its underlying chipset.

1.3 Technical assistance

For assistance or clarification on information in this document, submit a case on the Qualcomm CDMA Tech website at https://support.cdmatech.com/.

2 Overview

The SPM intercepts the PMIC device power supplies with series-to-sense resistors in the path of the power planes, as illustrated in Figure 1. There are two types of power supplies in this platform: switch regulators and a linear regulator. For the switch regulators, the sense resistor is part of the sensing loop. For the linear regulator, the sense resistor becomes part of the power/ground plane resistance.

For SPM support there are also two different HW implementations. The first is a legacy solution which includes an SPM daughtercard and an NRT Viper Board. The second implementation is what is in place on the MTP8974 and utilizes a Cypress PSoC (Programmable Solution on Chip).

3 SPM daughtercard with NRT Viper Board

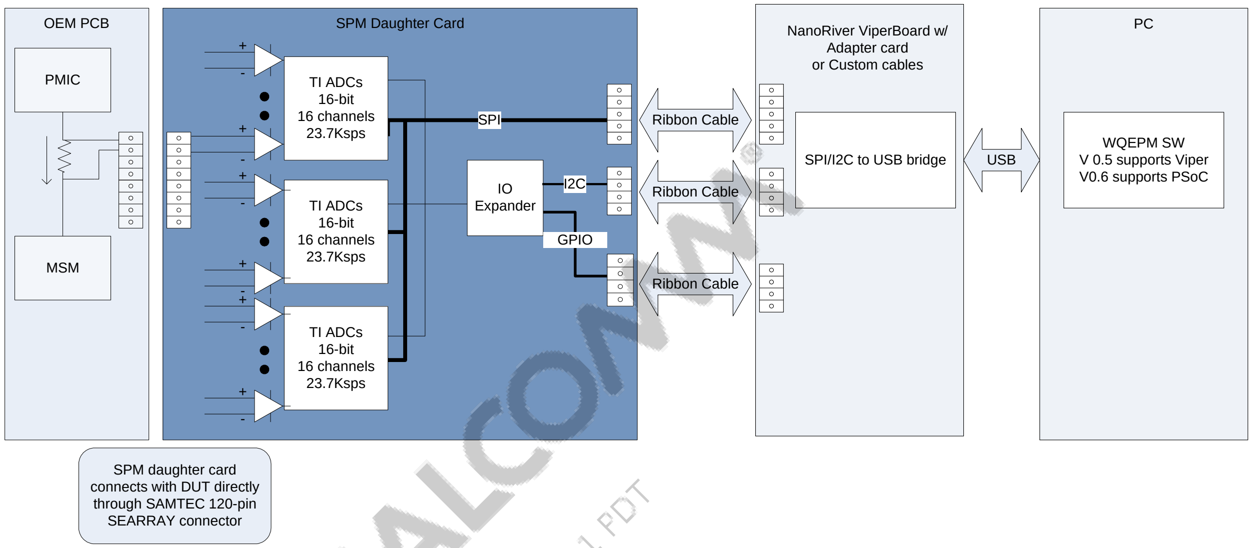

Figure 1 SPM block diagram

Each sense resistor is connected to an operational amplifier to amplify the voltage across it. The operational amplifier also provides noise rejection to filter any common mode noise from the sense resistor.

The operational amplifier, with gain (100x), has its output connected to an analog-to-digital converter (ADC). The ADC sampling frequency is up to 23.7 K samples per second (kSPS) in auto-scan mode. The ADC is set up and controlled by the host PC via the SPI bus. The LPF bandwidth is 200 kHz. The Op-amps and ADCs are on the SPM daughtercard. The design files to enable customers to build this SPM daughtercard are available in DP25-N6594-1, which is available on Docs and Downloads.

The ADC SPI interface is connected to the NRT ViperBoard, which converts the SPI to the USB to connect to a PC. The NRT ViperBoard can support up to 15kSPS.

3.1 Specification (preliminary)

- System accuracy for current measurement: 5-10%
- Unit-to-unit accuracy for current measurement: ±4%
- DC offset calibration possible to adjust absolute accuracy
- Two GPIO pins are dedicated for software triggering
- The overall sampling rate is up to 15 kSPS end-to-end

- The SPM circuitry only supports external access through WQEPM on the PC. WQEPM version 0.6 will support the PSoC SPM solution as well as the NRT Viper-Board solution
- The SPM interfaces with the PC via the NRT ViperBoard (USB)
- The SPM design will provide up to 48 combined current and voltage rails measured simultaneously. Each channel measures a voltage via a sense resistor that generates up to a 4.75 V full-scale signal. Sampling frequency is 23.7 kSPS in ADC auto-scan mode, and 11.85 kSPS, when chopping mode is on. Refer to the ADS1158 Data Sheet for more details
- ADC resolution is Vref/0x7800. Under ideal conditions, the measurement accuracy is within 0.3 LSB (with absolute Vref, 0 offset and gain errors in the measurement path), and the precision is also within 0.3 LSB, but is affected by the overall system noise. Both will be determined by the empirical data
- The minimum discernible current can be measured if it is above the system noise floor, as determined by the analysis and empirical data
- The EPM can connect with an OEM device under test (DUT) via a Samtech Searray 120-pin (20 × 6) connector (SEAF-20-05.0-S-06-2-A female connector on the DUT and SEAM-20-02.0-S-06-2-A male connector on the EPM)

3.2 SPM to DUT Interface

The SPM connects to the DUT via a Samtech Searray 20 × 6 connector (SEAF-20-05.0-S-06-2-A female connector on the DUT and SEAM-20-02.0-S-06-2-A male connector on SPM).

3.3 SPM channel assignment

Table 1 Example monitored power grids

Channel	Rsense (Ω)	Power rail	Source	Description	V_{nom}
1	0.002	VBATT	VBATT	VBATT	4.2
2	0.002	VPH_PWR_RF	VBATT	Power to RF card	4.2
3	0.002	VBATT_DEBUG	VBATT	VBATT_DEBUG	4.2
4	0.2	EPM_VPH_PWR	VBATT	Power to EPM circuit	4.2
5	0.02	VREG_S1B	PM8841 S1	MSM VDD_MEM, VDD_EBIx_CDC/PLL	0.95
6	0.002	VREG_S2B	PM8841 S2	MSM VDD_CORE	0.9
7*					
8	0.002	VREG_KRAIT	PM8841 S5, S6, S7, and S8	MSM VDD_KRAIT (4 cores)	0.9
9*					
10	0.03	VREG_S3B	PM8841 S3	MSM VDD_MODEM	1.15

Channel	Rsense (Ω)	Power rail	Source	Description	V_{nom}
11*					
12	0.01	VREG_S4B	PM8841 S4	MSM VDD_GFX	0.9
13*					
14	0.03	VREG_L1	PM8941 L1	MSM, DDR3, Conn. Card	1.225
15	0.05	VREG_L4	PM8941 L4	MSM VDD_A1, WTR VDD_RF1	1.15
16	0.03	VREG_L11	PM8941 L11	MSM VDDA WLAN, WCN	1.25
17	0.05	VREG_S3A	PM8941 S3	VDD_P3	1.8
18	0.03	VREG_S2A	PM8941 S2	WCD, LDO's	2.15
19	0.1	VREG_L12	PM8941 L12	MSM PLLs, MIPI	1.8
20	0.03	VREG_L15	PM8941 L15	WTR VDD_RF2	2.05
21	0.1	VREG_L14	PM8941 L14	MSM VDD_A2	1.8
22	0.5	VREG_L6	PM8941 L6	MSM VDD_USB_1P8, WCN VDD_1P8	1.8
23	0.02	VREG_S3A	PM8941 S3	MSM, WTR VDD_DIO, WCD, PMIC LDOs	1.8
24	0.2	VREG_L16	PM8941 L16	RFswitch, eLNA, QPA	2.7
25	1	VREG_LVS1	PM8941 LVS1	Sensors 1.8V	1.8
26	0.02	VREG_BOOST_BYP		Boost/Bypass VPH_PWR	3.3
27	1	VREG_L24	PM8941 L24	MSM VDD_USB_3P3	3.3
28	1	VREG_L9	PM8941 L9	MSM VDD_P5, VDD_UIM1	2.95
29	0.07	VREG_L19	PM8941 L19	WCN VDD_2P9V	2.9
30	0.2	VREG_L18	PM8941 L18	Sensors 2.85V	2.85
31	0.05	WLED Boost		WLED_Boost	30

* Note: Channels 7, 9, 11, and 13 are used for voltage measurements in the MTP8974 PSoC config. The SPM daughtercard cannot support voltage measurements on these channels without bypassing the op amp on these channels. So these channels are available for customers to update the config file for channels to support customer specific needs.

3.4 SPM connector pin map

There are four common ways that the CAD pinout is represented on the schematic. Figure 2 and Figure 3 show two of these pinouts, while the other two ways show the numbers snaked instead of wrapping around. It does not matter which model is used as long as it corresponds correctly to the SPM connector pin map shown in Figure 2.

48+	48-	GND	42+	42-	36+	36-	GND	30+	30-	24+	24-	GND	18+	18-	12+	12-	GND	6+	6-	6
47+	47-	41+	41-	GND	35+	35-	29+	29-	GND	23+	23-	17+	17-	GND	11+	11-	5+	5-	GND	5
46+	46-	GND	40+	40-	34+	34-	GND	28+	28-	22+	22-	GND	16+	16-	10+	10-	GND	4+	4-	4
45+	45-	39+	39-	GND	33+	33-	27+	27-	GND	21+	21-	15+	15-	GND	9+	9-	3+	3-	GND	3
44+	44-	GND	38+	38-	32+	32-	GND	26+	26-	20+	20-	GND	14+	14-	8+	8-	GND	2+	2-	2
43+	43-	37+	37-	GND	31+	31-	25+	25-	GND	19+	19-	13+	13-	GND	7+	7-	1+	1-	GND	1
20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	

Figure 2 SPM connector pin map

120	119	118	117	116	115	114	113	112	111	110	109	108	107	106	105	104	103	102	101
100	99	98	97	96	95	94	93	92	91	90	89	88	87	86	85	84	83	82	81
80	79	78	77	76	75	74	73	72	71	70	69	68	67	66	65	64	63	62	61
60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41
40	39	38	37	36	35	34	33	32	31	30	29	28	27	26	25	24	23	22	21
20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1

Figure 3 SPM connector alternate pin map

4 Cypress PSoC

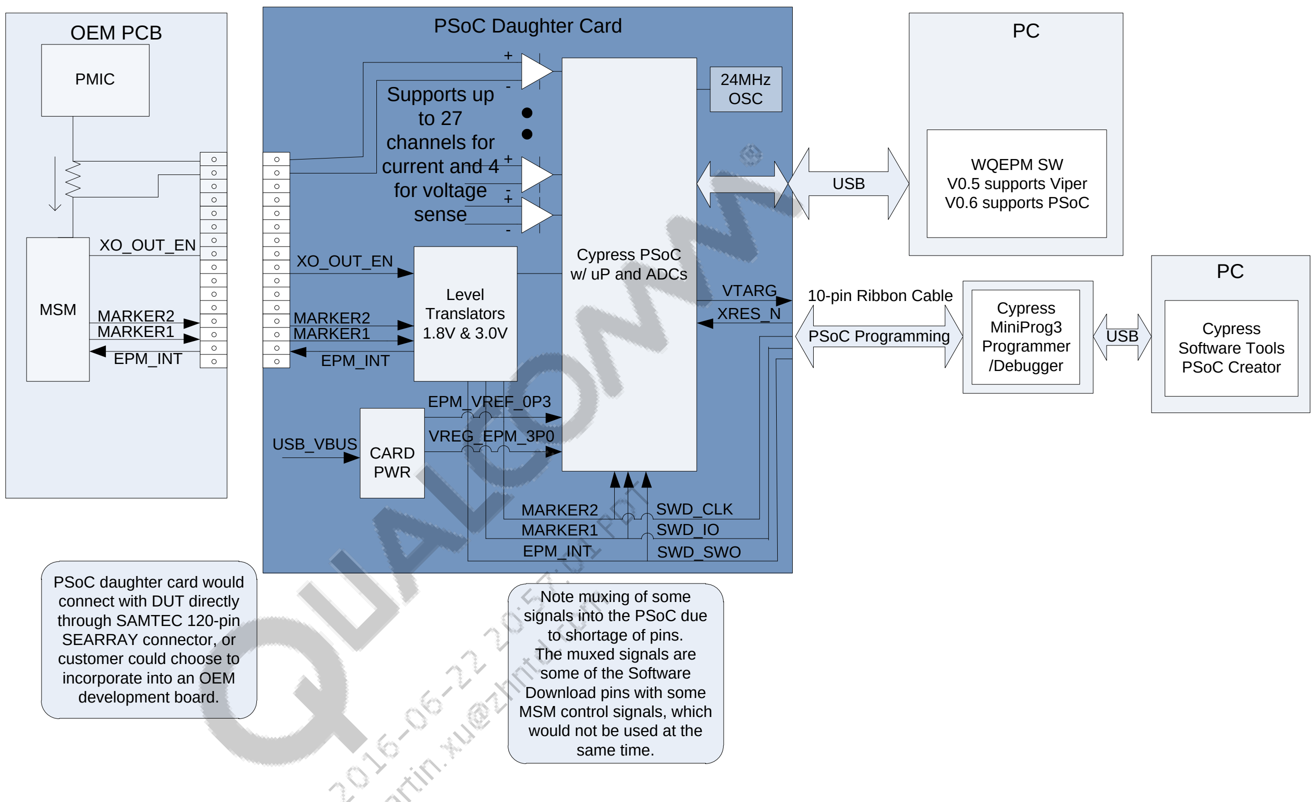

Figure 4 SPM with PsoC block diagram

Each sense resistor is connected to an operational amplifier to amplify the voltage across it. The operational amplifier also provides noise rejection to filter any common mode noise from the sense resistor.

The operational amplifier output is connected to a Cypress PSoC (Programmable Solution on Chip). The Cypress PSoC has a 32-bit ARM Cortex-M3 CPU core, one 20-bit Delta-Sigma ADC, and two 12-bit SAR (Successive Approximation) ADCs. The USB interface to the PC is connected to the HS USB port on the PSoC. The schematic reference to assist customers with either creating a PSoC daughtercard or incorporating the PSoC electronics on a developement board will be released as *Software Power Measurement (SPM) with PSoC Preliminary Reference Schematic* (80-NA437-48).

- System accuracy for current measurement: TBD
- Unit-to-unit accuracy for current measurement: TBD
- DC offset calibration possible to adjust absolute accuracy
- Two GPIO pins are dedicated for software triggering

- The overall sampling rate is TBD kSPS end-to-end
- The SPM circuitry only supports external access through WQEPM on the PC. WQEPM version 0.6 will support the PSoC SPM solution.
- The PSoC interfaces with the PC via HS USB.

4.1 PSoC to DUT Interface

The PSoC to DUT interface could be either a PSoC daughter card interface that would connect through SAMTEC 120-pin SEARRAY connector, or the customer could choose to incorporate it into an OEM development board. The schematic reference will be provided for the PSoC relevant hardware, but customers will be responsible for layout and building the PSoC daughter card and all that it entails.

4.2 PSoC channel assignment

Table 2 Example monitored power grids

Channel	Rsense (Ω)	Power rail	Source	Description	V_{nom}
1	0.002	VBATT	VBATT	VBATT	4.2
2	0.002	VPH_PWR_RF	VBATT	Power to RF card	4.2
3	0.002	VBATT_DEBUG	VBATT	VBATT_DEBUG	4.2
4	0.2	EPM_VPH_PWR	VBATT	Power to EPM circuit	4.2
5	0.02	VREG_S1B	PM8841 S1	MSM VDD_MEM, VDD_EBIx_CDC/PLL	0.95
6	0.002	VREG_S2B	PM8841 S2	MSM VDD_CORE	0.9
7		VREG_S2 (voltage)	PM8841 S2B	MSM VDD_CORE	0.9
8	0.002	VREG_KRAIT	PM8841 S5, S6, S7, and S8	MSM VDD_KRAIT (4 cores)	0.9
9		VREG_KRAIT (Voltage)	PM8841 S5, S6, S7, and S8	MSM VDD_KRAIT (4 cores)	0.9
10	0.03	VREG_S3B	PM8841 S3	MSM VDD_MODEM	1.15
11		VREG_S3B (voltage)	PM8841 S3	MSM VDD_MODEM	1.15
12	0.01	VREG_S4B	PM8841 S4	MSM VDD_GFX	0.9
13		VREG_S4B (voltage)	PM8841 S4	MSM VDD_GFX	0.9
14	0.03	VREG_L1	PM8941 L1	MSM, DDR3, Conn. Card	1.225
15	0.05	VREG_L4	PM8941 L4	MSM VDD_A1, WTR VDD_RF1	1.15

Channel	Rsense (Ω)	Power rail	Source	Description	V_{nom}
16	0.03	VREG_L11	PM8941 L11	MSM VDDA WLAN, WCN	1.25
17	0.05	VREG_S3A	PM8941 S3	VDD_P3	1.8
18	0.03	VREG_S2A	PM8941 S2	WCD, LDO's	2.15
19	0.1	VREG_L12	PM8941 L12	MSM PLLs, MIPI	1.8
20	0.03	VREG_L15	PM8941 L15	WTR VDD_RF2	2.05
21	0.1	VREG_L14	PM8941 L14	MSM VDD_A2	1.8
22	0.5	VREG_L6	PM8941 L6	MSM VDD_USB_1P8, WCN VDD_1P8	1.8
23	0.02	VREG_S3A	PM8941 S3	MSM, WTR VDD_DIO, WCD, PMIC LDOs	1.8
24	0.2	VREG_L16	PM8941 L16	RFswitch, eLNA, QPA	2.7
25	1	VREG_LVS1	PM8941 LVS1	Sensors 1.8V	1.8
26	0.02	VREG_BOOST_BYP		Boost/Bypass VPH_PWR	3.3
27	1	VREG_L24	PM8941 L24	MSM VDD_USB_3P3	3.3
28	1	VREG_L9	PM8941 L9	MSM VDD_P5, VDD_UIM1	2.95
29	0.07	VREG_L19	PM8941 L19	WCN VDD_2P9V	2.9
30	0.2	VREG_L18	PM8941 L18	Sensors 2.85V	2.85
31	0.05	WLED Boost		VREG_WLED	30

5 WQEPM Software Tool

5.1 Overview

The WQEPM application allows the user to obtain power measurement results from power rails on a supported target device. The results can be viewed and analyzed on any terminal (e.g., Windows, Linux) with any of the following browsers at the specified version or later:

- Chrome 9.0
- Firefox 3.5
- Internet Explorer 9.0
- Safari 12.0

The WQEPM application supports three types of interfaces, as seen in Figure 5. These three interfaces are:

- The WQEPM Browser User Interface from a local or a remote browser to the Windows PC with the WQEPM Server/Data Manager application installation
- The shared WQEPM Browser User Interface from a browser remote to the Windows PC with the WQEPM Server/Data Manager application installation
- Client scripts from any common network accessible computer using WQEPM Automation interfaces

All three of these interfaces use the http WQEPM APIs discussed in this document. See the WQEPM APIs section.

The WQEPM Server/Data Manager application communicates with an external Data Acquisition Board, which communicates with the target device. The NRT ViperBoard is new in WQEPM 0.5 and supports approximately a ten times increase in the sample rate achievable with the NRT MiniBoard.

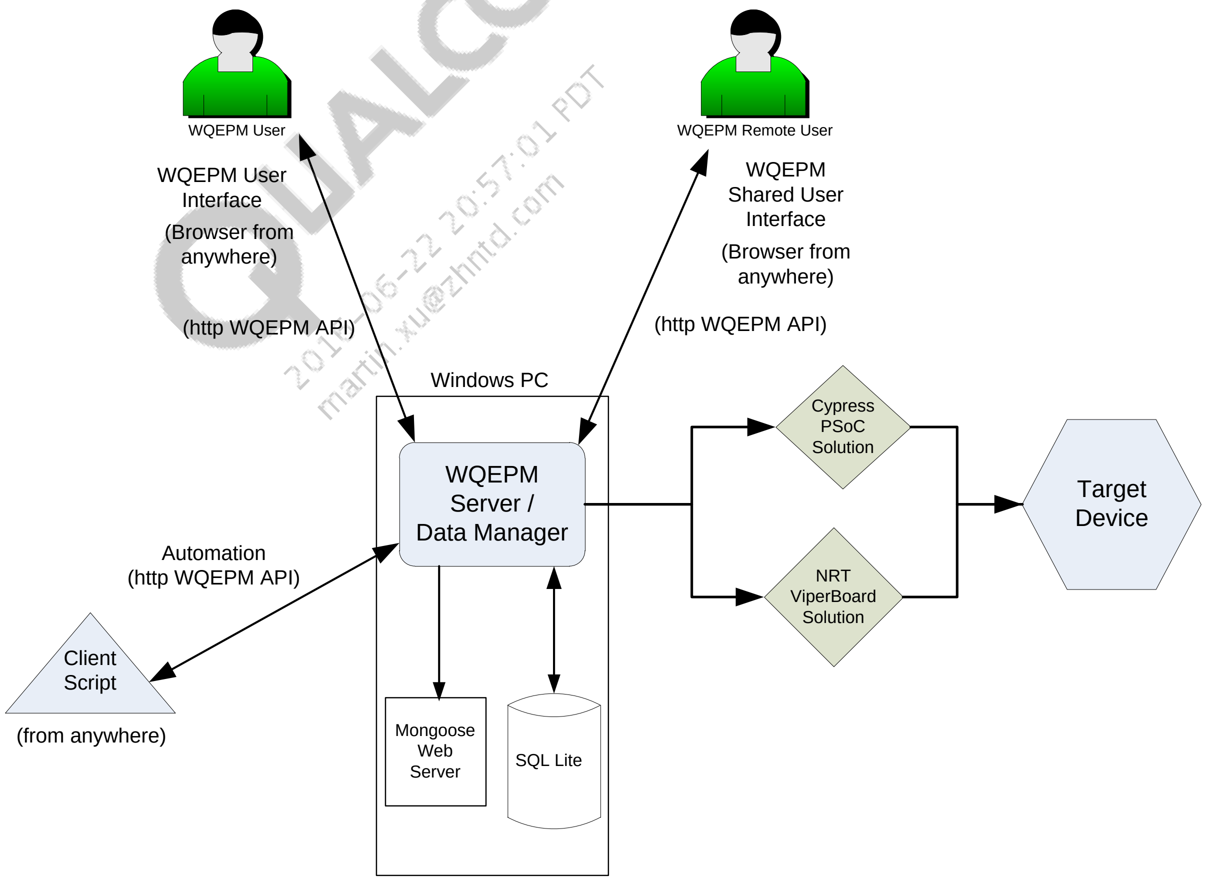

Figure 5 Interfaces to the WQEPM application on a Windows PC

More information on the WQEPM interface will be available with the release of the WQEPM version 0.6.

5.2 Features

Features of the WQEPM version 0.4 include the following:

- Configures the MiniBoard and the EPM circuitry on the target device for power data collection
- Collects and graphically displays power data with zoom-able plots
- Provides left mouse click-and-drag in the plot area to display detailed power information in the highlighted area
- Moves forward and backward in time to view collected data
- Monitors voltage and/or current on multiple system power rails
- Provides automatic minimum, maximum, and mean calculations on the data
- Plots multiple power rails per chart/tab
- Allows multiple charts/tabs per browser page with time synchronization option
- Saves restore, delete channel configurations
- Displays gain/resistor/voltage value per channel.
- Disables auto-scale (Y-axis) with user set upper/lower limits (clip display)
- Pauses data display (data collection continues in background)
- Displays statistics on measurement points while display paused
- Exports channel data (CSV format)
- Shares display view (name/save URL)
- Monitors GPIO channels
- Uses dynamic voltage (for targets that provide reading) in power calculations
- Initializes NRT MiniBoard and ADS1158s on target device using data in device configuration file instead of hard coding
- Launches WQEPM browser GUI from WQEPM server GUI command menu
- Provides a time correlation between WQEPM server/data manager and browser host (remote access)
- Provides a local/remote browser support for the WQEPM browser user interface that internally uses HTTP WQEPM APIs
- Provides automation support via HTTP WQEPM APIs (scripts)

- Integrates Mongoose 3.0 server and SQLite 3.7.3 database into the WQEPM server/data manager
- Provides Windows-only host support for the WQEPM server/data manager in WQEPM 0.5.1

The following features were added in WQEPM version 0.5:

- Support for the NRT ViperBoard with 10x sampling improvement over the MiniBoard, including adjustable sampling rate
- Automatic detection and connection to either the NRT MiniBoard or ViperBoard
- Support for utilizing the ViperBoard timer at 8 µs resolution for timestamps
- Support for adding new target devices without recompiling WQEPM
- WQEPM status, stopped or running, into the WQEPM server GUI
- The Clear Database button in WQEPM browser GUI changed to delete DB tables and free disk space
- The database changed to be disabled by default (samples are available only in the WQEPM server non-persistent cache)
- A warning message if the database is larger than 2 GB
- Support for recognizing the version of WQEPM adapter board and displaying a BMS-related warning message/link
- Support for APQ8064 and MSM8x30 devices (based on MCN variants)

5.3 Installing WEQPM

To install the WQEPM, use the following installation steps:

1. Order and purchase the NRT MiniBoard/ViperBoard from the NRT website (http://www.nanorivertech.com/miniboard or http://www.nanorivertech.com/viperboard.html). The website's **Buy ViperBoard Now** tab enables customers to purchase the NRT ViperBoard. Inform Nano River Technologies that the NRT MiniBoard needs to contain firmware level 27. The ViperBoard firmware version is 1281.
2. Install the NRT ViperBoard software on the Windows PC. Refer to the NRT website (http://nanorivertech.com/) for more detailed information.
   a. *If* a version of the Microsoft Visual Studio 2010 product is not installed on the Windows PC that the WQEPM application is installed on, the Microsoft Visual C++ 2010 redistributable package (x86) must be downloaded from the Microsoft website (http://www.microsoft.com/download/en/details.aspx?id=5555) and installed.
3. Install the provided WQEPM application on the Windows PC. Refer to the *Web-based Qualcomm Embedded Power Monitor Version 0.5 User Guide* (80-N4253-3 Rev. B) for more detailed information.

4. Ensure that the standard USB Type A to USB Type B cable is available.
5. Ensure the availability of the cables connected to the target device with the NRT MiniBoard or the Viperboard.

NOTE: A channel configuration file is installed for the target power monitoring device by the installation process. This channel configuration file is in one of the following folders and may be edited, if necessary.

- For the 32-bit Windows versions, refer to C:\Program Files\Qualcomm\WQEPM\Config\.
- For the 64-bit Windows versions, refer to C:\ProgramFiles(x86)\Qualcomm\WQEPM\Config\.

6 Designing an SPM Ready Board

To design an SPM-ready board, use the following guidelines:

- Op-amp polarity: It is mandatory that the PMIC side of any op-amp input is connected to the positive side of the op-amp. If connected in reverse, the op-amp will drive as close to ground as possible, due to uni-polar power. That would result in a 0 at the ADC's output.

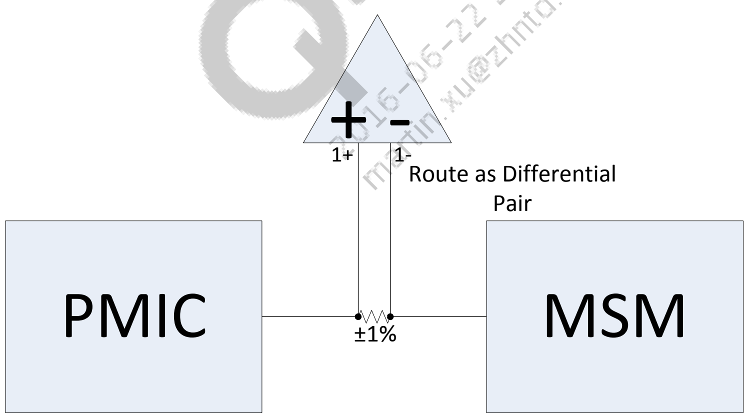

Figure 6 Positive input

- Use resistors with ±1% (or better) tolerance. Since the WQEPM uses the optimal resistor value input into the config file, mismatched resistance will add more error. If a resistor is 10% off from the nominal, the current readings have >10% error.
- Treat the traces to the op-amp pins as a differential pair. Because the drop across the sense resistors can sometimes be smaller than 1 mV, noise can play a major role on the outcome if the noise only couples onto one of the traces (+1 mV induced onto the positive-only side would create 100% error). To minimize this, these two traces should run as close together as

possible all the way from the sense resistor up to the Samtech connector. Noise coupled onto one line will be the same on the second line and will effectively be ignored.

- Prevent the sense resistors from greatly affecting the PDN of the power lines. When using sense resistors, make sure to get resistor sizing appropriate to how much current goes through the resistor. Resistors on high power paths need to have a higher current rating. Also make sure that power lines with larger currents have the appropriate number of vias going to the sense resistors. Running 1.5 A through one microvia will create an issue on the PDN network and potentially damage the PCB, due to thermal issues. As with any PDN, you want to minimize droop on the power line to prevent impacts to circuit operation.

7 Connections to be made

7.1 Connecting the SPM daughter card to the NRT Viper-Board Connector

There are two ways to accomplish these connections. The first is for customer to make their own custom cables using the following pinout information. The second would be to purchase the SPM adapter card, also known as the WQEPM adapter card in *WQEPM 0.5 User Guide* (80-N4235-3 Rev. B).

7.1.1 Customer created cables

Table 3 NRT boards pinout

Signal names	SPM (connector –pin number)	NRT card (connector – pin number) ViperBoard
PWR_MON_ENABLE	J1-4	X2-1 or X2-2
I2C_ADC_CLK_3.3V	J1-3	X2-17
I2C_ADC_DAT_3.3V	J1-2	X2-18
NC	J1-1	Can be NC
ADC1_CS_N (3.3V)	J2-5	X3-6
EPM_CLK_3P3	J2-4	X3-7
EPM_MOSI_3P3	J2-3	X3-9
EPM_MISO_3P3	J2-2	X3-8
GND	J2-1	X3-1
ADC3_CS_N (3.3V)	J3-1	X2-6
ADC2_CS_N (3.3V)	J3-2	X2-3
EPM_MARKER1_3P3	J3-3	Can be NC*
EPM_MARKER2_3P3	J3-4	Can be NC*

* EPM Marker information is passed to the ViperBoard through the ADCs on the SPM daughter card. So separate connections are not necessary.

The following images should help in making the connections to the Viperboard.

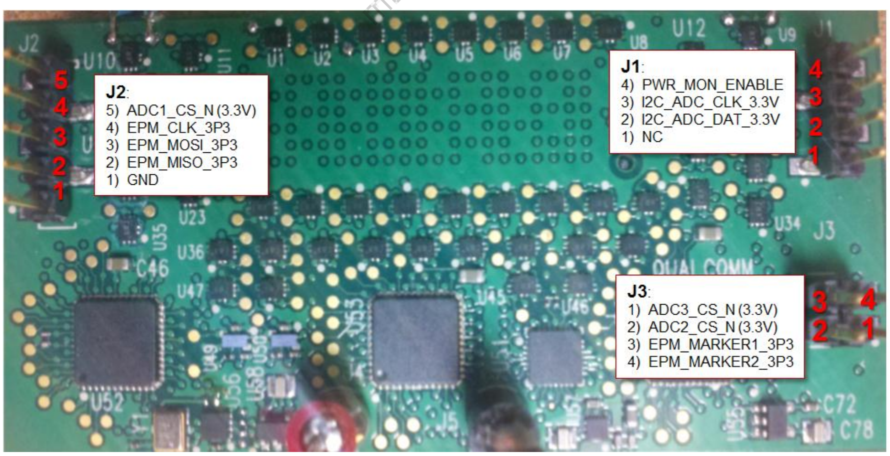

Figure 7 SPM daughter card pinout

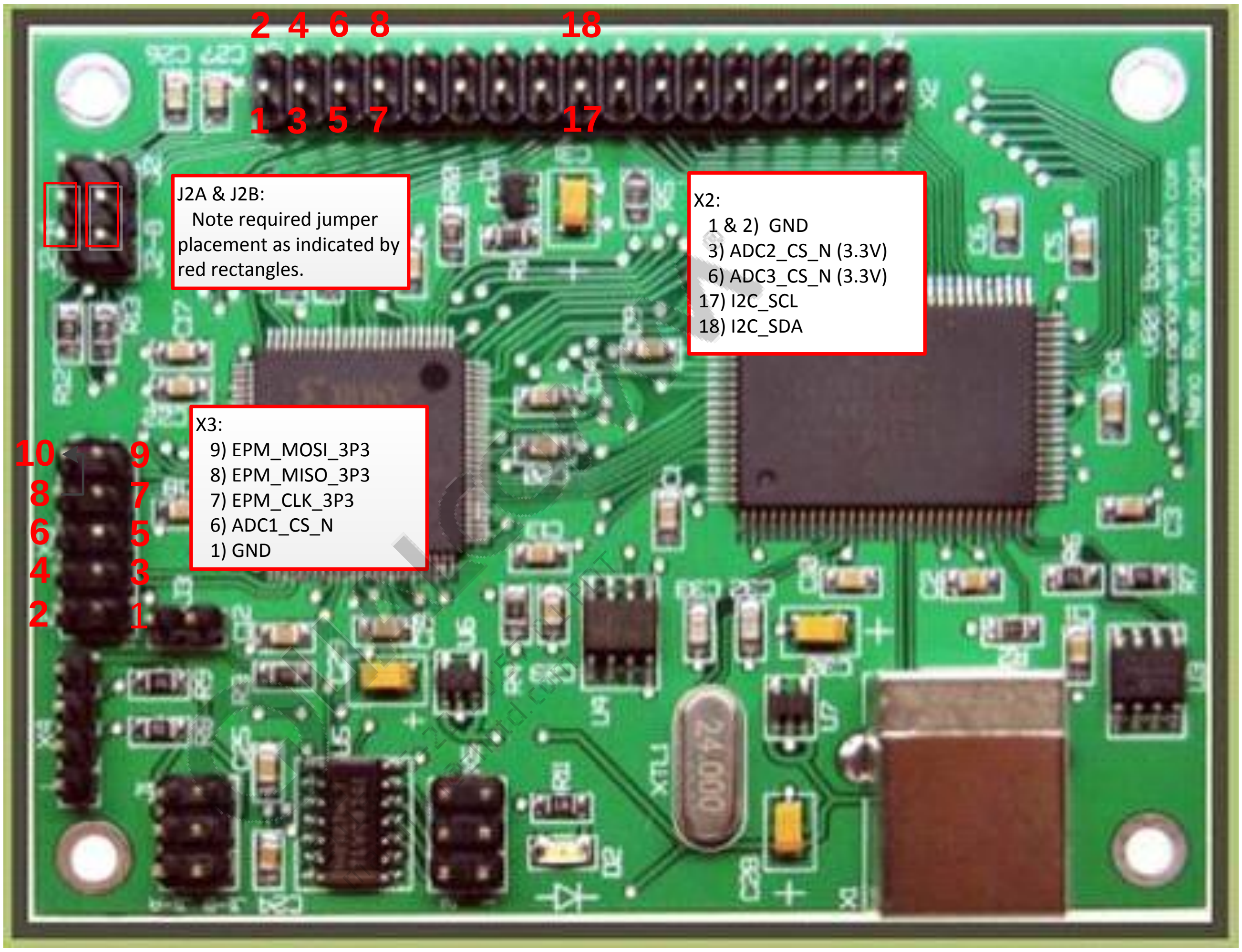

Figure 8 Viperboard pinout with USB cable (customized firmware version 1281)

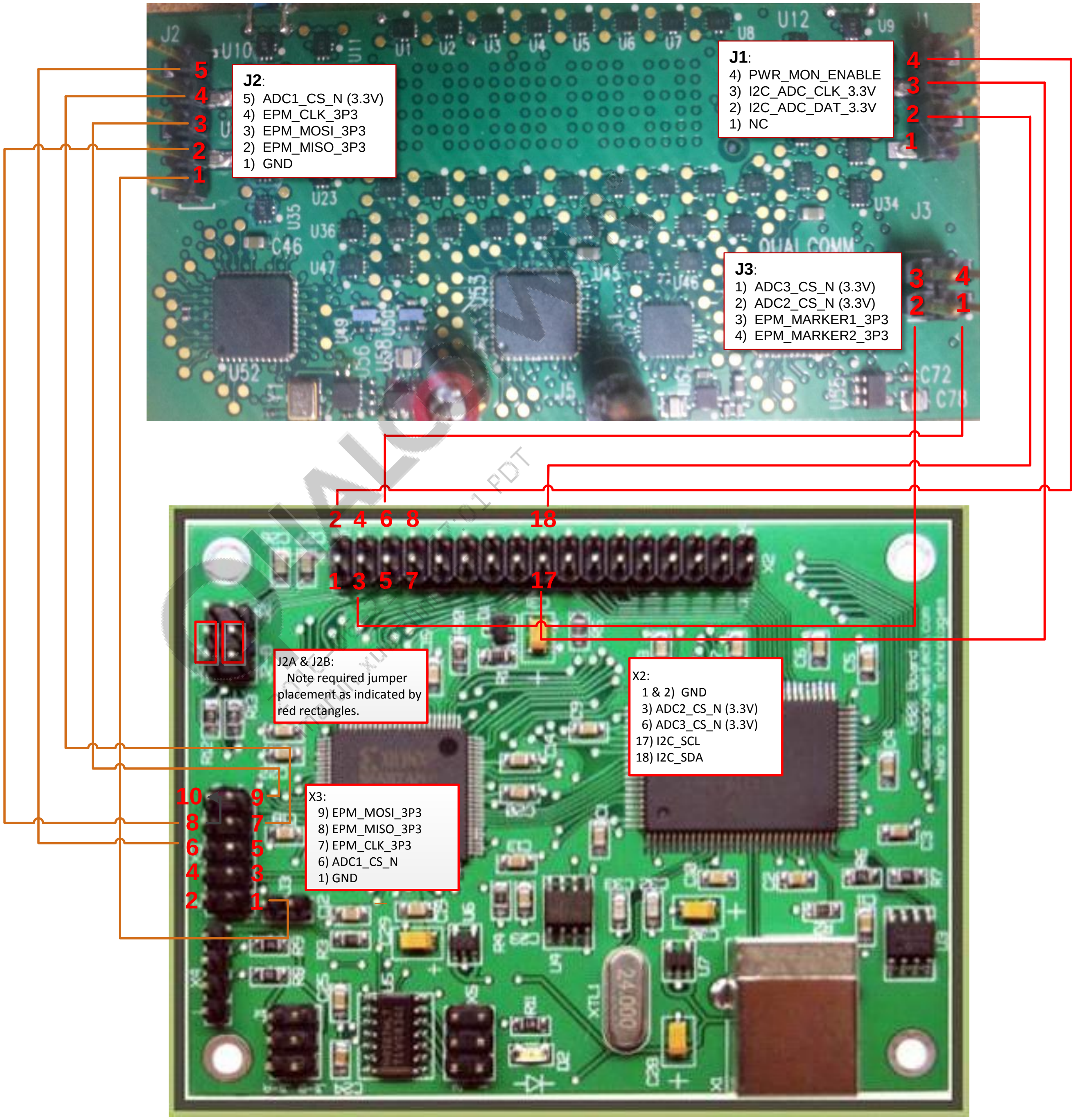

Figure 9 Viperboard and SPM connections without the SPM adapter card

7.1.2 WQEPM adapter card kit from Qualcomm

The WQEPM Adapter Board Only Kit (MCN 65-NA623-1) can be purchased through Qualcomm. There are also associated cables that should be purchased to connect from the SPM daughtercard to the adapter card. As seen in Figure 4, the DUT is connected to the SPM daughtercard. The SPM daugthercard then connects to the adapter board using the cables specified in the *WQEPM 0.5 User Guide* (80-N4235-3). The adapter board connects to the Viper-Board.

Low- side BMS systems can have earth ground sneak paths. Designs need to ensure there are no sneak paths to ground.

For more information refer to the *WQEPM 0.5 User Guide* (80-N4253-3 Rev. B).

7.2 Connections to the PSoC daughter card

Connections to the PSoC daughter card include the following:

- USB connector to the PC
- Programming connector that allows downloads and updates to the PSoC software
- The PSoC to DUT interface could be either a PSoC daughter card interface that would connect through SAMTEC 120-pin SEARRAY connector, or the customer could choose to incorporate it into an OEM development board. The schematic reference will be provided for the PSoC relevant hardware, but customers will be responsible for layout and building the PSoC daughter card and all that it entails.

8 Running Simulations

More information to follow in future revision of this document.

9 Configuration File

The configuration file is what the WQEPM system uses to determine what the sense resistor values are on the device and how to group different power rails. The default location for the configuration file on Windows is C:\Program Files(x86)\Qualcomm\WQEPM\Config. To use the SPM, the configuration file named , *undefined at* this time, must be edited.

NOTE: Due to the security settings on some computers, it might be necessary to copy this file and edit it in another directory, and then copy it back into this directory.

The two most important categories to be edited in the configuration file are *Gain* and *Resistance*. This is due to how the WQEPM calculates the current values.

$$i = \frac{Vin}{Gain * Resistance}$$

- ***Gain*** is meant to offset the gain that the op-amp provides. Gain should be set to 100 if using the SPM daughter card with the Viperboard. Gain could be 100 or 10 if using the design for the PSoC. Confirm your op-amp gain. If a different op-amp is used with a different gain, the config file must be adjusted appropriately.
- ***Resistance*** should match the resistor values on the phone (resistance is in mΩ).
- ***Name*** is the name of the power rail. This shows up in the WQEPM software.
- ***Category*** is used to group the different power rails together. This is useful for finding different rails and toggling rails on and off as a group (in the web browser).
- ***Voltage*** has no obvious affect for rails with constant voltage. It is used to quickly state power consumed (P = VI). Voltage does have an effect on power graphs when WQEPM displays a power graph for rails with variable voltages like MSM core or application processor cores. Power can still be used for comparison from software version to software version, but for power, this graph will be shifting due to changes in voltage.
- ***Units*** should be left as mA. Voltage can only be directly measured when no op-amp is used, which is not how this SPM board is designed.
- ***Description*** is the description of the channel.
- ***ID*** corresponds to each individual ADC's input. These match up to the channels. ADC0, ID0 corresponds to channel 1, while ADC1, ID0 corresponds to channel 17.

10 WQEPM Browser User Interface

Refer to the *Web-based Qualcomm Embedded Power Monitor Version 0.5 User Guide* (80-N4235-3 Rev. B) for more information about the WQEPM browser user interface when using a browser. The version 0.6 WQEPM tool will be the first to include information and support for PSoC.