TI Designs
Three Phase Rogowski Coil Based E-Meter Solution

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Design Resources

TIDM-3PHMETER-ROGOWSKI	Tool Folder Containing Design Files
MSP430F67791A	Product Folder
TPS54060	Product Folder

TI E2E™ Community

ASK Our E2E Experts
WEBENCH® Calculator Tools

Design Features

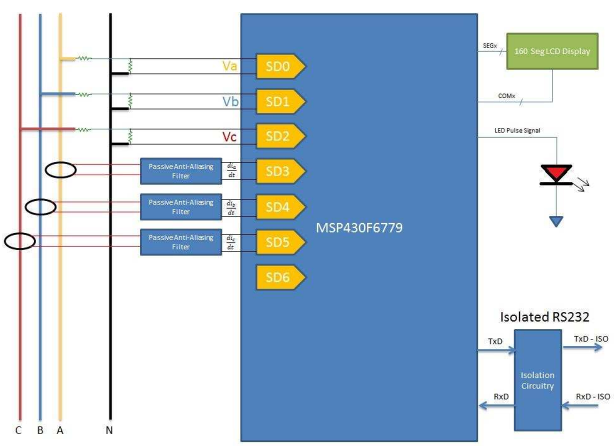
The board can be configured to:

- 3-phase 0.2% energy metering solution
- Software di/dt integration and energy calculation library provides for easy code development
- Software integrator solution – minimal hardware changes to migrate from existing C- based solutions
- No effect of DC components of current
- Current sensing immune to EMI
- No phase shift in current measurement

Featured Applications

The applications are as follows:

- E-meter with Rogowski coil current sensors
- Utility metering
- Power quality meters
- Grid infrastructure meters



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1 System Description

This design, featuring the MSP430F67791A microcontroller, implements a highly integrated single chip electricity metering solution with support for Rogowski Coil current sensors. Hardware and software design files are provided to enable calculation of various parameters for multi-phase energy measurement such as RMS current and voltage, active and reactive power and energies, power factor, and frequency. The added hardware and software support for Rogowski coils make it easy to interface with Rogowski coils with minimal hardware changes when migrating from traditional current transformers. The Rogowski coil current sense library implements an efficient software integration of the Rogowski output, enabling this to be a single chip solution for three-phase e-metering. The software package also includes a dummy application for quick and easy evaluation of the hardware and software.

2 Design Features

This design is modelled after the EVM430-F6779 metering EVM, and has the same feature set as that board, except for the current measurement front-end, which has been modified to support Rogowski coils. Keeping a similar design as the CT based EVM enables easy migration from CT based solutions to a Rogowski coil based current measurement solution. The software library has been developed to perform integration of the Rogowski coil output and calculate active, reactive and apparent powers, along with frequency and optionally, RMS voltage and current. The library functions are easily accessible through an API, making it easy to develop host applications to run the library and run auxiliary functions like display, communications and calibration. A dummy application is also packaged with the software, featuring a UART based interface to interact with the meter. The RS232 port on the meter can be connected to a PC and the user can log the metering data, and read and write each phase's calibration data to the flash memory using any serial port monitor (such as HyperTerminal).

3 Block Diagram

Figure 1 shows the basic block diagram of the EVM. The phase voltages are fed to the microcontroller's Sigma-Delta ADC inputs after passing through a resistor divider. The di/dt output of the Rogowski coils are passed through passive anti-aliasing filters before feeding into the controller's sigma delta inputs. No analog integration or gain stage is needed for the Rogowski coil outputs, since the software takes care of integration, and each of the controller's sigma delta blocks features a built in programmable gain amplifier with a gain of up to 128.

The built in LCD controller of the MCU is used to interface with a 160 segment LCD for displaying the metering results, and an isolated RS-232 interface is used to communicate with a PC using the dummy application.

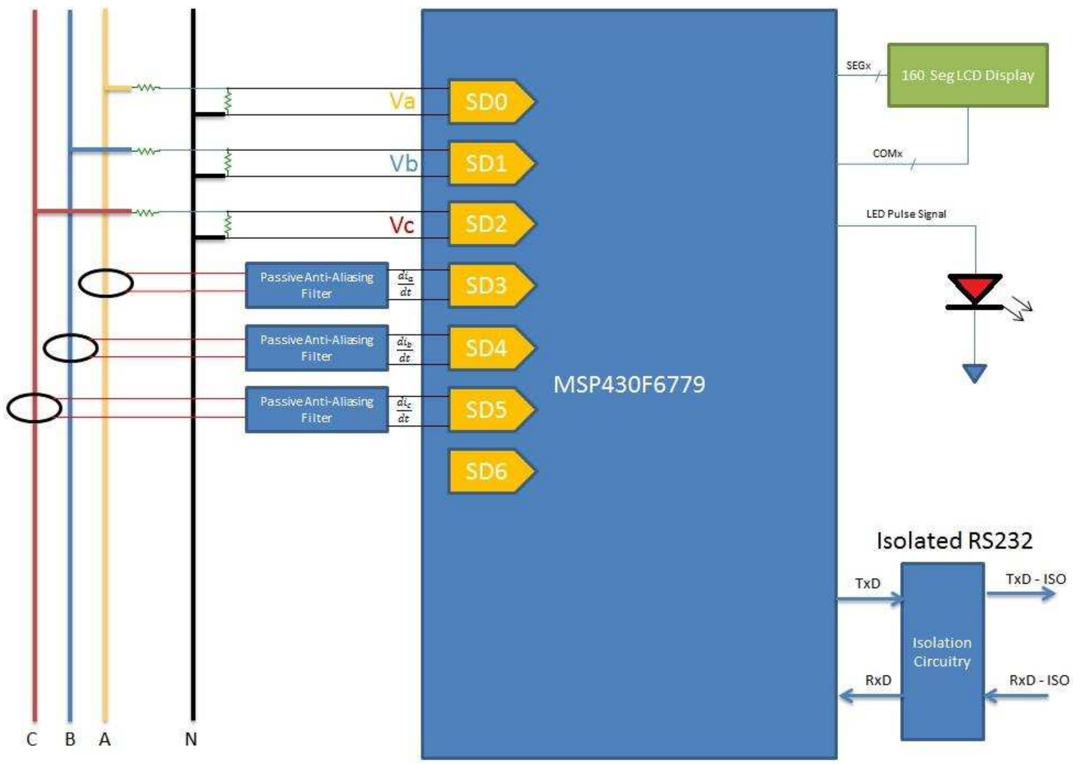


Figure 1. Block Diagram of Rogowski Coil EVM

4 Circuit Design and Component Selection

4.1 *Power Supply*

Power supply to the board can either be provided by the MSP430 FET programmer during debugging, or using the switching power supply module on board. The switching power supply provides a single output voltage of 3.3 V directly from the ac mains at 100 V to 230 V RMS. In the configuration shown, the meter is powered as long as there is AC voltage on Phase C, corresponding to pad LINE 3 on the hardware and P3+1 on the schematic. The internal circuitry of a switching power supply is omitted from this application report. For the drive of the power supply, refer to the documentation of the power supply module.

4.2 *Analog Inputs*

The MSP430 analog front end, which consists of the ΣΔ ADC, is differential and requires that the input voltages at the pins do not exceed ±930 mV (gain = 1). To meet this specification, the current and voltage inputs must be divided down. In addition, the ΣΔ24 allows a maximum negative voltage of -1 V. Therefore, AC signals from mains can be directly interfaced without the need for level shifters. This section describes the analog front end used for voltage and di/dt channels.

4.2.1 Voltage Inputs

The voltage from the mains is usually 230 V or 120 V and must be brought down to a range of 930 mV. The analog front end for voltage consists of spike protection varistors followed by a simple voltage divider and a RC low-pass filter that acts like an anti-alias filter. Figure 2 shows the voltage divider and anti-alias circuit implemented on the board.

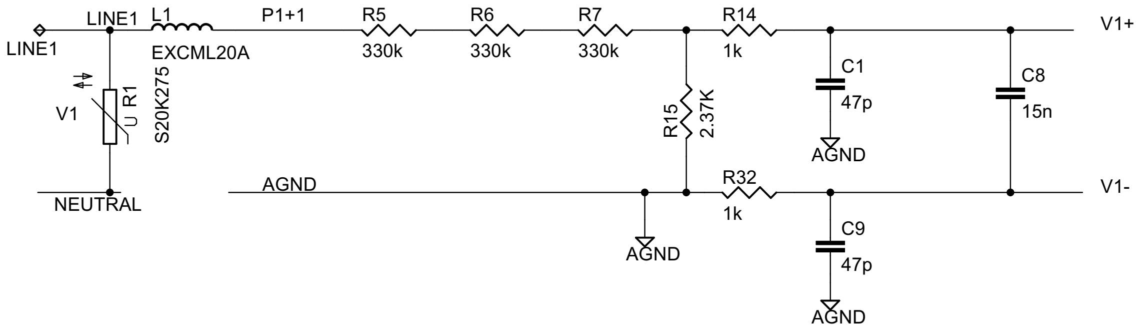
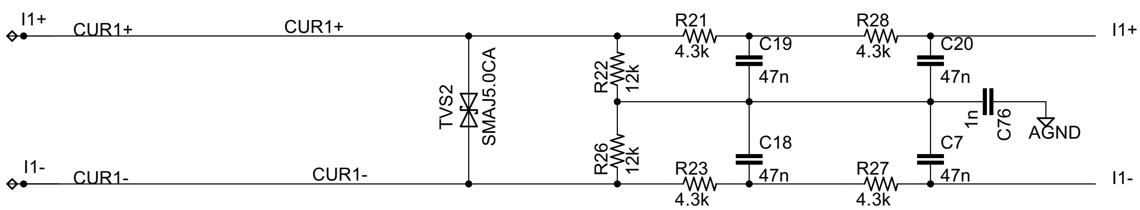


Figure 2. Voltage Input Circuit

4.2.2 4.2.2 di/dt Input

The di/dt inputs from the Rogowski coils must be passed through a passive 2-pole RC filter in order to reject any high frequencies that may cause aliasing in the ADC, especially since the coils have a very high bandwidth. di/dt Input Front End illustrates the passive anti-alias filter used in the design. A TVS diode is provided at the input in order to prevent the input to the sigma delta from going beyond the specified limits.



di/dt Input Front End

5 Software Description

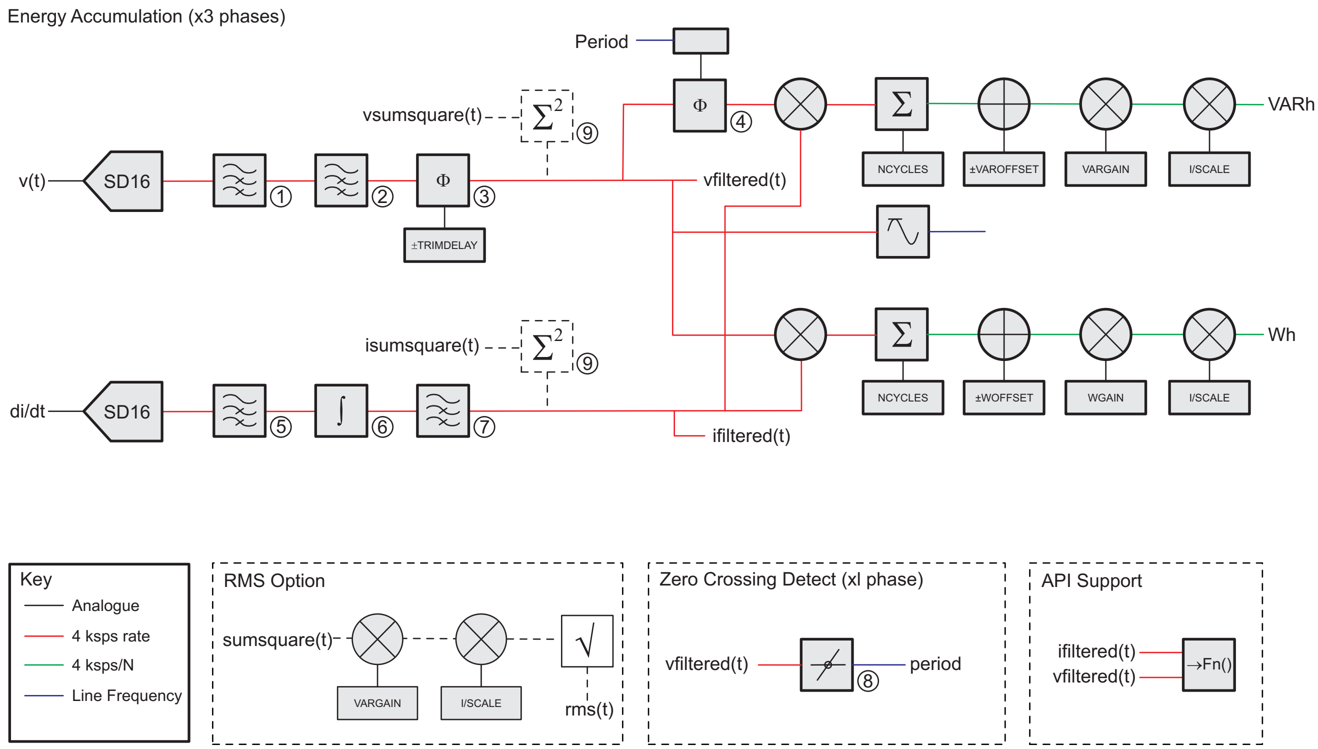
This section describes the Softdidt Rogowski Coil metering library and the dummy application used to test and calibrate the EVM. The software is developed in the IAR Embedded Workbench for MSP430 microcontrollers.

The software for the three-phase metrology using Rogowski coils is discussed in this section. The application programmer's interface (API) functions are described together with their function parameters and their return values. The software itself is supplied as a library, which exposes a clearly defined API with C prototyped function entry points, and which can be linked against application code, making software development easy. The following functionality is accessible using these API calls:

- Configuration for run time adapting the library (calibration constants to include gain, phase, and zero offset trim, other run time options such as choice of test pulse output)
- Event capture for easy application interfacing (low line voltage, over current, reverse current)
- Signal processing chain hooks for advanced users (intermediate calculation values)

5.1 High-Level Architecture of the Software

Software Signal Flow describes the basic signal flow through the software. Voltage samples acquired by the SD24 are passing through two high-pass filters before being corrected for the signal path delay. Current samples pass through a single high-pass filter for DC-removal before being integrated and passed on through an additional high-pass filter, which compensates for the cancellation of the pole of the first high-pass filter in the integrator. After that, the filtered voltage and current samples are used to calculate the active and reactive energy. They also can be accessed by the API calls. For the calculation of the reactive energy, the voltage samples are shifted by 90° before being multiplied with the current samples. For both paths, the calibration values for offset and gain are applied and the results are finally scaled to the units published in the API documentation below.



Software Signal Flow

5.2 Energy Meter Software

This section details the contents of the package and the available API calls. Note that only minor adjustments for the sensor are necessary and that all other functions can be used as-is.

5.2.1 Contents of the Library Package

The package for the library contains the following files:

- The file softdidt.h in the directory Library\include. This is the file containing the export definitions for the API functions and their return codes and the setup definitions for the phases. The contents will be detailed later in this guide.
- The file Library.r43 in the directory Library\Release. This is the Rogowski-coil software library against which the application code needs to be linked.
- An example project in the directory Dummyapp is detailed later in this document.

5.2.2 API Functions

5.2.2.1 Initialization Functions

The following list the initialization functions.

DiDtInitLibrary()

Prototype	uint16_t DiDtInitLibrary(void)
Parameters	None
Return Value	uint16_t version - library version number in the form 0xHHLL
Description	Performs any required software initialization of the library.
Comments	0xHH is the major version number and 0xLL is the minor version number; changes to the major version number represent incompatible feature set changes.

DiDtInitHardware()

Prototype	status_t DiDtInitHardware(const sensor_routing_t *adcchannels)
Parameters	sensor_routing_t * adcchannels - filled with the mapping between ADC channel and sensor input, one for each phase
Return Value	status_t result – result code
Description	Informs the library of the hardware set up.
Comments	The library expects that the processor clock is already running at its high rate, and this function call will configure the ADC channels and one timer needed to run.

DiDtInitSensors()

Prototype	status_t DiDtInitSensors(const sensor_setups_t *sensors)
Parameters	sensor_ setups_t * sensors - array of setup structures, one for each phase
Return Value	status_t result – result code
Description	Sets up any sensor to sensor variations for the attached Rogowski coils.
Comments	None

DiDtInitAccumulators()

Prototype	status_t DiDtInitAccumulators(const sensor_accumulators_t *sensors)
Parameters	sensor_accumulators_t * sensors - accumulator structure to update
Return Value	status_t result – result code
Description	Initialise the accumulator set
Comments	This function is required to set the continuation point for the accumulators after a power cycle, for example having retrieved them from non-volatile memory.

5.2.2.2 Obtaining Running Results

The following functions are used to obtain running results.

DiDtReadSnapshot()

Prototype	status_t DiDtReadSnapshot(sensor_results_t *sensors)
Parameters	sensor_results_t * sensors - result structure to update
Return Value	status_t result – result code
Description	Collects the last second snapshot of the sensor readings.
Comments	Calling this function at a rate faster than the accumulation period will merely return the last snapshot multiple times. Callers can check if the data has been updated since the last poll by inspecting the sequence number, which is incremented once per accumulation period.

DiDTReadAccumulators()

Prototype	status_t DiDtReadAccumulators(sensor_accumulators_t *sensors)
Parameters	sensor_accumulators_t * sensors - accumulator structure to update
Return Value	status_t result – result code
Description	Reads the current accumulator set.
Comments	Calling this function at a rate faster than the accumulation period has no effect, the accumulators are read only.

5.2.2.3 Runtime Changes

The following functions are for runtime changes.

DiDtAdjustTestPulse()

Prototype	status_t DiDtAdjustTestPulse(const test_pulse_t *setting)
Parameters	Test_pulse_t setting - pointer to test pulse settings
Return Value	status_t result – result code
Description	Updates the test pulse settings
Comments	A setting change also clears out the internal pulse accumulator since it would be in the wrong scale; this is therefore also the case at startup when calling this function for the first time.

5.2.2.4 Registering Callout Functions

The following functions are for registering callout functions.

DiDtRegisterMetrologyCallout()

Prototype	status_t DiDtRegisterMetrologyCallout(metrocallout_t function, void *param)
Parameters	status_t DiDtRegisterMetrologyCallout(metrocallout_t function, void *param) void * param - An opaque parameter to pass to the function when it is called
Return Value	status_t result – result code
Description	Registers a single function with the library that will be called when a metrology event occurs
Comments	None

DiDtRegisterSampleCallout()

Prototype	status_t DiDtRegisterSampleCallout(samplecallout_t function, void *param)
Parameters	samplecallout_t function - Function to register, or NULL to deregister void * param - An opaque parameter to pass to the function when it is called
Return Value	status_t result – result code
Description	Registers a single function with the library that will be called when raw sample data is available for each phase.
Comments	None

5.2.3 Data Types

The following data types are used in addition to those in <stdint.h> per ISO9899:1999.

Table 1. Data Types

Data Type	Description
bool_t	A boolean taking the values TRUE (!FALSE) or FALSE (0) only
status_t	An alias of uint16_t for returning success or error codes
adcchannel_t	An alias of uint16_t for specifying an ADC channel number
adcgain_t	An alias of uint16_t for specifying the ADC gain value
metro_reason_t	An alias of type uint16_t containing reason codes which may be passed to callout functions to inform the application code that some interesting event has occurred within the metrology. The codes are detailed in Section 4.2.5.
metrocallout_t	A function pointer called when the library has interesting events to report, called with a subreason code indicating the event of interest, and the opaque handle that was supplied when the function pointer was registered
samplecallout_t	A function pointer called when the library has interesting events to report, called with the filtered voltage and current sample, and the opaque handle that was supplied when the function pointer was registered
phasemask_t	A bitmap of active phases when passing multiple structures around

5.2.4 Data Structures

The data structures used in the library and the API functions can be found in the header file softdidt.h. In this header file, the scaling of the different results is also explained. The two main structures used throughout the software, sensor_results_t and sensor_accumulators_t, contain the measurement results that are detailed in Section 5.2.4.1 and Section 5.2.4.2. The structures used during calibration of the system are outlined in their respective sections.

5.2.4.1 sensor_results_t

Table 2 describe the fields in sensor_results_t.

Table 2. Fields in sensor_results_t

Variable	Type	Scaling	Remark
Vrms	Uint16_t	V*2-7	RMS Voltage
Irms	Uint16_t	V*2-8	RMS Current
wh	Uint16_t	Wh/s*2-8	Active Energy
varh	Uint16_t	VARh/s*2-8	R
watts	Uint16_t	W	Instantanous Active Power
line_frequency	Uint16_t	Hz*2-10	Frequency
wh_forward	Uint8_t	-	Direction of Wh (Fwd=1)

Table 2. Fields in sensor_results_t (continued)

Variable	Type	Scaling	Remark
varh_forward	Uint8_t	-	Direction of VARh (Fwd=1)
sequence	Uint8_t	-	Free running sequence number

5.2.4.2 *sensor_accumulators_t*

This structure contains the current results for each phase in a sub-structure “phases” of the type sensor_accumulator_t and the phasemask defining the phase(s) used.

Table 3. Fields in sensor_accumulators_t

Variable	Type	Scaling	Remark
net_wh	int64_t	Wh *2-8	Net Wh (active)
net_varh	int64_t	VARh *2-8	Net VARh (reactive)

5.2.5 Callout Reasons

The following reason codes may be passed to the callout functions to inform the application code that some interesting event has occurred within the metrology.

Table 4. Metrology Callout Reasons

Definition	Description
SUBREASON_VOLTAGE_SAG	Voltage sag in progress
SUBREASON_OVER_CURRENT	Gross over-current detected
SUBREASON_REVERSE_CURRENT	Reverse current detected
SUBREASON_SUSPECT_FREQUENCY	Suspect mains frequency
SUBREASON_ACCURACY_LOST	Calculation accuracy error detected. NOTE: The library manages the intermediate accuracy internally; therefore, this code is not currently used.
SUBREASON_NEW_SNAPSHOT	New summation results are available

6 Meter Demo

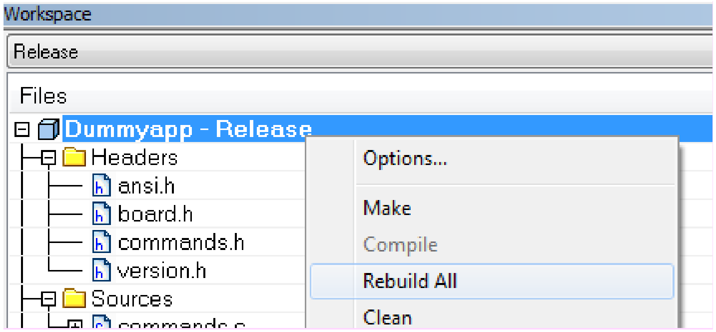
6.1 *EVM Overview*

6.1.1 Loading the Example Code

Opening the Project

The source code is developed in the IAR™ IDE using IAR compiler version 6.x. The project files cannot be opened in earlier versions of IAR. If the project is loaded in a version later than 6.x, a prompt to create a backup is displayed, and you can click YES to proceed. For the first time it is recommended to completely rebuild the project.

Open IAR Embedded Workbench, find and load the project Dummyapp.ewp, and rebuild all. (Refer to Rebuilding the Project).



Rebuilding the Project

Load the project onto the EVM by clicking “Debug and Download” from the Project drop down menu. This will launch the application.

Calibrating Over Rs232

Calibration is best performed using a meter test station and test pulse, but a rough calibration can be performed using a known current and voltage source via the serial terminal. Connect to the display PCB via the isolated serial port using 9600bps 8N1 and no handshaking. The description here describes a zero offset calibration of just one phase, but in a production situation all three phases could be zero offset calibrated in parallel, with the addition of more complex software.

To start calibration:

Select the phase to operate on, here, using phase A
phase=0
and read back the active settings using read

If the flash memory has been erased the values will all be 0xFFFF, a sensible initial set of values to start with would be to enter the following assignments:

wh_gain=16384

wh_offset=0

varh_gain=16384

varh_offset=0

delay=0

creep_threshold=0

write

Zero Offset

Apply a known current of 15A and 240V and 0, this is convenient because it is 3600W per phase (which in internal units corresponds to 256 × 2-8Wh/s). The actual current should merely be selected to be well away from zero.

Turn logging on and observe the output values over a couple of seconds. Sum the values for each phase and divide by 256, this coarse correction should then be applied to the default of 16384 set earlier. For example

log=1
A, +230, -2, 3234
B, +260, +1, 3656
C, +255, -3, 3585
A, +233, -2, 3235
B, +260, +1, 3656
C, +256, -3, 3600
wh_gain=18118

Rebuilding the Project (continued)

calculated as (16384 × 2 × 256) / (230 + 233) = 18118

Apply zero current to the meter and accumulate energy over a reasonable period of time, in this example 30 seconds is selected

zero offset=30

the meter will calculate the correction factor and update the local RAM copy.

Delay trim

Set the test load to 15A and 240V and 60, adjust the delay register in the range 0-255 to achieve an output of 128 × 2^{-8}Wh/s.

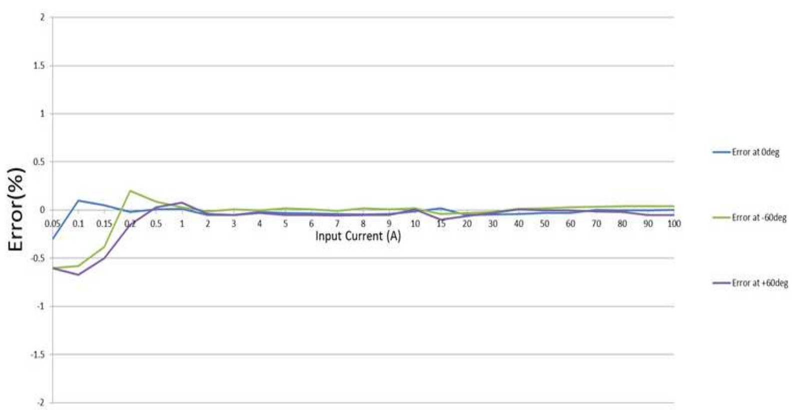
Gain trim

Apply a known current of 15A and 240V and 0, check the gain having set the phase and zero offset. Having applied the new calibration values, the results can be committed to flash using the write command. In the event of a mistake, the modified values can be discarded by either selecting another phase with the 'phase' command or reading back the stored settings with 'read'.

7 Test Results and Calibration

Metrology Results

The metrology results obtained by using a metrology test setup are shown in Error (%) vs. Input Current (A), at 230V, 50Hz. The meter was tested from 0.05A to 100A (Dynamic range of 2000:1) at 230V, and 0º, +60º and -60º current. The test pulse generated by the meter was fed into the test setup which compared the test pulse frequency against the actual power to generate the error percentage.



Error (%) vs. Input Current (A), at 230V, 50Hz

8 Design Files

This section provides the schematics and layout images used for this design.

8.1 Schematics

The schematics are presented in the following order:

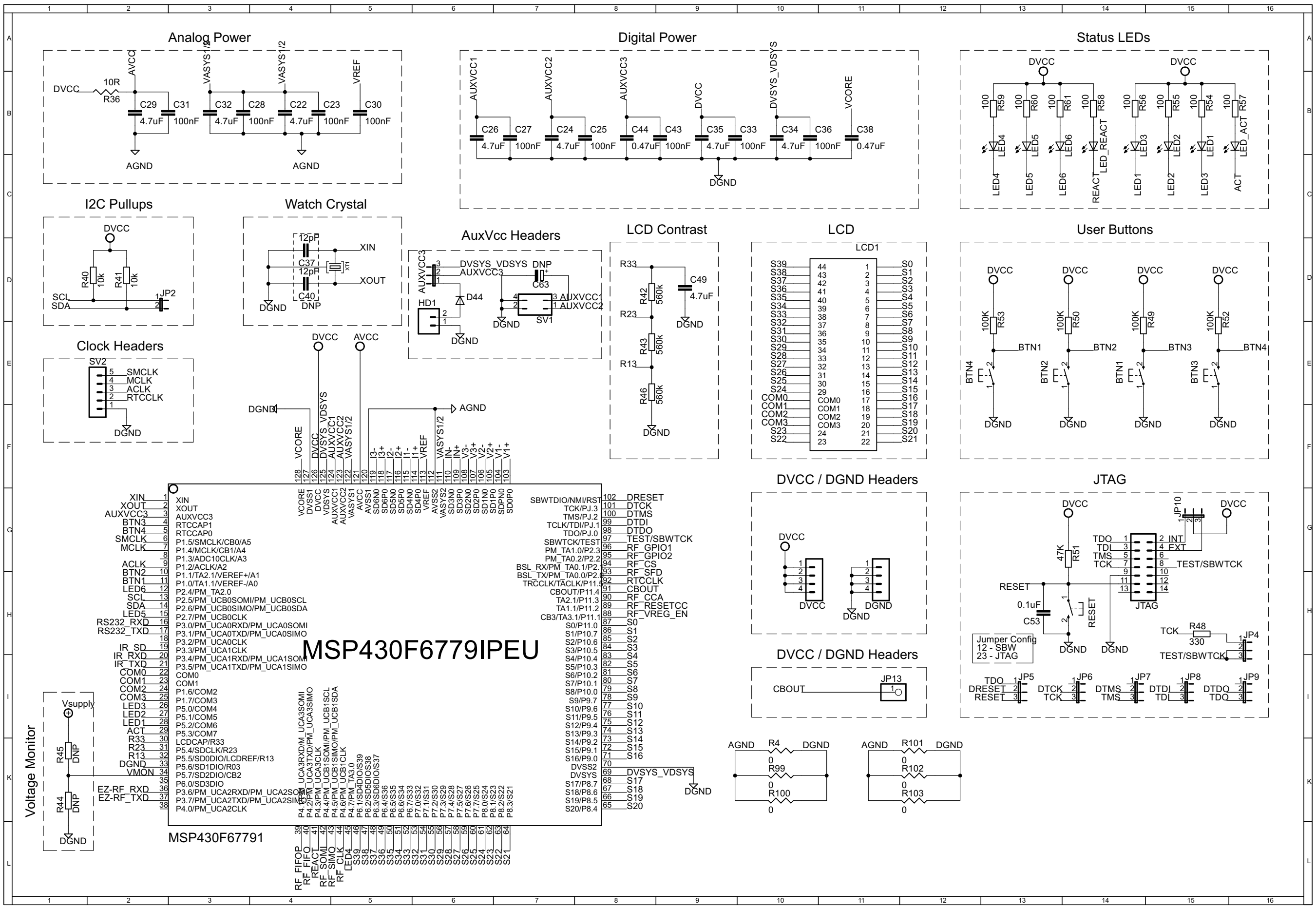


Figure 3. Schematics Page 1

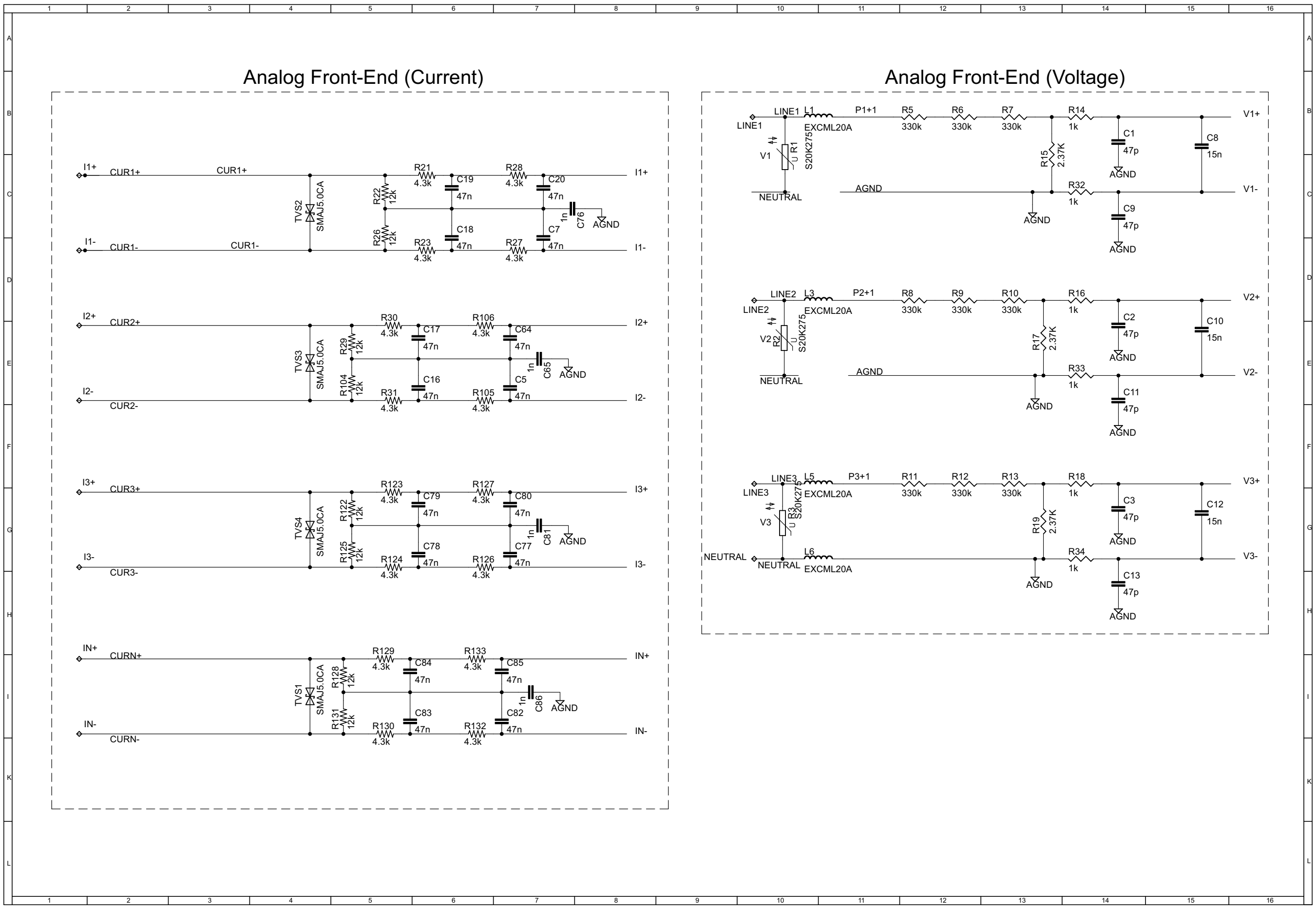


Figure 4. Schematics Page 2

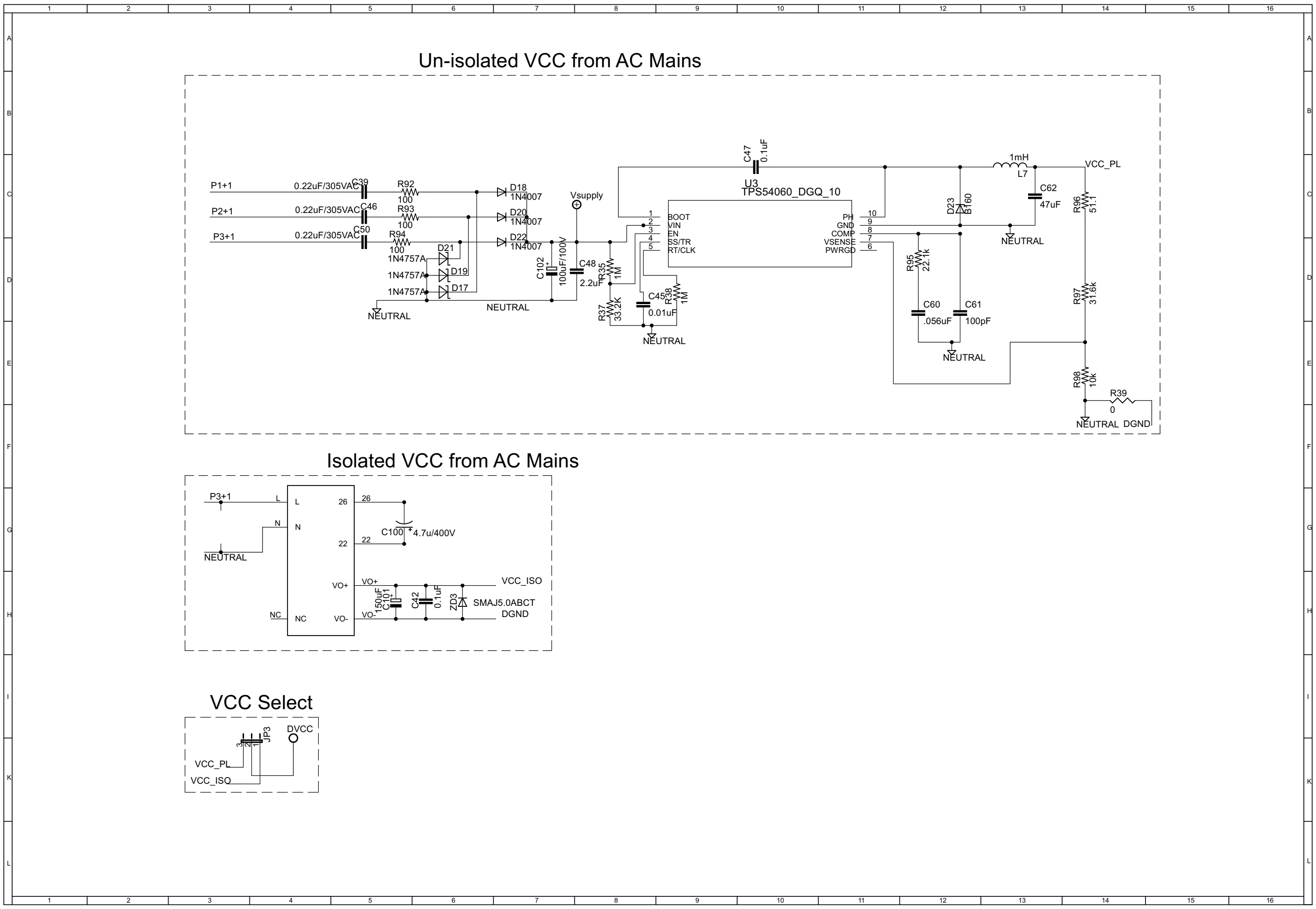


Figure 5. Schematics Page 3

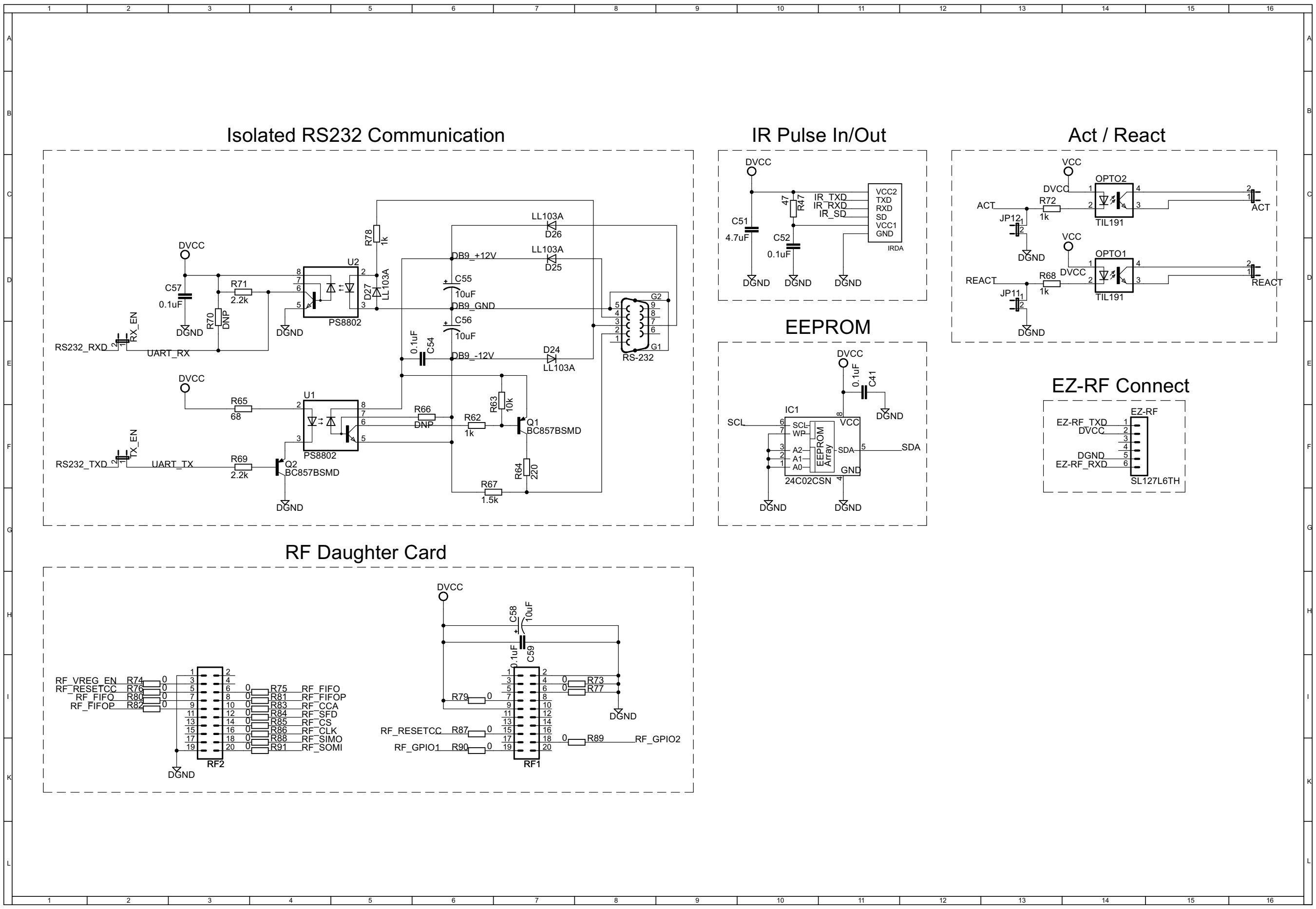


Figure 6. Schematics Page 4

Bill of Materials

Table 5. BOM

Qty	Value	Digikey #	Description	Eagle Library Package	Board Designator
1	24C02CSN	24LC02B-I/SN-ND	IC EEPROM 2KBIT 400KHZ 8S	24C02CSN	IC1
1	32.768 KHZ	300-8341-1-ND	CRYSTAL 32.768 KHZ 6PF SM	LF Crystal	XT1
2	12pF	311-1059-1-ND	CAP CER 12PF 50V 5% NPO	C-EUC0603	C37 C40
4	1n	399-1136-1-ND	CAP CER 0.001UF 50V 10% X	C-EUC0805	C65 C76 C81 C86
3	15n	311-1143-1-ND	CAP CER 0.015UF 50V 10% X	C-EUC0805	C8 C10 C12
16	47nF	399-8092-1-ND	CAP CER 0.047UF 25V Y5V 060	C-EUC0805	C17 C19 C5 C7 C16 C18 C20 C64 C77 C78 C79 C80 C82 C83 C84 C85
9	100nF	311-1343-1-ND	CAP CER 0.1UF 50V Y5V 060	C-EUC0603	C23 C25 C27 C28 C30 C31 C33 C36 C43
7	0.1uF	311-1343-1-ND	CAP CER 0.1UF 50V Y5V 060	C-EUC0603	C41 C42 C52 C53 C54 C57 C59
2	0.47uF	311-1428-1-ND	CAP CER 0.47UF 16V 10% X7	C-EUC0603	C38 C44
9	4.7uF	311-1455-1-ND	CAP CER 4.7UF 10V 10% X5R	C-EUC0603	C22 C24 C26 C29 C32 C34 C35 C51 C49
6	47p	311-1484-1-ND	CAP CER 47PF 500V 5% NPO	C-EUC0805	C1 C2 C3 C9 C11 C13
1	10uF	399-3685-1-ND	CAP TANT 10UF 6.3V 20% 12	CPOL-USCT3216	C55 C56 C58
1	4.7u/400V	399-6097-ND	CAP ALUM 4.7UF 400V 20% R	CPOL-USE5-10.5	C100
8	-	3M9447-ND	CONN HEADER VERT SGL 2P	JP1E	ACT JP2 JP11 JP12 REACT RX_EN TX_EN HD1
8	-	3M9448-ND	CONN HEADER VERT SGL 3P	JP2E	JP3 JP4 JP5 JP6 JP7 JP8 JP9 JP10 AUXVCC3
8	-	961105-6404-AR	CONN HEADER VERT SGL 5P	MA05-1	SV2
3	-	3M9449-ND	CONN HEADER VERT SGL 4P	MA04-1	DGND DVCCs
1	-	A106735-ND	CONN HEADER VERT DUAL	JP2Q	SV1
4	S20K275	495-1417-ND	VARISTOR 275V RMS 20MM	R S20K275	R1 R2 R3
2	Orange	511-1245-ND	LED 3.1MM 610NM ORANGE	LED3MM	LED_3 LED_4
2	Green	511-1247-ND	LED 3.1MM 563NM GREEN T	R LED3MM	LED_1 LED_6

Table 5. BOM (continued)

Qty	Value	Digikey #	Description	Eagle Library Package	Board Designator
2	Red	511-1249-ND	LED 3.1MM 650NM RED TRAN	LED3MM	LED_ACT LED_REACT
2	Yellow	511-1251-ND	LED 3.1MM 585NM YELLOW T	LED3MM	LED_2 LED_5
2	BC857BSMD	568-6094-1-ND	TRANSISTOR PNP 45V 100M	BC857BSMD	Q1 Q2
1	TFBS4711-TT1	751-1068-1-ND	TXRX IRDA 115.2KBIT 1.9MM	TFBS4711-TT1	IRDA
1	-	A32036-ND	CONN D-SUB RCPT STR 9PO	F09VP	RS1
4	LL103A	LLSD103ADICT-ND	DIODE SCHOTTKY 40v 350M	D-SOD-80	D24 D25 D26 D27
1	-	MHC14K-ND	CONN HEADER 14 POS STR	ML14	JTAG
6	EXCML20A	P10191CT-ND	BEAD CORE 4A 100 MHZ 080	EXCELSA390805	L1 L3 L5 L6
1	150uF	P14374-ND	CAP ALUM 150UF 10V 20% R	CPOL-EUE2-5	C101
4	-	P8079SCT-ND	SWITCH TACTILE SPST-NO 0	PB	BTN1 BTN2 BTN3 BTN4 RESET
2	TIL191	PS2501-1A-ND	OPTOCOUPLER 1CH TRANS	TIL191	OPTO1 OPTO2
2	PS8802	PS8802-1-F3-AXCT-ND	OPTOISOLATOR ANALOG HS	PS8802	U1 U2
1	68	RMCF0603FT68R0CT-ND	RES TF 68 OHM 1% 0.1W 060	R-EU_R0603	R65
8	100	RMCF0603JT100RCT-ND	RES 100 OHM 1/10W 5% 0603	R-EU_R0603	R54 R55 R56 R57 R58 R59 R60 R61
2	1k	RMCF0603JT1K00CT-ND	RES 1K OHM 1/10W 5% 0603	R-EU_R0603	R62 R68 R72 R78
1	1.5k	RMCF0603JT1K50CT-ND	RES 1.5K OHM 1/10W 5% 060	R-EU_R0603	R67
1	220	RMCF0603JT220RCT-ND	RES 220 OHM 1/10W 5% 0603	R-EU_R0603	R64
2	2.2k	RMCF0603JT2K20CT-ND	RES 2.2K OHM 1/10W 5% 060	R-EU_R0603	R69 R71
1	330	RMCF0603JT330RCT-ND	RES 330 OHM 1/10W 5% 0603	R-EU_R0603	R48
1	47K	RMCF0603JT47K0CT-ND	RES 47K OHM 1/10W 5% 0603	R-EU_R0603	R51

Table 5. BOM (continued)

Qty	Value	Digikey #	Description	Eagle Library Package	Board Designator
1	47	RMCF0603JT47R0CT-ND	RES 47 OHM 1/10W 5% 0603	R-EU_R0603	R47
18	0	RMCF0603ZT0R00CT-ND	RES 0.0 OHM 1/10W 0603 SM	R-EU_R0603	R73 R74 R75 R76 R77 R79 R80 R81 R82 R83 R84 R85 R86 R87 R88 R89 R90 R91
5	560k	RMCF0603FT560KCT-ND	RES TF 560K OHM 1% 0.125	R-EU_R0603	R42 R43 R46
4	100K	RMCF0603JT100KCT-ND	RES 100K OHM 0.1W 5% 0805	R-EU_R0603	R49 R50 R52 R53
3	10k	RMCF0603JT10K0CT-ND	RES 10K OHM 0.1W 5% 0805	R-EU_R0603	R40 R41 R63
1	10R	RMCF0805JT10R0CT-ND	RES 10 OHM 1/8W 5% 0805 S	RES0805	R36
8	12k	311-12.0KCRCT-ND	RES 12k OHM 1/8W 5% 0805 S	RES0805	R22 R26 R29 R104 R122 R125 R128 R131
16	4.3k	311-4.3KARCT-ND	RES 4.3k OHM 1/8W 5% 0805 S	RES0805	R21 R23 R27 R28 R30 R31 R105 R106 R123 R124 R126 R127 R129 R130 R132 R133
6	1k	RMCF0805JT1K00CT-ND	RES 1.0K OHM 1/8W 5% 0805	RES0805	R14 R16 R18 R32 R33 R34
3	2K37	RMCF0805FT2K37CT-ND	RES 2.37K OHM 1/8W 1% 080	RES0805	R15 R17 R19
9	330k	RMCF0805JT330KCT-ND	RES 330K OHM 1/8W 5% 0805	RES0805	R5 R6 R7 R8 R9 R10 R11 R12 R13
7	0	RMCF0805ZT0R00CT-ND	RES 0.0 OHM 1/8W 0805 SMD	RES0805	R4 R39 R99 R100 R101 R102 R103
2	-	Must Order From Samtec	CONN HEADER 20POS 1.27M	TFM-110-02-SM-D-A-K	RF1 RF2
1	SMAJ5.0ABCT	SMAJ5.0ABCT-ND	DIODE TVS 5.0V 400W UNI 5	DIODE-DO214AC	ZD3
4	SMAJ5.0CA	SMAJ5.0CABCT-ND	DIODE TVS 5.0V 400W BI 5%	SMAJ5.0CA	TVS1 TVS2 TVS3 TVS4
1	SL127L6TH		Mill-Max 850-10-006-20-001000	SL127L6TH	EZ-RF
1	TI_160SEG_LCD	Custom-made		TI_160SEG_LCD	LCD1
	DNP			R-EU_R0603	R44 R45
	DNP			DNP	C63
1	DNP			R-EU_R0603	R66
1	DNP			R-EU_R0603	R70

Table 5. BOM (continued)

Qty	Value	Digikey #	Description	Eagle Library Package	Board Designator
1	CUI_XR	102-1801-ND	Isolated Power Supply, 3.3 V, 700mA	CUI_XR	U$1
1	MSP430F67791AIPEU	MSP430F67791AIPEUR-ND			
1	100uF	1189-1020-ND	CAP Electrolytic 100uF 100V 2	10 mm x 20 mm, 5 mm leads	C102
3	0.22uF	495-2320-ND	CAP poly 0.22uF 305VAC/630V	18 mm x 7 mm, 15 mm leads	C39 C46 C50
1	2.2uF	445-4497-2-ND	CAP Ceramic 2.2uF 100V X7R	1210	C48
1	0.01uF	445-5100-1-ND	CAP CER 10000PF 25V 10% X	603	C45
1	47uF	587-1383-1-ND	CAP Ceramic 47uF 10V X5R 1	1210	C62
1	0.1uF	399-1095-1-ND	CAP Ceramic 0.1uF 10V X5R 0	603	C47
1	.056uF	490-6433-1-ND	CAP Ceramic .056uF 25V X7R	603	C60
1	100pF	399-6841-1-ND	CAP Ceramic 100pF 25V NPO,	603	C61
1	B160	641-1107-1-ND	Diode Schottky 1A 60V B160 S	SMB	D23
3	48V	1N4757ADICT-ND	Diode Zener 51V 1W 1N4757A	DO-41	D17 D19 D21
3	1N4007	1N4007FSCT-ND	DIODE GEN PURPOSE 1000V	DO-41	D18 D20 D22
1	1mH	Must order from CoilCraft (M	Inductor, SMT, MSS1038-105 (	0.402 x 0.394 inch	L7
1	1M	A102234CT-ND	RES 1M OHM 1/16W 0.1% 0603	603	R35,R38
1	33.2k	RNCS0603BKE33K2CT-ND	RES 33.2K OHM 1/16W .1% 06	603	R37
1	22.1k	A102241CT-ND	RES 22.1K OHM 1/16W 1% 06	603	R95
1	51.1	A102292TR-ND	RES 51.1 OHM 1/16W 1% 060	603	R96
1	31.6k	A102261DKR-ND	RES 31.6K OHM 1/16W 1% 06	603	R97
1	10.0k	A102331CT-ND	RES 10.0K OHM 1/16W 0.1% 0	603	R98
3	100	P100W-2BK-ND	RES 100 OHM 2W 5% AXIAL	12 mm length, 4 mm diameter	R92 R93 R94

Table 5. BOM (continued)

Qty	Value	Digikey #	Description	Eagle Library Package	Board Designator
1	TPS54060ADGQ	296-30339-5-ND	IC REG BUCK ADJ 0.5A 10MS	MSOP-10	U3

PBC Layout Prints

The layout implemented is a 2-layer design. This section illustrates the PCB layout prints.

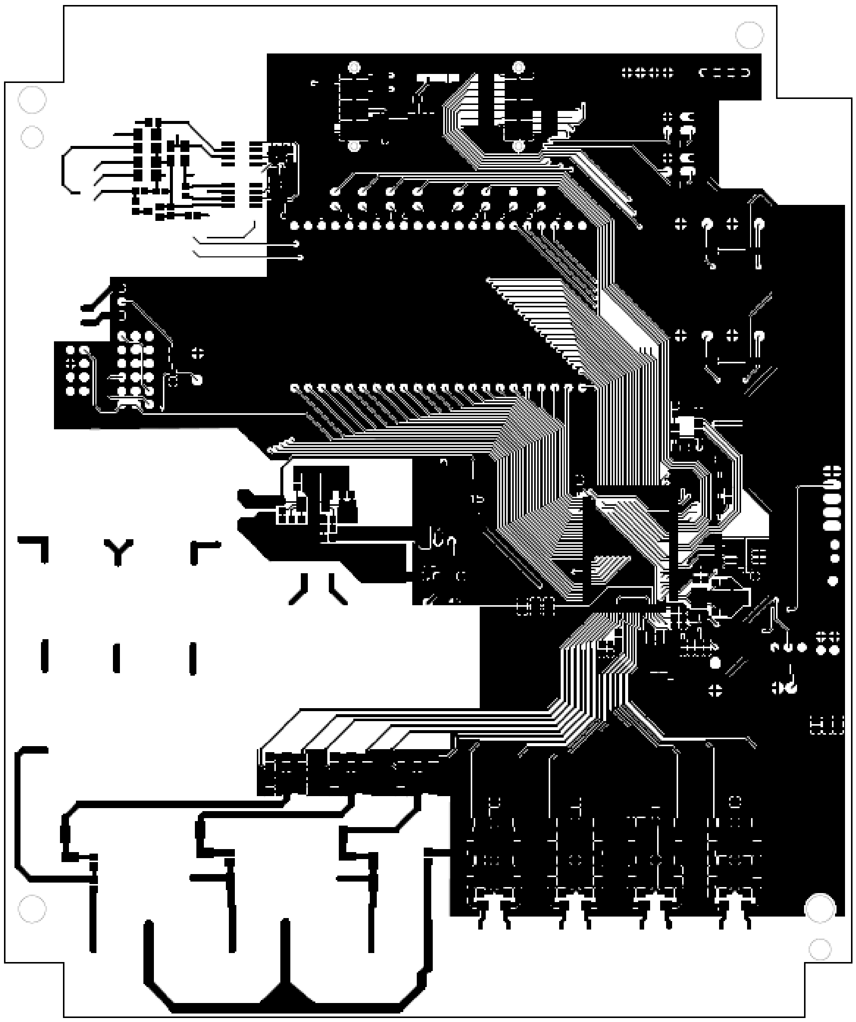


Figure 7. Top Layer Plot 1

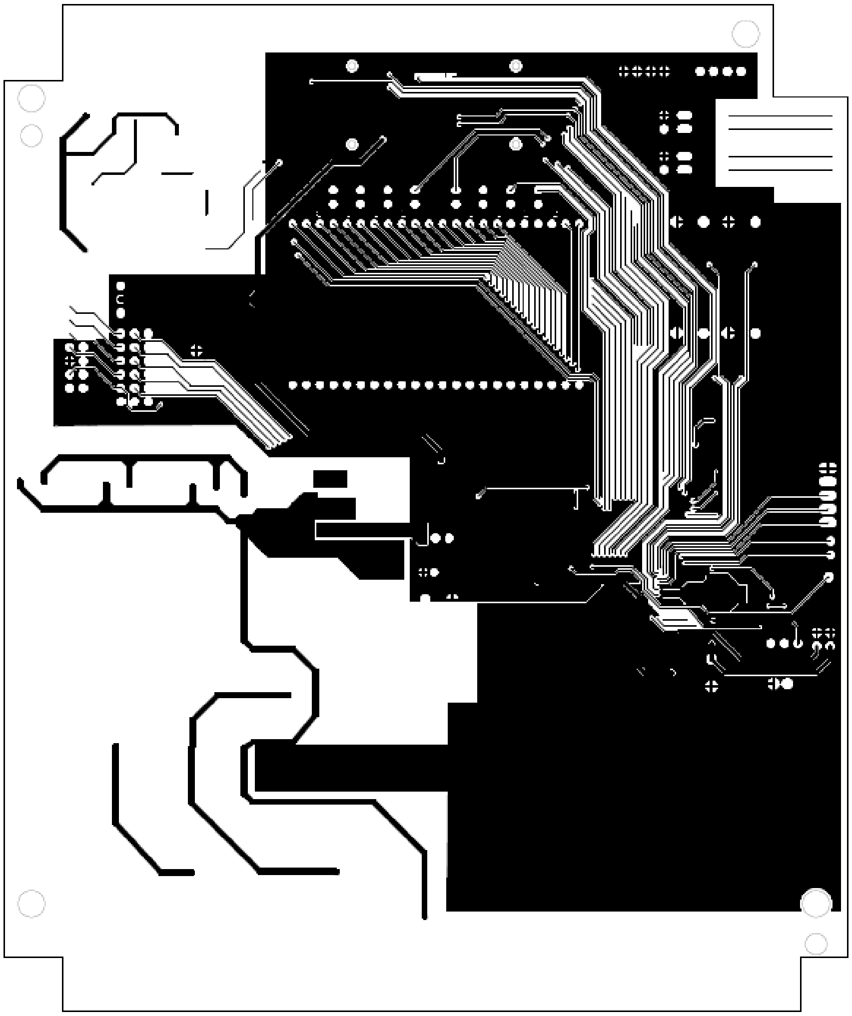


Figure 8. Bottom Layer Plot 2

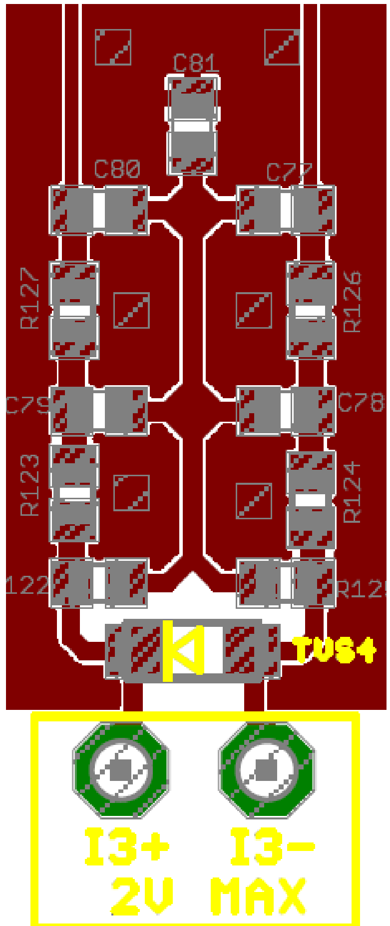


Figure 9. Ldi/dt Input Front End

8.2 CAD Project

To download the CAD project files, see the design files at TIDM-3PHMETER-ROGOWSKI .

8.3 Gerber Files

To download the Gerber files, see the design files at TIDM-3PHMETER-ROGOWSKI

9 Software Files

To download the software files, see the design files at TIDM-3PHMETER-ROGOWSKI

10 About the Author

ANIRBAN GHOSHworks at TI as an Applications Engineer in the Smart Grid Business Unit, for electricity metering and metrology related projects.

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