![ANALOG DEVICES]

Evaluation Board Documentation
ADE7878 Energy Metering IC

EVAL-ADE7878EB

FEATURES

Evaluation board designed to be used together with accompanying software to implement a fully functional three-phase energy meter

Easy connection of various external transducers via screw terminals

Easy modification of signal conditioning components using PCB sockets

LED indicators on logic outputs CF1, CF2, CF3, IRQ0, and IRQ1

Optically isolated metering components and USB based communication with PC

External voltage reference option available for on-chip reference evaluation

PC COM port-based firmware updates

GENERAL DESCRIPTION

The ADE7878 is a high accuracy, 3-phase electrical energy measurement IC with serial interfaces and three flexible pulse outputs. The ADE7878 incorporates seven ADCs, reference circuitry and all signal processing required to perform total (fundamental and harmonic) active, reactive and apparent energy measurement, fundamental active and reactive energy measurement and rms calculations.

This documentation describes the ADE7878 evaluation kit hardware, firmware and software functionality. The evaluation board contains an ADE7878 and a LPC2368 microcontroller. The ADE7878 and its associated metering components are optically isolated from the microcontroller. The microcontroller communicates with the PC using a USB interface. Firmware updates can be loaded using one PC com port and a regular serial cable.

The ADE7878 evaluation board and this documentation, together with the ADE7878 data sheet provide a complete evaluation platform for the ADE7878.

The evaluation board has been designed so that ADE7878 can be evaluated in an energy meter. Using appropriate current transducers, the evaluation board can be connected to a test bench or high voltage (240Vrms) test circuit. On-board resistor dividers networks provide the attenuation for the line voltages. This application note describes how the current transducers should be connected for the best performance. The evaluation board requires two external 3.3V power supplies and the appropriate current transducers.
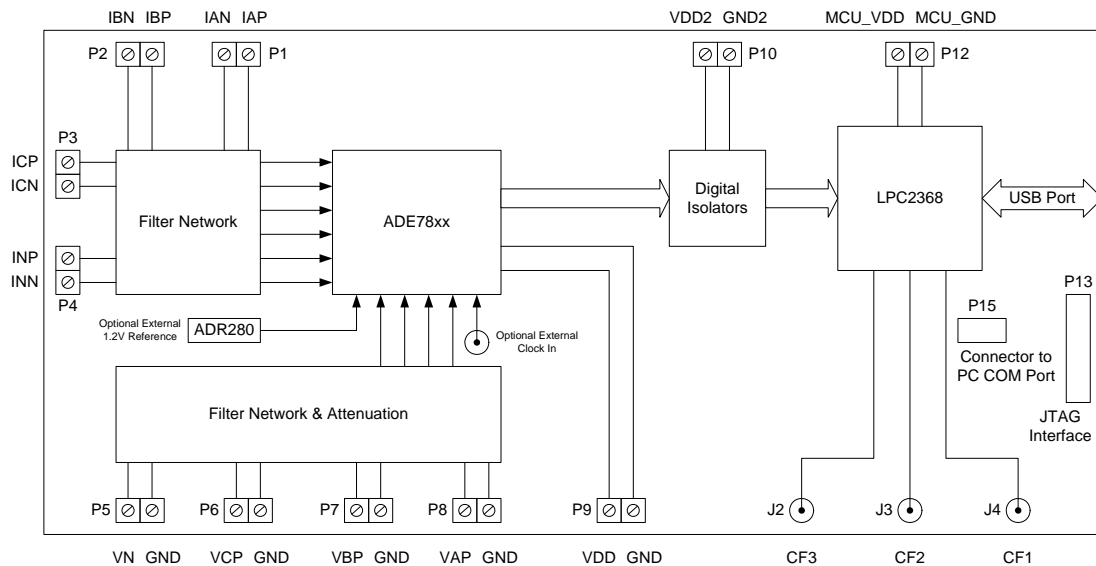

Figure 1. Functional Block Diagram

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EVALUATION BOARD POWER SUPPLIES

The board has three different power domains: one that supplies the microcontroller and one side of the isocouplers, one that supplies the other side of the optocouplers and one that supplies ADE7878. The ground of the microcontroller's power domain is connected to the ground of the PC through the USB cable. The ground of ADE7878 power domain is determined by the ground of the phase voltages VAP, VBP, VCP and VN and must be different from the ground of the microcontroller's power domain.

The microcontroller 3.3V supply is provided at P12 connector. ADE7878 3.3V supply is provided at P9 connector. The same supply should also be provided at P10 connector, the connector that supplies the other side of the isocouplers.

ANALOG INPUTS (P1, P2, P3, P4, P6, P7, AND P8)

Current and voltage signals are connected at the screw terminals P1 – P4 and P5 - P8 respectively. All analog input signals are filtered using the on-board anti-aliasing filters before being connected to ADE7878. The components used on the board are the recommended values to be used with ADE7878.

Current Sense Inputs (P1, P2, P3, and P4 Connectors)

ADE7878 measures 3 phase currents and the neutral current. Current transformers or Rogowski coils can be used to sense the currents, but not mixed together. ADE7878 contains different internal PGA gains on phase currents and on the neutral current, so sensors with different ratios can be used. The only requirement is to have same scale signals at PGAs outputs, otherwise the mismatch functionality of ADE7878 is compromised (Please see Neutral Current Mismatch chapter in ADE7878 data sheet for more details). Figure 2 shows the structure used for the phase A current: the sensor outputs are connected to P1 connector. The resistors R1 and R2 are the burden resistors and by default, they are not populated. They can also be disabled using JP1A and JP2A jumpers. The RC networks R9/C9 and R10/C10 are used to provide phase compensation when a current transformer is being used. They can be disabled using JP3A and JP4A jumpers. The RC networks R17/C17 and R18/C18 are the antialiasing filters. The default corner frequency of these low pass filters is 8.8KHz (1KΩ/18nF). These filters can easily be adjusted by replacing the components on the evaluation board.

All the other current channels, that is phase B, phase C and neutral current have similar input structure.

Using a Current Transformer as the Current Sensor

Figure 3 shows how a current transformer can be used as a current sensor in one phase of a 3-phase 4-wire distribution system (Phase A). The other two phases and the neutral current requires similar connections.
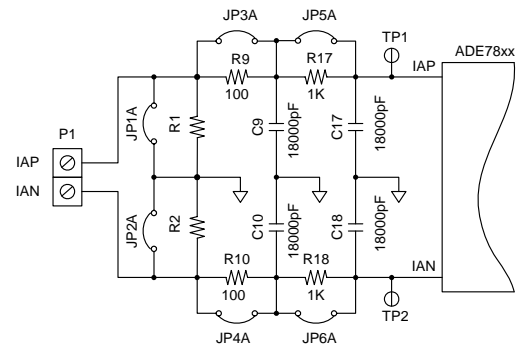

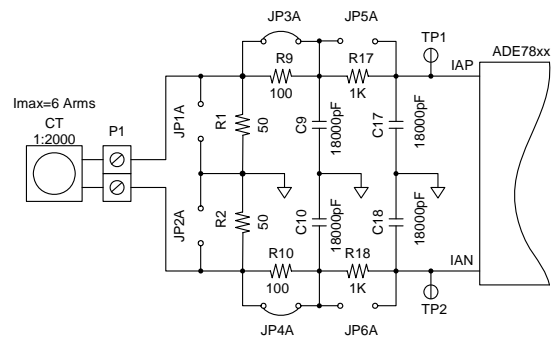Figure 2. Phase A Current Input Structure on Evaluation Board

Figure 3. Example of a Current Transformer Connection

The burden resistors R1 and R2 have to be chosen function of current transformer ratio and maximum current of the system. The jumpers JP1A and JP2A should be opened if R1 and R2 are used. The antialiasing filters should be enabled by opening jumpers J5A and J6A (please see Figure 3).

The transformer's secondary current is converted to a voltage by using a burden resistor across the secondary winding outputs. Care should be taken when using a current transformer as the current sensor. If the secondary is left open, that is no burden is connected, a large voltage could be present at the secondary outputs. This can cause an electric shock hazard and potentially damage electronic components.

Most current transformers introduce a phase shift that the manufacturer indicates in the data sheet. This phase shift can lead to significant energy measurement errors, especially at low power factors. ADE7878 can correct the phase error using APHCAL[9:0], BPHCAL[9:0] and CPHCAL[9:0] phase calibration registers as long as the error stays between -6.732° and +1.107° at 50Hz. Please see ADE7878 data sheet for more details. The software supplied with the ADE7878 evaluation board allows user adjustment of phase calibration registers.

For this particular example, burden resistors of 50 ohm signify an input current of 7.05 Arms at ADE7878 ADC full scale input (0.5V). In addition, the PGA gains for the current channel have to be set at 1. For more information on setting PGA gains, please see ADE7878 data sheet. The evaluation software allows the user to configure the current channel gain.

Votage Sense Inputs (P5, P6, P7, and P8 Connectors)

The voltage inputs connections on the ADE7878 evaluation board can be directly connected to the line voltage sources. The line voltages are attenuated using a simple resistor divider network before it is presented to ADE7878. The attenuation network on the voltage channels is designed such that the corner frequency (3dB frequency) of the network matches that of the antialiasing filters in the current channels inputs. This prevents obtaining large energy errors at low power factors.

Figure 4 shows a typical connection of the phase A voltage inputs: the resistor divider is enabled by opening JP7A jumper. The antialiasing filter on VN data path is enabled by opening JP7N jumper. JP8B and JP8N are opened. The analog input VN is connected to AGND via the antialiasing filter R25/C25 using JP8N connector.

The attenuation networks can be easily modified by the user to accommodate any input level. However, the value of R32 (1KΩ), should be modified only together with the corresponding

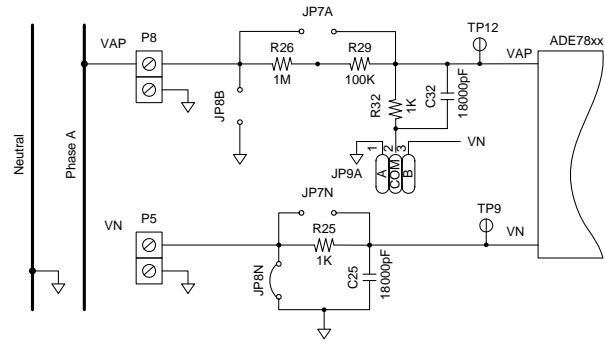resistors in the current channel (R17 and R18 on phase A current data path).

Figure 4. Phase A Voltage Input Structure On Evaluation Board

The maximum signal level permissible at VAP, VBP and VCP pins of ADE7878 is 0.5V peak. Although ADE7878 analog inputs can withstand ±2V without risk of permanent damage, the signal range should not exceed ±0.5V with respect to AGND for specified operation.

Table 1. Recommended Settings for Evaluation Board Connectors

Jumper	Option	Description
JP1	unsoldered	It connects AGND to Earth. By default, it is unsoldered.
JP1A, JP1B, JP1C, JP1N,	open	They connect IAP, IBP, ICP and INP to AGND. By default, they are open.
JP2	closed	It connects ADE7878 VDD power supply (VDD_F at P9 connector) to the power supply of the isocouplers (VDD2 at P10 connector). By default it is closed.
JP2A, JP2B, JP2C, JP2N	open	They connect IAN, IBN, ICN and INN to AGND. By default, they are open.
JP3	soldered	It connects padd metal below ADE7878 to AGND. By default, it is soldered.
JP3A, JP3B, JP3C, JP3N	closed	They disable the phase compensation network in IAP, IBP, ICP and INP dat path. By default, they are closed.
JP4	soldered	It connects C3 to DVDD. By default, it is soldered.
JP4A, JP4B, JP4C, JP4N	closed	They disable the phase compensation network in IAN, IBN, ICN and INN data path. By default, they are closed.
JP5	soldered	It connects C5 to AVDD. By default, it is soldered.
JP5A, JP5B, JP5C, JP5N	open	They disable the phase antialiasing filter in IAP, IBP, ICP and INP data path. By default, they are open.
JP6	soldered	It connects C41 to REF pin of ADE7878. By default, it is soldered.
JP6A, JP6B, JP6C, JP6N	closed	It disables the phase antialiasing filter in IAN, IBN, ICN and INN data path. By default, they are closed.
JP7	closed	It enables the supply to the microcontroller. When open, takes out the supply to the microcontroller. By default, it is closed.
JP7A, JP7B, JP7C	open	It disables the resistor divider in VAP, VBP and VCP data path. By default, they are open.
JP7N	open	It disables the antialiasing filter in VN data path. By default, it is closed.
JP8	open	It sets the microcontroller in flash memory programming mode. By default, it is open.
JP8A, JP8B, JP8C	open	They connect VAP, VBP and VCP to AGND. By default, they are open.
JP8N	open	It connects VN to AGND. By default, it is open.
JP9	open	When closed, signals the microcontroller to declare all I/O pins as outputs. It is used when another microcontroller is used to manage ADE7878 through P38 socket. By default, it is open.
JP9A, JP9B, JP9C	soldered to pin 1 (AGND)	They connect the ground of antialiasing filters in VAP, VBP and VCP data path to AGND or VN. By default, they are soldered to AGND.

Jumper	Option	Description
JP10	open	It connects external voltage reference to ADE7878. By default, it is open.
JP11	soldered to pin 1	It connects CLKIN pin of ADE7878 to 16.384MHz crystal (pin 1 of JP11) or to an external clock input provided at J1. By default, it is soldered to pin 1.
JP12	soldered to pin 3 (AGND)	It connects DGND (pin 2 of JP12) of ADE7878 to Earth (pin 1 of JP12) or to AGND (pin 3 of JP12).
JP35, JP33	open	If I2C communication between LPC2368 and ADE7878 is used, these connectors should be closed with 0Ω resistors. In this case, JP36 and JP34 connectors should be opened. By default, the SPI is the communication used between LPC2368 and ADE7878, so these connectors are open.
JP31, JP37	open	If HSDC communication is used, then these connectors should be closed with 0Ω resistors. In this case, JP35 and JP33 connectors should also be closed. By default, the SPI is the communication used between LPC2368 and ADE7878, so these connectors are open.
JP36, JP34, JP32, JP38	closed with 0Ω resistors	If SPI communication is used between LPC2368 and ADE7878, these connectors should be closed and JP35, JP33, JP31, JP37 should be opened. By default, the SPI is the communication used between LPC2368 and ADE7878, so these connectors are closed.

SETTING UP THE EVALUATION BOARD AS AN ENERGY METER

Figure 5 shows a typical setup for the ADE7878 evaluation board. In this example, an energy meter for a 4 wire, three phase distribution system is shown. Current transformers are used to sense the phase and neutral currents and are connected as shown in Figure 5. The line voltages are connected directly to the evaluation board as shown. Note the state of all jumpers must match the indication in Figure 5 and the fact the board is supplied from two different 3.3V power supplies, one for the ADE7878 domain, VDD, and one for LPC2368 domain, MCU_VDD. As the two domains are isolated to ensure there is no electrical connection between the high voltage test circuit and the control circuit, the power supplies should have floating voltage outputs.

The evaluation board is connected to the PC using a regular USB cable supplied with the board. When the evaluation board has been powered up and is connected to the PC, the enumeration process begins and the PC recognizes new hardware and asks to install the appropriate driver. The driver is found in VirCOM_Driver_XP folder of the CD. After the driver has been installed, the supplied evaluation software can be launched. The next section describes the ADE7878 evaluation software in detail and how it can be installed and uninstalled.
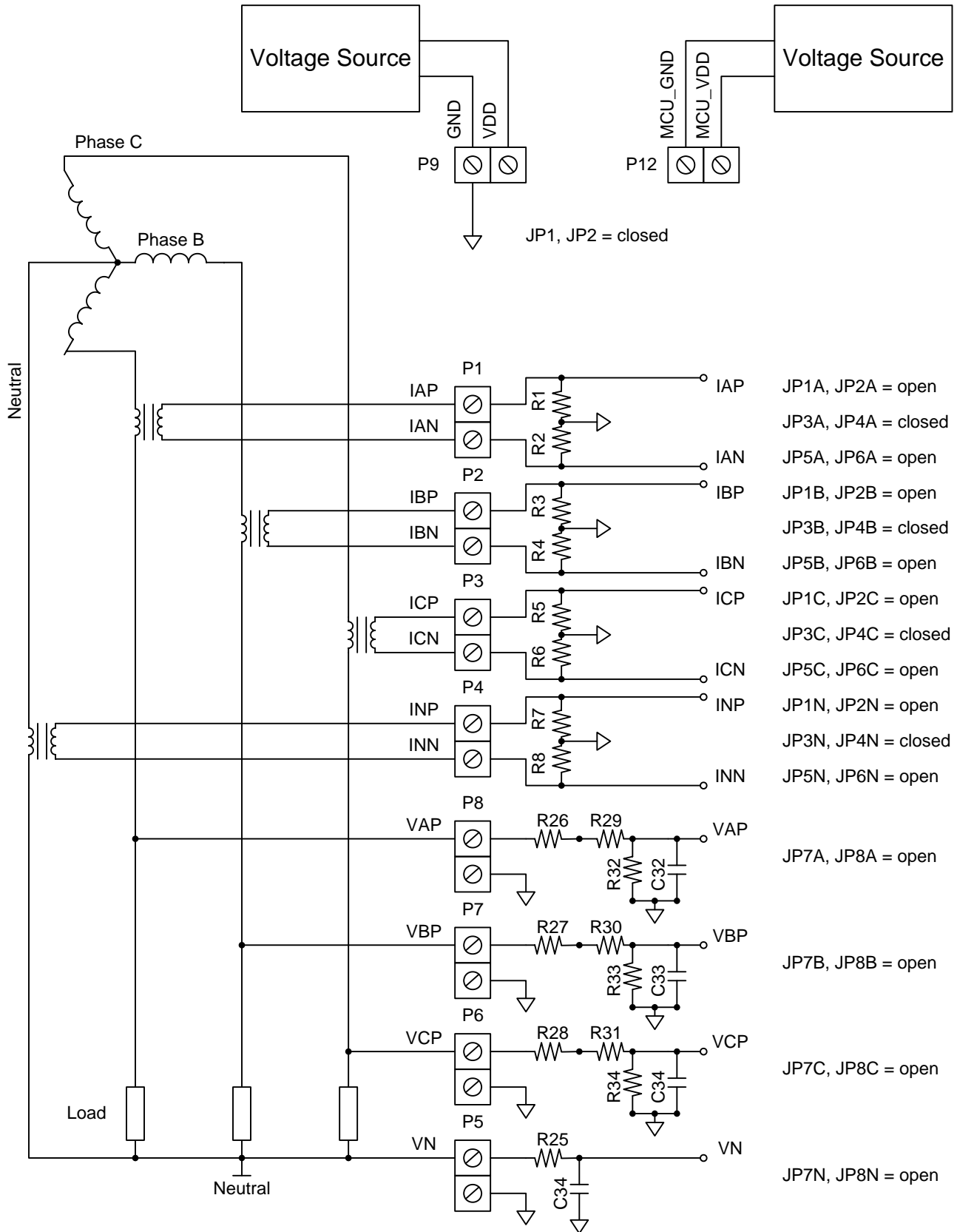
Figure 5. Typical Setup for the ADE7878 Evaluation Board

Activating Serial Communication ADE7878 – LPC2368

The ADE7878 evaluation board comes with the communication between ADE7878 and LPC2368 set through SPI ports. Jumpers JP32, JP34, JP36 and JP38 are closed using 0Ω resistors and JP31, JP33, JP35 and JP37 are open. In this case, the SPI port should be chosen as active port in the ADE7878 control panel. Communication between ADE7878 and LPC2368 is also possible using the I²C ports. To accomplish this, jumpers JP31, JP33, JP35 and JP37 should be closed using 0Ω resistors and JP32, JP34, JP36 and JP38 should be open. In this case, the I²C port should be chosen as active port in the ADE7878 control panel (See Table 2).

Table 2. Jumpers State to Activate SPI or I²C Communication

Active Comm	Jumpers closed with 0Ω resistors	Jumpers open
SPI (default)	JP32, JP34, JP36, JP38	JP31, JP33, JP35, JP37
I²C	JP31, JP33, JP35, JP37	JP32, JP34, JP36, JP38

Using the Evaluation Board with another microcontroller

It is possible to manage the ADE7878 mounted on the evaluation board with a different microcontroller mounted on another board. The ADE7878 may be connected to this other board through two connectors: P11 or P38. P11 is placed on the same power domain as the ADE7878. P38 is placed on the power domain of the LPC2368 and communicates with the ADE7878 through the isocouplers. If P11 is used, then the power domain of the LPC2368 should not be supplied at P12. If P38 is used, a conflict may arise with LPC2368 I/O ports. Two choices are provided to deal with this situation:

-One is to keep the LPC2368 running and close JP9. This tells LPC2368 to set all its I/Os high in order to allow the other microcontroller to communicate with the ADE7878. Once JP9 is closed, the reset button S2 should be pressed low to force LPC2368 to reset. This is necessary because JP9 state is checked inside LPC2368 program only once after reset.

-The other choice is to cut the power supply of LPC2368 by disconnecting JP7.

ADE7878 EVALUATION SOFTWARE

The ADE7878 evaluation board is supported by Windows based software that allows the user to access all the functionality of ADE7878. The software communicates with the LPC2368 microcontroller using the USB as a virtual COM port. On its side, LPC2368 communicates with ADE7878 to accomplish the requests arrived from the PC.

Installing the ADE7878 Software

The ADE7878 Software is supplied on one CD-ROM. It contains two projects: one that represents the LPC2368 project and one LabView based program that runs on the PC. The LPC2368 project is already loaded into the processor, but the LabView based program must be installed. Place the CR-ROM in the CDROM reader and double click on LabView_project\installation_files\setup.exe. This launches the setup program that automatically installs all the software components including the uninstall program and creates the required directories.

To launch the software, simply go to the Start->Programs->ADE7878 Eval Software menu and click on "ADE7878 Eval Software".

Uninstalling the ADE7878 Software

Both the ADE7878 Eval Software program and the NI run-time engine are easily uninstalled by using the Add/Remove Programs option in the control panel. Simply select the program to uninstall and click the Add/Remove button.

When installing a new version of the ADE7878 evaluation software, the previous version should be first uninstalled.
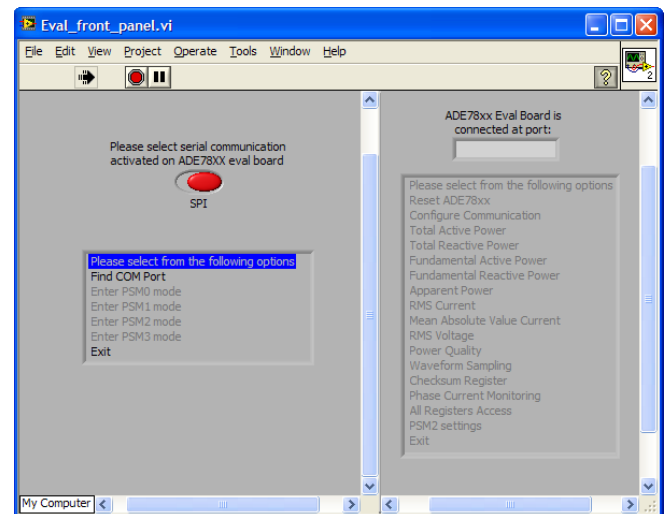

Figure 6. Front panel of ADE7878 Software

Front Panel Screen

When the software is launched, the front panel screen is opened. Three windows compose this screen: the main menu at the left, the submenu at the right and a window showing the communication port used by PC to connect to the evaluation port (see Figure 6). The serial port chosen on the board is introduced using a switch. By default, the communication between the microcontroller and ADE7878 uses the SPI port. Note the active serial port must first be set in hardware. See Activating Serial Communication ADE7878 – LPC2368 section for details on how to set it up.

The main menu has only one choice enabled, "Find COM Port". Clicking on it starts a process in which the PC tries to connect to the evaluation board and learn what PC port to use. It uses the Echo function of the Communication protocol (see Communication Protocol Between Microcontroller and ADE7878). It visualizes the port that matches the protocol and then sets it to 9600 baud, 8 data bits, no parity, no flow control, 1 stop bit. If the evalution board is not connected, the port is

visualized as "XXXXX". In this case, all the windows of the evaluation software are still accessible, but no communication can be executed. In both cases, whether the search for COM port is successful or not, the cursor is put back at "Please select from the following options" in the main menu, "Find COM Port" is greyed out and the next main menu options are enabled (see Figure 7). These options allow the user to command ADE7878 in any of PSM0 or PSM3 power modes. The other power modes PSM1 and PSM2 are not available for now because initializations have to be made in PSM0 before using ADE7878 in one of these modes.
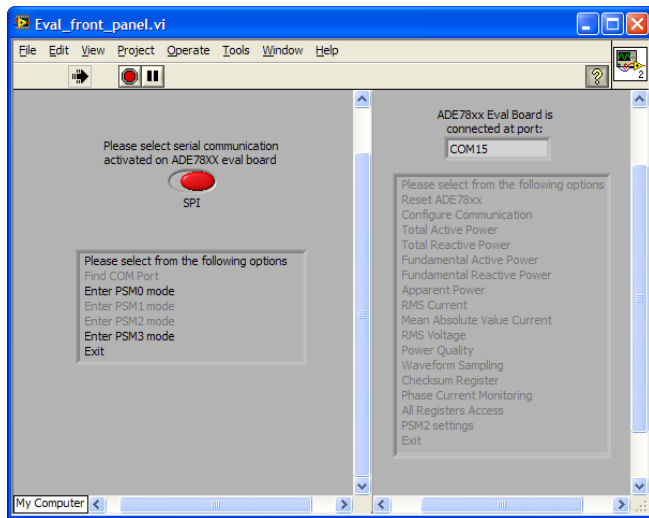

Figure 7. Front panel after the COM port has been identified

PSM0 – Normal Power Mode

Right after the evaluation board has been powered up, ADE7878 is in PSM3 sleep mode. When "Enter PSM0 mode" choice is selected, the microcontroller manipulates PM0 and PM1 pins of ADE7878 to switch it into PSM0 mode. It waits 50msec for the circuit to power up and if the SPI is the communication activated on the board, it executes 3 SPI write operations to address 0xEBFF of ADE7878 to activate the SPI port. If the operation has been correctly executed or the I2C communication is used, the message "Configuring LPC2369 – ADE7878 communication was successful" is displayed and the user has to click "OK" to continue. The only error that may occur during this operation is communication related, so if this happens, the following message is visualized: "Configuring LPC2368 – ADE7878 communication was not successful. Please check the communication between the PC and ADE7878 evaluation board and between LPC2368 and ADE78xx".

Bit 1 (PORT_LOCK) of CONFIG2[7:0] register is now set to 1 to lock in the serial port choice. Then DICOEFF register is initialized with 0xFF8000 and the DSP of ADE7878 is started by writing RUN=0x1. At the end of this process, the entire main menu is greyed out and the submenu is enabled. In this way, the user can now manage all the functionalities of ADE7878 in PSM0 mode. To switch ADE7878 in another power mode, Exit

button of submenu has to be clicked. The state of the front panel is presented in Figure 8.

Reset ADE7878

When "Reset ADE7878" is selected, the $\overline{RESET}$ pin of ADE7878 is kept low for 20msec and then is set high. If the operation was correctly executed, the message "ADE7878 was reset successfully" is displayed and the users have to click "OK" to move forward. The only error that may occur during this operation is communication related, so if this happens, the following message is visualized: "The communication between PC and ADE7878 evaluation board or between LPC2368 and ADE78xx did not function correctly. There is no guarantee the reset of ADE7878 has been performed."

Configure Communication

When "Configure Communication" is selected, the screen presented in Figure 9 is opened. This menu is useful if an ADE7878 reset has been performed and the SPI is not anymore the active serial port. User selects SPI port and then clicks OK button to update selection and lock the port. If the port selection is successful, the message "Configuring LPC2368 – ADE7878 communication was successful" is displayed and the users have to click "OK" to move forward. If a communication error happens, then the message "Configuring LPC2368 – ADE7878 communication was not successful. Please check the communication between the PC and ADE7878 evaluation board" is displayed. Then CONFIG2[7:0] register is written with bit 1 (PORT_LOCK) set to 1, so the user does not need to remember to set it once the communication is set. CONFIG2[7:0] is then read back and visualized together with bit 1 (PORT_LOCK).

If EXIT button is pressed, the window is closed and the cursor is put at "Please select from the following options" in the submenu of the Front Panel screen.
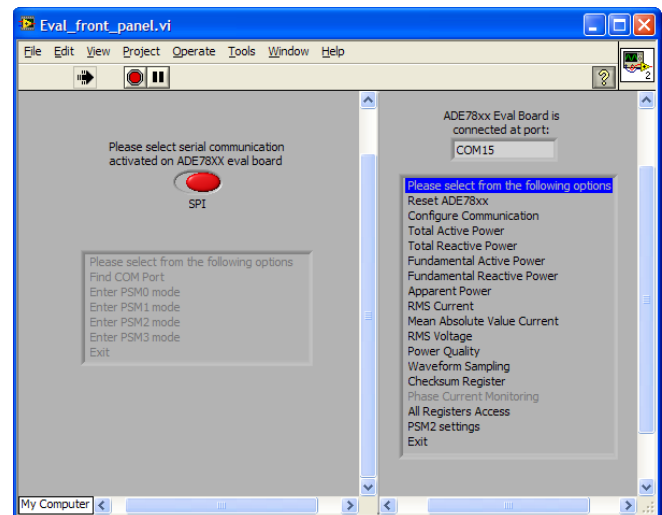

Figure 8. Front panel after ADE7878 enters PSM0 mode

Total Active Power

When "Total Active Power" is selected, the panel presented in Figure 10 is opened. The screen has two horizontal halfs: the one below shows the total active power data path of one phase and the one above shows bits, registers and commands necessary to the power management. The Active Data Path button manages which data path is shown in the bottom half. Some registers or bits, like WTHR0[31:0] or bit 0 (INTEN) of CONFIG[15:0] are common to all data paths, independent of which phase is shown. In that case, when they are updated, all the values in all data paths are updated. HPFDIS[23:0] register is present twice in the data path. In this case, only its value from the current data path is written into ADE7878. All the other instances take this value directly.
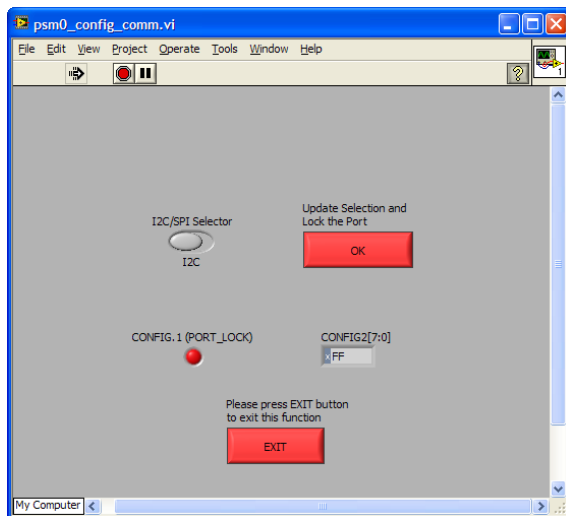

Figure 9. Configure Communication panel

"Read" button reads all registers that manage the total active power and visualizes them. Registers from the inactive data paths are also read and updated.

"Write" button writes all registers that manage the total active power into ADE7878. Registers from the inactive data paths are also written.

ADE7878 status window shows the power mode in which ADE7878 is into (it should always be PSM0 in this window), the active serial port (it should always be SPI) and CHECKSUM[31:0] register. After every READ and WRITE operation, CHECKSUM[31:0] register is read and visualized.

When "CFx Configuration" button is pressed, a new panel is opened (see Figure 11). This panel gives access to all bits and registers that configure the CF1, CF2 and CF3 outputs of ADE7878. Read and Write buttons update and visualize their values. Similar to Total Active Power panel, CHECKSUM[31:0] register is read back whenever a read or write operation is executed. To select more than one choice in TERMSELx, x=1, 2, 3 bits of COMPMODE[15:0] register, just press CTRL keypad when clicking on them. EXIT button closes the panel returns to Total Active Power panel.

When "Read Energy Registers" button is pressed, a new panel is opened (see Figure 12). This panel gives access to bits and registers that configure the energy accumulation. Read Setup and Write Setup buttons update and visualize their values. Similar to Total Active Power panel, CHECKSUM[31:0] register is read back whenever a read or write operation is executed. "Read All Energy" registers button reads all energy registers in that instant, whithout regard to the mode in which they function.

The panel also gives the choice of reading the energy registers synchronous to CFx, x=1, 2, 3 interrupts or using line cycle accumulation mode. When "Read energy registers synchronously with CF1 pulses" button is pressed, the following happens:

- STATUS0[31:0] is read and then written back, so all non zero interrupt flag bits are cancelled.

- bit 14 (CF1) in MASK1[31:0] register is set to 1 and the interrupt protocol is started (please see Communication Protocol Between Microcontroller and ADE7878 chapter for protocol details). The microcontroller waits until $\overline{IRQ0}$ pin goes low. If the wait is longer than the timeout the user indicates in 3sec increments, then an error message is displayed: "No CF1 pulse was generated. Verify all the settings before attempting to read energy registers in this mode!" When $\overline{IRQ0}$ pin goes low, STATUS0[31:0] register is read and written back to cancel bit 14 (CF1) and then the energy registers involved in CF1 signal are read and visualized. A timer in 10msec increments can be used to measure the reaction time after $\overline{IRQ0}$ pin goes low.

- The operation is repeated as long as the button remains pressed.

The process is similar when the other CF2, CF3 and line accumulation buttons are pressed.

It is recommended to always use a timeout when dealing with interrupts. By default, the timeout is set to 10 (indicating 30 sec timeout) and the timer is set to 0 (indicating the STATUSx[31:0], x=1, 2 and energy registers are read immediately after $\overline{IRQ0}$ goes low).

When selected, "Total Reactive Power", "Fundamental Active Power" and "Fundamental Reactive Power" buttons open panels very similar with the Total Active Power panel. They are presented in Figure 13, Figure 14 and Figure 15.
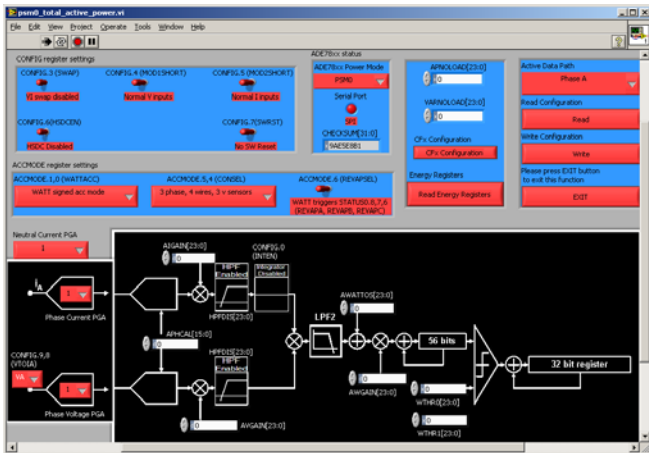
Figure 10. Total active energy panel
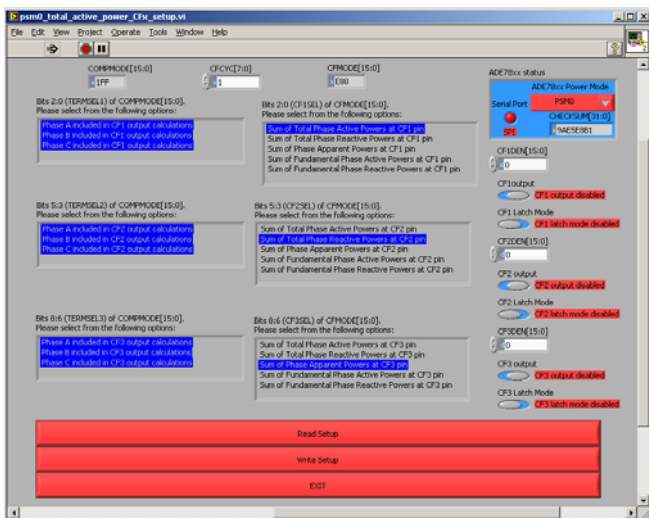
Figure 11. CFx Configuration panel
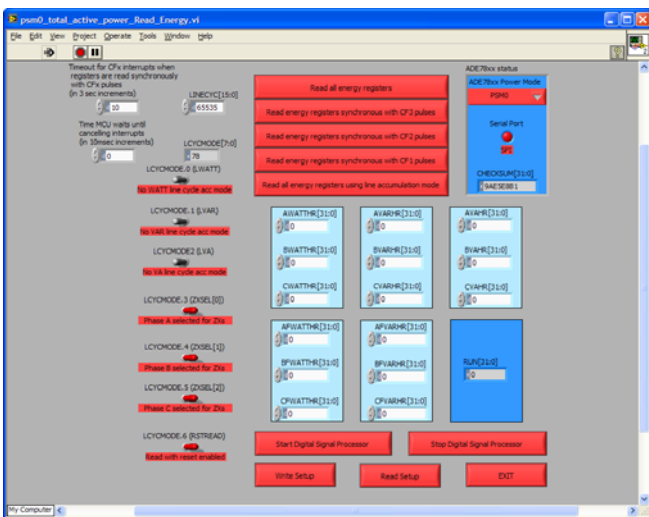
Figure 12. Read Energy Registers panel

Figure 13. Total Reactive Power panel

Figure 14. Fundamental Active Power panel

Figure 15. Fundamental Reactive Power panel

Apparent Power

When "Apparent Power" is selected, a new panel is opened (Figure 16). Similar to the other panels that deal with power measurement, this panel is divided in two horizontal halves: the one below shows the apparent power data path of one phase

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and ADE7878 status and the one above shows bits, registers and commands necessary to the power management.

Current RMS

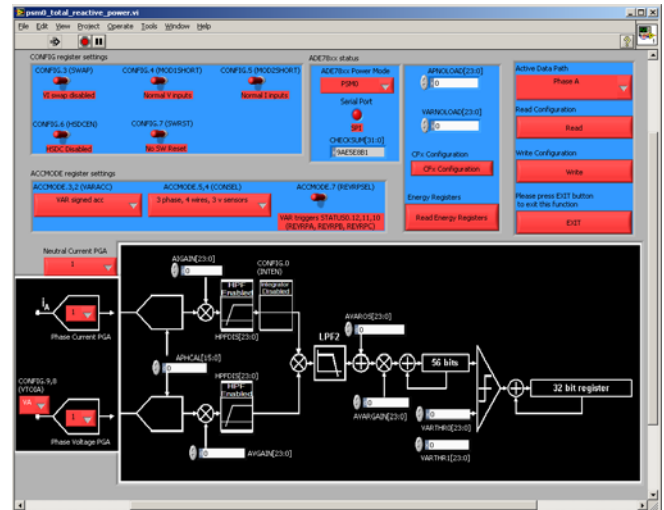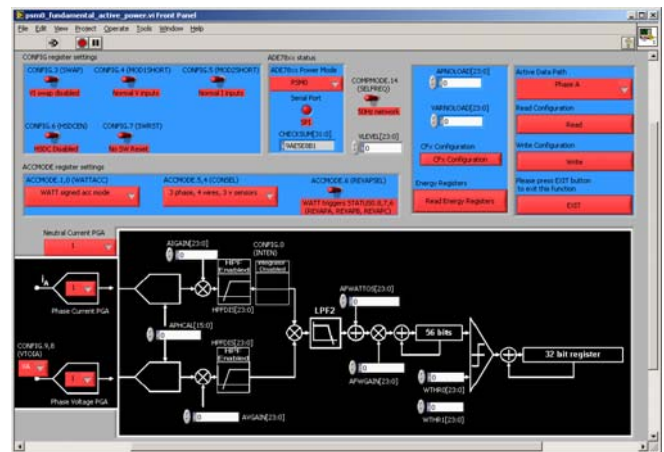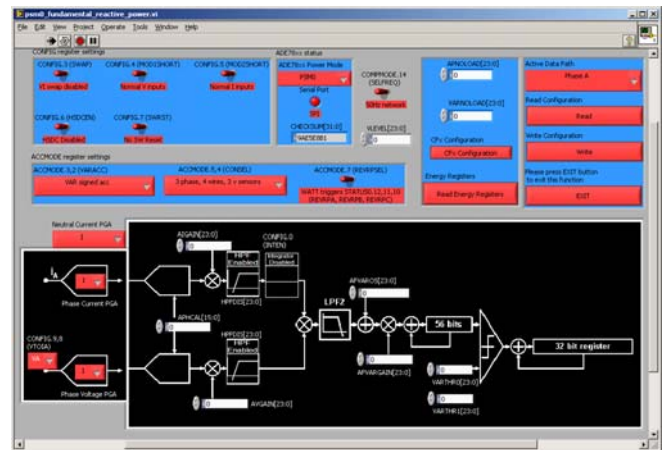When "Current RMS" is selected, a new panel is opened (Figure 17). All data paths of all phases are available.

"Read Setup" button reads all registers shown in the panel. "Write Setup" button writes xIRMSOS[23:0] (x=A,B,C,N) registers.

"Start/Stop Digital Signal Processor" buttons manage RUN[15:0] register.

"Read xIRMS" registers button uses ZXIA, ZXIB and ZXIC interrupts at $\overline{IRQ1}$ pin to read xIRMS[23:0] (x=A,B,C,N) registers 10 consecutive times and then compute and visualize their average. If no interrupt occurs for a time indicated by the timeout (in 3 sec increments), then the following message is visualized: "No ZXIA, ZXIB or ZXIC interrupt was generated.

Verify at least one sinusoidal signal is provided between IAP-IAN, IBP-IBN or ICP-ICN pins." A delay can be introduced (in 10msec increments) between the time $\overline{IRQ1}$ pin goes low and the moment the xIRMS registers are read. The operation is repeated as long as the button remains pressed.
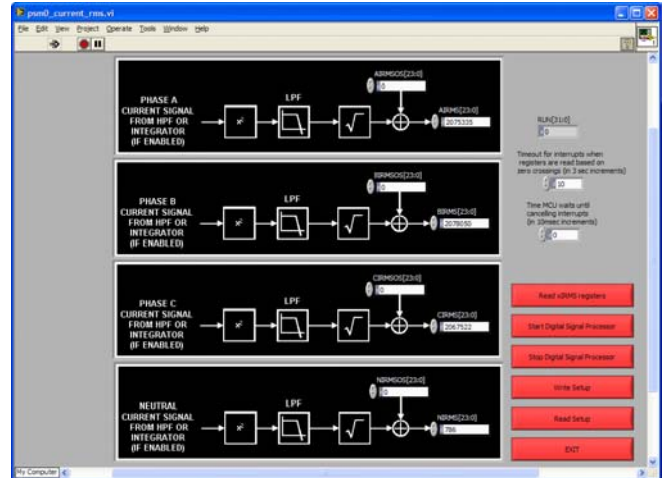

Figure 16. Apparent Power panel

Figure 17. Current RMS panel

Mean Absolute Value Current

When "Mean Absolute Value Current" is selected, a new panel is opened (Figure 18). When "Read xIMAV Registers" button is pressed, xIMAV[19:0](x=A, B, C) registers are read 10 consecutive times and then their average is computed and visualized. After this operation, the button is returned back high automatically. In addition, ADE7878 status is visualized.

Voltage RMS

This panel is very similar with the Current RMS panel. "Read Setup" button executes a read of xVRMSOS[23:0] and xVRMS[23:0] (x=A, B, C) registers.

"Write Setup" writes xVRMSOS[23:0] registers into ADE7878. "Start/Stop Digital Signal Processor" buttons manage RUN[15:0] register.

"Read xVRMS" registers button uses ZXVA, ZXVB and ZXVC interrupts at $\overline{IRQ1}$ pin to read xVRMS[23:0] (x=A,B,C) registers 10 consecutive times and then compute and visualize their average. If no interrupt occurs for a time indicated by the timeout (in 3 sec increments), then the following message is visualized: "No ZXVA, ZXVB or ZXVC interrupt was generated. Verify at least one sinusoidal signal is provided between VAP-VN, VBP-VN or VCP-VN pins." A delay can be introduced (in 10msec increments) between the time $\overline{IRQ1}$ pin goes low and the moment the xVRMS[23:0] registers are read. The operation is repeated as long as the button remains pressed.
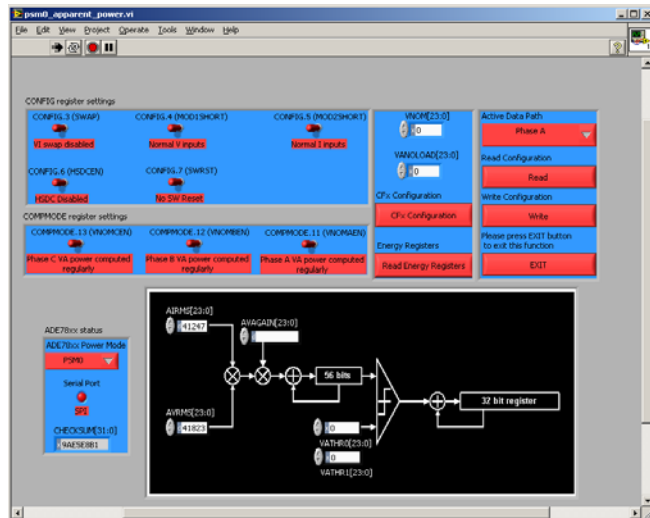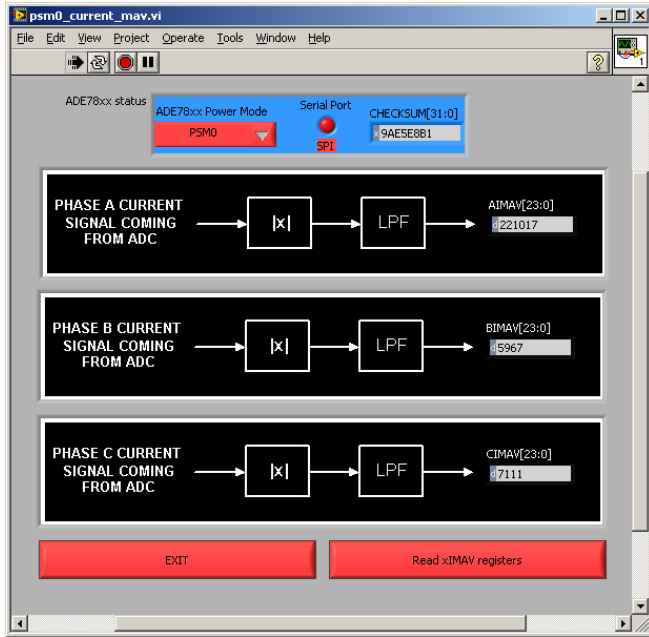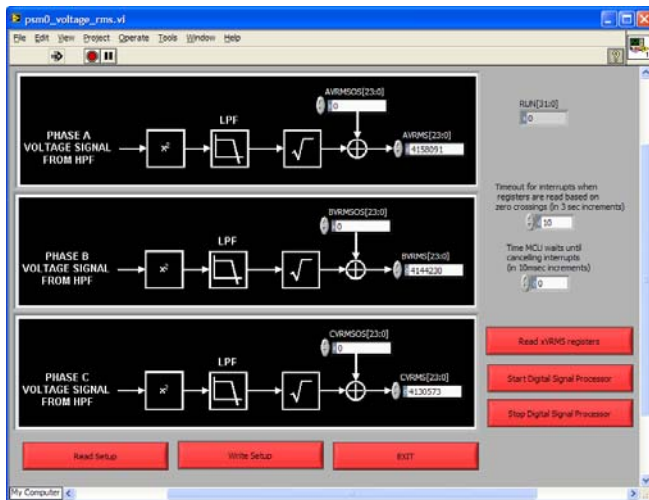
Figure 18. Mean Absolute Value Current panel

Figure 19. Voltage RMS panel

Power Quality

Power Quality panel is divided in two horizontal halfs. The bottom one shows various registers that manage various power quality measurements function of Active Measurement button. The one above shows ADE7878 status and various buttons that manage the measurements. When "Read Configuration" button is pressed, all power quality registers (MASK1[31:0], STATUS1[31:0], PERIOD[15:0], MMODE[7:0], ISUM[27:0], OVLVL[23:0], OILVL[23:0], PHSTATUS[15:0], IPEAK[31:0], VPEAK[31:0], SAGLVL[23:0], SAGCYC[7:0], ANGLE0[15:0], ANGLE1[15:0], ANGLE2[15:0], COMPMODE[15:0], CHECKSUM[31:0], PEAKCYC[7:0]) are read and the ones belonging to the active window are visualized. Based on PERIOD[15:0] register, the line frequency is computed and visualized in the Zero Crossing Measurement window. Based on

ANGLEx[15:0] (x=0,1,2) registers, cos(ANGLEx) are computed and visualized.

When "Write Configuration" button is pressed, MMODE[7:0], OVLVL[23:0], OILVL[23:0],   SAGLVL[23:0], SAGCYC[7:0], COMPMODE[15:0], PEAKCYC[7:0] are written into ADE7878 and then CHECKSUM[31:0] is read back and visualized.

When "Wait For Interrupts" button is pressed, the interrupts enabled by the user in MASK1[31:0] register are monitored. When $\overline{IRQ1}$ pin goes low, STATUS1[31:0] register is read and its bits visualized. Then, ISUM[27:0], PHSTATUS[15:0], IPEAK[31:0], VPEAK[31:0], ANGLE0[15:0], ANGLE1[15:0], ANGLE2[15:0] registers are also read and visualized. A timeout should be introduced in 3 seconds increments to ensure the program does not wait indefinitely for interrupts and a timer (in 10msec increments) is provided to allow reading the registers with a delay from the moment the inyterrupt is triggered.

"Active Measurement" button gives access to Zero Crossing measurements, Neutral Current Mismatch management, Overvoltage & Overcurrent management, Peak detection, Sag detection and Time Intervals Between Phases (see Figure 20, Figure 21, Figure 22, Figure 23, Figure 24).

The line frequency is computed using PERIOD[15:0] register based on the following formula:

$$f = \frac{256000}{PERIOD}[Hz]$$

Based on ANGLE0[15:0], ANGLE1[15:0], ANGLE2[15:0] measurements, the cosine of them is computed using the following formula:

$$cos(ANGLEx) = cos\left(\frac{ANGLEx \cdot 360 \cdot 50}{256000}\right)$$
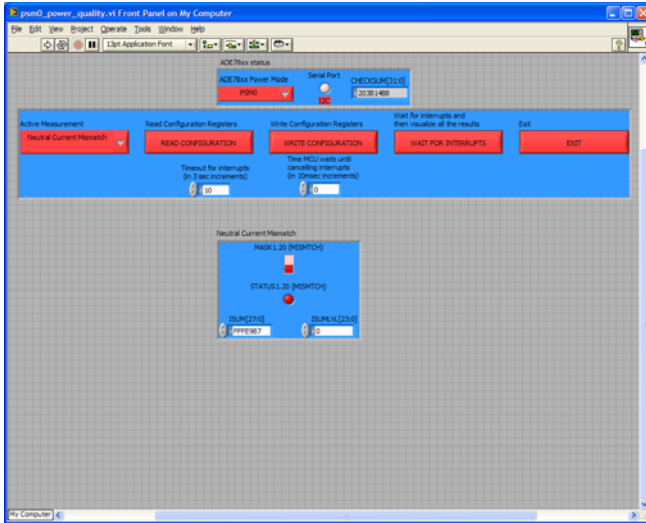

Figure 20. Zero Crossing Measurements panel
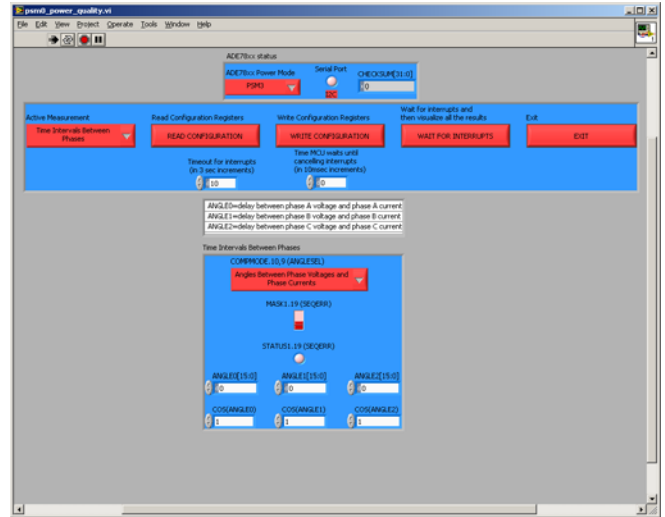
Figure 21. Neutral Current Mismatch panel

Figure 22. Overvoltage & Overcurrent management panel

Figure 23. Peak management panel

Figure 24. Time Intervals Between Phases panel

Waveform Sampling

This panel (see Figure 25) uses HSDC port to acquire data from the ADE7878 and visualize it. It can be accessed only if the communication between ADE7878 and LPC2368 is I²C. See Activating Serial Communication ADE7878 – LPC2368 section for details on how to set I²C communication on the ADE7878 evaluation board.

The HSDC transmits data to LPC2368 at 4MHz because this is the maximum speed the slave SPI of LPC2368 can receive data. The panel contains some switches that must be set before acquiring data:

-One switch chooses what quantities are visualized: phase currents and voltages or phase powers. For every set of quantities, only two can be acquired at a time. This choice is done using the buttons "Select Waveform1" and "Select Waveform2".

-A second switch allows for acquired data to be stored in files for further utilization.

-The acquisition time should also be set before an acquisition is ordered. By default, this time is 150msec. It is limited for phase currents and voltages for up to 1sec, but for phase powers is unlimited. This difference appears because the LPC2368 must execute in real time three tasks using the ping pong buffer method: continuously receiving data from HSDC, storing it into its USB memory, sending it to the PC. More time it takes the HSDC to transmit data, more time LPC2368 has to transmit data to the PC. As transmitting 6 phase currents and voltages at 4MHz takes 103.25μsec, less than 125 μsec, but transmitting 9 phase powers takes 133.25μsec, more than 125 μsec, the first quantities are transmitted by HSDC at 8KHz update rate and the second at 4KHz rate. This means the phase currents and voltages can be acquired only for up to 1sec before the LPC2368 goes out of bandwidth and the powers can be acquired for an unlimited time.

To start the acquisition, press "ACQUIRE DATA" button. The data is visualized on two different plots, Waveform1 and Waveform2. If the switch to allow storing of data into files is turned on, the program asks for the name and location of files before storing Waveform1 and Waveform2.
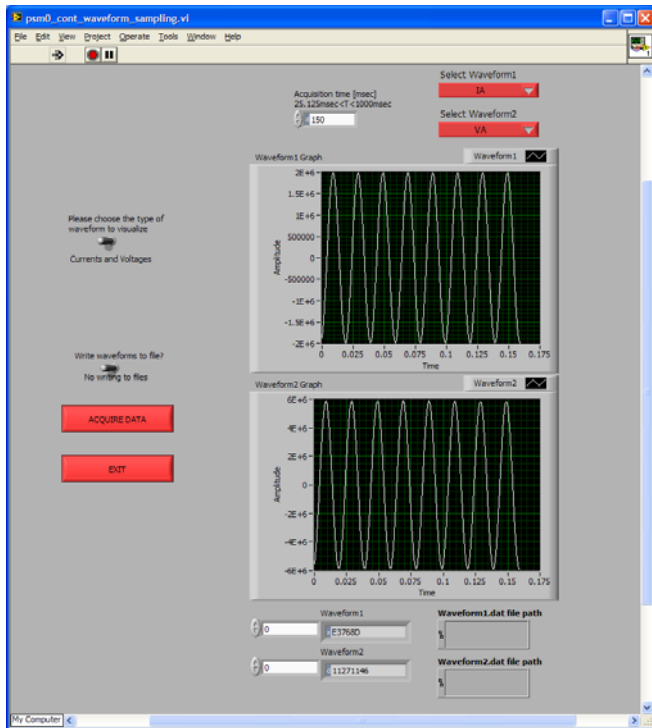
Figure 25. Waveform sampling panel

CHECKSUM Register

This panel gives access to all ADE7878 registers that are used to compute CHECKSUM[31:0] register (see Figure 26). The user can read/write the value of these registers by clicking on "Read"/"Write" buttons. LabView program estimates the value of CHECKSUM[31:0] register and visualizes it whenever one of the registers is changed. When "Read" button is pressed, aside from reading the registers, CHECKSUM[31:0] is also read and visualized. In this way, the user can compare the value of CHECKSUM[31:0] estimated by LabView with the value read from ADE7878. They should always be identical.
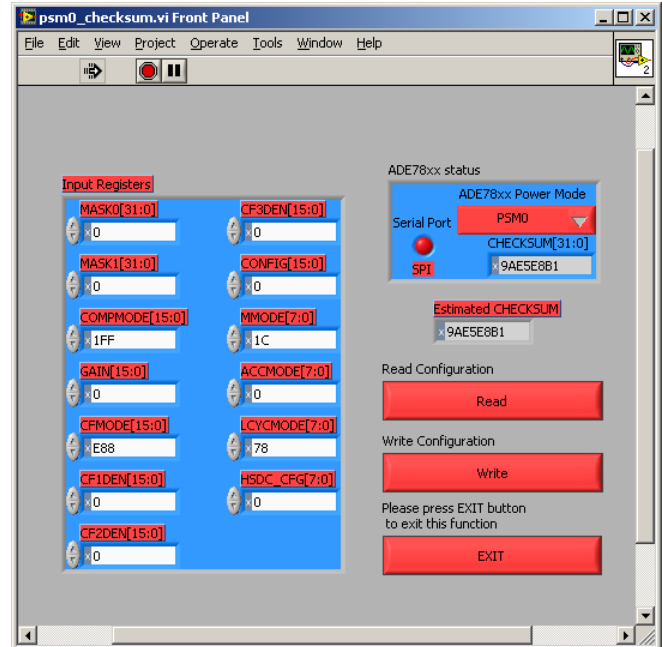
Figure 26. CHECKSUM Register panel

All Registers Access

This panel gives read/write access to all ADE7878 registers. Because of their number, the panel can scroll up/down and has multiple "Read", "Write" and "End" buttons (see Figure 27, Figure 28). The registers are placed in alphabetical order, starting from upper left corner and going vertically.
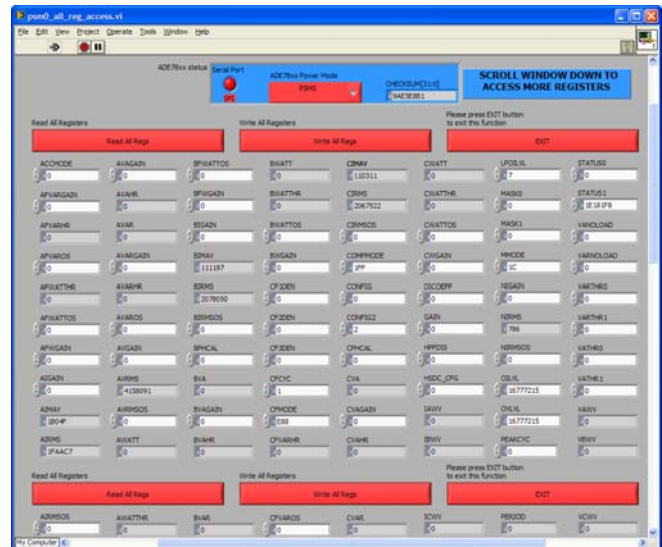
Figure 27. Panel giving access to all ADE7878 registers (1)
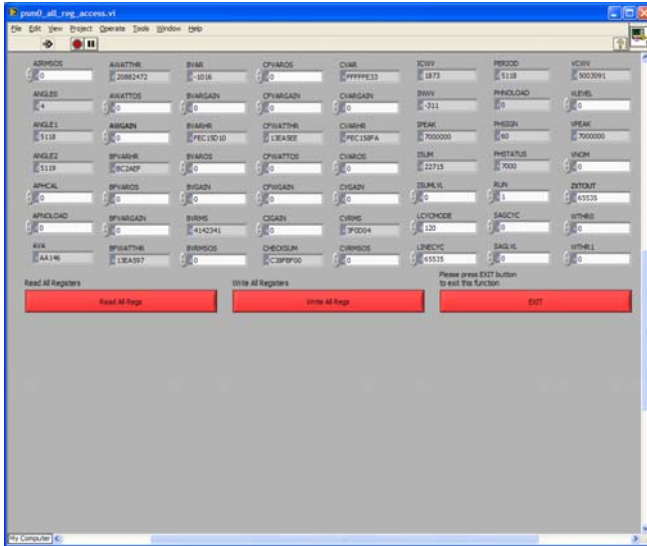
Figure 28. Panel giving access to all ADE7878 registers (2)

PSM2 Settings

This panel gives access to LPOILVL[7:0] register that is used to access PSM2 low power mode (see Figure 29). The user can manipulate its LPOIL[2:0] and LPLINE[4:0] bits. The value shown into LPOILVL[7:0] register is composed from these bits and then visualized. Writing a value to LPOILVL[7:0] register window directly does not have any consequence.
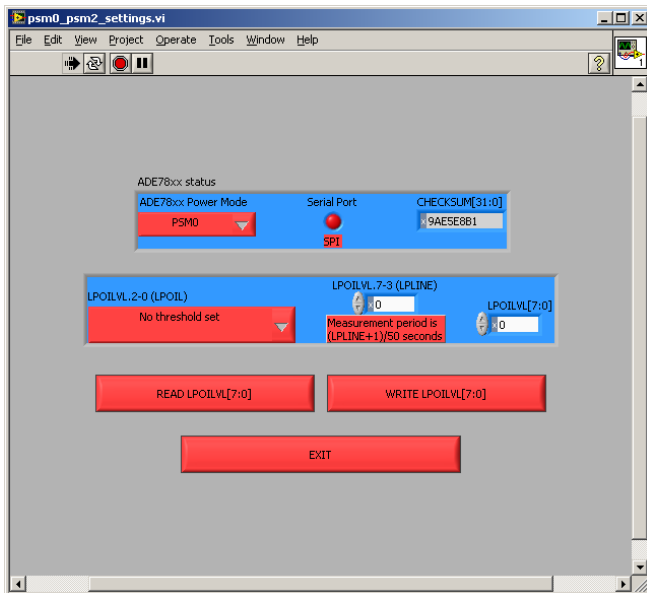
Figure 29. PSM2 settings panel

Enter PSM1 Mode

When "Enter PSM1 mode" is selected, the microcontroller manipulates PM0 and PM1 pins of ADE7878 to switch it into PSM1 reduced power mode. Then the submenu only allows accessing the Mean Absolute Value Current function because this is the only ADE7878 functionality in this reduced power mode (see Figure 30).
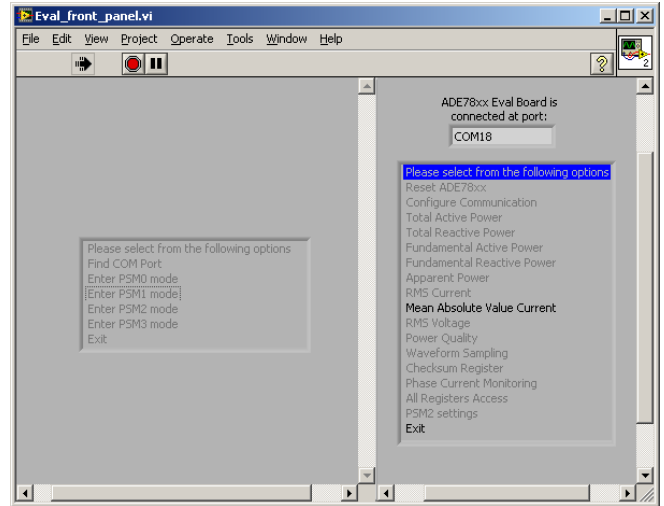

Figure 30. Front Panel after ADE7878 enters PSM1 mode

Mean Absolute Value Current in PSM1 Mode

This panel is very similar to the panel accessible in PSM0 mode (see Mean Absolute Value Current Chapter for details). The only difference is that ADE7878 status does not show CHECKSUM[31:0] register because it is not available in PSM1 mode (Figure 31)
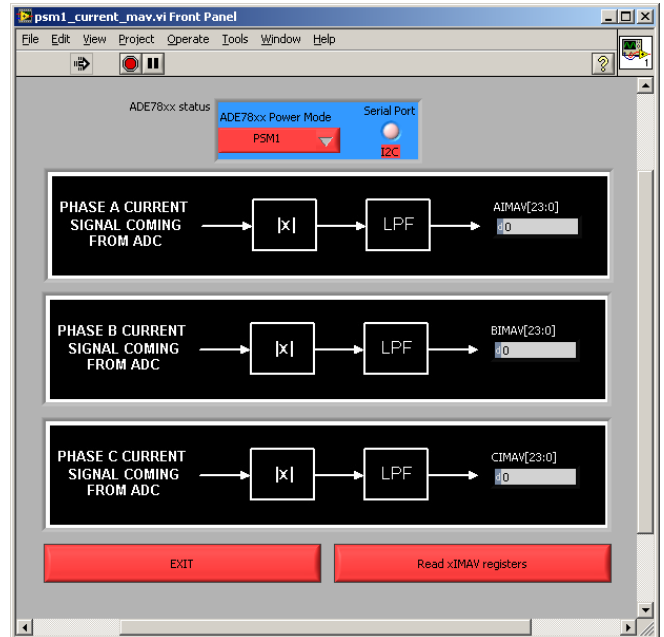
Figure 31. Mean AbsoluteValue Currents Panel in PSM1 mode

Enter PSM2 Mode

When "Enter PSM2 mode" is selected, the microcontroller manipulates PM0 and PM1 pins of ADE7878 to switch it into PSM2 low power mode. Then the submenu only allows accessing the Phase Current Monitoring function because this is the only ADE7878 functionality in this low power mode.

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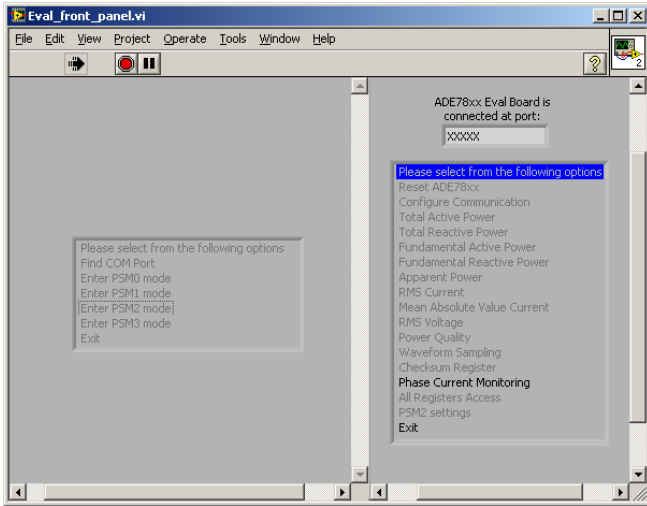
Figure 32. Front Panel after ADE7878 enters PSM2 mode

Phase Current Monitoring

This panel allows the user to visualize the state of $\overline{IRQ0}$ and $\overline{IRQ1}$ pins because in PSM2 low power mode, ADE7878 compares the phase currents against a threshold determined by LPOILVL[7:0] register (see Figure 33). The button "READ STATUS OF $\overline{IRQ0}$ AND $\overline{IRQ1}$ PINS" reads the status of these pins, visualizes and interprets it. This operation is managed by LPOILVL[7:0] register and it can only be modified in PSM0 mode. The panel offers this option by switching ADE7878 in PSM0 and then back in PSM2 when one of "READ/WRITE LPOILVL" buttons is pressed. To avoid toggling both PM0 and PM1 pins in the same time during this switch, ADE7878 is ordered first in PSM3 when changing modes.
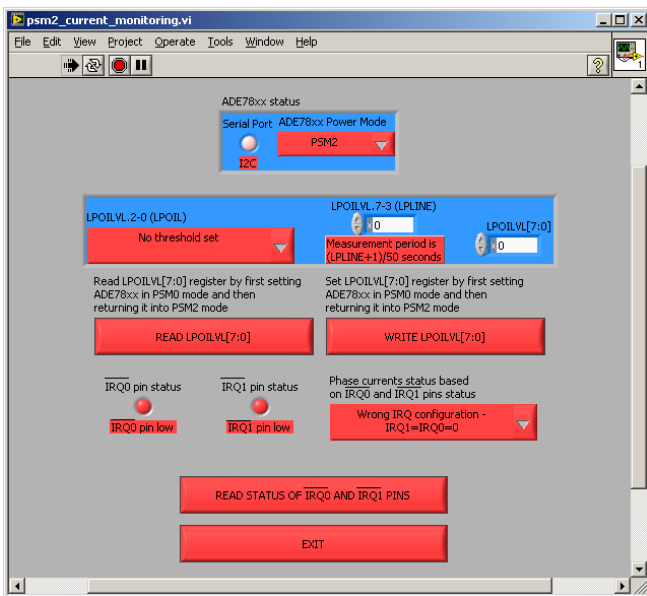
Figure 33. Panel managing Current Monitoring in PSM2 mode

Enter PSM3 Mode

In PSM3 sleep mode, the ADE7878 has most of its internal circuits turned off. Therefore, no submenu is activated while in

this mode. User can press one of "Enter PSM0, PSM1 or PSM2" buttons to order ADE7878 in one of these power modes.

COMMUNICATION PROTOCOL BETWEEN MICROCONTROLLER AND ADE7878

This chapter lists the protocol commands that have been implemented to manage ADE7878 from the PC using the microcontroller.

The microcontroller is a pure slave during the communication. It receives a command from PC, it excutes it and then sends an answer to the PC. The PC should wait the answer before sending a new command to the microcontroller.

Table 3. Echo Command—Message from PC to Microcontroller

Byte	Description
0	'A'=0x41
1	N=Number of bytes transmitted after this byte
2	Data byte N-1 (MS)
3	Data byte N-2
4	Data byte N-3
…	…
N	Data byte 1
N+1	Data byte 0 (LS)

Table 4. Echo Command—Answer from Microcontroller to PC

Byte	Description
0	'R'=0x52
1	'A'=0x41
2	N=Number of bytes transmitted after this byte
3	Data byte N-1 (MS)
4	Data byte N-2
…	…
N+1	Data byte 1
N+2	Data byte 0 (LS)

Table 5. Power Mode Select—Message from PC to Microcontroller

Byte	Description
0	'B'=0x42 - change PSM mode
1	N=1
2	Data Byte 0:
	0x00=PSM0
	0x01=PSM1
	0x02=PSM2
	0x03=PSM3

Table 6. Power Mode Select—Answer from Microcontroller to PC

Byte	Description
0	'R'=0x52
1	'~'=0x7E to acknowledge the operation was successful

Table 7. Reset—Message from PC to Microcontroller

Byte	Description

0	'C'=0x43 - toggle RESET pin and keep it low for at least 10msec
1	N=1
2	Data Byte 0: this byte can have any value

Table 8. Reset—Answer from Microcontroller to PC

Byte	Description
0	'R'=0x52
1	'~'=0x7E to acknowledge the operation was successful

Table 9. I²C/SPI Select (Configure Communication)— Message from PC to Microcontroller

Byte	Description
0	'D'=0x44 - Select I2C, SPI and initialize them. Then sets CONFIG2[7:0]=0x2 to lock in the port choice. When I2C is selected, enable also SSP0 of LPC2368 (used for HSDC)
1	N=1
2	Data Byte 0: 0x00=I2C, 0x01=SPI

Table 10. I²C/SPI Select (Configure Communication)— Answer from Microcontroller to PC

Byte	Description
0	'R'=0x52
1	'~'=0x7E to acknowledge the operation was successful

Table 11. Data Write—Message from PC to Microcontroller

Byte	Description
0	'E'=0x45
1	N= Number of bytes transmitted after this byte. N can be 1+2,2+2, 4+2 or 6+2
2	MS byte of the address
3	LS byte of the address
4	Data byte N-3 (MS)
5	Data byte N-4
6	Data byte N-5
…	…
N+2	Data byte 1
N+3	Data byte 0 (LS)

Table 12. Data Write—Answer from Microcontroller to PC

Byte	Description
0	'R'=0x52
1	'~'=0x7E to acknowledge the operation was successful

Table 13. Data Read—Message from PC to Microcontroller

Byte	Description
0	'F'=0x46
1	N= Number of bytes transmitted after this byte. N=3
2	MS byte of the address
3	LS byte of the address
4	M=number of bytes to be read from the address above. M can be 1, 2, 4 or 6

Table 14. Data Read—Answer from Microcontroller to PC

Byte	Description

0	'R'=0x52
1	MS byte of the address
2	LS byte of the address
3	Byte 5, 3,1 or 0 (MS)read at the location indicated by address. The location may contain 6, 4, 2 or 1 bytes. The content is transmitted MS byte first.
4	Byte 4, 2 or 0
5	Byte 3, 1
6	Byte 2, 0
7	Byte 1
8	Byte 0

Table 15. Interrupt Setup—Message from PC to Microcontroller

Byte	Description
0	'J'=0x4A
1	N=8 - Number of bytes transmitted after this byte.
2	MS byte of MASK1[31:0] or MASK0[31:0] address
3	LS byte of MASK1[31:0] or MASK0[31:0] address
4	Byte3 of the desired value of MASK0[31:0] or MASK1[31:0]
5	Byte2
6	Byte1
7	Byte0
8	Time Out Byte - Time the MCU must wait for the interrupt to be triggered. It is measured in 3sec increments. Time Out Byte (TOB)=0 means the timeout is disabled
9	IRQ timer - Time the MCU leaves the $\overline{IRQx}$, x=0,1pin low before writing back to clear the interrupt flag. It is measured in 10msec increments. Timer=0 means the timeout is disabled

Table 16. Interrupt Setup—Message from Microcontroller to PC

Byte	Description
0	'R'=0x52
1	Byte3 of STATUS0[31:0] or STATUS1[31:0] If the program waited for TOB*3sec and the interrupt was not triggered, then the Byte3=Byte2=Byte1=Byte0=0xFF
2	Byte2 of STATUS0[31:0] or STATUS1[31:0]
3	Byte1 of STATUS0[31:0] or STATUS1[31:0]
4	Byte0 of STATUS0[31:0] or STATUS1[31:0]

The microcontroller executes the following operations once Interrupt Setup command is received:

- Reads STATUS0[31:0] or STATUS1[31:0] (depending on the address received from PC) and if it shows an interrupt already triggered (one of its bits equal to 1), it erases it by writing it back.
- Writes MASK0[31:0] or MASK1[31:0] with the value received from PC.
- Waits for the interrupt to be triggered. If the wait gets more than the time out specified in the command, then sends back 0xFFFFFFFF.
- If the interrupt is triggered, it reads STATUS0[31:0] or STATUS1[31:0] and then writes it back to clear it. The value

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read at this point is the value sent back to the PC so the user can see the source of the interrupts.

- Sends back the answer.

Table 17. Interrupt Pins Status—Message from PC to Microcontroller

Byte	Description
0	'H'=0x48
1	N=1 - Number of bytes transmitted after this byte
2	Any byte. This byte is not used at all. It is used only because N must not be 0.

Table 18. Interrupt Pins Status—Answer from Microcontroller to PC

Byte	Description
0	'R'=0x52
1	A number representing the status of $\overline{IRQ0}$ and $\overline{IRQ1}$ pins.
	0: $\overline{IRQ0}$ =low, $\overline{IRQ1}$ =low
	1: $\overline{IRQ0}$ =low, $\overline{IRQ1}$ =high
	2: $\overline{IRQ0}$ =high, $\overline{IRQ1}$ =low
	3: $\overline{IRQ0}$ =high, $\overline{IRQ1}$ =high
	The reason of $\overline{IRQ0}$ and $\overline{IRQ1}$ order is because on the microcontroller's IO port, $\overline{IRQ0}$ =P0.1 and $\overline{IRQ1}$ =P0.0

Acquire HSDC Data Continuously

This function acquires data from HSDC continuously for a defined time period and for up to two variables. The microcontroller sends data in packages of 4Kbytes.

The following table describes the protocol when two instantaneous phase currents or voltages are acquired.

Table 19. Acquire HSDC Data Continuously—Message from PC to Microcontroller if phase currents and voltages are acquired

Byte	Description
0	'G'=0x47
1	N= Number of bytes transmitted after this byte. N=30
2	0. This corresponds to byte3 of IA. But as this byte is only a sign extension of byte2, it is not sent back by the microcontroller.
3	Increment_IA_Byte2. If IA is to be acquired, then bytes 3, 4, 5 are 1. Otherwise they are 0.
4	Increment_IA_Byte1
5	Increment_IA_Byte2
6	0
7	Increment_VA_Byte2. If VA is to be acquired, then bytes 7, 8, 9 are 1. Otherwise they are 0.
8	Increment_VA_Byte1
9	Increment_VA_Byte0
10	0
11	Increment_IB_Byte2. If IB is to be acquired, then bytes 11, 12, 13 are 1. Otherwise they are 0.
12	Increment_IB_Byte1

Byte	Description
13	Increment_IB_Byte0
14	0
15	Increment_VB_Byte2. If VB is to be acquired, then bytes 15, 16, 17 are 1. Otherwise they are 0.
16	Increment_VB_Byte1
17	Increment_VB_Byte0
18	0
19	Increment_IC_Byte2. If IC is to be acquired, then bytes 19, 18, 19 are 1. Otherwise they are 0.
20	Increment_IC_Byte1
21	Increment_IC_Byte0
22	0
23	Increment_VC_Byte2. If VC is to be acquired, then bytes 23, 24, 25 are 1. Otherwise they are 0.
24	Increment_VC_Byte1
25	Increment_VC_Byte0
26	0
27	Increment_IN_Byte2. If IN is to be acquired, then bytes 27, 28, 29 are 1. Otherwise they are 0.
28	Increment_IN_Byte1
29	Increment_IN_Byte0
30	Byte1 of M. M is a 16 bit number. The number of 32 bit samples that will be acquired by the microcontroller is (2*M+1)*67 per channel.
31	Byte0 of M

If two of phase powers are to be acquired, the protocol changes , see Table 20.

Table 20. Acquire HSDC Data Continuously—Message from PC to Microcontroller if phase powers are acquired

Byte	Description
0	'G'=0x47
1	N= Number of bytes transmitted after this byte. N=38
2	0. This corresponds to byte3 of AVA. But as this byte is only a sign extension of byte2, it is not sent back by the microcontroller.
3	Increment_AVA_Byte2. If AVA is to be acquired, then bytes 3, 4, 5 are 1. Otherwise they are 0.
4	Increment_AVA_Byte1
5	Increment_AVA_Byte2
6	0
7	Increment_BVA_Byte2. If BVA is to be acquired, then bytes 7, 8, 9 are 1. Otherwise they are 0.
8	Increment_BVA_Byte1
9	Increment_BVA_Byte0
10	0
11	Increment_CVA_Byte2. If CVA is to be acquired, then bytes 11, 12, 13 are 1. Otherwise they are 0.
12	Increment_CVA_Byte1
13	Increment_CVA_Byte0
14	0
15	Increment_AWATT_Byte2. If AWATT is to be acquired, then bytes 15, 16, 17 are 1. Otherwise they are 0.
16	Increment_AWATT_Byte1
17	Increment_AWATT_Byte0

Byte	Description
18	0
19	Increment_BWATT_Byte2. If BWATT is to be acquired, then bytes 19, 18, 19 are 1. Otherwise they are 0.
20	Increment_BWATT_Byte1
21	Increment_BWATT_Byte0
22	0
23	Increment_CWATT_Byte2. If CWATT is to be acquired, then bytes 23, 24, 25 are 1. Otherwise they are 0.
24	Increment_CWATT_Byte1
25	Increment_CWATT_Byte0
26	0
27	Increment_AVAR_Byte2. If AVAR is to be acquired, then bytes 27, 28, 29 are 1. Otherwise they are 0.
28	Increment_AVAR_Byte1
29	Increment_AVAR_Byte0
30	0
31	Increment_BVAR_Byte2. If BVAR is to be acquired, then bytes 31, 32, 33 are 1. Otherwise they are 0.
32	Increment_BVAR_Byte1
33	Increment_BVAR_Byte0
34	0
35	Increment_CVAR_Byte2. If CVAR is to be acquired, then bytes 35, 36, 37 are 1. Otherwise they are 0.
36	Increment_CVAR_Byte1
37	Increment_CVAR_Byte0
38	Byte1 of M. M is a 16 bit number. The number of 32 bit samples that will be acquired by the microcontroller is $(2*M+1)*67$ per channel.
39	Byte0 of M

After receiving the command, the microcontroller enables the HSDC port, and acquires $67*7*4=1876$ bytes into buffer0. As soon as buffer0 is filled, data is acquired in buffer1 (equal in size to buffer0), while $2*3*67=402$ bytes (134 24-bit words) from buffer0 are transmitted to the PC. As soon as buffer1 is filled, data is acquired into buffer0 while 402 bytes from buffer1 are transmitted to the PC. Only the less significant 24 bits of every 32 bit instantaneous value is sent to PC in order to decrease the size of the buffer sent to PC. The most significant 8 bits are only an extension of a 24 bit signed word anyway, so no information is lost. The protocol used by the microcontroller to send data to the PC is as follows:

Table 21. Acquire HSDC Data Continuously—Answer from Microcontroller to PC

Byte	Description
0	'R'=0x52
1	Byte 2 (MS) of word 1
2	Byte 1 of word 1
3	Byte 0 (LS) of word 1
4	Byte 2 (MS) of word 2
5	Byte 1 (MS) of word 2
…	...
402	Byte 0 (LS) of word 134

Start ADE7878 DSP

This function orders the microcontroller to start the DSP. The Microcontroller writes RUN register with 0x1.

Table 22. Start ADE7878 DSP—Message from PC to Microcontroller

Byte	Description
0	'N'=0x4E
1	N= Number of bytes transmitted after this byte. N=1
2	Any byte

Table 23. Start ADE7878 DSP—Answer from Microcontroller to PC

Byte	Description
0	'R'=0x52
1	'~'=0x7E to acknowledge the operation was successful

Stop ADE7878 DSP

This function orders the microcontroller to stop the DSP. The Microcontroller writes RUN register with 0x0.

Table 24. Stop ADE7878 DSP—Message from PC to Microcontroller

Byte	Description
0	'N'=0x4F
1	N= Number of bytes transmitted after this byte. N=1
2	Any byte

Table 25. Stop ADE7878 DSP—Answer from Microcontroller to PC

Byte	Description
0	'R'=0x52
1	'~'=0x7E to acknowledge the operation was successful

UPGRADING MICROCONTROLLER FIRMWARE

Although the evaluation board is supplied with the microcontroller firmware already installed, the ADE7878 Evaluation Software CD provides the microcontroller LPC2368 project developed under IAR Embedded Workbench Environment for ARM. Users in possession of this tool can modify the project at will and can download it using an IAR J-Link debugger. As an alternative, the executabale can be downloaded using a program called Flash Magic, available on the Evaluation Software CD or at this website: http://www.flashmagictool.com/

Flash Magic uses the PC COM port to download the microcontroller firmware. In the following, the procedure to use Flash Magic is presented:

-Plug a serial cable into connector P15 of ADE7878 evaluation board and into a PC COM port. As an alternative, use ADE8052Z-DWDL1 ADE downloader from Analog Devices together with a USB cable.

-Launch the Device Manager under Windows XP by writing devmgmt.msc into Start->Run window. This helps in

identifying which COM port is used by the serial cable. Plug USB2UART board into connector P15 of ADE7878 evaluation board with VDD pin of USB2UART aligned at pin 1 of P15.

- Connect Jumper JP8. This means the P2.10/ $\overline{EINT0}$ pin of the microcontroller is connected to ground.
- Supply the board with two 3.3V supplies at connectors P10 and P12. Press and release RESET button S2 on ADE7878 evaluation board
- Launch Flash Magic and choose the following options:

COM port: COMx as seen in the Device Manager above

Baud rate: 115200

Device: LPC2368

Interface: None (ISP)

DOscillator Freq. (MHz): 12.0

Check Erase all Flash + Code Rd Block box

Choose *ADE7878_Eval_Board.hex* file from \Debug\Exe project folder

Check Verify after programming box

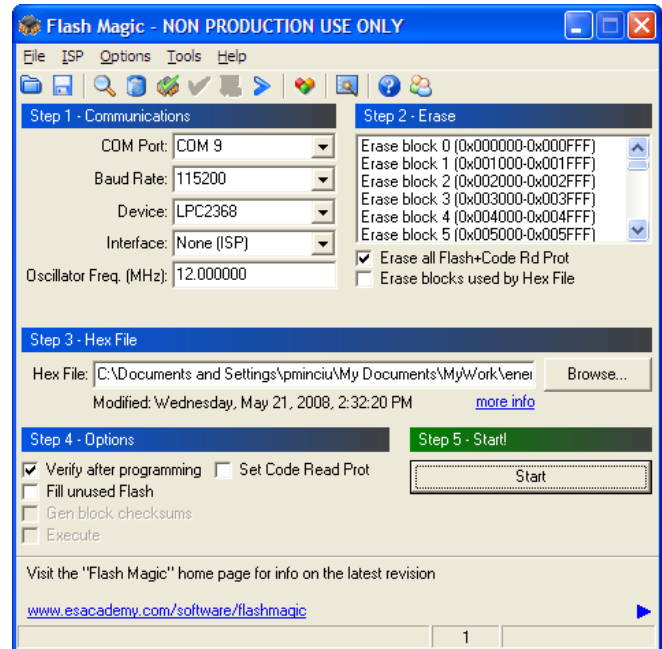An image of Flash Magic with the above settings is presented in Figure 34:

Figure 34. Flash Magic settings

- Click Start for the download process to begin
- After the process finishes, please extract the jumper JP8.
- Reset the ADE7878 evaluation board by pressing and releasing RESET button S2. At this point, the program should be functional and an USB cable may be connected to the board. When the PC recognizes the evaluation board and asks for a driver, please point it to \VirCOM_Driver_XP folder of the project. The file ADE7878_eval_board_vircomport.inf is the driver.
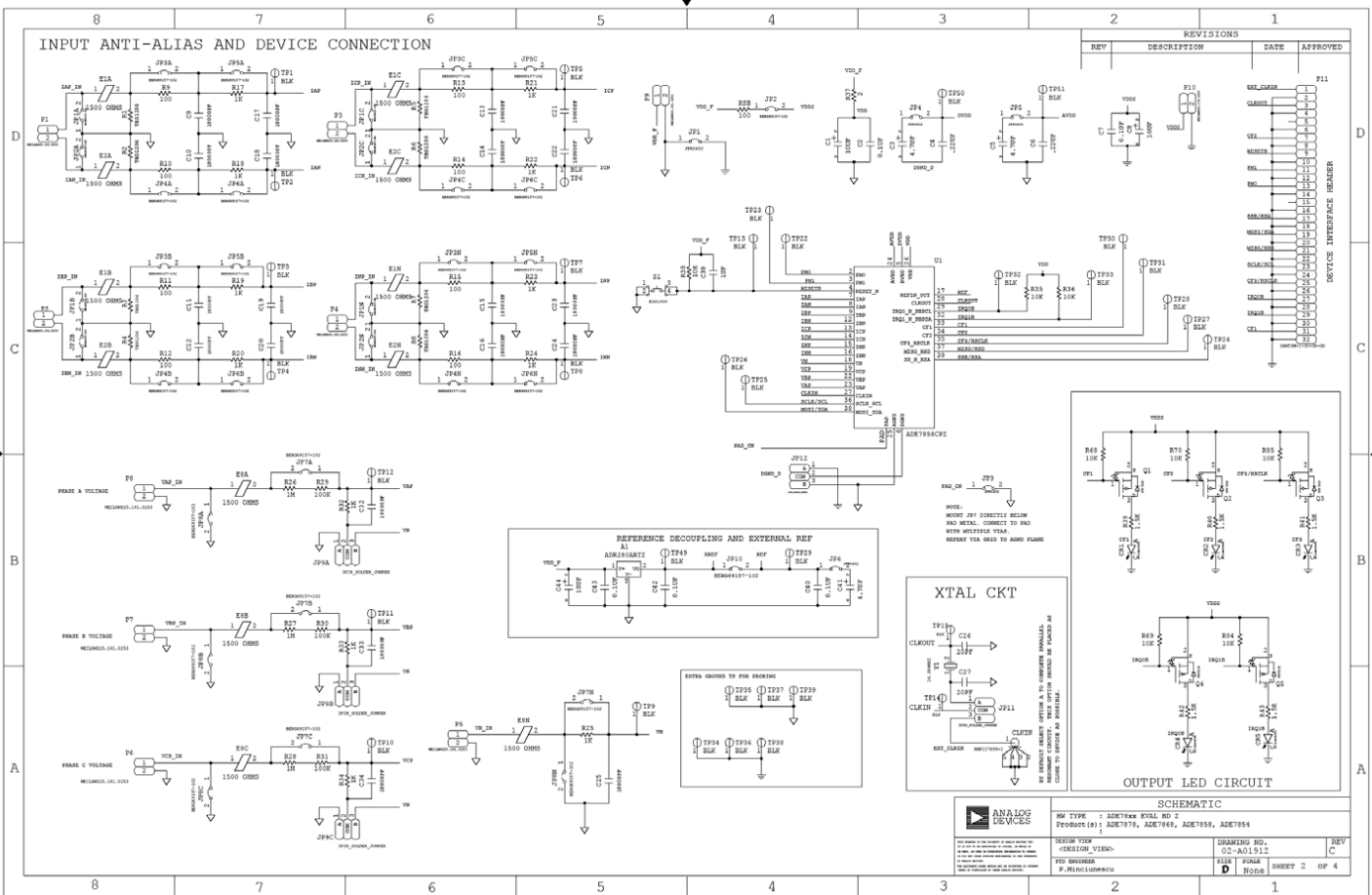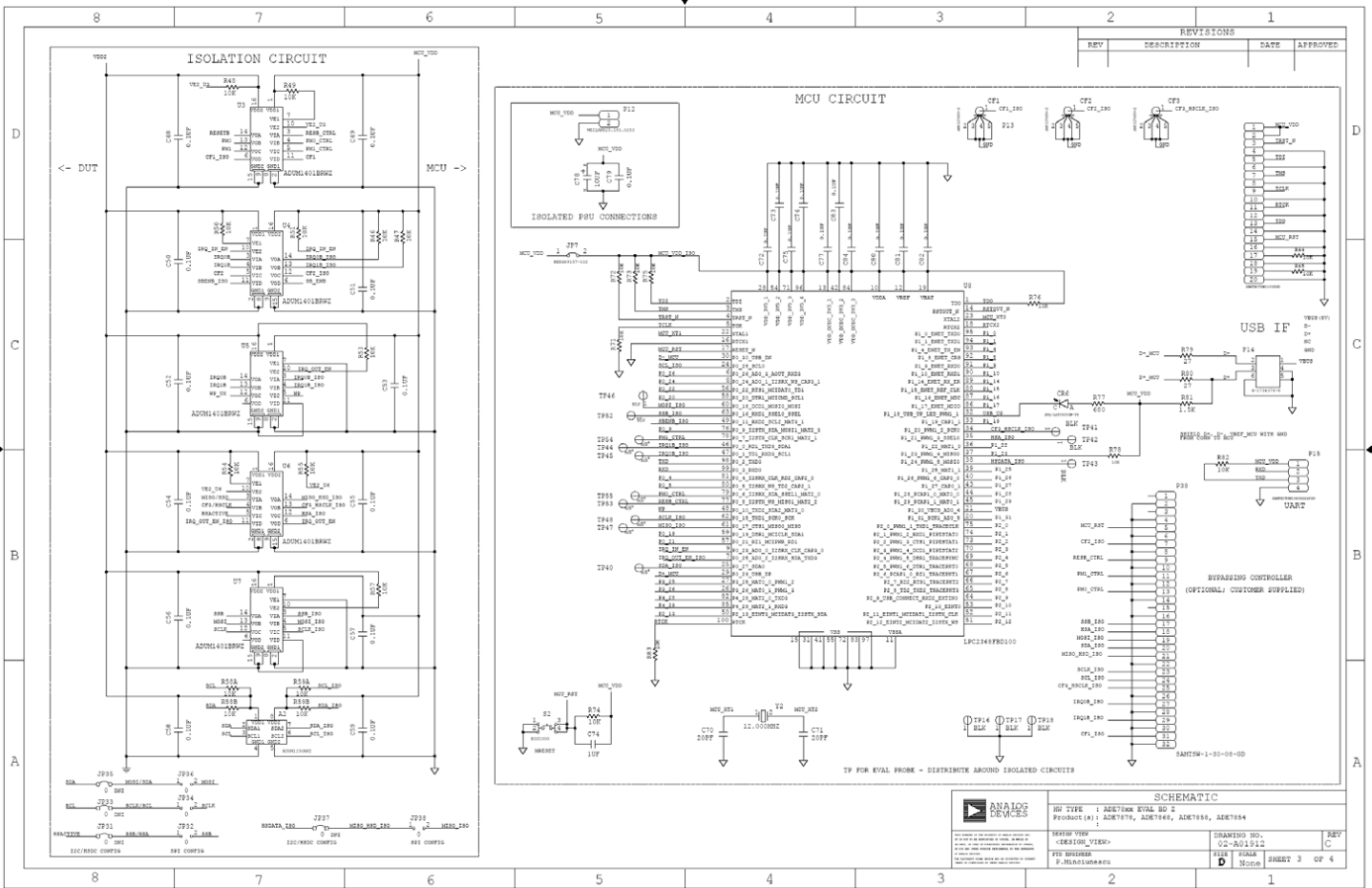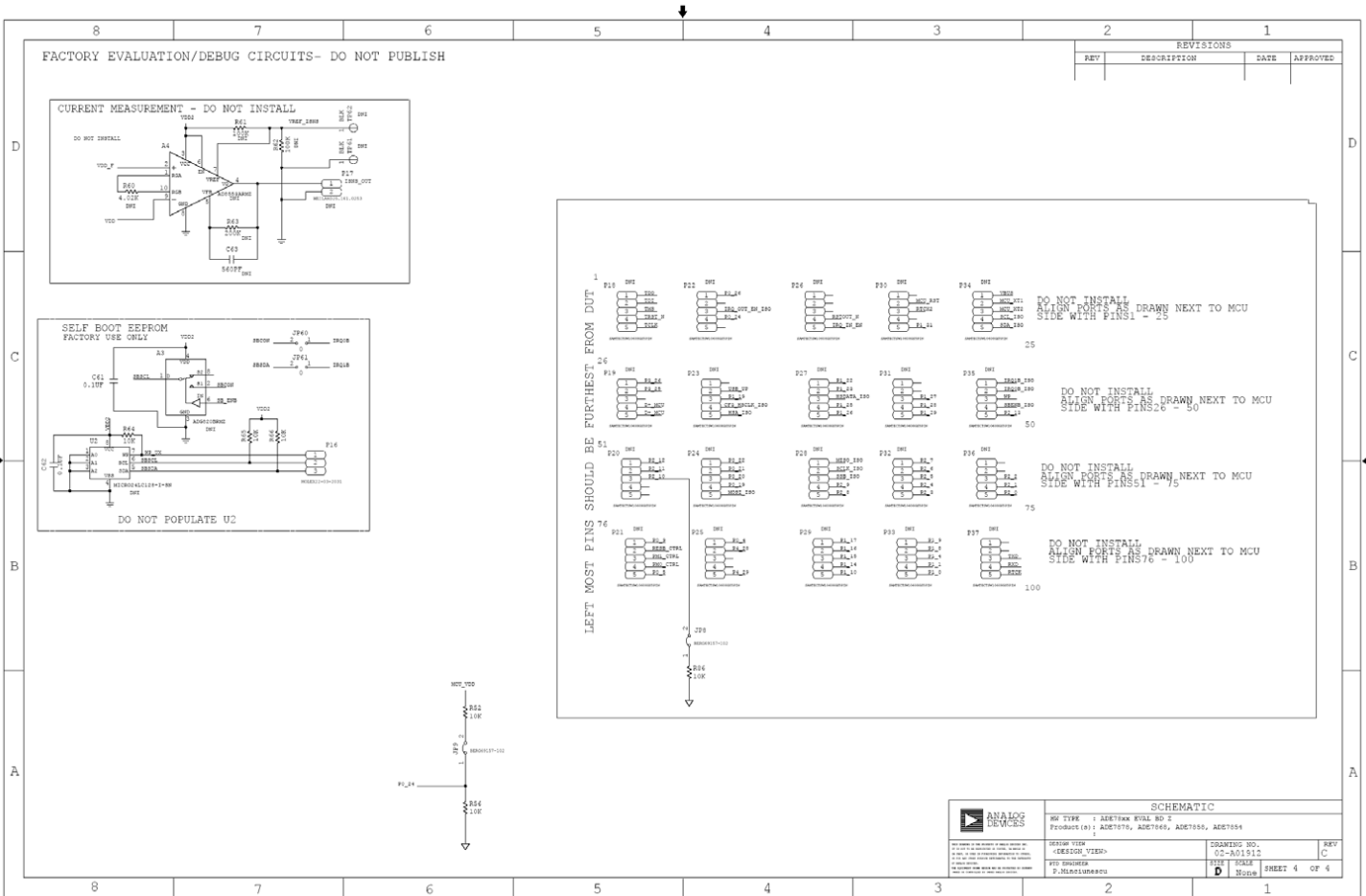
EVALUATION BOARD BOM

Table 26.

Designator	Value	Description
A1	ADR280ARTZ	IC-ADI 1.2V ULTRALOW POWER HGH PSRR VOLT REF
A2	ADUM1250ARZ	IC SWAPPABLE DUAL ISOLATOR
C1,C8,C44,C78	10UF	CAP TANT SMD 3528
C9-C25,C32-C34	18000PF	CAP CER
C2,C7,C40,C42,C43,C48-C59,C61,C62,C72,C73,C75-C77,C79-C84	0.1UF	CAP CER X7R
C26,C27,C70,C71	20PF	CAP CER NP0
C3,C5,C41	4.7UF	CAP TANT CHIP
C38,C74	1UF	CAP CER X7R
C4,C6	.22UF	CAP CER
CF1-CF3,CLKIN	AMP227699-2	CONN-PCB COAX BNC ST
CR1-CR5	28-21SRCTR8T1	DIODE LED RED SMD
CR6	SML-LXT0805GW-TR	LED GREEN SURFACE MOUNT
E1A,E1B,E1C,E1N,E2A,E2B,E2C,E2N,E8A,E8B,E8C,E8N	1500 OHMS	INDUCTOR CHIP FERRITE BEAD 0805
JP2,JP7-JP10,JP1A-JP8A,JP1B-JP8B,JP1C-JP8C,JP1N-JP8N	BERG69157-102	CONN-PCB BERG JMPR ST MALE 2P
JP32,JP34,JP36,JP38,JP60,JP61	0	RES JMPR SMD 0805 (OPEN)
P1-P10,P12	WEILAND25.161.0253	CONN-PCB TERM BLK 2P ST
P11,P38	SAMTSW-1-30-08-GD	CONN-PCB HDR SHRD ST 32 PIN MALE
P13	SAMTECTSW11008GD	CONN-PCB BERG HDR ST MALE 20P
P14	4-1734376-8	CONN-PCB USB TYPE B R/A THRU HOLE
P15	SAMTECTSW10608GS4PIN	CONN-PCB BERG HDR ST MALE 4P
P16	MOLEX22-03-2031	CONN-PCB STRAIGHT HEADER 3PIN
Q1-Q5	FDV302P	TRANS DIGITAL FET P CHAN
R1-R8	TBD1206	RES CHIP SMD 1206
R9-R16,RSB	100	RES PREC THICK FILM CHIP R1206
R17-R25,R32-R34	1K	RES PREC THICK FILM CHIP R0805
R26-R28	1M	RES MF RN55
R29-R31	100K	RES MF RN55
R35,R36,R38,R44-R57,R64-R66,R68-R76,R78,R82-R86,R58A,R58B,R59A,R59B	10K	RES PREC THICK FILM CHIP R0805
R37	2	RES FILM SMD 0805
R39-R43,R81	1.5K	RES PREC THICK FILM CHIP R1206
R77	680	RES FILM SMD 0805
R79,R80	27	RES FILM SMD 1206
S1,S2	B3S1000	SW SM MECHANICAL KEYSWITCH
TP1-TP18,TP22-TP55	BLK	CONN-PCB TST PNT BLK
U1	ADE7858CPZ	IC-ADI POLY-PHASE MULTIFUNC ENERGY METERING IC
U3-U7	ADum1401BRWZ	IC-ADI QUAD CHANNEL DIGITAL ISOLATOR
U8	LPC2368FBD100	IC ARM7 MCU FLASH 512K 100LQFP
Y1	16.384MHZ	IC CRYSTAL
Y2	12.000MHZ	IC CRYSTAL QUARTZ
A3	ADG820BRMZ	IC-ADI 1.8V TO 5.5V 2:1 MUX/SPDT SWITCHES
A4	AD8553ARMZ	IC-ADI 1.8V TO 5V AUTO-ZERO IN-AMP WITH SHUTDOWN
C63	560PF	CAP CER NP0
JP31,JP33,JP35,JP37	0	RES JMPR SMD 0805 (SHRT)

Designator	Value	Description
P17	WEILAND25.161.0253	CONN-PCB TERM BLK 2P ST
P18-P37	SAMTECTSW10608GS5PIN	CONN-PCB BERG HDR ST MALE 5P
R60	4.02K	RES PREC THICK FILM CHIP R0805
R61,R62	100K	RES PREC THICK FILM CHIP R0805
R63	200K	RES PREC THICK FILM CHIP R1206
TP61,TP62	BLK	CONN-PCB TST PNT BLK
U2	MICRO24LC128-I-SN	IC SERIAL EEPROM 128K 2.5V

EVALUATION BOARD SCHEMATIC

FACTORY EVALUATION/DEBUG CIRCUITS- DO NOT PUBLISH

CURRENT MEASUREMENT - DO NOT INSTALL

SELF BOOT EEPROM
FACTORY USE ONLY

DO NOT POPULATE U2

LEFT MOST PINS SHOULD BE FURTHEST FROM DUT

DO NOT INSTALL
ALIGN PORTS AS DRAWN NEXT TO MCU
SIDE WITH PINS1 - 25

DO NOT INSTALL
ALIGN PORTS AS DRAWN NEXT TO MCU
SIDE WITH PINS26 - 50

DO NOT INSTALL
ALIGN PORTS AS DRAWN NEXT TO MCU
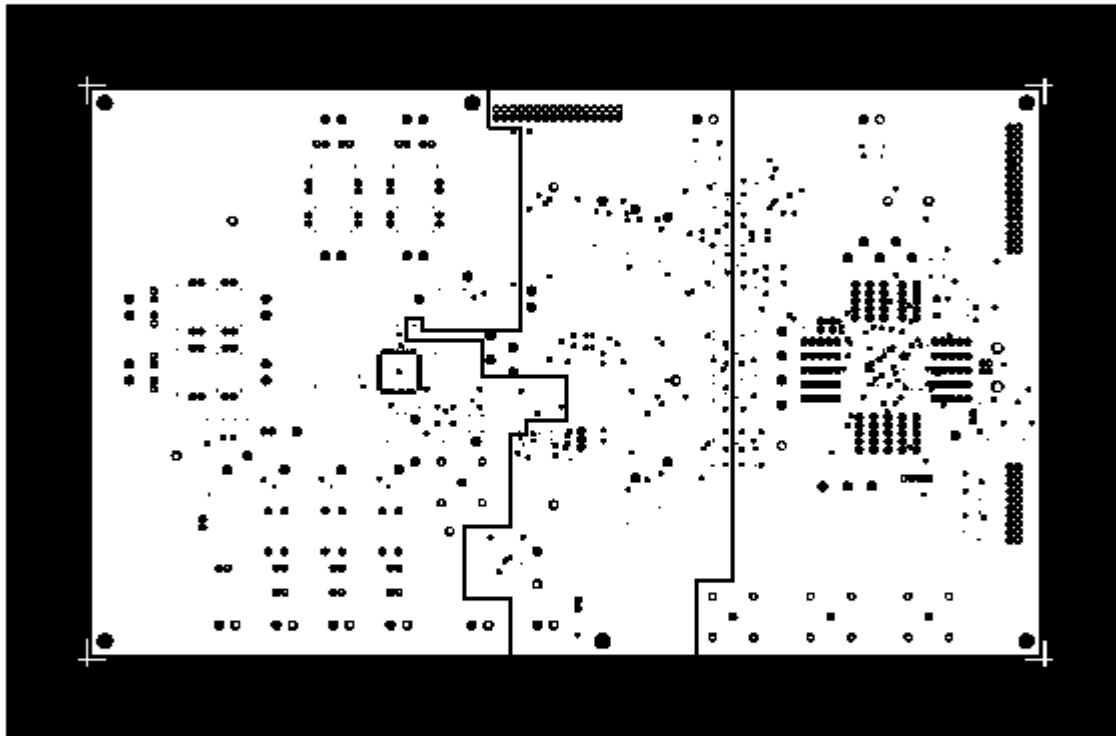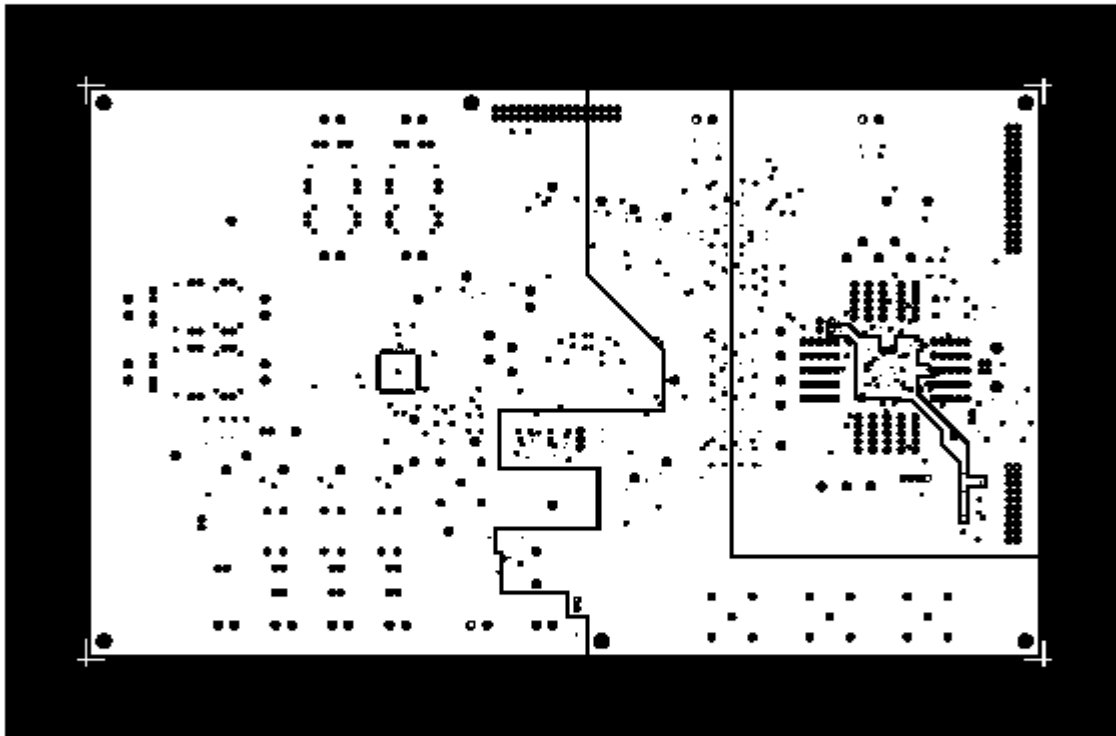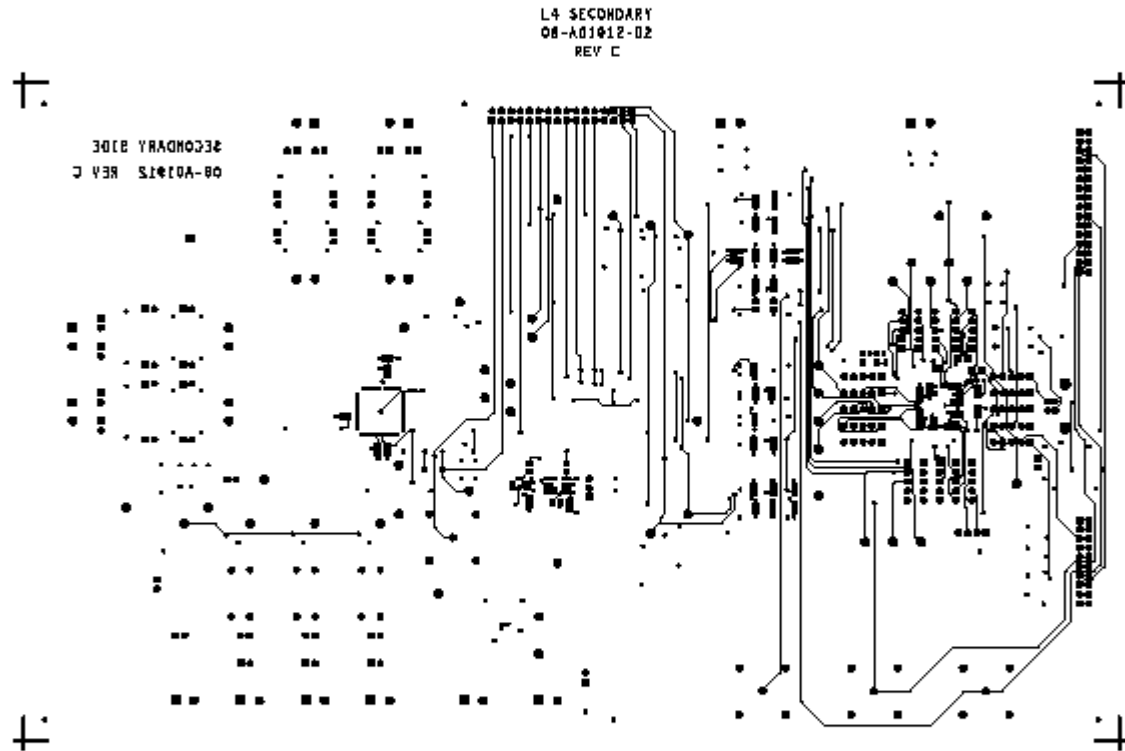SIDE WITH PINS51 - 75

DO NOT INSTALL
ALIGN PORTS AS DRAWN NEXT TO MCU
SIDE WITH PINS76 - 100

SCHEMATIC

EVALUATION BOARD LAYOUT

L1 PRIMARY
08-A01012-01
REV C

E78XX EVAL BD 2
PRIMARY SIDE
08-A01012 REV C

L4 SECONDARY
08-A01012-02
REV C

SECONDARY SIDE
08-A01012 REV C

NOTES

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DEVICES

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