

DESCRIPTION


Demonstration circuit 907 includes six different Current Sense circuits featuring the LTC6102/6101, LT6100, LT1787, LTC2054, and LTC2439-1. The general organization of the latest version, DC907A-B, is shown in Figure 1. The original version, DC907A-A, provided the A-grade LTC6101 instead of the ultra-precise LTC6102, but with the same basic functionality. The DC907A-B may be used with the IsenseB.exe software executable or stand-alone (for DC907A-A, use Isense.exe instead). The balance of this Quick Start Guide will refer to the newer version, but unless indicated, will be valid for the older combination as well.

Operation with PC software requires the use of USB interface controller, DC590B. In stand-alone operation, the LTC6102, LTC6101, LT6100, and LT1787 circuits will power up from the positive power source voltage(s) being monitored. The LTC2054 circuit (negative supply monitor), requiring an additional positive supply, is most

conveniently used in the USB-powered environment (the LTC2439-1 Analog-to-Digital connection requires the DC590B and software).

Each of the six current sense circuits operate with their own dedicated sense resistor and I/O connections, and may all be operated concurrently. A V_{IN} , V_{OUT} , and GND banana-jack connection is provided for each sense circuit to make evaluation connections simple. Each circuit represents a typical application solution and provides operating characteristics as shown in the Performance Summary table. For convenience, digitized voltage readouts are provided for each circuit, along with the current measurements.

Design files for this circuit board are available. Call the LTC factory.

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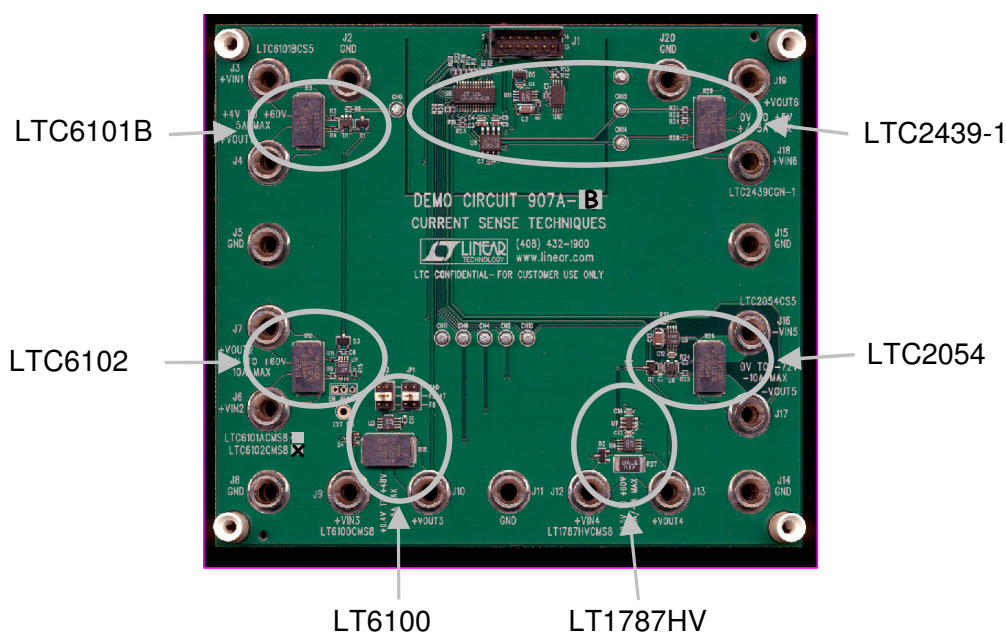


Figure 1. General Layout of DC907A-B

LTC6102/6101, LT6100, LT1787, LTC2054, AND LTC2439-1

PERFORMANCE SUMMARY

Specifications are at $T_A = 25^\circ\text{C}$

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
V_{IN}	Input Voltage Compliance Range	LTC6101B	4		60	V
		LTC6101A (DC907A-A only)	4		60	V
		LTC6102 (DC907A-B only)	4		60	V
		LT6100	6.4		48	V
		LT1787HV	2.5		60	V
		LTC2054	-72		0	V
		LTC2439-1	0		5	V
V_{OS}	Input Offset Accuracy	LTC6101B			± 0.45	mV
		LTC6101A (DC907A-A only)			± 0.3	mV
		LTC6102 (DC907A-B only)			± 0.01	mV
		LT6100			± 0.3	mV
		LT1787HV			± 0.15	mV
		LTC2054			± 0.003	mV
		LTC2439-1			± 0.005	mV
I_{OUT}	Output Current Readout Accuracy (using supplied resistors)	LT6100, LTC2439-1			± 1.5	%
		Others			± 3	%
I_{OUT}	Output Current Readout Range (using supplied resistors)	LTC6101B	0		5	A
		LTC6101A (DC907A-A only)	0		10	A
		LTC6102 (DC907A-B only)	0		10	A
		LT6100	0		5	A
		LT1787HV	-1		2	A
		LTC2054	-10		0	A
		LTC2439-1	-5		5	A
V_{OUT}	Output Voltage Readout Accuracy (using supplied resistors)				± 2	%
F_{SAMPLE}	Update Rate of Readouts	Acquiring from all circuits		1		Hz

OPERATING PRINCIPLES

The basic method of current sensing in this demo circuit collection is the use of a precision low-value resistance inserted into the current path to be monitored. According to Ohm's Law, the voltage drop across the "sense" resistance will be proportional to the current flow:

$$V_{SENSE} = I_{SENSE} \cdot R_{SENSE}$$

The circuits in DC907 show various solutions to scaling and level-translating the small V_{SENSE} signal to a level appropriate for an analog-to-digital converter (ADC) input.

In one circuit, the 5V compliance window of an LTC2439-1 high-resolution differential-input ADC is used to directly digitize V_{SENSE} without any additional components. In low-voltage applications, this can often be the best method to use. Since this is an inherently bidirectional readout, it is useful in monitoring charge/discharge of low-voltage power cells, for example.

In telecom applications with -48V power sources to monitor, special translation methods are needed to accommodate the wide range, below ground voltage compliance that is required. One such application is demonstrated on DC907 using the ultra-precise LTC2054

LTC6102/6101, LT6100, LT1787, LTC2054, AND LTC2439-1

operational-amplifier to detect the V_{SENSE} signal. The configuration uses the amplifier to control a transistor conductance, forming a precision voltage-to-current conversion. The controlled current is then drawn from a load resistor returned to a potential above ground, thus the controlled current is reconverted to a voltage-drop that is in the working range of the ADC. The overall circuit function provides unidirectional voltage amplification that is essentially as accurate as the resistors chosen in the circuit. Power is provided to the LTC2054 by a locally connected wide input-range 5V regulator (LT3010-5), so that the amplifier “rides” on the negative power feed.

For wide-range bidirectional current monitoring, the LT1787HV circuit is useful to consider. This part performs a voltage-to-current-to-voltage operation similar to the previous method described, but is completely integrated and suited to positive voltage applications. This part has a fixed gain of 8 and an excellent offset-error specification.

Another fully integrated positive monitor is the LT6100. This unidirectional sense amplifier provides several pin-

strappable gains. This part is unusual in that it is powered from a low voltage and the sense inputs operate at higher potentials than the supply. Additionally, the current in the sense pins remains at a vanishingly small level even when the power to the part is off, making it attractive in battery applications.

For positive unidirectional monitoring, the most flexible parts are the LTC6101 and LTC6102. These use another voltage-to-current-to-voltage type function, but the gain resistors are provided by the user, so the gain and accuracy of the circuit can be tailored to the application. DC907A-B provides circuits for both the LTC6101B and LTC6102 parts. For the more precise LTC6102 device, the sense resistance is lower (and gain higher) to demonstrate additional useful measurement range that the part offers.

The LTC2439-1 ADC previously mentioned is also used to digitize the current and voltages for all the other current-sense sub-circuits on DC907.

The Bill-of-Material and electrical Schematic diagram of DC907 are shown in Figures 17 and 18, respectively.

QUICK START PROCEDURE FOR COMPUTER-BASED EVALUATION

Demonstration circuit 907 is easy to set up to evaluate the performance of the LTC6102/6101, LT6100, LT1787, LTC2054, and LTC2439-1 using the QuickEval™ USB adapter and a dedicated software executable.

For stand-alone evaluation, relevant test signals can be measured at various test-turrets as described in later sections. The data acquisition rate of the ADC used in DC907 does not necessarily reflect the available bandwidth of the monitor signal being evaluated. An oscilloscope and load step producing equipment are required for detailed time-domain response evaluations.

Follow the procedure below for all part evaluations using the USB adapter:

1. Obtain DC590B and download the IsenseB.exe software. Use Isense.exe for the DC907A-A version.
2. Connect J3 on the DC590B QuickEval™ USB Controller to a host PC using the supplied USB interface cable.
3. Connect DC907 J1 to the DC590B USB Controller J4 using the supplied 14-wire ribbon cable. Start the IsenseB.exe application and the user screen for the DC907 will appear as shown in Figure 2. The application will automatically abort if either of the DC590B cables are not connected or the DC907 version does not correspond correctly with the application.
4. This completes the setup of the data-acquisition functionality of the DC907. The following sections detail the hookup and operation specific to each evaluation sub-circuit. Refer to the DC907 schematic diagram in Figure 18 to understand each specific sub-circuit implementation on the demo board.

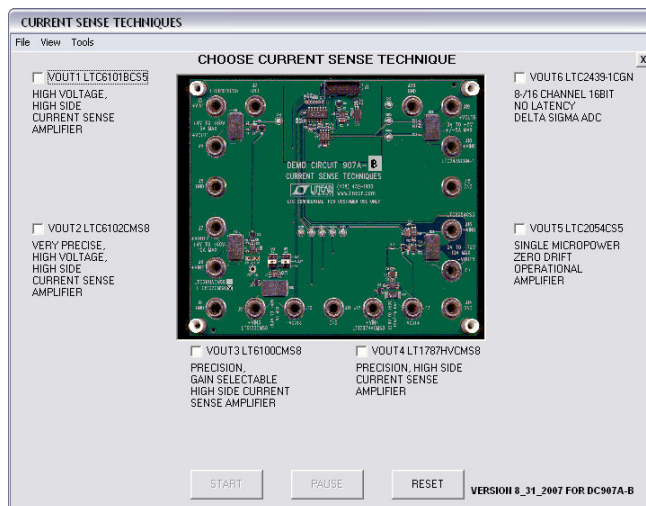


Figure 2. IsenseB.exe Startup Window when the DC907A-B Current Sense Demo Board is Properly Connected.

LTC6102/6101, LT6100, LT1787, LTC2054, AND LTC2439-1

EVALUATION OF THE LTC6101B

The LTC6101B is the SOT-23 device (U1) in the upper left corner of DC907. Perform the following steps to properly connect and operate this demo sub-circuit:

1. Refer to Figure 3 for the following connections.
2. Connect a power source (between 4V and 60V) to J3 (+VIN1), with a power return to J2 (GND). If desired, a current measuring instrument may be placed in series with the power connection as shown.
3. Connect a load to J4 (+VOUT1) with a current return to J5 (GND). Be sure the load current will not exceed the indicated capability of 5A, or component overheating and/or damage to the circuit could occur (this limitation is due to component selections used and not the LTC6101B specifically).
4. Mouse-click a check in the VOUT1 LTC6101BCS5 enable box and then mouse-click the START box. The window will then show, as in Figure 4, a continuously updated current and voltage as furnished to the load connections. To suspend updating, mouse-click the PAUSE box. The RESET box returns the program to the initial setup state so that other demo sub-circuits can be activated, etc. A red readout represents an out-of-range result or condition that may be beyond safe limits. A yellow readout is acceptable, but indicates being near a limit. Green readouts are well within nominal conditions.
5. For time-domain measurements and/or stand-alone evaluation, the current-monitor output signal is available on the CHO turret as indicated in Figure 3.

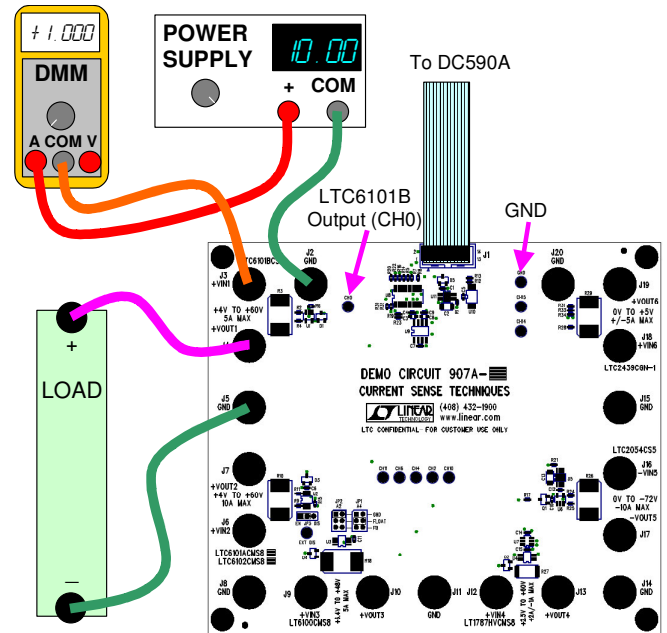


Figure 3. LTC6101B Power and Load Connections

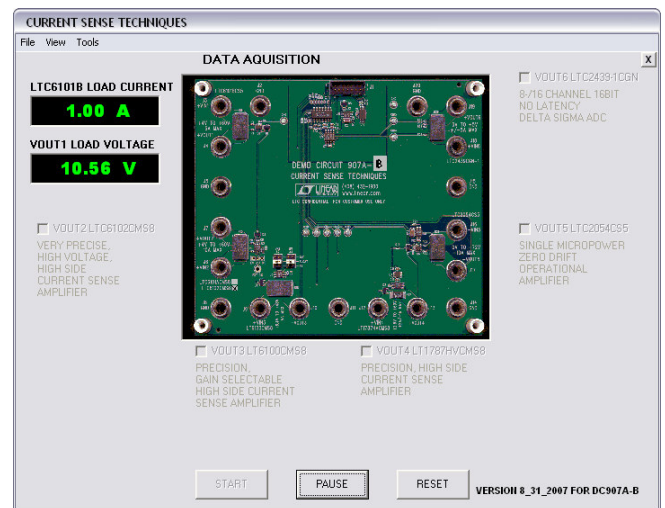


Figure 4. LTC6101B IsenseB.exe display (Current and Voltage at +VOUT1)

LTC6102/6101, LT6100, LT1787, LTC2054, AND LTC2439-1

EVALUATION OF THE LTC6102 (OR LTC6101A IN DC907A-A)

The LTC6102 is the MSOP-8 device (U2) in the lower left-hand side of DC907A-B. In DC907A-A this device is the LTC6101A, performing the same function (but with less precision). Perform the following steps to properly connect and operate this demo sub-circuit:

1. Refer to Figure 5 for the following connections.
2. Connect a power source (between 4V and 60V) to J6 (+VIN2), with a power return to J8 (GND). If desired, a current measuring instrument may be placed in series with the power connection as shown.
3. Connect a load to J7 (+VOUT2) with a current return to J5 (GND). Be sure the load current will not exceed the indicated capability of 10A, or component overheating and/or damage to the circuit could occur (this limitation is due to component selections used and not the LTC6101 or LTC6102 specifically).
4. Mouse-click a check in the VOUT2 LTC6102CMS8 enable box and then mouse-click the START box to begin data-acquisition (with DC907A-A and Isense.exe, this field is labeled for the LTC6101ACMS8). The display will then show, as in Figure 6, a continuously updated current and voltage as furnished to the load connections. To suspend updating, mouse-click the PAUSE box. The RESET box returns the program to the initial setup state. A red readout represents an out-of-range result or condition that may be beyond safe limits. A yellow readout is acceptable, but indicates being near a limit. Green readouts are well within nominal conditions.
5. For time-domain measurements and/or stand-alone evaluation, the current-monitor output signal is available on the CH2 turret as indicated in Figure 5.

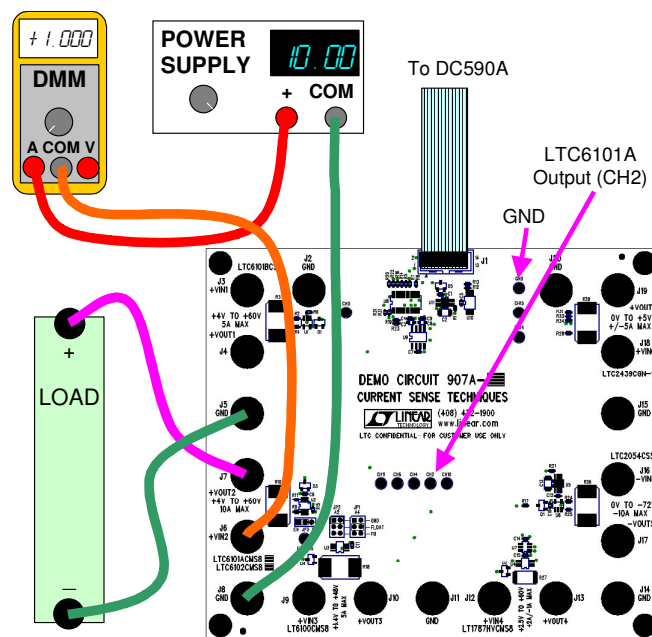


Figure 5. LTC6102 Power and Load Connection

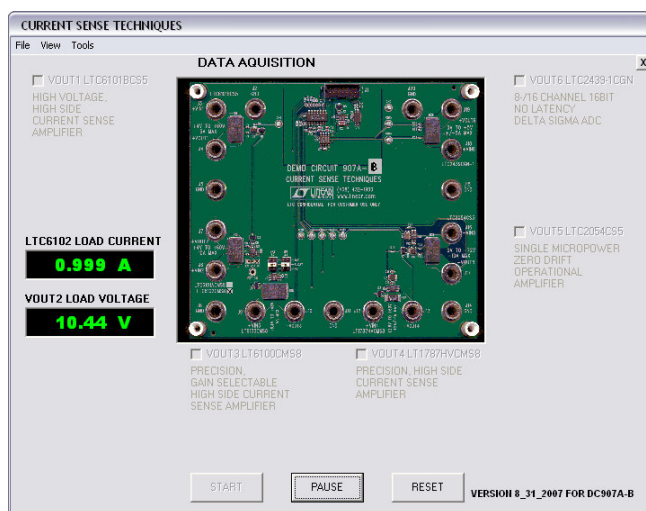


Figure 6. LTC6102 IsenseB.exe display (Current and Voltage at +VOUT2)

LTC6102/6101, LT6100, LT1787, LTC2054, AND LTC2439-1

EVALUATION OF THE LT6100

The LT6100 is the MSOP-8 device (U3) in the left bottom side of DC907. Perform the following steps to properly connect and operate this demo sub-circuit:

1. Refer to Figure 7 for the following connections.
2. Connect a power source (between 6.4V and 48V) to J9 (+VIN3), with a power return to J8 (GND). If desired, a current measuring instrument may be placed in series with the power connection as shown.
3. Connect a load to J10 (+VOUT3) with a current return to J11 (GND). Be sure the load current will not exceed the indicated capability of 5A, or component overheating and/or damage to the circuit could occur (this limitation is due to component selections used and not the LT6100 specifically).
4. Mouse-click a check in the VOUT3 LT6100CMS8 enable box and then select a gain of 10 from the pop-up menu list. Set or verify that the JP1 and JP2 configuration matches the pop-up drawing and mouse-click the OK box. Mouse-click the START box to begin data-acquisition. The IsenseB.exe presentation will then show, as in Figure 8, a continuously updated current and voltage as furnished to the load connections. To suspend updating, mouse-click the PAUSE box. The RESET box returns the program to the initial setup state. A red readout represents an out-of-range result or condition that may be beyond safe limits. A yellow readout is acceptable, but indicates being near a limit. Green readouts are well within nominal conditions.
5. For time-domain measurements and/or stand-alone evaluation, the current-monitor output signal is available on the CH4 turret as indicated in Figure 7.

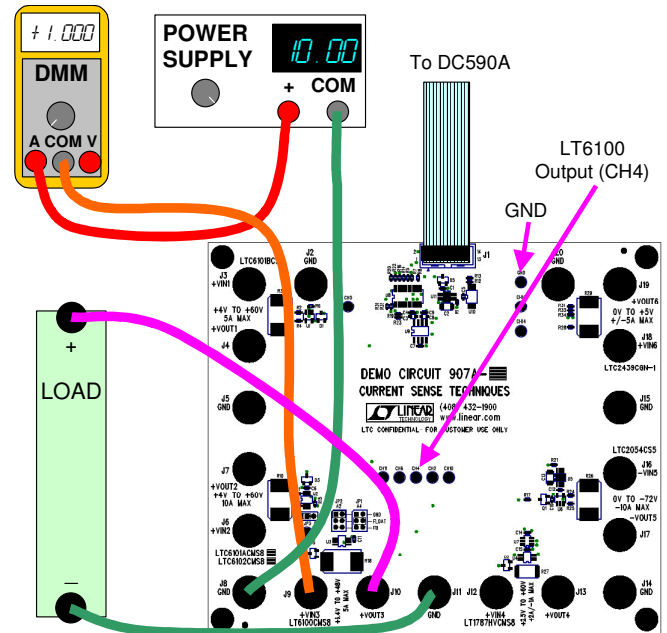


Figure 7. LT6100 Power and Load Connection

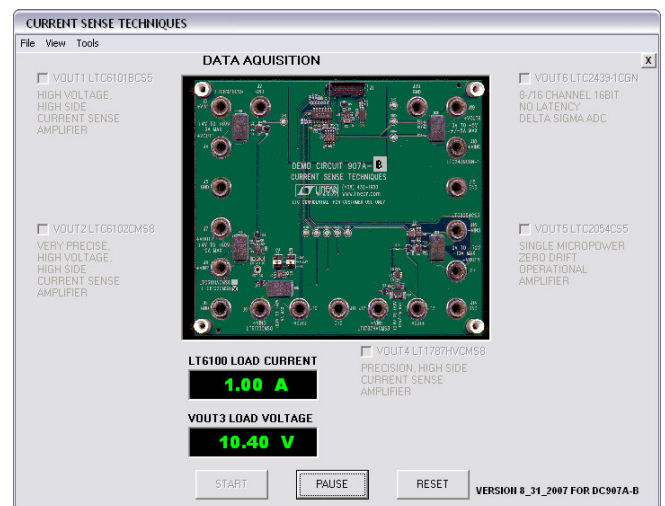


Figure 8. LT6100 IsenseB.exe display (Current and Voltage at +VOUT3)

LTC6102/6101, LT6100, LT1787, LTC2054, AND LTC2439-1

EVALUATION OF THE LT1787HV

The LT1787HV is the MSOP-8 device (U4) in the right bottom side of DC907. Perform the following steps to properly connect and operate this demo sub-circuit:

1. Refer to Figure 9 for the following connections.
2. Connect a power source (between 2.5V and 60V, at least 3V to properly power-up ancillary circuitry on the DC907 in stand-alone evaluation) to J12 (+VIN4), with a power return to J11 (GND). If desired, a current measuring instrument may be placed in series with the power connection as shown.
3. Connect a load to J13 (+VOUT4) with a current return to J14 (GND). Be sure the bi-directional load current will not exceed the indicated capability of +2A/-1A, or component overheating and/or damage to the circuit could occur (this limitation is due to component selections used and not the LT1787HV specifically).
4. Mouse-click a check in the VOUT4 LT1787HVCMS8 enable box and then mouse-click the START box to begin data-acquisition. The display will then show, as in Figure 10, a continuously updated current and voltage as furnished to the load connections. To suspend updating, mouse-click the PAUSE box. The RESET box returns the program to the initial setup state. A red readout represents an out-of-range result or condition that may be beyond safe limits. A yellow readout is acceptable, but indicates being near a limit. Green readouts are well within nominal conditions.
5. For time-domain measurements and/or stand-alone evaluation, the differential current-monitor output signal is available on the CH6/CH11 turrets as indicated in Figure 9.

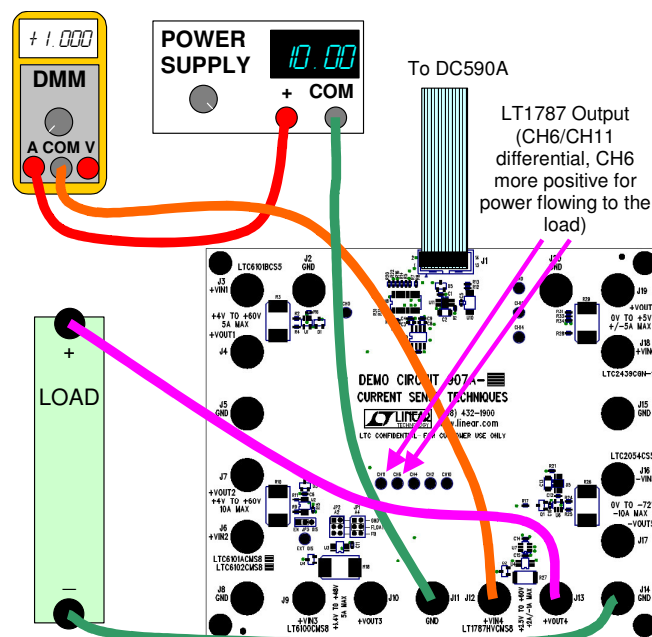


Figure 9. LT1787 Power and Load Connection

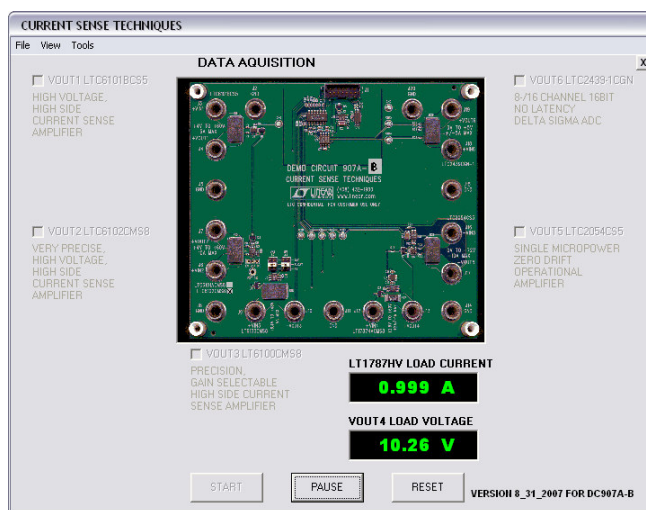


Figure 10. LT1787 IsenseB.exe display (Current and Voltage at +VOUT4)

LTC6102/6101, LT6100, LT1787, LTC2054, AND LTC2439-1

EVALUATION OF THE LTC2054

The LTC2054 is the SOT-23 device (U4) in the lower right side of DC907. Perform the following steps to properly connect and operate this demo sub-circuit:

1. Refer to Figure 11 for the following connections.
2. Connect a NEGATIVE power source (between 0.0V and -72V) to J16 (-VIN5), with a power return to J15 (GND). If desired, a current measuring instrument may be placed in series with the power connection as shown. For stand-alone tests, a positive supply of at least 6V must also be connected to J3 (or J6, J9, or J12) to properly power-up ancillary circuitry on the DC907.
3. Connect a load to J17 (-VOUT5) with a current return to J14 (GND). Be sure the load current will not exceed the indicated capability of -10A, or component overheating and/or damage to the circuit could occur (this limitation is due to component selections used and not the LTC2054 specifically).
4. Mouse-click a check in the VOUT4 LTC2054CS5 enable box and then mouse-click the START box to begin data-acquisition. The IsenseB.exe presentation will then show, as in Figure 12, a continuously updated current and voltage as furnished to the load connections. To suspend updating, mouse-click the PAUSE box. The RESET box returns the program to the initial setup state. A red readout represents an out-of-range result or condition that may be beyond safe limits. A yellow readout is acceptable, but indicates being near a limit. Green readouts are well within nominal conditions.
5. For time-domain measurements and/or stand-alone evaluation, the current-monitor output signal is available differentially on the CH10/CH11 turrets as indicated in Figure 11.

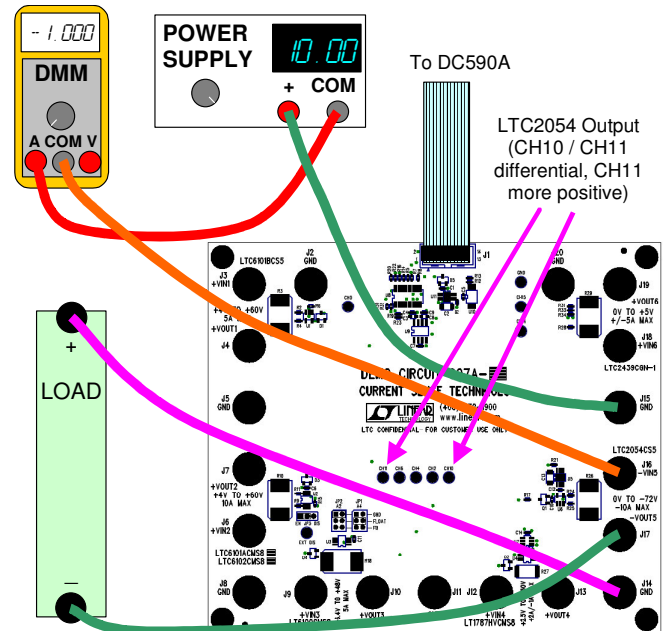


Figure 11. LTC2054 Power and Load Connection

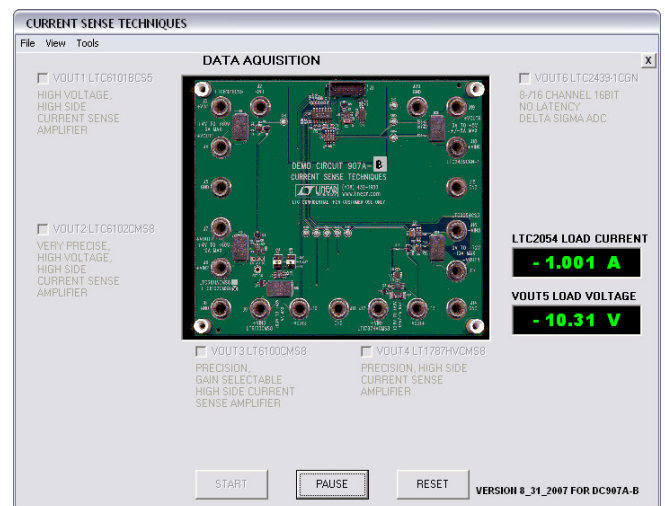


Figure 12. LTC2054 IsenseB.exe display (Current and Voltage at -VOUT5)

LTC6102/6101, LT6100, LT1787, LTC2054, AND LTC2439-1

EVALUATION OF THE LTC2439-1

The LTC2439-1 multi-channel ADC is the SSOP-28 device (U8) near the J1 ribbon connector of DC907. Perform the following steps to properly connect and operate this direct ADC connection demonstration:

1. Refer to Figure 13 for the following connections. Note that the IsenseB.exe environment is required to exercise the ADC functionality of this sub-circuit, therefore stand-alone operation is not defined.
2. Connect a low-voltage power source (between 0.0V and 5.0V) to J18 (+VIN6), with a power return to J15 (GND). If desired, a current measuring instrument may be placed in series with the power connection as shown.
3. Connect a load to J19 (+VOUT6) with a current return to J20 (GND). Be sure the bi-directional load current will not exceed the indicated capability of +5A/-5A, or component overheating and/or damage to the circuit could occur (this limitation is due to component selections used and not the LTC2439-1 specifically).
4. Mouse-click a check in the VOUT6 LTC2439-1CGN enable box and then mouse-click the START box to begin data-acquisition. The IsenseB.exe presentation will then show, as in Figure 14, a continuously updated current and voltage as furnished to the load connections. To suspend updating, mouse-click the PAUSE box. The RESET box returns the program to the initial setup state. A red readout represents an out-of-range result or condition that may be beyond safe limits. A yellow readout is acceptable, but indicates being near a limit. Green readouts are well within nominal conditions.
5. For accuracy verification measurements, the sense-resistor signal is available differentially on the CH14/CH15 turrets as indicated in Figure 13.

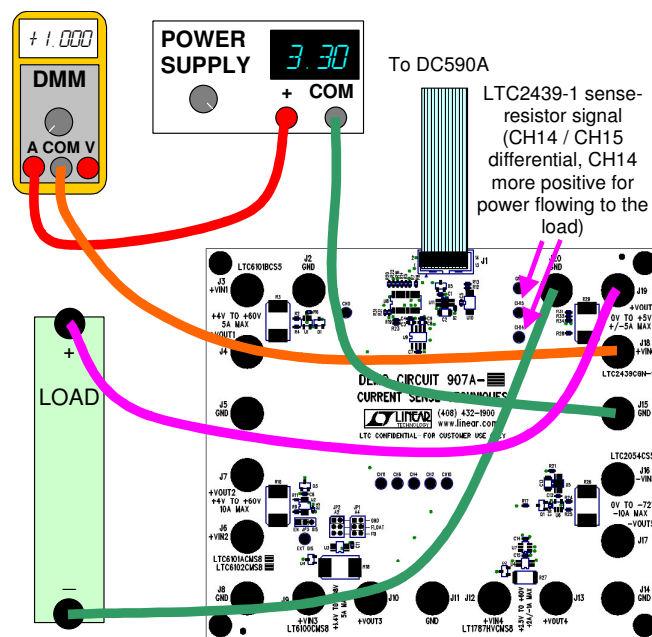


Figure 13. LTC2439-1 Power and Load Connection

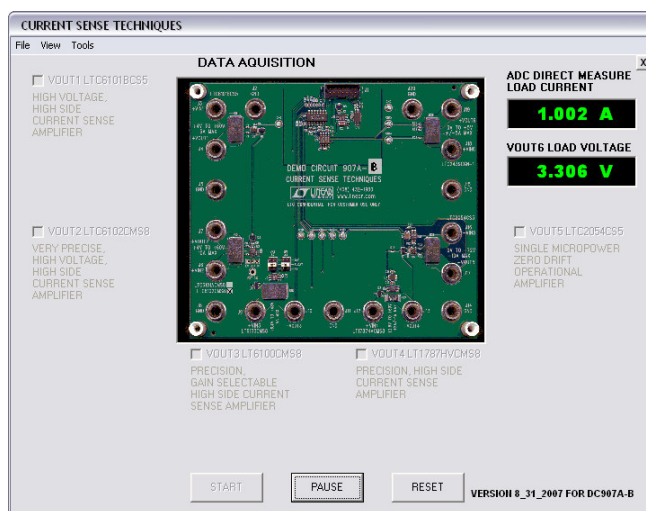


Figure 14. LTC2439-1 IsenseB.exe display (Current and Voltage at +VOUT6)

LTC6102/6101, LT6100, LT1787, LTC2054, AND LTC2439-1

MORE FEATURES OF DC907 SOFTWARE

1. In the setup screen of the DC907 software, any combination of enable boxes may be selected prior to mouse-clicking the START box. All the selected sub-circuits will display concurrently in the same fashion they did individually. Figure 15 shows a case where all six sub-circuits are active.
2. The software also provides the ability to modify scaling factors and offsets in both the current and voltage calculations of each demonstration sub-circuit. This is useful for fine-tuning the constants to perform accurate calibrations, or to allow flexible reprogramming to reflect intentional component changes. This feature is accessed during data acquisition by way of the Calibrate... selection under the Tools menu. For each active demo sub-circuit, a small calibration screen can be opened that allows modification of the four constants. Figure 16 shows a typical calibrate screen. Each constant may be modified by mouse-clicking to place an editing cursor into the appropriate field and then making a change. After all desired changes have been made, mouse-click the Set box to begin using the new values. If undesirable changes are made, the Default box may be mouse-clicked to restore factory entries (the Set box will still need to be used afterward). The Cancel box is used to simply close out a screen without taking changes. Any value changes made are lost when the setup screen RESET box is used or the DC907 program is terminated.
3. Under the View menu, there is a View Product Page selection that further expands to provide convenient web resource links for each demo sub-circuit device of the DC907.
4. Note that power for the DC907 data acquisition is derived from the USB connection, but provided by an isolated DC/DC conversion on the DC590 card. This means the potential of the GND jacks on the board is floating with respect to Earth, though each demo sub-circuit is interconnected to that same GND reference potential. This prevents ground-loop

noise from perturbing the readings and virtually eliminates any possibility of damaging the USB port of the PC due to any mis-configuration of the current monitor circuits (damage to DC907 and/or DC590 might occur, however!).

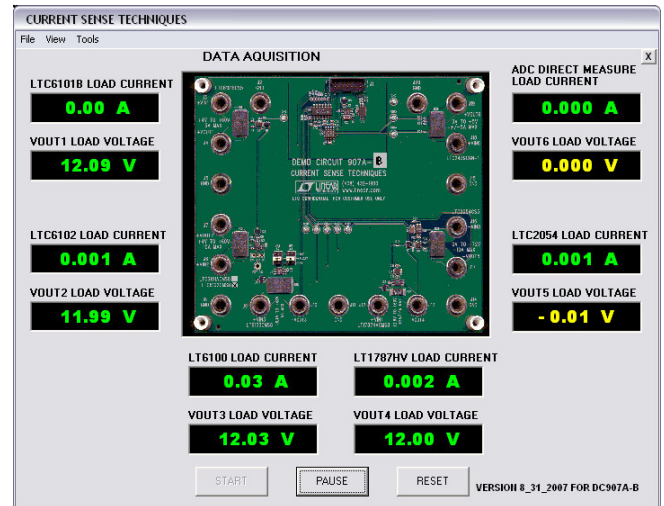


Figure 15. All Demo Sub-Circuits Displaying Concurrently

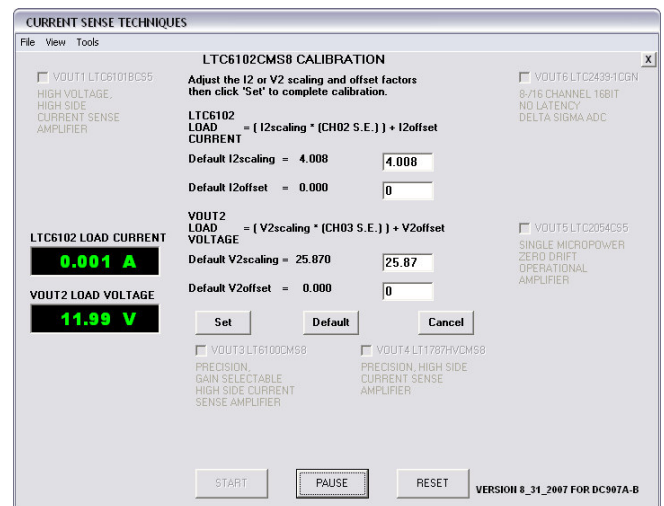


Figure 16. Individual Calibration Screens allow Tuning of the Display Functions

LTC6102/6101, LT6100, LT1787, LTC2054, AND LTC2439-1

Item	Qty	Reference	Part Description	Manufacture / Part #
1	4	C1,C12,C14,C15	CAP., X5R 1UF 6.3V, 20%, 0402	TDK, C1005X5R0J105M
2	2	C2,C13	CAP., X7R 1UF 100V, 20%, 1210	TDK, C3225X7R2A105M
3	1	C3	CAP., X5R, 10UF 6.3V, 20%, 0603	TDK, C1608X5R0J106M
4	2	C4,C10	CAP., X7R 0.01UF 16V 10%, 0402	AVX, 0402YC103KAT1A
5	4	C5,C6,C7,C9	CAP., X5R 0.1UF 16V, 20%, 0402	TDK, C1005X5R1C104M
6	0	C11	CAP., 0402	TBD
7	1	C8	CAP., X5R 4.7UF 10V, 20%, 0603	TDK, C1608X5R1A475MT
8	4	D1,D2,D3,D4	DIODE, HIGH SPEED SWITCHING, CMPD914, SOT23	CENTRAL SEMI., CMPD914
9	1	D5	DIODE, BAT54, SOT23	DIODE INC., BAT54-7
10	9	E1-E9	TESTPOINT, TURRET, 0.064"	MILL-MAX, 2308-2
11	0	E10	TESTPOINT, TURRET, 0.064"	OPT
12	2	JP1,JP2	JMP, 2X3, .079CC	COMM-CON, 2202S-06-G2
13	0	JP3	HEADER, 3PIN 1 ROW .079CC	OPT
14	2	SHUNTS FOR JP1&JP2 PIN 3&4	SHUNT, .079" CENTER	COMM-CON CCIJ2MM-138G
15	1	J1	HEADER, 2X7PIN, 0.079CC	MOLEX, 87331-1420
16	19	J2-J20	JACK, BANANA,KEY-575	KEYSTONE, 575-4
17	1	Q1	DMOSFET, VERTICAL, N-CH, ZVN3320F, SOT23	ZETEX, ZVN3320F
18	1	R1	RES., CHIP, 220 1/16W 5%,0402	VISHAY, CRCW0402220RJRT6
19	2	R2,R4	RES., CHIP, 499 1/16W 1%,0402	AAC, CR05-4990FM
20	3	R3,R18,R29	RES., 0.050 OHMS, 2W 1%, 4527	VISHAY/DALE, WSR-2-0.050-1%
21	6	R5,R14,R20,R23,R30,R35	RES., CHIP, 100K 1/16W 5%,0402	VISHAY, CRCW0402104JRT6
22	6	R6,R12,R13,R15,R33,R34	RES., CHIP, 4.99K 1/16W 1%,0402	VISHAY, CRCW04024K99FKTD
23	4	R7,R16,R22,R32	RES., CHIP, 4.02K 1/16W 1%,0402	AAC, CR05-4021FM
24	3	R8,R24,R25	RES., CHIP, 100 1/16W 5%,0402	AAC CR05-101JM
25	2	R9,R11	RES., CHIP, 200 1/16W 5%,0402	AAC, CR05-201JM
26	2	R26,R10	RES., 0.010 OHMS, 2W 1%, 4527	VISHAY/DALE, WSR-2-0.010-1%
27	1	R17	RES., CHIP, 1.24K 1/16W 1%,0402	VISHAY, CRCW04021241FRT6
28	1	R19	RES., CHIP, 1.69K 1/16W 1%,0402	AAC, CR05-1691FM
29	1	R21	RES., CHIP 1K 1/16W 5%,0402	AAC, CR05-102JM
30	1	R27	RES., 0.1 OHMS, 1%, 2512	VISHAY/DALE, WSL-2512-0.1-1%
31	2	R28,R31	RES., CHIP, 3.3K 1/16W 1%,0402	VISHAY, CRCW04023301F
32	1	U1	I.C., LTC6101BCS5, TSOT23-5	LINEAR TECH., LTC6101BCS5
33	1	U2	I.C., LTC6102CMS8, MS8	LINEAR TECH., LTC6102CMS8
34	1	U3	I.C., LT6100CMS8, MS8	LINEAR TECH., LT6100CMS8
35	1	U4	I.C., LT1787HVCMS8, MS8	LINEAR TECH., LT1787HVCMS8
36	2	U5,U11	I.C., LT3010EMS8E-5, MS8E	LINEAR TECH., LT3010EMS8E-5
37	1	U6	I.C., LTC2054CS5, SOT23-5	LINEAR TECH., LTC2054CS5
38	1	U7	I.C., LT1790BCS6-1.25, SOT23-6	LINEAR TECH., LT1790BCS6-1.25
39	1	U8	I.C., LTC2439CGN-1, SSOP16GN	LINEAR TECH., LTC2439CGN-1
40	1	U9	I.C., LT1236ACS8-5, SO8	LINEAR TECH., LT1236ACS8-5
41	1	U10	IC, 24LC025,TSSOP8	MICROCHIP, 24LC025-I /ST
42	4	STAND-OFFS ON BOTTOM SIDE	STAND-OFF, NYLON (SNAP ON), 0.25" TALL	KEYSTONE, 8831(SNAP ON)
43	1		STENCIL	STENCIL DC907A-2

Figure 17. DC907A-B Bill of Material

LTC6102/6101, LT6100, LT1787, LTC2054, AND LTC2439-1

