LTC2946
Wide Range I²C Power, Charge and Energy Meter

DESCRIPTION

Demonstration circuit 2156A features the LTC®2946 rail-to-rail system monitor that measures current, voltage, power, energy and charge. It features an operating range of 2.7V to 100V and includes a shunt regulator for operation from supplies above 100V to allow flexibility in the selection of input supply. The current measurement range of 0V to 100V is independent of the input supply. An onboard, 0.4% accurate, 12-bit ADC measures load current, input voltage and an auxiliary external voltage. A 24-bit power value is generated by digitally multiplying the measured 12-bit load current and input voltage data. Energy and charge data are generated by integrating power and current. Minimum and maximum values are stored and an overrange alert with programmable thresholds minimizes the need for software polling. Data is reported via a standard I²C interface. Shutdown mode reduces power consumption to 20µA.

The demo board features nested pads for a range of sense resistor package sizes to support currents of up to 15A range. The full scale sense voltage is 102.4mV. A 20mΩ sense resistor is populated on the board for 5.12A full scale. The full scale current can be changed by populating RSNS accordingly.

The DC2156A was designed to be connected to the DC590 and controlled through the QuikEval™ suite of software. All thresholds can be set and ADC registers read back through the QuikEval interface, which provides a convenient way to evaluate the LTC2946.

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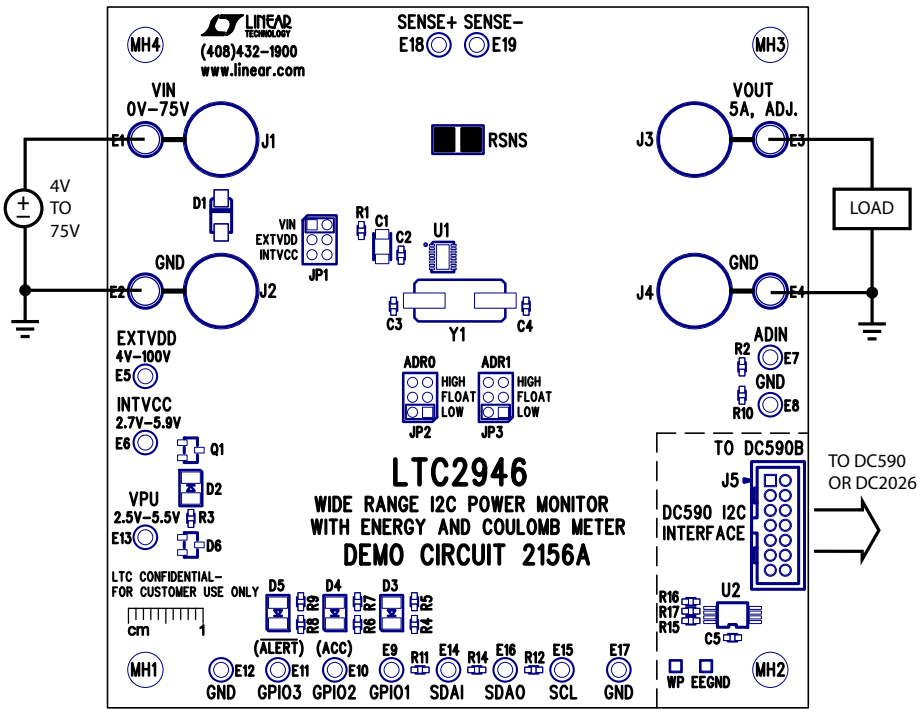


Figure 1. Typical Application Circuit

DC2156A PIN AND JUMPER DEFINITIONS

JUMPER SETTINGS

JP1: Selects the V_{DD} source. It can be set to V_{IN}, $INTV_{CC}$ or $EXTV_{DD}$ (which requires a voltage to be present at the $EXTV_{DD}$ turret.) Please see Powering the DC2156A section for examples of how these different settings are used.

JP2 (ADR0), JP3(ADR1): Selects the I^2C slave address of the LTC2946. Any changes here should also be made inside of QuikEval for communications to persist. By default, both jumpers are set to LOW which corresponds to an address of 0xDE.

TURRETS AND BANANA JACKS

Signal connections are made via the row of turret posts along the edges of the board.

GND: (5 turrets, 2 banana jacks) These turrets are connected directly to the ground planes.

V_{IN}: Main Supply Input. The LTC2946 measures the current flowing from V_{IN} to V_{OUT}.

V_{OUT}: Supply Output to Load. The LTC2946 measures the current flowing from V_{IN} to V_{OUT}.

$INTV_{CC}$: Internal Low Voltage Supply Input/Output. This turret is directly connected to the $INTV_{CC}$ pin. This turret is used to power internal circuitry and can be configured as a direct input, as a linear regulator from a higher voltage connected to V_{DD} or as a shunt regulator. In the default configuration with JP1 at V_{IN}, $INTV_{CC}$ is internally generated and is 5V. Please see LTC2946 data sheet for more details.

$EXTV_{DD}$: External Voltage Supply. This turret can be used to power the LTC2946 independently of the V_{IN} power path. Connect to 4V to 100V external supply if this option is selected through JP1.

ADIN: Input Measured by the Onboard ADC. Measures between 0V to 2.048V. ADIN is loaded with a 140k and 3k resistive divider to allow voltage measurements of up to 102.4V full scale.

VPU: Pull Up Voltage for the LEDs. Derived from a 5V isolated supply on the DC590. It powers the GPIO LEDs on the board. If a DC590 is not used and the DC2156A is operated independently, a 2.5V to 5V supply must be provided here, in order for the LEDs to work. 5V from DC590 and the VPU turret input voltage are diode-ORed by D6 to preclude back feeding from one source to the other.

$SENSE^+$: Supply Voltage and Current Sense Input. Used as a Kelvin input for the internal current sense amplifier. The voltage at this pin is also monitored by the onboard ADC with a full-scale input range of 102.4V. The full scale current sense voltage is 102.4mV.

$SENSE^-$: Current Sense Input. An external 20mΩ sense resistor (RSNS) is connected between $SENSE^+$ and $SENSE^-$ to measure a full scale current of 5.12A. See Hardware Setup section for details.

SCL: I^2C Clock input.

SDA/SDAI: I^2C Data Input. Connected to SDAO through 0Ω resistor R14. Remove R14 if opto-isolated I^2C functionality is desired.

SDAO: I^2C Data Output. Connected to SDAI through 0Ω resistor R14. Remove R14 if opto-isolated I^2C functionality is desired.

GPIO1: General Purpose Input/Output 1. Configurable general purpose output and logic input. Configured by default as General Purpose Output, pulls low to light D3.

GPIO2: General Purpose Input/Output 2. Configurable general purpose output, logic input, and ACC control input to gate internal accumulators. By default it is configured as ACC input and pulled high so that the energy and charge accumulation are active. If GPIO2 is configured as an output, LED D4 lights up when GPIO2 is asserted low.

GPIO3: General Purpose Input/Output 3. Configurable general purpose output, logic input, and ALERT# output. By default it is configured as ALERT#. As ALERT#, it is pulled to ground when a fault occurs to alert the host controller. LED D5 lights when ALERT# is asserted low.

DC2156A PIN AND JUMPER DEFINITIONS

CONNECTORS

DC590 Connector (J5): J5 allows connection of the DC2156A to the DC590 demo board through which the Linear Technology™ QuikEval software can communicate with the board. When DC590 is connected, 5V is provided to power the GPIO LEDs through this connector.

LED

$INTV_{CC}$ – D2: Lights up green when both VPU and LTC2946 are powered.

ALERT# (GPIO3) – D5: Fault Alert Output. Lights up red on an ALERT condition. Can also be monitored on the ALERT (GPIO3) turret.

ACC (GPIO2) – D4: Will light up amber when ACC is Low. By Default GPIO2 is an input, pulled high to VPU by D4 and R7.

GPIO1 – D3: General Purpose Output. Lights up green when pulled low. Default state is low.

HARDWARE SETUP OPTIONS

Flexible Operating Modes of the LTC2946

The LTC2946 current sense inputs, $SENSE^+$ and $SENSE^-$ are used to make Kelvin connections to a current sense resistor to measure the output current of a supply or the current consumption of a load. They feature a common mode range of 0V to 100V so that the output current of either a positive or negative supply can be measured, as well as current in either the positive or negative lead of the load. Thus a potentially bewildering number of measurement configurations are possible. To allow such flexibility, the $SENSE^+$ and $SENSE^-$ pins cannot be relied upon as a source of power; the LTC2946 features a separate V_{DD} pin for this purpose.

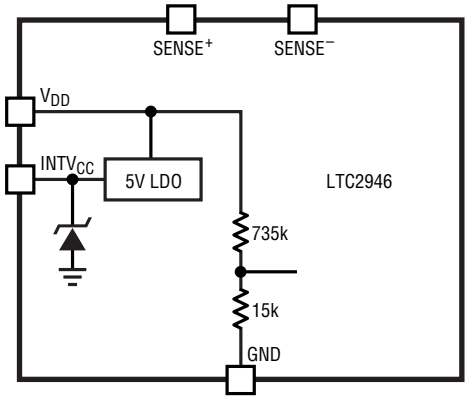


Figure 2. Simplified Supply Block Diagram

Power to operate LTC2946 is obtained from the V_{DD} pin or the $INTV_{CC}$ pin (see the block diagram in Figure 2). If a supply of 4V to 100V is available, V_{DD} can be used and an internal series regulator powers the device. If a supply of 2.7V to 5.9V is available, power may be applied directly to $INTV_{CC}$. In the event that no supply of less than 100V is available, the shunt regulator shown connected across $INTV_{CC}$ can be used in conjunction with an external dropping resistor to power the LTC2946.

Ringing

It comes as a surprise to many that seemingly innocent acts, such as making a connection to a live supply, cause ringing. Theory tells us that the amplitude of such ringing reaches approximately 2x the input voltage, but in practice this limit is sometimes exceeded. For general information on ringing, see the LTC1647 data sheet.

Since the V_{DD} pin current is small, ringing there is easily suppressed by a 51Ω/100nF RC filter (R1 and C1) without any compromise to the input voltage range. The $SENSE^+$ and $SENSE^-$ pins however are not so easily protected.

To protect these pins and to prevent damage to the LTC2946 that might arise from ringing, V_{IN} is clamped by an SMAT70A TVS (D1). D1 has a minimum breakdown voltage of 77V at room temperature and thus V_{IN} DC input rating to 75V maximum. While D1 may be removed to operate V_{IN} up to 100V, always remember that any excursion above this value may destroy the LTC2946.

HARDWARE SETUP OPTIONS

Powering The DC2156A

The LTC2946 offers great flexibility in terms of supply options owing to its separate V_{DD} and SENSE pins.

Jumper JP1 is used to select the source of power for V_{DD} and allows easy configuration of the various supply options.

If JP1 is set to V_{IN}, then V_{DD} is powered from V_{IN} (Figure 3a and Figure 3b). In this configuration, sensing is done on the same rail which is supplying power to the LTC2946. Provide 4V to 75V at V_{IN} in this configuration to power the LTC2946. The 75V limitation is set by the zener clamp D1 which protects the LTC2946 against voltage transients exceeding 100V, while the 4V limitation is the minimum operating voltage of the V_{DD} pin. D1 can be removed if the full voltage range of 100V is desired.

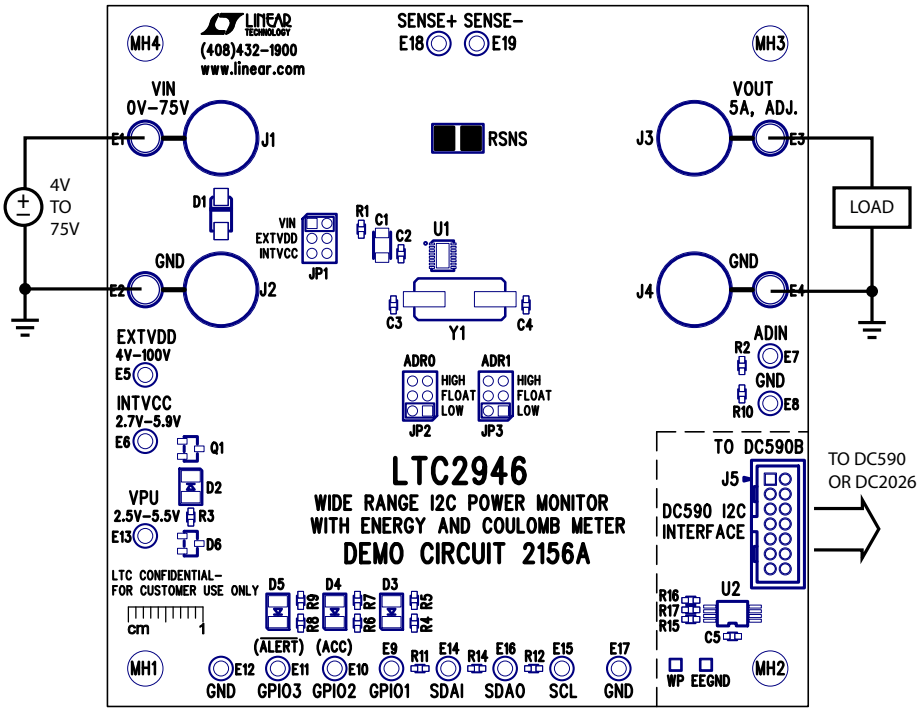


Figure 3a. DC2156A Is Powered from V_{IN}

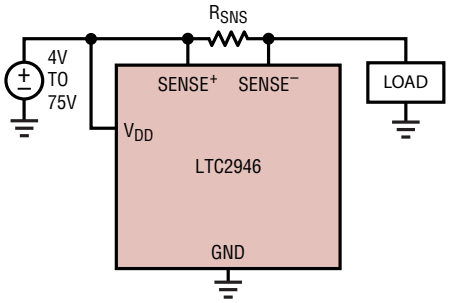


Figure 3b. LTC2946 Powered from V_{IN}

HARDWARE SETUP OPTIONS

If JP1 is set to $EXTV_{DD}$ then V_{DD} is powered by the $EXTV_{DD}$ turret (Figure 4a and Figure 4b). Provide a separate 4V to 100V at the $EXTV_{DD}$ turret in this configuration. The maximum input V_{IN} is limited to 75V by D1. D1 can be removed if the full voltage range of 100V is desired.

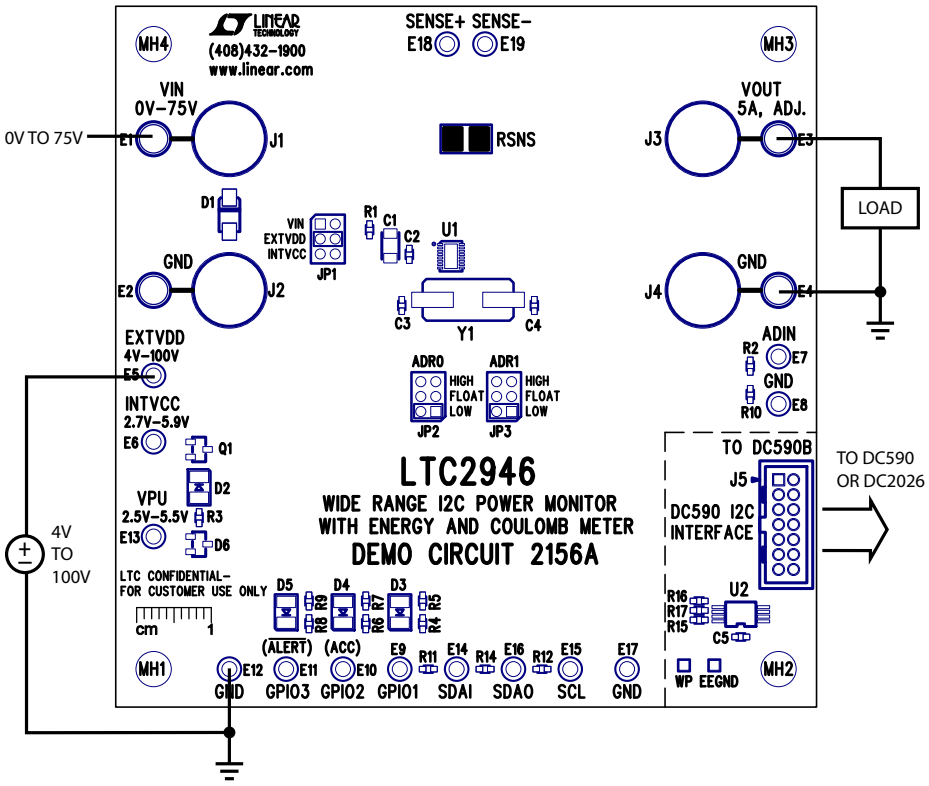


Figure 4a. DC2156A Powered from External V_{DD}

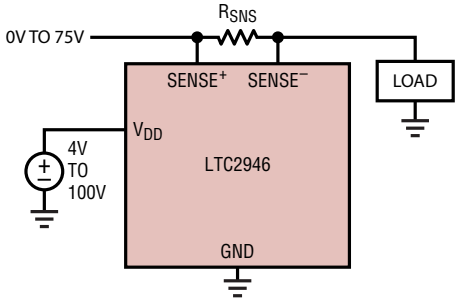


Figure 4b. LTC2946 Powered from External V_{DD}

HARDWARE SETUP OPTIONS

If JP1 is set to $INTV_{CC}$, then the LTC2946's internal circuitry is powered from $INTV_{CC}$. A low voltage supply (2.7V to 5.9V) connected to $INTV_{CC}$ helps minimize on-chip power dissipation (Figure 5a and Figure 5b). The device can also be used as a shunt regulator in this configuration to monitor rails higher than 100V.

Regardless of which configuration is selected, if the system is connected properly, the green $INTV_{CC}$ LED should be lit. By default the DC2156A is configured, with V_{IN} providing power to V_{DD}.

In order to support a wide range of applications, the LTC2946 demo board also features multiple nested sense pads to support high current monitoring. These pads are Kelvin sensed. By default the board supports current monitoring of up to 5.12A. An appropriate sense resistor can be used to support monitoring of desired current levels up to 20A with an on-board sense resistor. The SENSE+ and SENSE– turrets may be used to connect to an external sense resistor and power path for any current level. Remove RSNS in this case.

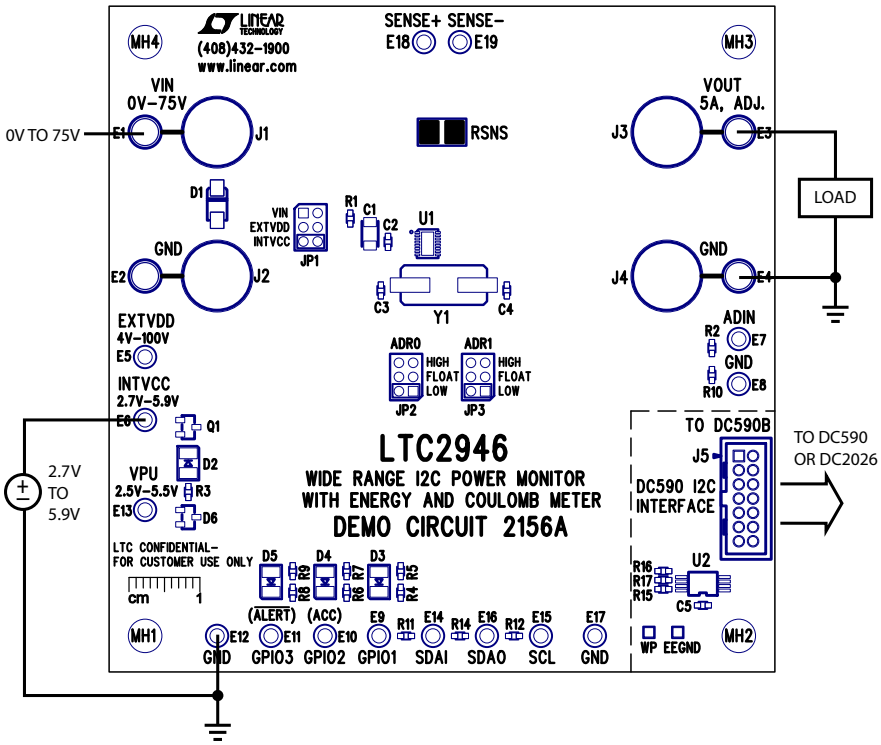


Figure 5a. DC2156A Powered from $INTV_{CC}$

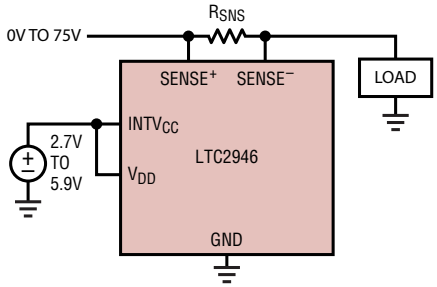


Figure 5b. LTC2946 Powered from $INTV_{CC}$

HARDWARE SETUP OPTIONS

DC2156A Shunt Regulator

For supply voltages above 100V, the shunt regulator at $INTV_{CC}$ can be used in both high and low side configurations to provide power to the LTC2946 through an external shunt resistor, R_{SHUNT}. R_{SHUNT} should be sized according to the following equation:

$$\frac{V_{S(MAX)} - 5.9V}{35mA} \leq R_{SHUNT} \leq \frac{V_{S(MIN)} - 6.7V}{1mA + I_{LOAD(MAX)}} \quad (1)$$

where $V_{S(MAX)}$ and $V_{S(MIN)}$ are the operating maximum and minimum of the supply. $I_{LOAD(MAX)}$ is the maximum external current load that is connected to the shunt regulator.

Figure 6a shows a high side power monitor with an input monitoring range of 80V to 200V in a high side shunt regulator configuration. The device ground is separated from circuit ground through R_{SHUNT} and clamped at 6.3V below the input supply, V_{IN}. Note that due to the different ground levels, the I^2C signals from the LTC2946 need to be level

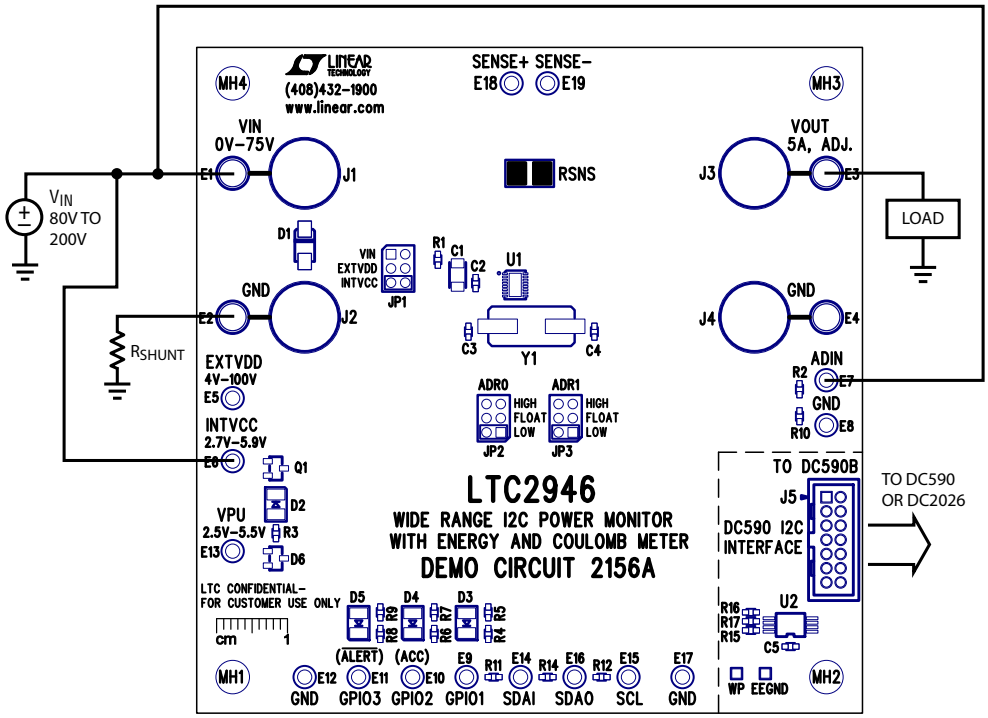


Figure 6a. Powering DC2156A from High Side Shunt Regulator to Allow for Input Voltage Higher than 100V

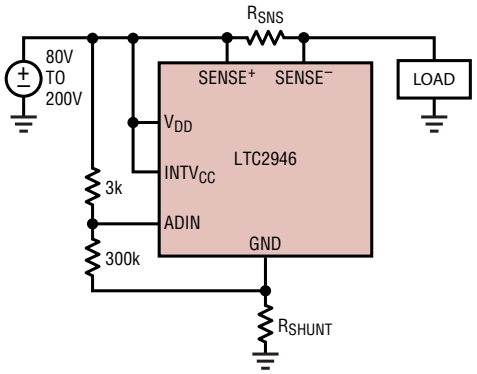


Figure 6b. Powering LTC2946 from High Side Shunt Regulator to Allow for Input Voltage Higher than 100V

HARDWARE SETUP OPTIONS

shifted for communication with other ground referenced components. The DC590, as well as the Linduino™, provide the necessary isolation in this case. The bus voltage can be measured with an appropriate external divider connected to ADIN for full scale operation at 200V. Make sure to set CA[7] in the CTRLA register so that the ADC measures ADIN with reference to $INTV_{CC}$ instead of the GND pin.

Figure 7a shows a high side rail-to-rail power monitor which derives power from a greater than 100V secondary supply. The voltage at $INTV_{CC}$ is clamped at 6.3V above ground in a low side shunt regulator configuration to power the part.

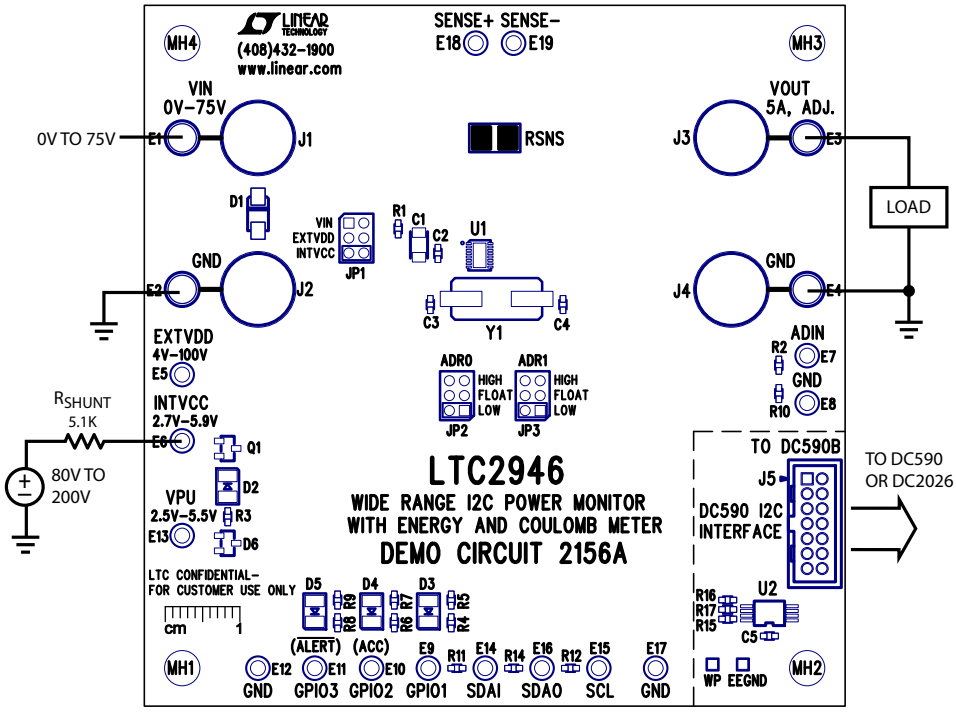


Figure 7a. DC2156A Derives Power from Low Side Shunt Regulator in High Side Current Sense Topology

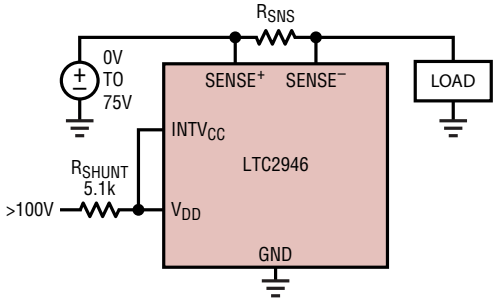


Figure 7b. DC2156A Derives Power from Low Side Shunt Regulator in High Side Current Sense Topology

HARDWARE SETUP OPTIONS

In low side power monitors, the device ground and the current sense inputs are connected to the negative terminal of the input supply as shown in Figure 8a. The low side shunt regulator configuration allows operation with input supplies above 100V by clamping the voltage at $INTV_{CC}$.

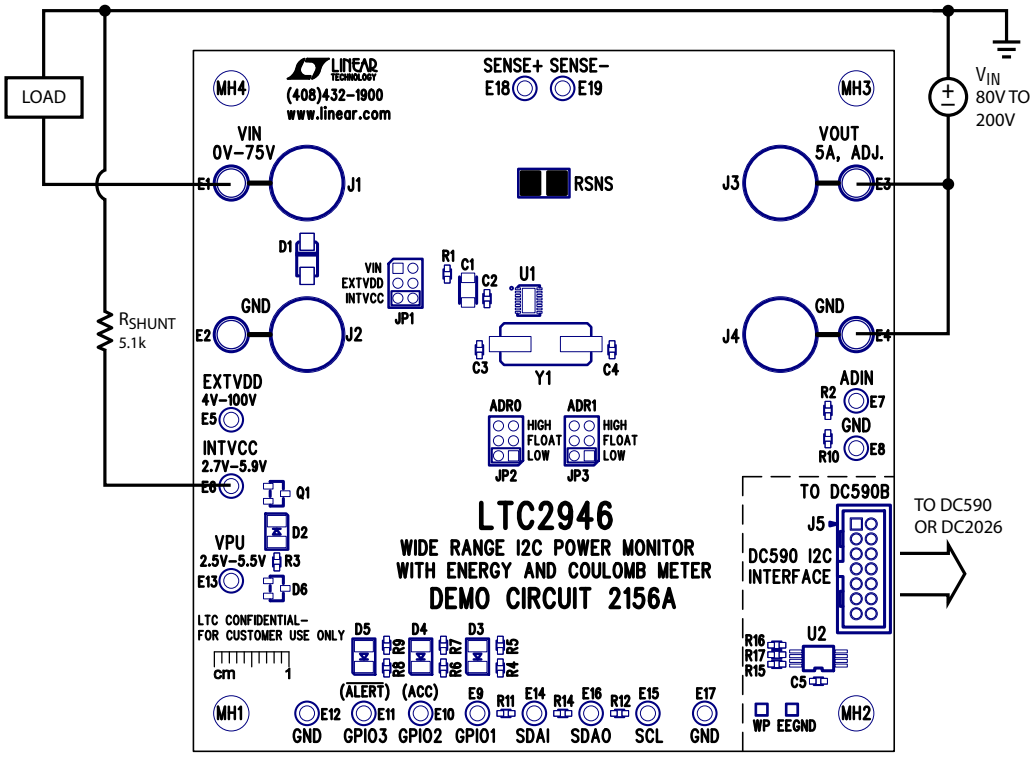


Figure 8a. DC2156A Derives Power through Low Side Shunt Regulator in Low Side Current Sense Topology

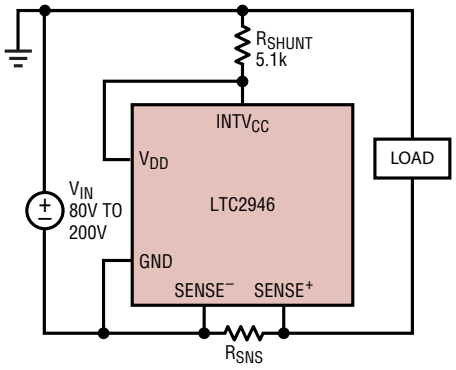


Figure 8b. LTC2946 Derives Power through Low Side Shunt Regulator in Low Side Current Sense Topology

HARDWARE SETUP OPTIONS

-48V System Monitoring

The DC2156A can also be configured to provide power monitoring in -48V Telecom applications by setting JP1 to $EXTV_{DD}$, with the -48V input tied to V_{OUT} and GND and the -48V return tied to $EXTV_{DD}$. The DC590 provides isolation and level shifting, as the I^2C interface is operating at -48V with respect to -48V RTN, which is normally near earth ground potential.

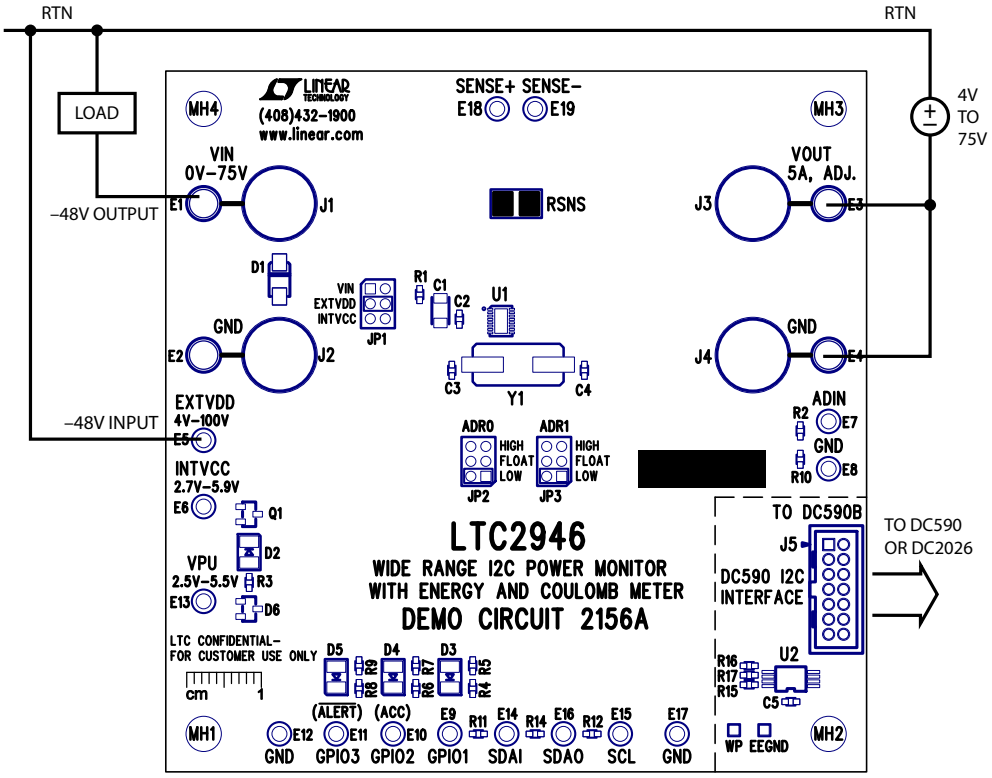


Figure 9a. Current Monitoring in a –48V System

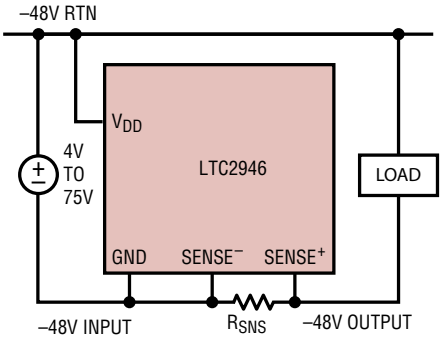


Figure 9b. Current Monitoring in a –48V System

QUICK START PROCEDURE

The various features of DC2156A can be demonstrated by using Linear Technology's QuikEval Software. QuikEval is a USB-based product demonstration and data acquisition software meant to be used in conjunction with the DC590 that connects to individual daughter cards for specific Linear Technology products. This software can be found on the Linear Technology website at:

http://ltspice.linear.com/software/ltcqev.exe

Connect the DC590 to the PC using the USB cable provided with the DC590. Now, connect the DC590 to the DC2156A. The setup should look like Figure 10.

Ensure power is applied to the DC2156A in any one of the configurations described earlier in this manual and that a load is connected to the board.

Once setup is complete, run the QuikEval Software. QuikEval should auto-detect the DC2156A and provide the user with a control panel.

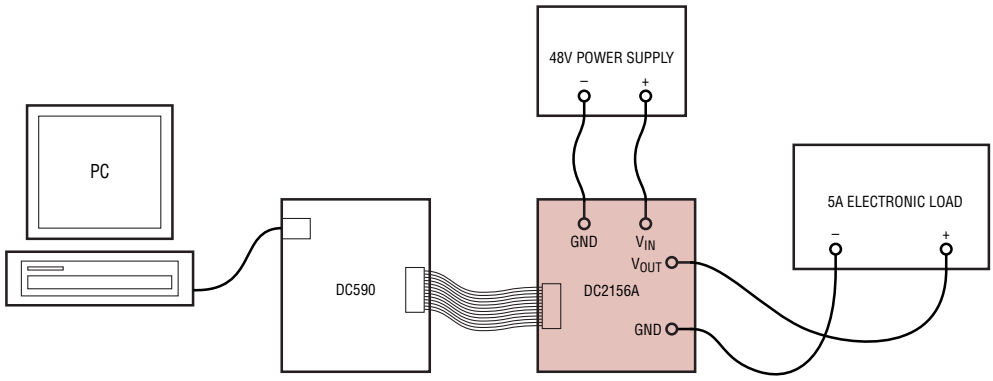


Figure 10. Hardware Bench Setup

INTERFACING WITH THE DC2026

This board can also interface with the DC2026 Linduino board which is part of the Linduino Firmware Development Program. The Linduino Firmware Development Program provides users with convenient driver code, written in C, for a wide range of LTC products. Please see the Linduino page for more details.

The DC2026 comes preloaded with a DC590 emulator firmware which allows easy interface with QuikEval. See Figure 10 for connections but substitute the DC590 with the DC2026. QuikEval will launch the GUI as it would with the DC590. The DC2026 can also be used as a development platform, example software along with drivers can be found on the product landing page: http://www.linear.com/product/LTC2946.

DC2156A SOFTWARE USER INTERFACE

The DC2156A software user interface was designed to allow the user to quickly evaluate the LTC2946. The user has the ability to set fault thresholds, enable/disable and clear alerts, change the source for the V_{IN} measurement as well as monitor voltage, current, power, charge and energy. RSNS is set to 20mΩ by default on the DC2156A, should any changes be made on the board, the corresponding value should be entered into the software control panel. By pressing Start, the software interface will begin using the DC590 for data collection.

The LTC2946 software UI is split up into two main components. The Data Acquisition Terminal and a Tabbed Interface. A screen shot of the GUI is shown in Figure 11.

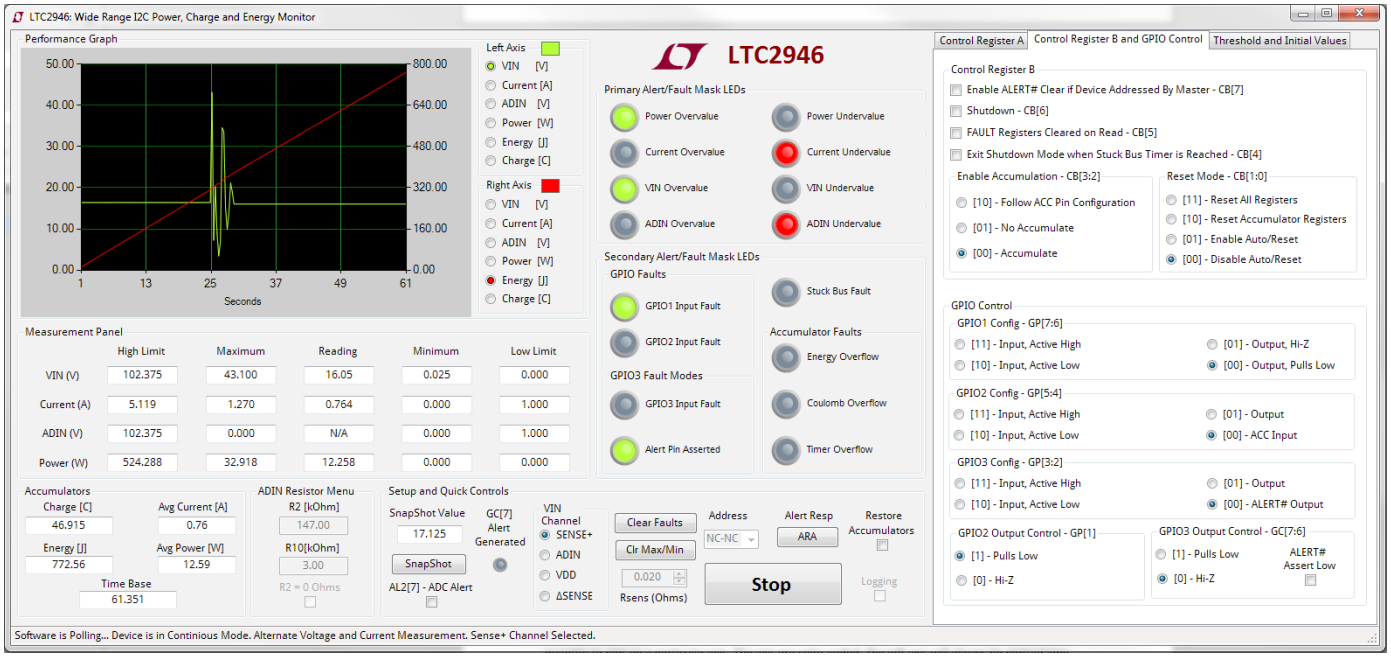


Figure 11. LTC2946 Software UI

DATA ACQUISITION TERMINAL

The Data Acquisition Terminal display is always in view of the user, providing convenient controls to quickly perform common functions and displaying real time voltage, current, power, charge and energy data.

The Data Acquisition Terminal consists of the following components.

Performance Graph

The performance graph plots data in real time for up to the last minute. Older data, once scrolled off the screen, is discarded. The user can choose to log all the data in a .csv file by clicking on the logging checkbox which is also found on the Data Acquisition Terminal.

The performance graph can plot any two quantities from V_{IN}, Current, ADIN, Power, Energy and Charge concurrently on the same plot. Radio buttons located next to the plot allow the user to select which quantity to plot on a particular axis. The axes are color coded. The left axis will always be plotted lime green and the right axis will always be plotted in red. These color codes are conveniently placed next to the radio buttons for user reference.

DC2156A SOFTWARE USER INTERFACE

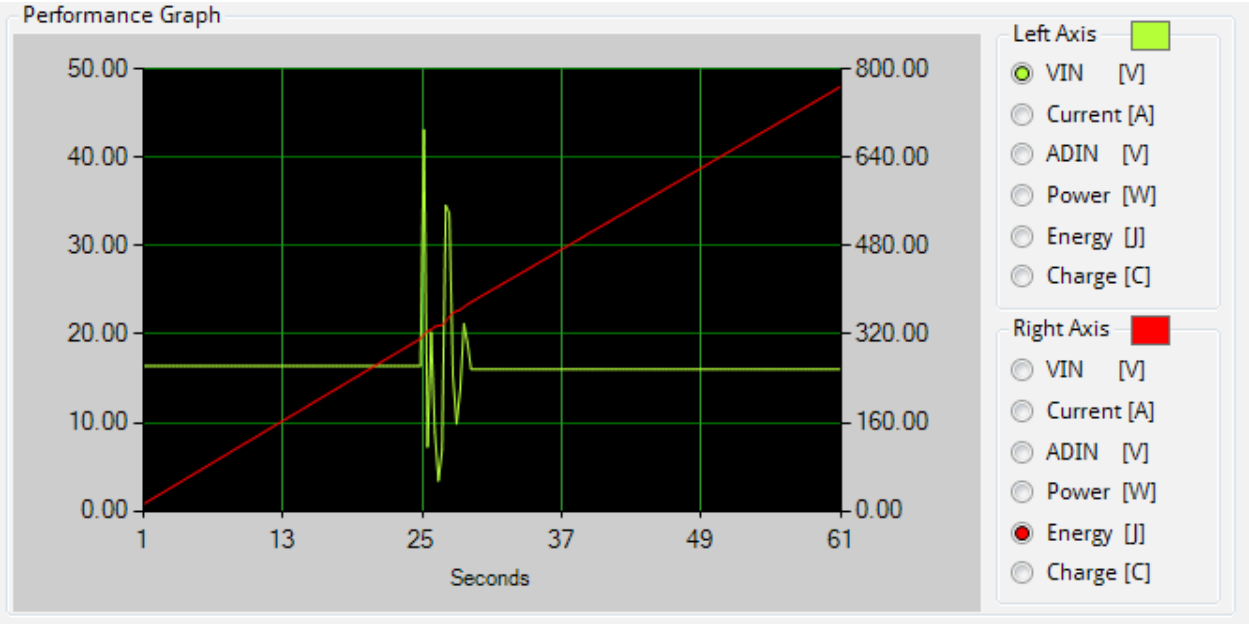
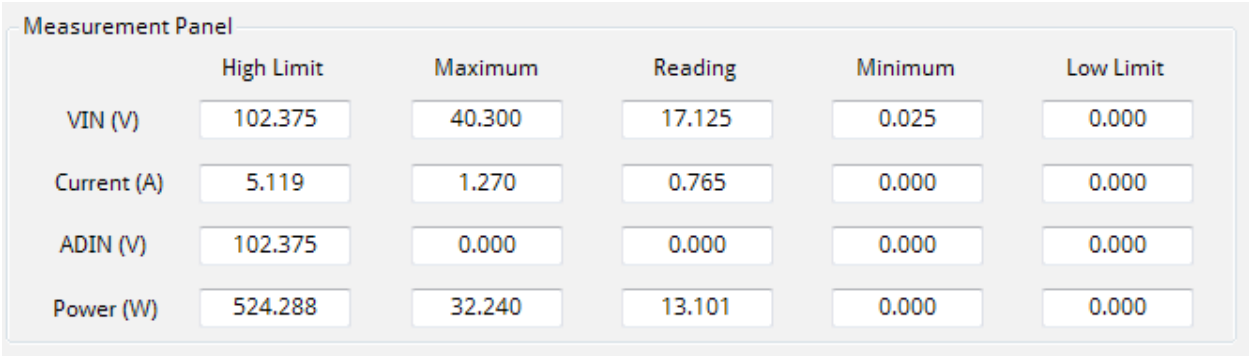


Figure 12. Performance Graph

Note: You cannot plot the same quantity on both axes. Attempting to do so will result in the next available quantity being selected instead.

Measurement Panel

The measurement panel provides text based output of V_{IN} and ADIN registers in volts, current registers in amperes and power registers in watts. For each quantity this panel displays the values of the maximum and minimum registers, the high and low limit threshold registers and the real time reading register. These values get updated with each polling of the device if there is any change.



	High Limit	Maximum	Reading	Minimum	Low Limit
VIN (V)	102.375	40.300	17.125	0.025	0.000
Current (A)	5.119	1.270	0.765	0.000	0.000
ADIN (V)	102.375	0.000	0.000	0.000	0.000
Power (W)	524.288	32.240	13.101	0.000	0.000

Figure 13. Measurement Panel

DC2156A SOFTWARE USER INTERFACE

Accumulator Panel

The onboard accumulators have their own dedicated panel which displays the charge, energy and time base register values. The GUI takes this one step further by providing the user with two extra text boxes which depict the average current and power from the time the control panel initiated the polling of the device. These values get updated with each polling of the device if there is any change.

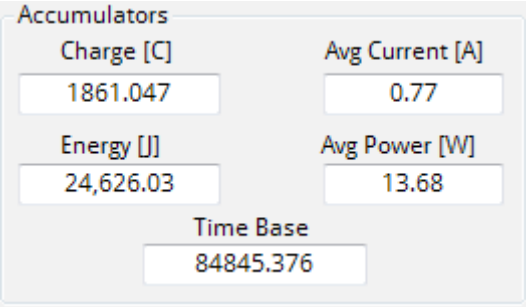


Figure 14. Accumulator Panel

ADIN Resistor Panel

The ADIN pin on the demo board has a resistive divider, in the form of R2 and R10, which allows the user to measure voltages up to 102V. Since the ADIN pin has a full-scale voltage of 2.048V, the voltage displayed is scaled internally by the GUI based on the values entered in the R2 and R10 text boxes. If the values of the onboard resistors changed, then these text boxes should be updated to reflect that change to get proper scaling. If no scaling is desired or if the ADIN pin is to be connected directly to a voltage source of up to 2.048V then the "R2 = 0 Ohms" checkbox can be checked to eliminate the internal scaling present in the GUI.

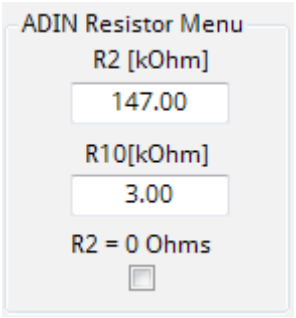


Figure 15. Resistor Menu

Setup and Quick Controls Panel

The Setup and Quick Controls panel allows the user to quickly change the sense resistor value (this must match the sense resistor present on the board), clear fault registers as well as the maximum and minimum registers of all quantities, set the device address, perform ARA in the case of an alert, as well as put the part in snapshot mode. There are two special checkboxes present in the Setup and Quick Controls panel which require further explanation.

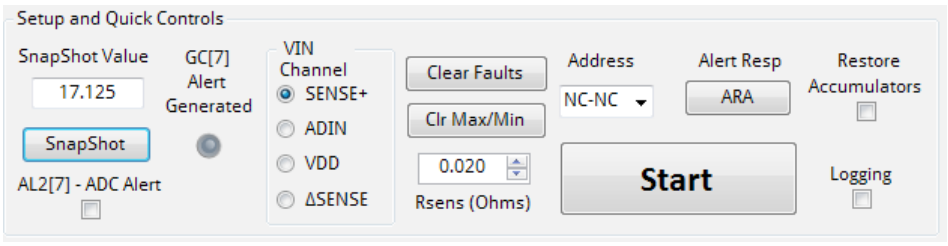


Figure 16. Setup and Quick Controls

DC2156A SOFTWARE USER INTERFACE

The Logging checkbox, once checked, will enable the GUI to store V_{IN}, ADIN, current, power, energy and charge register values in a user defined .csv file. It will also log the value of the fault register (in hexadecimal) so that the user can see at what particular instant the fault register changed value during a fault. Note that this checkbox greys out once the start button is clicked and must be selected before the start button is clicked if logging is desired.

The Restore Accumulators checkbox enables the user to individually clear accumulator overflow faults while still retaining values. Each accumulator in the LTC2946 has its own dedicated status and fault bits. Status bits represent real-time status of the part. If a fault occurs and then goes away, the status bit would get set and then reset with the fault event. The fault bit would stay latched. The accumulator status bits behave slightly differently in the sense that they stay latched once an accumulator overflows and do not get reset until the accumulator itself is reset. This is because an accumulator is still in overflow state once it rolls over until it is reset. The only way to reset the accumulators is by setting bits CB[1:0] to either 10 or 11. This however resets ALL of the accumulator registers. To prevent this from happening and to allow the user to only reset a single accumulator fault, the Restore Accumulators checkbox first stores the information from all the accumulators, resets the accumulators and then restores the accumulator values in the accumulator registers which were not selected to be reset.

Alert/Fault Mask LEDs

In order to provide a friendly user interface, the LTC2946 abstracts the ALERT mask and FAULT registers from the user in the form of clickable LEDs. Each LED maps to a corresponding bit in the ALERT and FAULT registers. For example, the POWER OVERVALUE LED maps to bit 7 in the ALERT1 and FAULT1 registers. Similarly, the GPIO1 Input Fault LED maps to Bit 6 in the ALERT2 and FAULT2 registers and so forth.

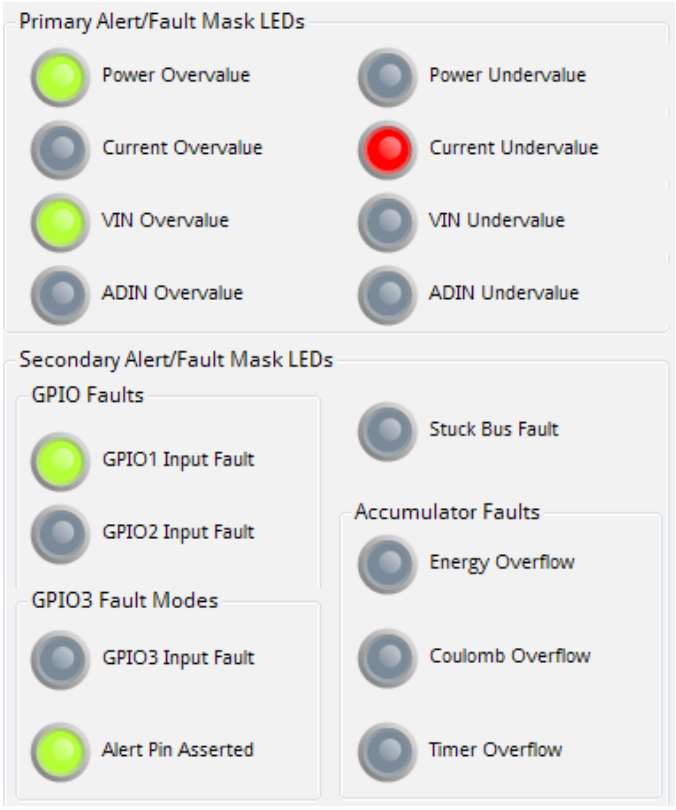


Figure 17. Alert/Fault Mark LEDs

The LEDs have three states which indicate the status of the FAULT and ALERT registers.

An inactive LED, represented with a grey color, indicates that neither the alert bit nor the corresponding fault bit is set.

An armed LED, represented with a green color, indicates that the corresponding alert bit has been set, however no fault event has occurred. This arms the ALERT# pin to pull low if that particular fault event occurs.

A faulted LED, represented with a red color, indicates that the corresponding fault bit has been set. Clicking on a faulted LED will clear that fault by resetting the corresponding fault bit. The LED will then return to its previous state whether it was inactive or armed.

DC2156A SOFTWARE USER INTERFACE

TAB INTERFACE

The tabbed interface allows the user to cycle between the various control and threshold registers of the LTC2946 without losing view of the data. It consists of the following three tabs.

Control Register A

As the name suggests, this tab gives the user direct access to the CTRLA register in the form of radio buttons. Here, the user can configure the ADIN pin reference, offset calibration, voltage channel as well as the duty cycle of measurements easily.

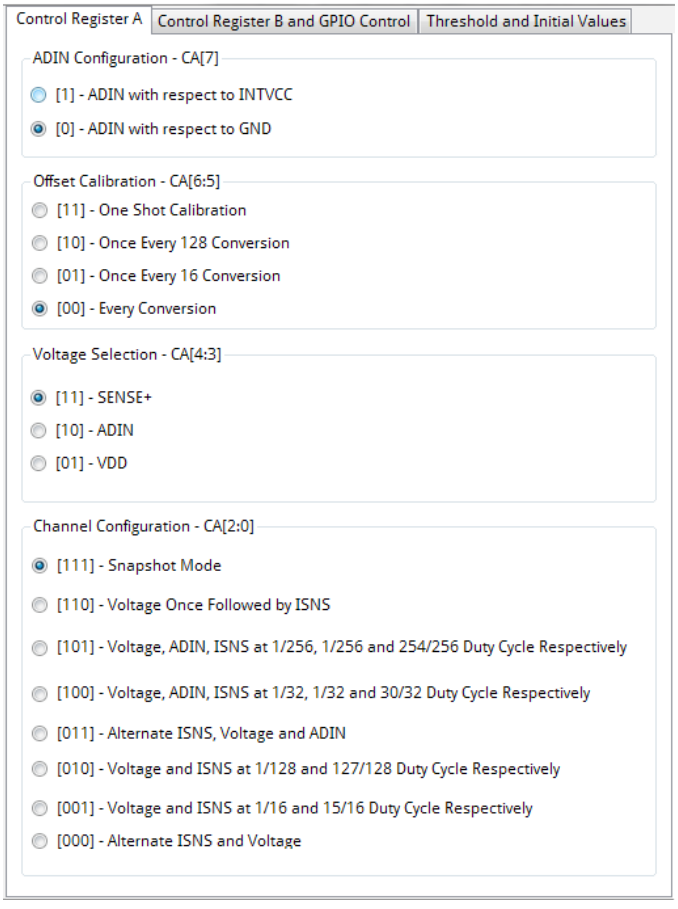


Figure 18. Control Register A

Control Register B and GPIO Control

This tab provides access to the CTRLB and allows control of the GPIO pins through registers GPIO_CFG and GPIO3_CTRL.

The CTRLB register can be used to put the part in shutdown mode as well as to configure handling of fault events. The state of the individual GPIO pins can also be configured through this tab.

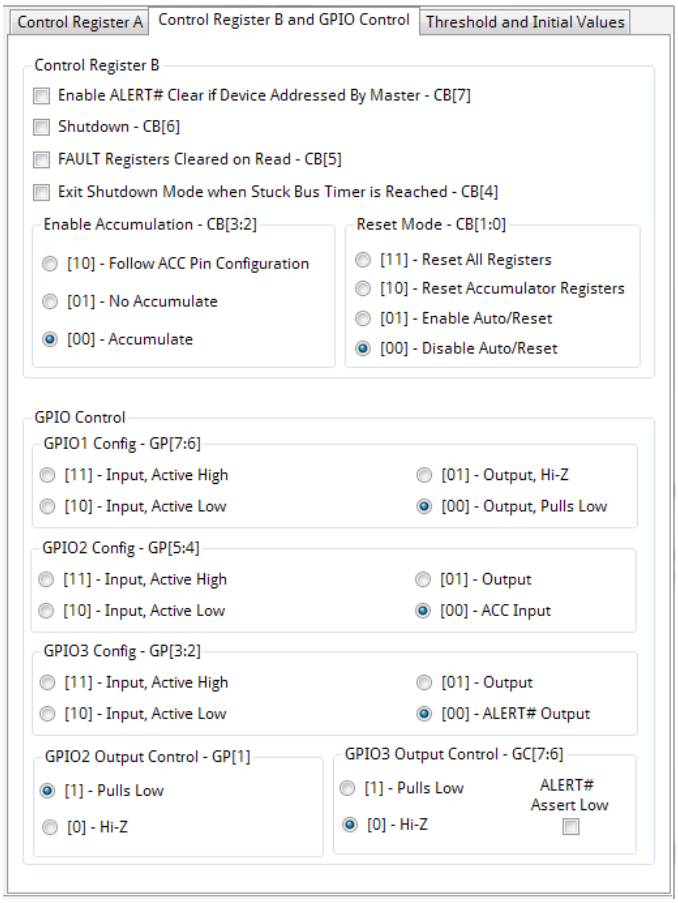


Figure 19. Control Register B and GPIO Control

DC2156A SOFTWARE USER INTERFACE

Threshold and Initial Values

This tab provides access to the threshold registers within the LTC2946. The user can set the maximum and minimum thresholds of power, current, V_{IN} and ADIN here by entering the desired value and then clicking the corresponding button. Once the button is clicked, the data is first validated. If it is out of range a message box will pop up and request the user to enter data within the valid range. Once valid data is sent to the part, the corresponding text box in the Measurements Panel will be updated to reflect this change.

The user can also set the initial values for the accumulators here. The time base is entered in hexadecimal format while the charge and energy values are entered in coulombs and joules, respectively. Similar to the threshold section, the information must be sent by clicking on the corresponding button so that the data is first validated and then sent to the part.

This tab also allows the user to set the frequency of their crystal oscillator if they are using one. The demo board comes equipped with a 4MHz clock which is the default value. If no external clock is desired, the crystal present on the demo board can be removed and the "Use LTC2946's Internal Clock (5% Trimmed 250kHz)" checkbox can be selected to use the part's internal clock.

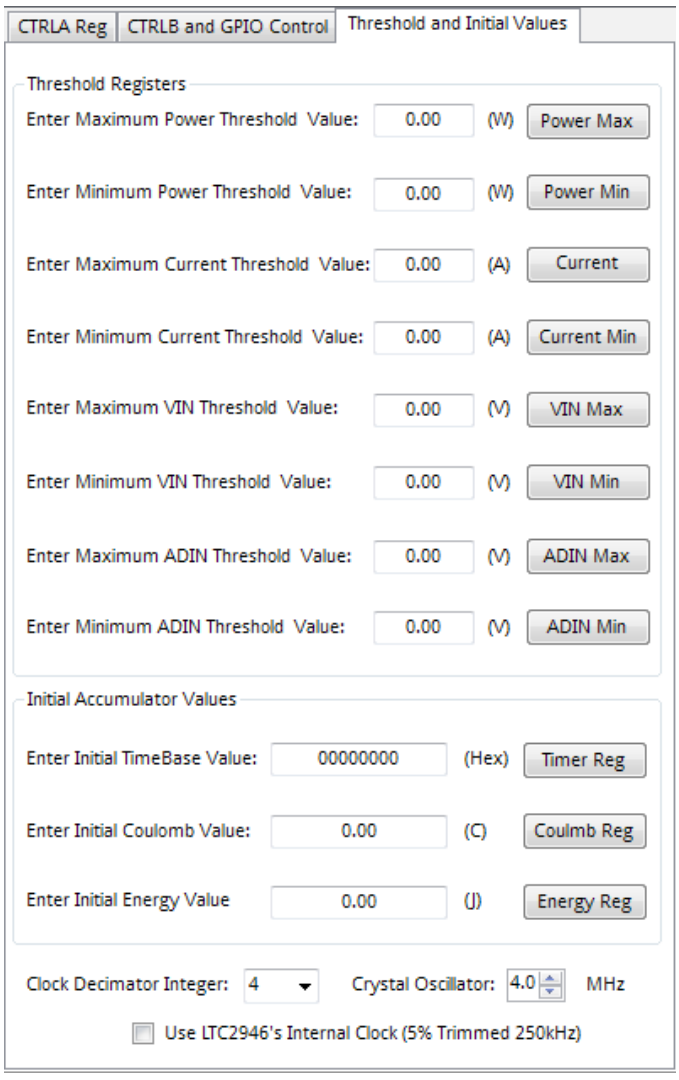


Figure 20. Threshold and Initial Values

PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Required Circuit Components				
1	1	C1	CAP., X7R 0.1µF 200V 10% 1206	AVX, 12062C104KAT2A
2	2	C2, C5	CAP., X5R 0.1µF 25V 10% 0603	AVX, 06033D104KAT2A
3	2	C3, C4	CAP., C0G, 36pF 25V 5% 0603	AVX, 06033A360JAT2A
4	1	D1	VOLTAGE SUPPRESSOR, 70V	Diodes/Zetex, SMAT70A
5	2	D2, D3	LED, GRN PLCC-2 (B-SIZE)	Vishay, VLMC3101-GS08
6	1	D4	LED, AMBER PLCC-2 (B-SIZE)	Vishay, VLMH3100-GS08
7	1	D5	LED, RED PLCC-2 (B-SIZE)	Vishay, VLMS3000-GS08
8	1	D6	DIODE, DUAL SCHOTTKY, SOT-23	Fairchild, BAT54C
9	4	E1, E2, E3, E4	TP, TURRET, .094"	Mill-Max, 2501-2-00-80-00-00-07-0
10	15	E5–E19	TP, TURRET, .064"	Mill-Max, 2308-2-00-80-00-00-07-0
11	3	JP1, JP2, JP3	HEADERS, DBL. ROW 2 X 3 2mm CTRS.	Sullins, NRPN032PAEN-RC
12	4	J1, J2, J3, J4	BANANA JACK, NON-INSULATED	Keystone, 575-4
13	1	J5	CONN., HEADER, 14 PIN, 2mm	Molex, 87831-1420
14	1	Q1	MOSFET N-CHAN,60V 115MA SOT23	Diodes/Zetex, 2N7002-7-F
15	1	RSNS	RES., LRC 0.020Ω 1.0W 1% 2010	IRC, LRF20 10LF-01-R020-F
16	1	R1	RES., CHIP 51Ω 0.1W 5% 0603	Vishay, CRCW060351R0JNEA
17	1	R2	RES., CHIP 147k 0.1W 1% 0603	Vishay, CRCW0603147KFKEA
18	4	R3, R5, R7, R9	RES., CHIP 3.3k 0.1W 5% 0603	Vishay, CRCW06033K30JNEA
19	3	R4, R6, R8	RES., CHIP 100k 0.1W 5% 0603	Vishay, CRCW0603100KJNEA
20	1	R10	RES., CHIP 3k 0.1W 1% 0603	Vishay, CRCW06033K00FKEA
21	0	R11, R12	RES, 0603	Opt
22	1	R14	RES, 0Ω, 0603	Vishay, CRCW0603000JNEA
23	3	R15, R16, R17	RES., CHIP 5.1k 0.1W 5% 0603	Vishay, CRCW06035K10JNEA
24	1	U1	I.C., POWER MONITOR, DFN16DE-4X3	Linear Technology, LTC2946IDE
25	1	U2	I.C., SERIAL EEPROM TSSOP-8	Microchip, 24LC025-I/ST
26	1	Y1	XTAL, 4 MHz, Y-ABLS	Abracon Corp., ABLS-4.000MHz-B2-T
28	3	SHUNTS AS SHOWN ON ASSY DWG	SHUNT, 2mm CTRS.	Samtec 2SN-BK-G
29	4	MH1–MH4	STAND-OFF, NYLON 0.25"	Keystone, 8831 (SNAP ON)

SCHEMATIC DIAGRAM

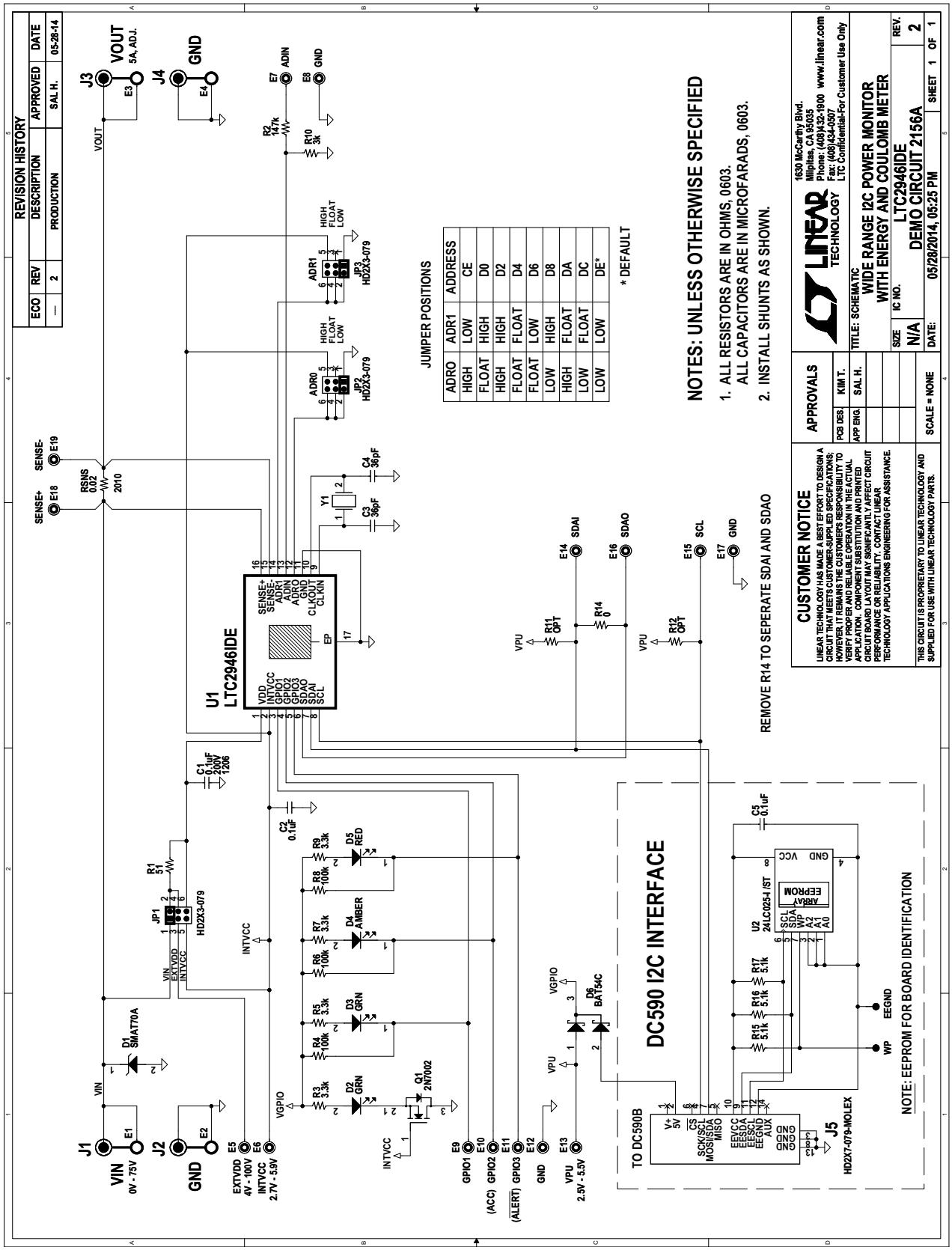


Figure 21. DC2156A Demo Circuit Schematic

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