ANALOG DEVICES

User Guide
UG-1180

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Universal Evaluation Board for the

FEATURES

Pin accessible, standalone
Simplified operation: connect a power supply and scope and start looking at waveforms
On-board precision 5 V reference included for accurate gain measurements
Factory tested
Four optional control loops available but not necessary for operation; may be bypassed as desired
Safe: only low power circuitry is present; no accidental power discharges

ADDITIONAL EQUIPMENT NEEDED

+12 V, +5 V, −5 V bench supply: Keysight E3631 or equivalent power supply with current metering and adjustable output current-limiting
±50 mV diode emulation/current-limiting bias voltage
Oscilloscope: Tektronix DPO7104 or multichannel equivalent
DMM: 4½ digit or greater
Test jumpers with grabber or mini-gator clips
Optional: power amplifier, Li-Ion battery, current transducer (low resistance shunt)

DOCUMENTS NEEDED

data sheet

GENERAL DESCRIPTION

The AD8452-EVALZ is a platform for the , designed for investigation of the analog and pulse-width modulation (PWM) features and performance without the added complications of a driver and/or switch mode power supply (SMPS) design. For convenience, a precision 5 V reference IC and four trim pots are built in to the evaluation board, for driving the battery current and voltage ISET and VSET inputs. All device pins are accessible with test loops or probe landings.

At the same time, the AD8452-EVALZ has the flexibility to interface and drive a typical half bridge inductor input SMPS with output levels in the 1 A to 15 A range. SMPS and associated components are specified and sourced by the user.

The is intended for use as the core controller for commercial battery test and formation systems. Its advanced miniaturization and extraordinarily high level of analog precision meet the challenge of mass production of high energy density storage lithium ion packs for transportation and energy storage in homes.

Figure 1 is a photograph of the AD8452-EVALZ. When working with the evaluation board, consult the data sheet for a detailed device Theory of Operation and for additional information in conjunction with this user guide.

EVALUATION BOARD PHOTOGRAPH

Figure 1.

TABLE OF CONTENTS

REVISION HISTORY

10/2017—Revision 0: Initial Version

OVERVIEW OF THE AD8452

The AD8452 is a front-end controller for battery test or formation systems. It is a 48-lead device in a 7 mm × 7 mm LQFP package, comprised of a high performance analog section and PWM.

A block diagram is shown in Figure 2. Refer to the AD8452 data sheet for a full description.

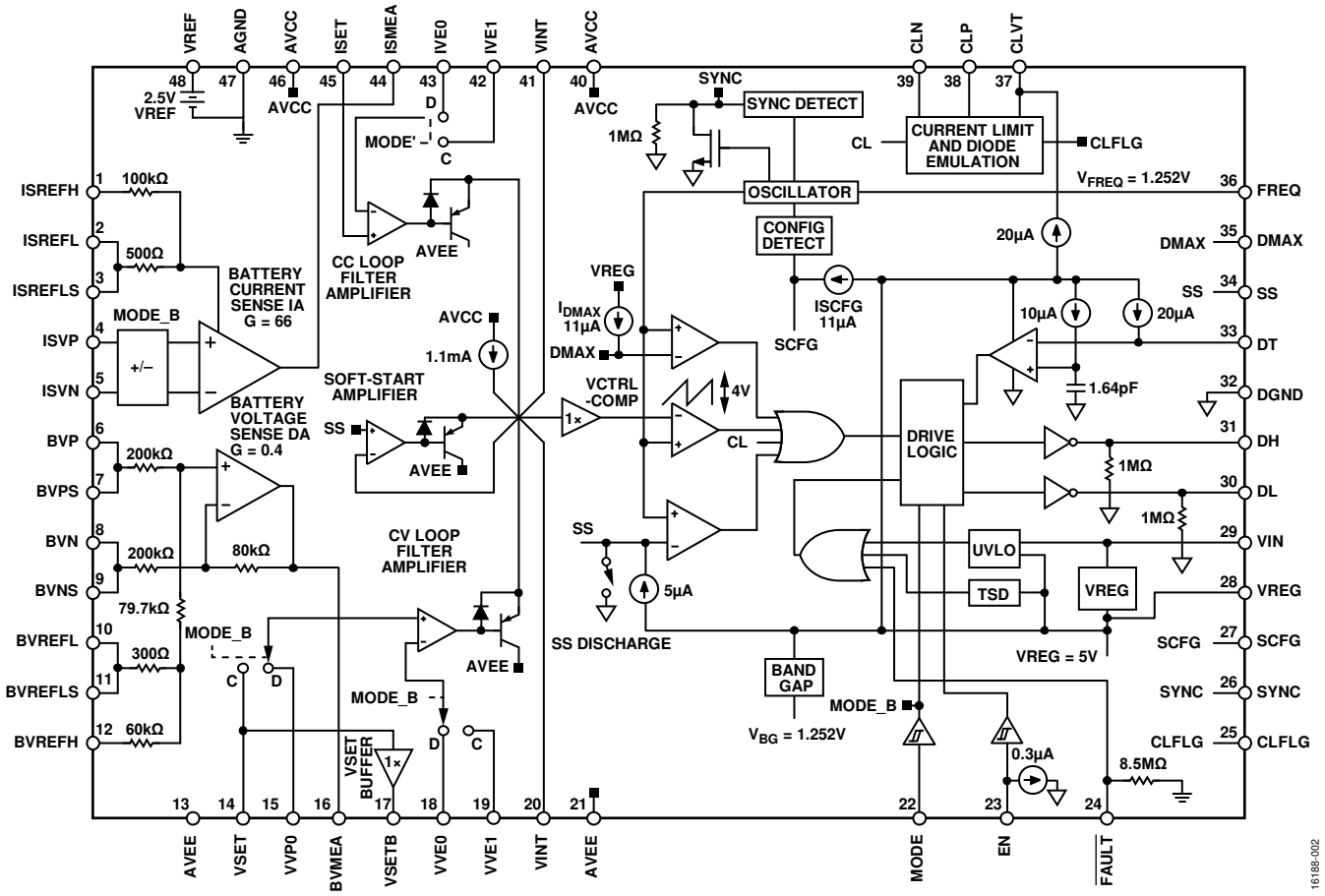

Figure 2. Detailed Block Diagram of the AD8452 Showing the High Performance Analog Section and the PWM Section

EVALUATION BOARD HARDWARE

Figure 3 is a system level block diagram comprising three functional system level block diagrams, an AD8452-EVALZ block diagram, including its user adjustable current and voltage control compensation matrix, and a simple precision reference (an ADR4550) for driving current and voltage inputs throughout the PWM conversion process to the outputs DH and DL.

The balance of the large signal system in Figure 3 is user supplied and consists of the metal-oxide semiconductor field effect transistor (MOSFET) driver and user supplied SMPS, an inductor-capacitor (L-C) output filter with a current limiting resistor (RCL), and a current sense shunt.

A description of some simple experiments with the AD8452 follows. The AD8452-EVALZ can be connected as the analog and PWM small signal digital controller of a complete battery formation system, allowing users to explore the AD8452 functions in detail, with an emulated system input/output (I/O) provided. The board can also be operated as a channel controller for a power channel custom designed to the unique needs and requirements of the user.

For more system information on system applications, including communication links, see the AD8452 UG-1181.

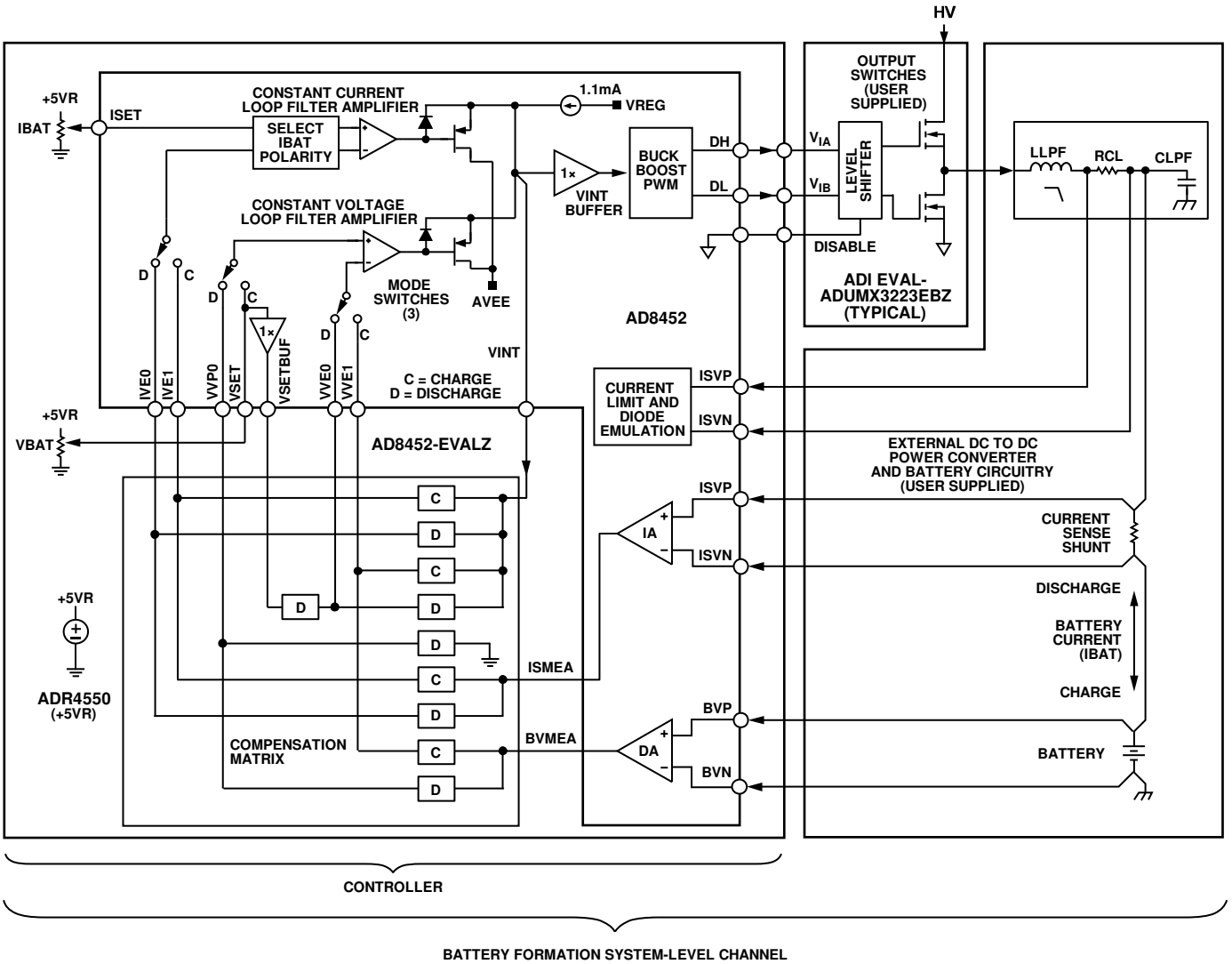

Figure 3. Block Diagram Showing the AD8452 and External Circuitry Boundaries

TEST SETUP

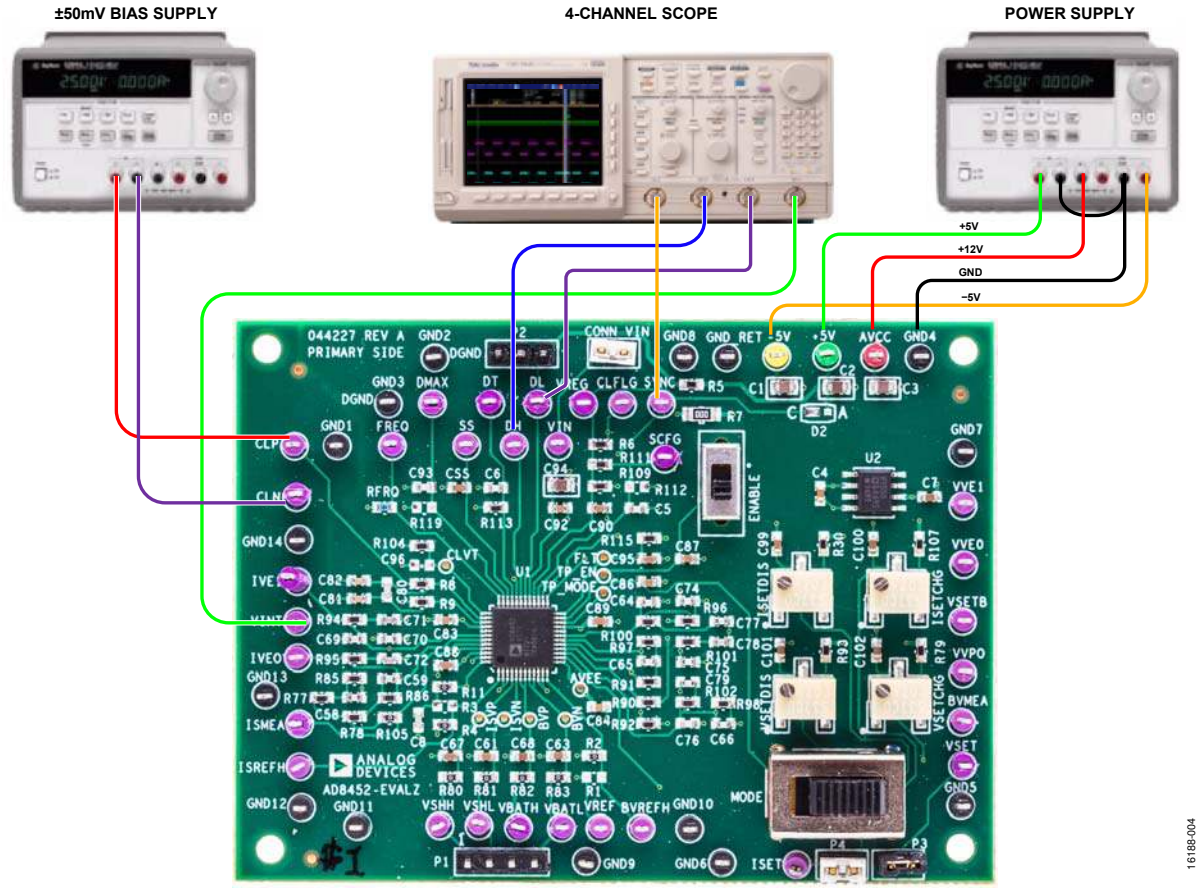

Figure 4. Typical Setup for the AD8452-EVALZ Bench Test

Jumper Positions

There are five 2-pin jumpers installed on the evaluation board (see Figure 5). Table 1 shows their location and function.

Table 1. Jumper Locations and Functions

Location	Function
P3	VSET input.
P4	ISET input.
CONN_VIN	Connects AVCC to VIN.
P1-1 and P1-2	Shorts ISVP and ISVN to keep instrumentation amplifier voltage input at 0 V.
P1-3 and P1-4 Inserted for Charge Mode Test	Shorts BVP and BVN to keep difference amplifier input at 0 V.
P1-3 and P1-4 Removed for Discharge Mode Test	Mimics the state of battery conditions during a discharge cycle by simulating a fully charged battery. The lower value VSET voltage establishes the withdrawal current from the higher voltage battery.

DC Testing—Board Setup and Power Supply Currents

With the evaluation board set up as shown in Figure 4, the power supply currents are those shown in Table 2. The test loops in Figure 4 are color coded: black is for ground; red for positive voltages; orange for negative voltages; green for 5 V logic supplies; and purple corresponds to the signal test points shown in the schematic (see Figure 8). When power is applied to the evaluation board, there can be a momentary current surge, especially if the filter capacitors are not recently charged. This behavior is normal, and the supply currents settle to their typical values in a few seconds. It is strongly recommended that the power supply used for experimenting feature current metering and current-limiting.

Table 2. Power Supply Load Currents by Supply Pin

Supply (V)	Power Supply Current Limiting (Optional) (mA)	Load Current (Typical)
AVCC (+12)	20	+9 mA
–5	10	–4 mA
+5	5	+1 µA

Pin VIN on the AD8452 (U1) is connected by Jumper CONN_VIN to Pin AVCC and the AVCC net on the evaluation board, and provides power to the PWM and 5 V low dropout (LDO) regulator sections. 5 V is externally available at Pin VREG for low current applications such as pull-up resistors, but loading of VREG should not exceed 5 mA. Jumper CONN_VIN can be removed if the user needs to test the device with higher supply voltages. Otherwise, it is recommended to remain in place.

5 V Reference Supply and Input Trimmers

The AD8452-EVALZ includes the ADR4550 on-board 5 V reference (U2) for a stable input source.

Four trimmers provide independent control voltages for current and voltage in both charge/discharge modes. This makes switching from charge to discharge possible without having to reset the current or voltage control levels. These levels are factory set and are not likely to require adjustment. Charge current, discharge current, and charge voltage are set at 2.5 V. Discharge voltage is set for 1.5 V so that tests of the PWM function can occur with the expected polarity of battery voltage and current flow.

Current Limit Threshold Voltage (at Pin CLVT)

The CLVT pin voltage is generated by forcing 20 µA through Resistor R104 (4.99 kΩ). When probing Pin CLVT to measure the voltage, look for a small bare copper dot above and to the left of U1, Pin 37. The voltage is 105 mV + 30 mV or − 25 mV To disable the current limit function, pull Pin CLVT high.

Instrumentation Amplifier (In-Amp)

When installed as intended in a system, the in-amp measures bidirectional battery current, and is controlled by the MODE function. If the mode switch is in charge (that is, the handle is to the right), Pin ISMEA measures 0.660 V with a 10 mV voltage from VSHH to VSHL. When the mode switch is in discharge mode, the voltage at ISMEA still reads 0.660 V, because the mode switch reverses the input voltage polarity. However, the voltage at ISMEA reads −0.660 V if the 10 mV input voltage polarity is reversed and the mode switch remains in charge mode. This type of test is useful to verify that the in-amp output swings both positive and negative outputs.

The inputs to the in-amp are floating. If the output voltage floats high, connect VSHL to a nearby ground pin with a grabber clip jumper or a small soldered wire.

Difference Amplifier

The difference amplifier measures battery voltage. The polarity of the voltage is always positive; however, the difference amplifier gain is <1 to reduce the integrator voltage to a value within the linear range of the integrator.

To exercise the difference amplifier, set the mode switch to the charge position (switch handle to the right), apply 1 V dc from a voltage source from VBATH to VBATL, and connect VBATL to a nearby ground pin with a grabber clip jumper). Verify that the output at BVMEA is 0.4 V ± 0.4 mV.

Pin FREQ and Pin SYNC

Apply power and activate the enable switch (move the switch handle to the lower position). Connect a digital multimeter (DMM) probe to Pin FREQ and verify that the dc voltage reads 1.25 V.

Under the same conditions, connect a scope probe to Pin SYNC. Observe a square wave with a period of 10 µs ± 1 µs.

Soft Start—DC at Pin SS and Turn On Ramp

Activate the enable switch. After 1 second, verify that the dc voltage on Pin SS reads 4.9 V to 5 V.

The only way to change the turn on delay of the AD8452 is to change Capacitor CSS. Use a good quality ceramic capacitor such as an NP0/C0G or a high dielectric X7 style, because the capacitor ramp time is a function of the 20 µA current source. Less stringent performance capacitors such as the Y5 series are sufficient for many applications, but can exhibit enough leakage to fail before the maximum applied voltage is realized. An easy calculation for capacitor value is to scale the capacitor by the desired ramp time. The default ramp time for the capacitor installed in the evaluation board is 1 sec, achieved with a 1 µF capacitor. To reduce the time by a factor of 10, exchange the 1 µF capacitor for a 0.1 µF model.

Test of PWM and Driver Outputs DH and DL for Charge and Discharge Modes

The following two experiments demonstrate the timing and waveform details of the AD8452 in real time, using a scope, with file storage capabilities for future reference. Figure 5 shows a photograph of the setup for the experiment, and Figure 6 and Figure 7 show a 100 kHz clock and PWM outputs of the high and low gate drivers (DH and DL, respectively), along with the controlling analog signal (VINT). Two slightly different setups demonstrate the operation of the AD8452 in charge and discharge modes.

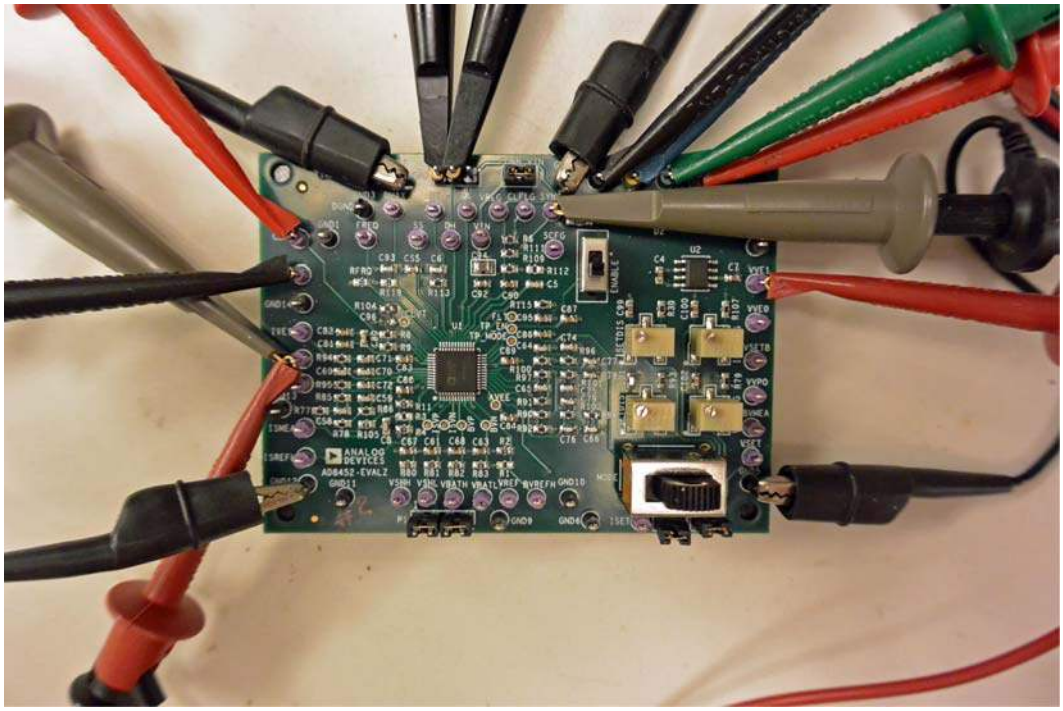

Figure 5. Typical Test Setup for Scope Observations

Charge Mode

Connect the vertical inputs of a 4-channel oscilloscope to the four outputs of the AD8452-EVALZ (listed in Table 3). The Pin DH and Pin DL waveforms are the control signals for the output power MOSFET switches.

Table 3. Scope Connections to Observe Driver Waveforms

Channel	Function	Pin
1	Displays the clock signal	SYNC (clock waveform)
2	High switch drive (DH)	Test Loop DH
3	Low switch drive (DL)	P2-2 (center pin)
4	Integrator output (VINT)	VINT

On the scope, set the vertical scale of all four channels to 5 V per division (5 V/div) and select Channel 1 as the trigger source. Before applying power to evaluation board, verify that the ENABLE switch is in the up position. Connect the amplifier inputs and jumpers according to the following steps:

1. Connect a jumper from the VINT test loop to the VVE1 test loop. This connection sets the gain of the constant voltage (CV) loop to unity.
2. Verify that there are shorting shunts installed from P1-1 to P1-2 and from P1-3 to P1-4. These jumpers set the output voltages V_{ISMEA} and B_{VMEA} to 0 V by ensuring that the current shunt and battery voltage inputs are 0 V.
3. Connect the positive lead from a 50 mV bias supply to Pin CLP (the current limit positive pin) to Pin CLN (the current limit negative pin).
4. Move the MODE switch to charge (switch handle to the right).
5. Enable the AD8452 by moving the ENABLE switch handle to the down position.

The output voltages appear as shown in Figure 6. Note that SYNC (Channel 1, the black pulse display) and DH (Channel 2, blue pulse display) are in phase with one another, while SYNC and DL (Channel 3, red) are 180° out of phase with one another. The antiphase relationship of DH and DL are important, because it ensures the two output devices are never switched on at the same time, and it forces current from the supply to the load (battery).

Discharge Mode

With the circuit disabled (the ENABLE switch is in the up position), follow the same steps as in the Charge Mode section, with the following exceptions:

1. Move the VINT jumper from the VVE1 test loop to the VVE0 test loop. This connection sets the CV loop gain to unity again, but in discharge mode.
2. Remove the shorting shunt from P1-3 to P1-4 and, using two jumpers, connect the VBATH test loop to 5 V, and connect the VBATL test loop to ground.
3. Reverse the polarity of the 50 mV bias supply by connecting the positive lead from the 50 mV bias supply to Pin CLN and the negative lead to Pin CLP.
4. Move the MODE switch to discharge (switch handle to the left). Enable the AD8452 by moving the ENABLE switch handle to the down position.

The output voltages appear as shown in Figure 7. Note that DL is in phase with SYNC, and DH is 180° out of phase with SYNC. This phase relationship forces current from the load (battery) back to the supply.

Another useful experiment can be performed using the same setup described previously, by changing scope settings. Instead of a 10 µs/div free running horizontal sweep, set the horizontal control to single sweep and the scale to a longer interval, such as 200 ms/div. Disable the AD8452, clear the scope screen of any prior waveforms and reenable the AD8452. Expect to see a timing sequence in which DH comes on before DL in charge mode, and the opposite in discharge mode. See the Soft Start section in the AD8452 data sheet for more details.

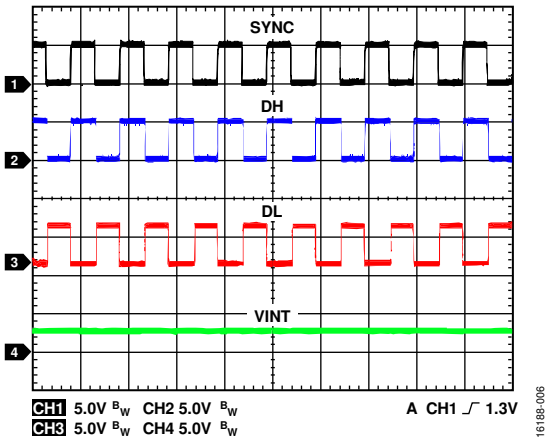

Figure 6. Operating in Charge Mode; Waveforms at the AD8452 PWM Outputs SYNC, DH, and DL, and Integrator DC Level VINT

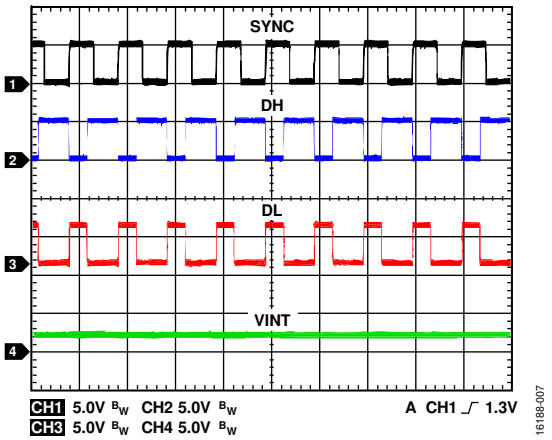

Figure 7. Operating in Discharge Mode; Waveforms at the AD8452 PWM Outputs SYNC, DH, and DL, and Integrator DC Level VINT

EVALUATION BOARD SCHEMATICS AND ARTWORK

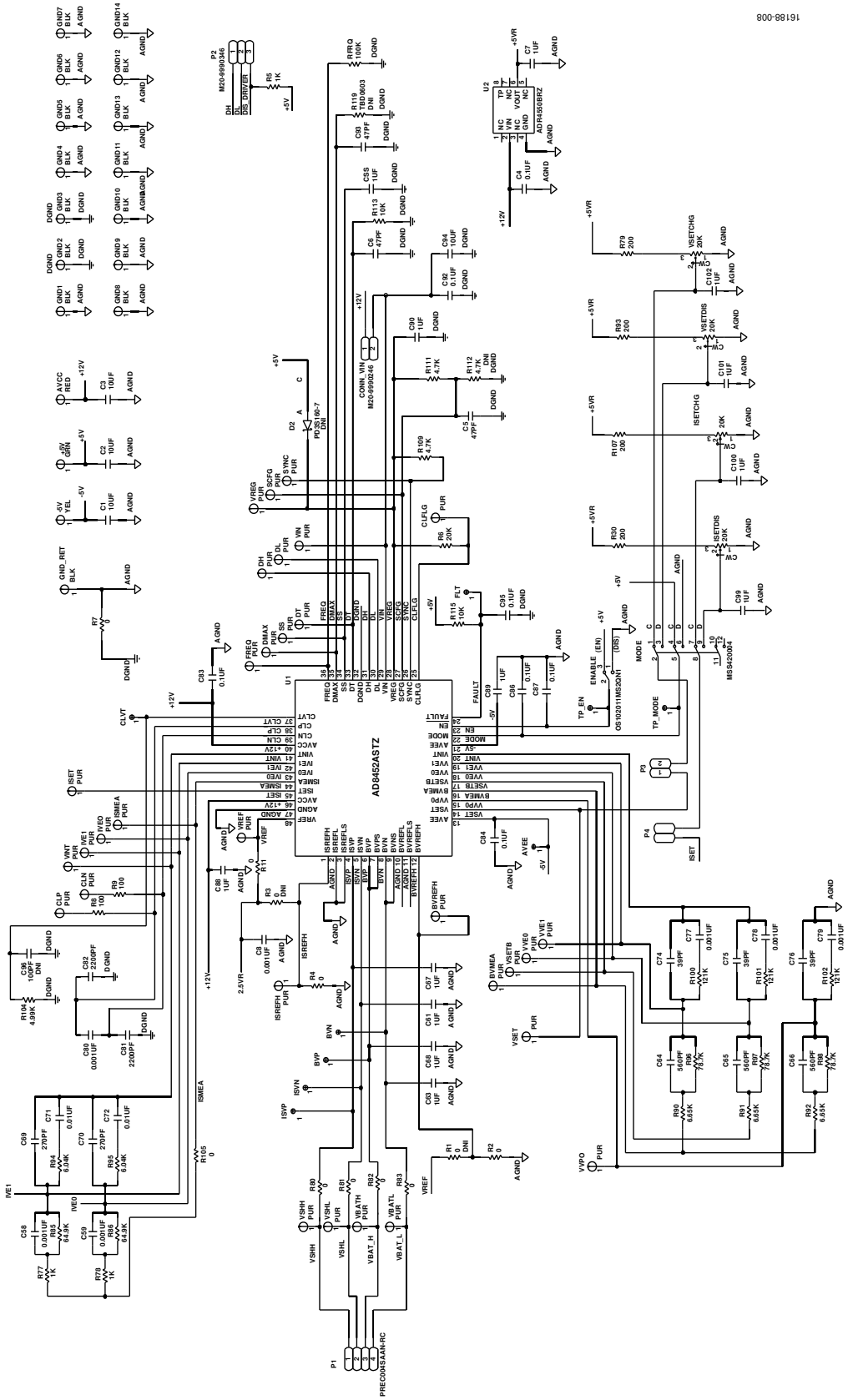

Figure 8. Schematic of the AD8452-EVALZ

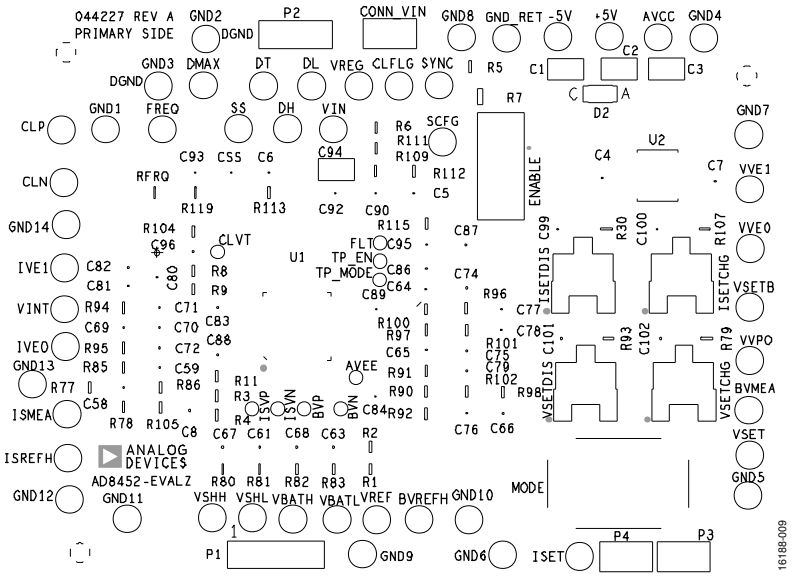

Figure 9. Primary Side Silk Screen

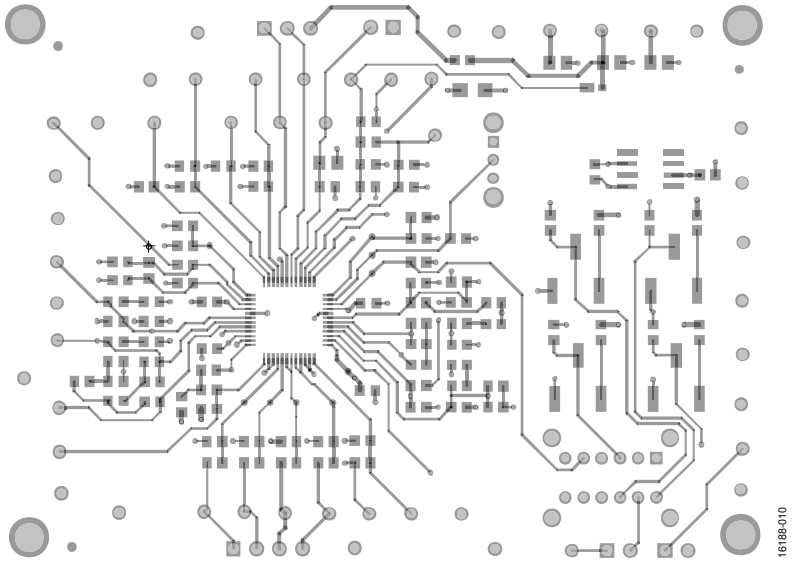

Figure 10. AD8452-EVALZ Primary Side—All Components Located on This Side

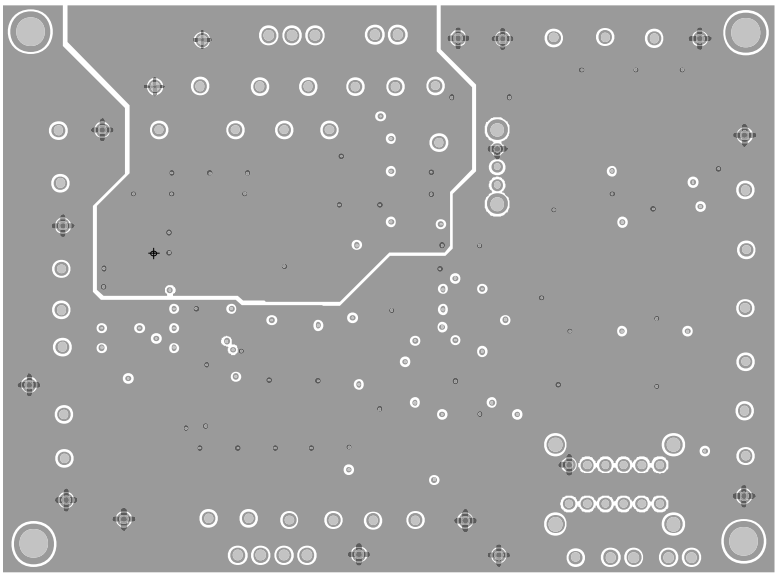

Figure 11. AD8452-EVALZ Layer Two—Ground

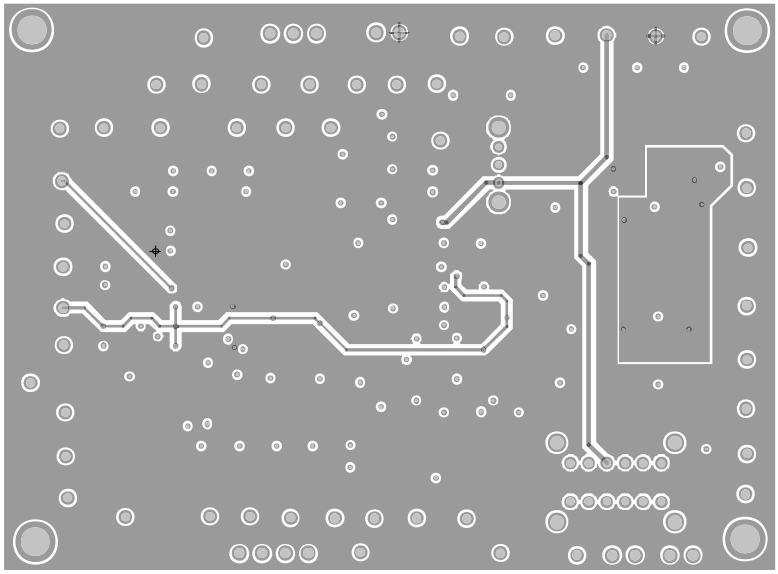

Figure 12. AD8452-EVALZ Layer Three—Power

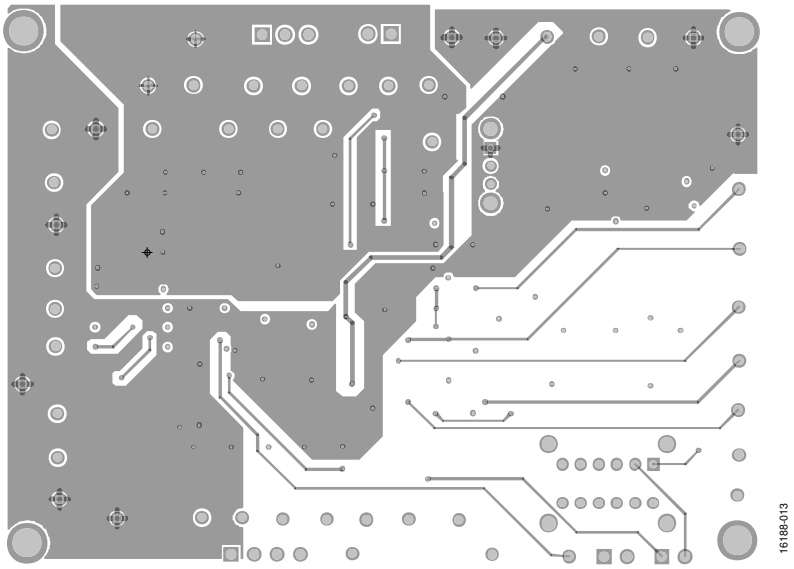

Figure 13. AD8452-EVALZ Bottom Layer—Copper

ORDERING INFORMATION

BILL OF MATERIALS

Table 4.

Reference Designator	Description	Manufacturer	Part Number
+5V	Connector, printed circuit board (PCB) test point, green	Components Corporation	TP-105-01-05
−5V	Connector, PCB test point, yellow	Components Corporation	TP-105-01-04
AVCC	Connector, PCB test point, red	Components Corporation	TP-105-01-02
BVMEA, BVREFH, CLFLG, CLN, CLP, DH, DL, DMAX, DT, FREQ, ISET, ISMEA, ISREFH, IVE1, IVEO, SCFG, SS, SYNC, VBATH, VBATL, VIN, VINT, VREF, VREG, VSET, VSETB, VSHH, VSHL, VVE0, VVE1, VVPO	Connectors, PCB test point, purple	Components Corporation	TP-105-01-07
C1, C2, C3, C94	Capacitors, ceramic, X6S, general purpose, 10 µF, 35 V, 10%	Murata	GRM21BC8YA106KE11L
C7, C61, C63, C67, C68, C88, C89, C90, C99, C100, C101, C102, CSS	Capacitors, ceramic, X5R, general purpose, 1 µF, 50 V, 10%	Taiyo Yuden	UMK107AB7105KA-T
C4, C83, C84, C86, C87, C92, C95	Capacitors, ceramic, X7R, 0603, 0.1 µF, 50 V, 10%	AVX	06035C104KAT2A
C5, C6, C93	Capacitors, ceramic, C0G, 47 pF, 50 V, 5%	AVX	06035A470JAT2A
C8, C58, C59, C77, C78, C79, C80	Capacitors, ceramic, C0G (NP0), general purpose, 0.001 µF, 50 V, 5%	Murata	GRM1885C1H102JA01D
C64, C65, C66	Capacitors, ceramic, C0G (NP0), general purpose, 560 pF, 50 V, 5%	Murata	GRM1885C1H561JA01D
C69, C70	Capacitors, ceramic, C0G (NP0), general purpose, 270 pF, 50 V, 5%	Murata	GRM1885C1H271JA01D
C71, C72	Capacitors, ceramic, C0G, 0.01 µF, 50 V, 5%	TDK	CGA3E2C0G1H103J080AA
C74, C75, C76	Capacitors, ceramic, NP0, 39 pF, 50 V, 5%	Murata	GRM1885C1H390JA01D
C81, C82	Capacitors, ceramic, chip, C0G, 0603, 2200 pF, 50 V, 5%	TDK	C1608C0G1H222J
CONN_VIN, P3, P4	Connectors, PCB header, one row, two way	Harwin	M20-9990246
ENABLE	Switch, SPDT, PCB mounted, slide	ITT	OS102011MS2QN1
GND1, GND2, GND3, GND4, GND5, GND6, GND7, GND8, GND9, GND10, GND11, GND12, GND13, GND14, GND_RET	Connectors, PCB test point, black	Components Corporation	TP-105-01-00
ISETCHG, ISETDIS, VSETCHG, VSETDIS	Resistors, 1/4 inch square, trimpot trimming, 20 kΩ, 10%	Bourns	3269W-1-203GLF
MODE	Switch slide, 4PDT	TE Connectivity	MSS420004
P1	Connector, PCB header, male, straight, 2.54 mm pitch, 3.05 mm solder tail	Sullins	PREC004SAAN-RC
P2	Connector, PCB header, 2.54 mm pitch, SIL vertical PC tail (tin)	Harwin	M20-9990346
R100, R101, R102	Resistors, precision, thick film chip, 121 kΩ, 1%	Panasonic	ERJ-3EKF1213V
R104	Resistor, precision, thick film chip, 4.99 kΩ, 1%	Panasonic	ERJ-3EKF4991V
R2, R4, R11, R80, R81, R82, R83, R105	Resistors, film, SMD, 0603, 0 Ω, 5%	Panasonic	ERJ-3GEY0R00V
R30, R79, R93, R107	Resistors, chip, SMD, 0603, 200 Ω, 1%	Panasonic	ERJ-3EKF2000V
R109, R111	Resistors, chip, 0603, 4.7 kΩ, 50 V, 1%	Bourns	CR0603-FX-4701ELF
R113, R115	Resistors, precision, thick film chip, R0603, 10 kΩ, 1%	Panasonic	ERJ-3EKF1002V
R5, R77, R78	Resistors, precision, thick film chip, R0603, 1 kΩ, 1%	Panasonic	ERJ-3EKF1001V
R6	Resistor, precision, thick film chip, 20 kΩ, 1%	Panasonic	ERJ-3EKF2002V
R7	Resistor, jumper, SMD, 1206, 0 Ω, 0%	Panasonic	ERJ-8GEY0R00V

Reference Designator	Description	Manufacturer	Part Number
R8, R9	Resistors, precision, thick film chip, R0603, 100 Ω, 1%	Panasonic	ERJ-3EKF1000V
R85, R86	Resistors, precision, thick film chip, 0603, 64.9 kΩ, 50 V	Panasonic	ERJ-3EKF6492V
R90, R91, R92	Resistors, thick film chip, 6.65 kΩ, 1%	Vishay	CRCW06036K65FKEA
R94, R95	Resistors, thick film chip, 0603, 6.04 kΩ, 75 V, 1%	Vishay	CRCW06036K04FKEA
R96, R97, R98	Resistors, precision, thick film chip, 0603, 78.7 kΩ, 50 V, 1%	Panasonic	RJ-3EKF7872V
RFRQ	Resistor, precision, thick film chip, 100 kΩ, 50 V, 1%	Panasonic	ERJ-3EKF1003V
U1	AD8452	Analog Devices	AD8452ASTZ
U2	ADR4550	Analog Devices	ADR4550BRZ

RELATED LINKS

Resource	Description
UG-1181	AD8452 Battery Testing and Formation Evaluation Board
AN-1319	Compensator Design for a Battery Charge/Discharge Unit Using the AD8450 or the AD8451

ESD Caution

ESD (electrostatic discharge) sensitive device. Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

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