ADP1653 Flash LED Driver Evaluation Board Manual

EVAL-ADP1653EB

FEATURES

Input voltage 2.7 V to 5.5 V
Boost solution supports up to 12 V
Evaluates 1 to 4 LED solutions
Configurable for 2-bit logic or I²C® interface
Jumpers for measurement of flash LED current and inductor current
TxMask for changing flash current on the fly
Evaluation software included

GENERAL DESCRIPTION

The evaluation system is composed of a motherboard and a daughterboard. The motherboard provides the I²C signals from the computer USB port and generates the I/O voltages and digital high and low signals for the daughterboard. For temperature measurement, the daughterboard can be either plugged directly into the motherboard or connected to the motherboard via the ribbon cable provided with the evaluation kit.

The motherboard features a 3.3 V regulator and a 1.8 V regulator. The jumpers on the bottom left of the motherboard set the VIC voltage, which is the I²C voltage for the control pins. Users can choose among the 1.8 V, 3.3 V, or 5 V USB or the external VBAT as the supply voltage for the daughterboard.

The daughterboard contains numerous jumpers and test points for easy evaluation of the board. Also included with the kit are two current probes that can be plugged directly into jumper heads to measure currents with current probes.

Warning

For safety reasons, do not look directly into the LEDs at close range. They are very bright and can cause eye injury.

FUNCTIONAL BLOCK DIAGRAM

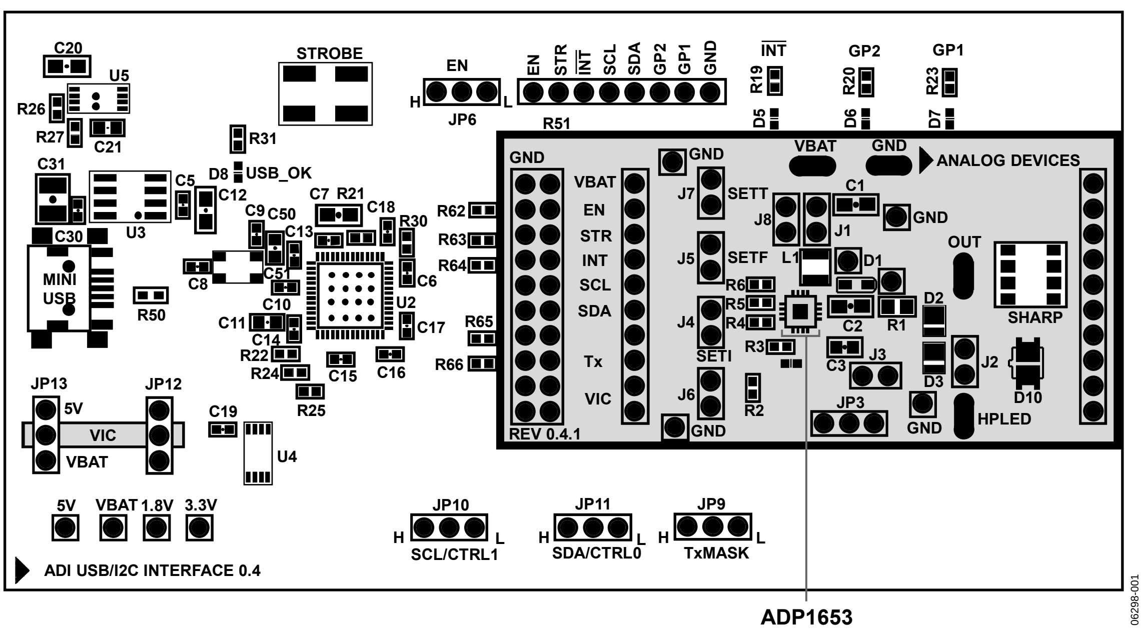


Figure 1.

One Technology Way, P.O. Box 9106, Norwood, MA 02062-9106, U.S.A.
Tel: 781.329.4700 **www.analog.com**
Fax: 781.461.3113

TABLE OF CONTENTS

SOFTWARE INSTALLATION

1. Insert the setup CD into the CD-ROM and run the file **ADP1653 Setup 0_5.exe**. When the dialog box shown in Figure 2 appears, click **Next>** to continue.

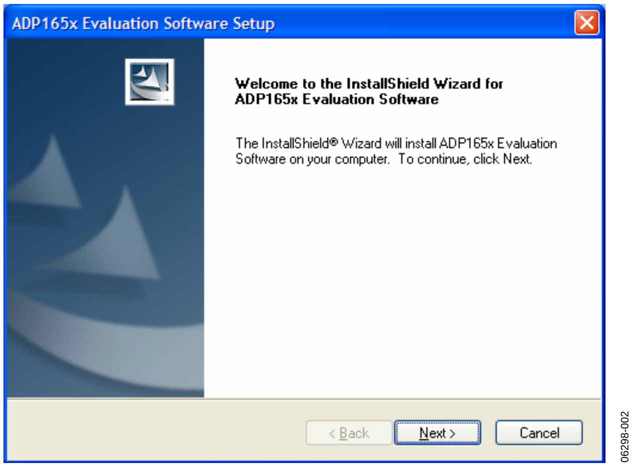


Figure 2. ADP165x Evaluation Software Setup

2. Click **Yes** to accept the license agreement.

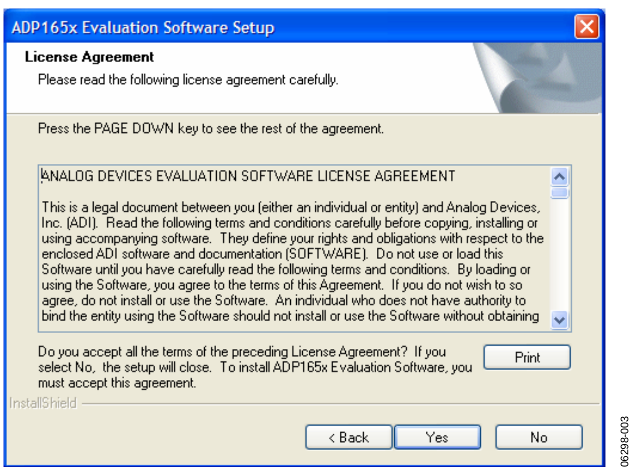


Figure 3. License Agreement

3. Click **Next>** to install the files to the default destination folder or click **Browse…** to choose a different file.

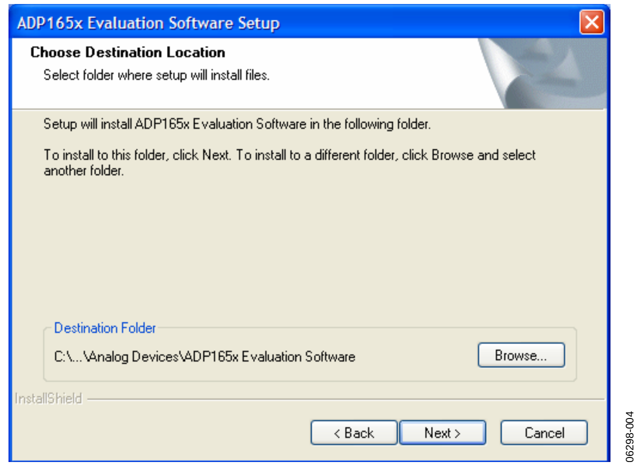


Figure 4. Choose Destination Location

4. Click **Next>** to continue with the installation.

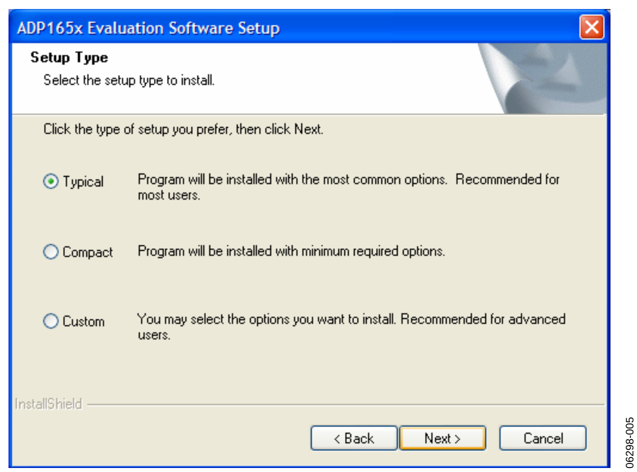


Figure 5. Setup Type

5. Click **Next>** to install the program to the default program folder.

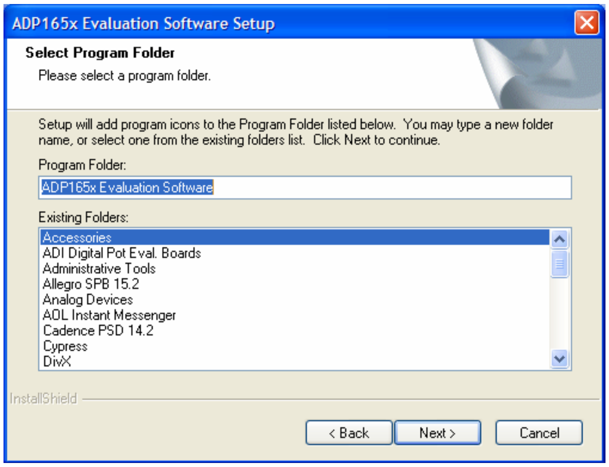


Figure 6. Select Program Folder

6. Wait while the program installs.

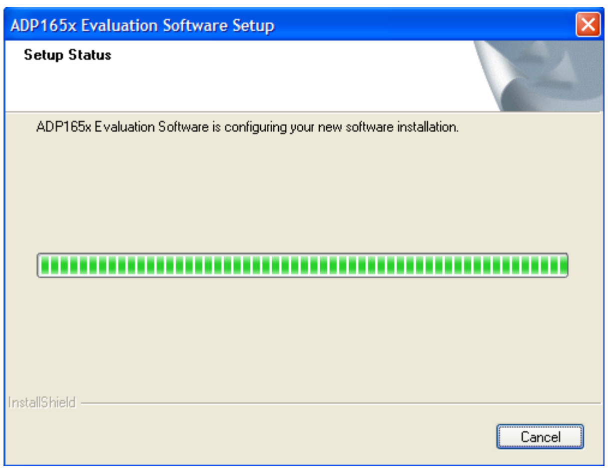


Figure 7. Status Setup

7. Click **Finish** to complete the installation.

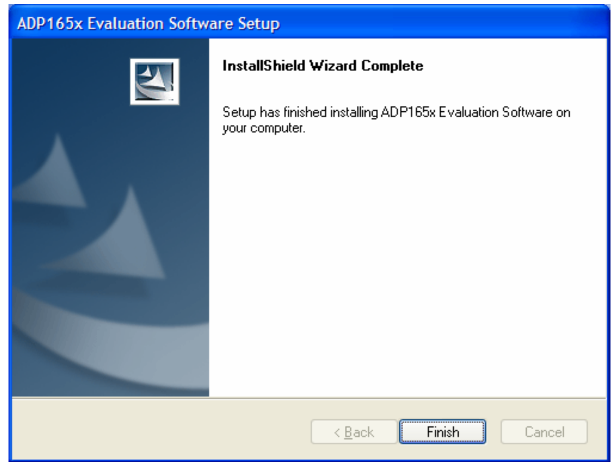


Figure 8. InstallShield Wizard Complete

USB DRIVER INSTALLATION

1. Plug the ADP1653 board into the computer using the USB cable provided with the evaluation kit. Once the system recognizes the board, the dialog box shown in Figure 9 appears.

2. Click **Next>** to install the driver.

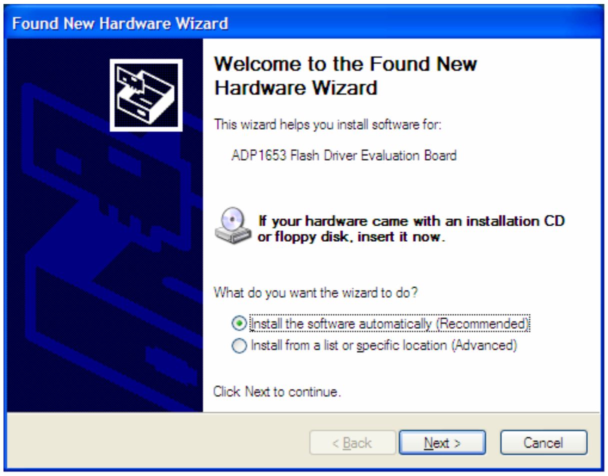
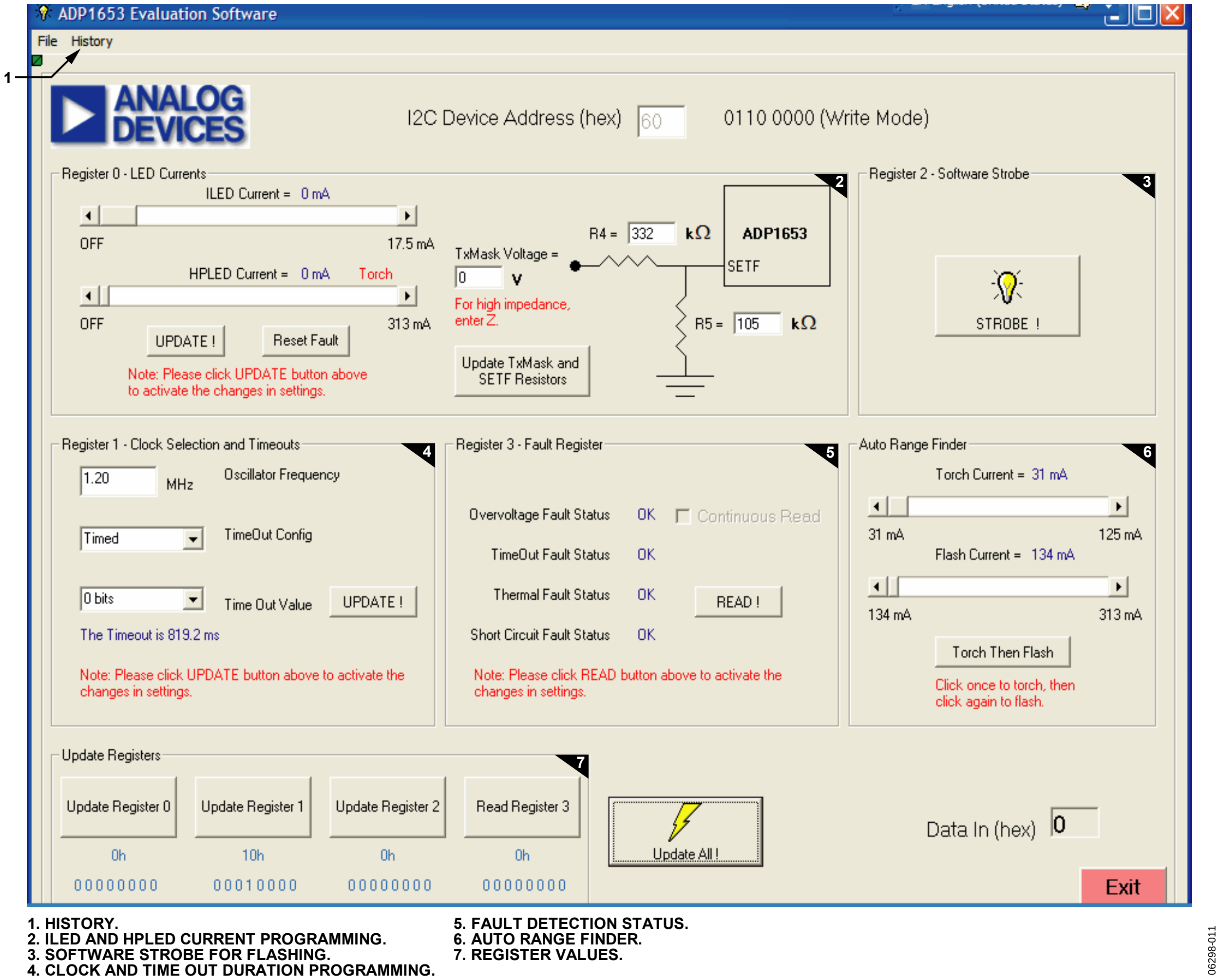


Figure 9. Found New Hardware Wizard

3. Click **Continue Anyway** and then **Finish** to complete the driver installation.

Figure 10. Hardware Installation

USING THE SOFTWARE



1. HISTORY.
2. ILED AND HPLED CURRENT PROGRAMMING.
3. SOFTWARE STROBE FOR FLASHING.
4. CLOCK AND TIME OUT DURATION PROGRAMMING.
5. FAULT DETECTION STATUS.
6. AUTO RANGE FINDER.
7. REGISTER VALUES.

Figure 11. Evaluation Board Software

Before running the software, ensure that the board is plugged into the computer USB port (the USB-OK LED on the motherboard should light up).

1. Click **START** > **All Programs** > **Analog Devices** > **ADP165x Evaluation Software0_5** > **ADP1653 Rev E.exe**. The software detects the presence of the board's USB interface and sends the following message: **I2C OK**.
2. Click **OK** to continue.

ILED AND HPLED CURRENT PROGRAMMING

To program the ILED current, slide the **ILED Current** scroll bar to the desired setting and click **UPDATE!**. For the HPLED current, enter the values of the TxMask voltage and the SETF resistors (R4 and R5), and then click **Update TxMask and SETF Resistors**. The default values are **TxMask Voltage** = 0 (GND), **R4** = 332 kΩ, and **R5** = 105 kΩ. As you change the values of the TxMask voltage and the SETF resistors, the HPLED current values shown adjust accordingly. Note that changing the values of the resistors and the TxMask voltage in the software does not change the actual current of the LEDs. To change the actual current, replace the physical resistors or change the TxMask voltage on the board. The **Update TxMask and SETF Resistors** button merely calculates the current levels that correspond to the values of the resistors and the TxMask voltage entered in the text boxes.

For the given values of the R4, R5, and TxMask voltage, the HPLED current is

$$I_{REF} = \frac{1.2\text{ V}}{R5} + \frac{1.2\text{ V} - V_{TxMask}}{R4}$$

$$I_{HPLED} = (35\text{ mA} + Code \times 15\text{ mA}) \times \frac{50\text{ k}\Omega \times I_{REF}}{1.2\text{ V}}$$

where I_{REF} is the reference current at the SETF pin, and *Code* is the HPLED register setting, ranging from 0 to 31.

Applying a TxMask voltage reduces the SETF reference current and therefore reduces the HPLED current. The maximum TxMask voltage allowed for R4 and R5 is

$$V_{TxMask} = 1.2\ \text{V} \times \left(1 + \frac{R4}{R5}\right)$$

Using a larger TxMask voltage causes a negative reference current and triggers the overvoltage protection. The interrupt LED turns on to indicate the fault.

Table 1 shows the maximum HPLED current (code = 31) for various values of R4, R5, and TxMask voltage. The first entry (R4 = 99999, R5 = 50 kΩ, and TxMask = Z) simulates the default internal reference current obtained by tying the SETF pin high. R4 = 99999 is equivalent to R4 being any numerical value.

Table 1. Maximum HPLED Currents

R4 (kΩ)	R5 (kΩ)	TxMask Voltage (V)	Maximum HPLED Current (mA)
99999[1]	50	Z	500
50	50	1.8	250
332	105	0	313
150	50	3.3	208

[1] R4 = 99999 is equivalent to R4 being any numerical value.

Slide the **HPLED Current** scroll bar to the desired setting and click **UPDATE!** to change the HPLED settings. Settings 1 to 11 are torch mode, and settings 12 to 31 are flash mode. All the settings are indicated next to the **HPLED Current** scroll bar. When the device is in flash mode, you must click either the **Physical Strobe** button on the motherboard or the **STROBE!** button in the software to flash the LEDs. Clicking **Reset Fault** clears any interrupts by resetting both ILED and HPLED settings to 0.

SOFTWARE STROBE

Instead of using the **Hardware Strobe** button on the motherboard, an I^2C software strobe can be used. When the HPLED register is in the flash setting, click **STROBE!** to flash the LEDs.

CLOCK AND TIMEOUT DURATION PROGRAMMING

Oscillator Frequency

Because the timeout duration that the software reports is based on the default 1.2 MHz, if the oscillator frequency is not exactly 1.2 MHz, the timeout duration shown is incorrect. As a result, you can enter the exact oscillator frequency measured on a scope and then click **UPDATE!** to calculate the correct timeout duration.

Timeout Configuration

The user can choose to run the device in the timed or untimed mode. In timed mode, the LEDs flash for the programmed timeout duration even if the strobe button is released prior to the end of the duration. In untimed mode, the LEDs flash for as long as the hardware strobe button is pressed until the programmed timeout duration is reached. The part then issues a timeout fault, and the interrupt LED lights up.

Timeout Value

The **Time Out Value** drop-down box is used to program the timeout duration.

FAULT DETECTION STATUS

The **Register 3 – Fault Register** section is used to read back the fault detection status from the ADP1653. When a fault occurs, the interrupt LED on the motherboard lights up. Click **READ!** to view information about the fault. Overvoltage fault occurs when the output voltage is greater than 10.2 V (nominal). Timeout fault occurs when the user presses the strobe button longer than the programmed timeout duration in the untimed mode. Thermal fault occurs when the device junction temperature is greater than 155°C. Short-circuit fault occurs if the HPLED pin remains grounded 820 ms after torch is enabled.

REGISTER VALUES

The register values section displays the value in each register in the hexadecimal format.

AUTO RANGE FINDER

The **Auto Range Finder** box is used to simulate the function of a camera's auto range finder, which is used to torch the LEDs to focus on the object in a dark room, for example, and then to flash the LEDs and take a picture. To use this feature, select the desired setting for both the torch and flash modes (1 to 11 for torch, 12 to 31 for flash). Then click **Torch Then Flash** once to torch the LEDs and once more to initiate a flash.

HISTORY

Whenever you issue a command (both read and write), it is recorded in the **History** dialog box shown in Figure 12.

To display the **History** dialog box, click the **History** menu on the main software dialog box or the Windows® **History** tab on the bottom. To clear the history, click **Clear History**.

You can copy and paste the history into a file for future evaluation purposes.

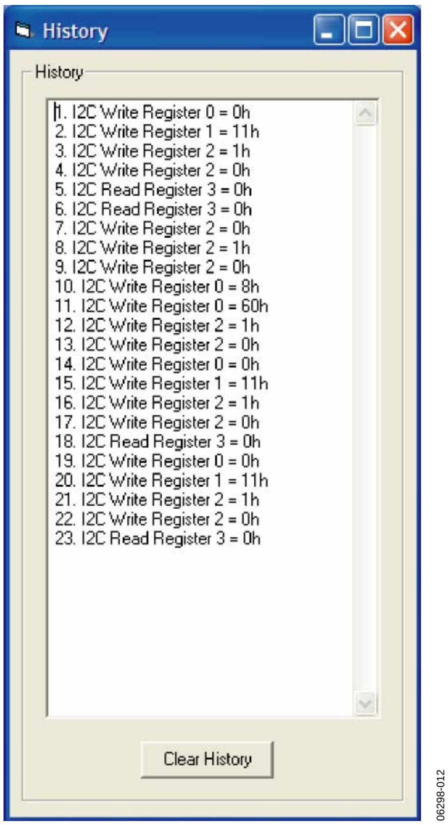


Figure 12. History

EVALUATION BOARD OVERVIEW

MOTHERBOARD

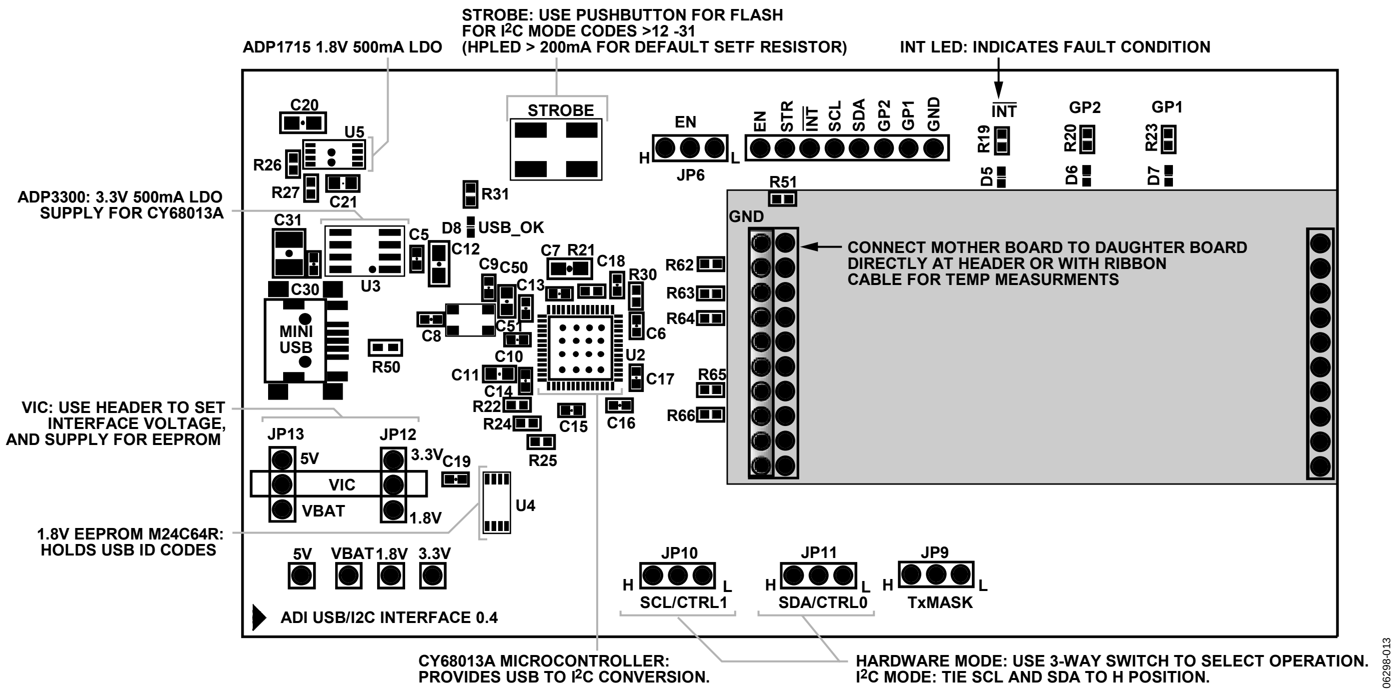


Figure 13. Motherboard

The ADP1653 motherboard provides the interface signals to the ADP1653 flash driver IC. These include the CTRL0/SDA and CTRL1/SCL lines for I²C or the control line voltages for the HW interface modes (strobe, enable, and TxMask).

The Cypress Semiconductor Corporation CY68013A provides the USB interface and I²C signals. The selected I²C frequency is 100 kHz. The Motorola M24C64R provides the USB address of the board. The interface voltage is selected with the VIC header on the board and is set to 3.3 V by default.

Typically, the daughterboard is inserted directly into the 20-pin header of the motherboard. For temperature measurements, however, the ribbon cable provided with the evaluation kit must be used to connect the motherboard and the daughterboard because the Cypress CY68013A is not rated at −40°C. The 8-pin header on the top of the motherboard can be used to connect external signals. A no connect state is selectable on all signals generated by the motherboard.

The $\overline{\text{INT}}$ red LED located at the top right of the board lights up when a fault is detected on the ADP1653. However, with the daughterboard connected and no V_{DD} supply to the ADP1653, the $\overline{\text{INT}}$ red LED also lights up even though this is normal operation. Table 2 shows the recommended settings when the device is first powered up.

Table 2. Recommended Settings

Control	Hardware Mode INTF = 1	I²C Mode INTF = 0
EN	High	High
CTRL0/SDA	See Table 3	Must be high
CTRL1/SCL	See Table 3	Must be high
STR	X = don't care	For HPLED setting > 12, enables flash

In the hardware mode, CTRL0 and CTRL1 determine the mode of operation. Table 3 shows the combinations of settings for the control pins and the corresponding modes.

Table 3. Control Pins

Mode of Operation	CTRL1	CTRL0
Disabled	0	0
ILED	0	1
Torch	1	0
Flash	1	1

MOTHERBOARD SCHEMATICS

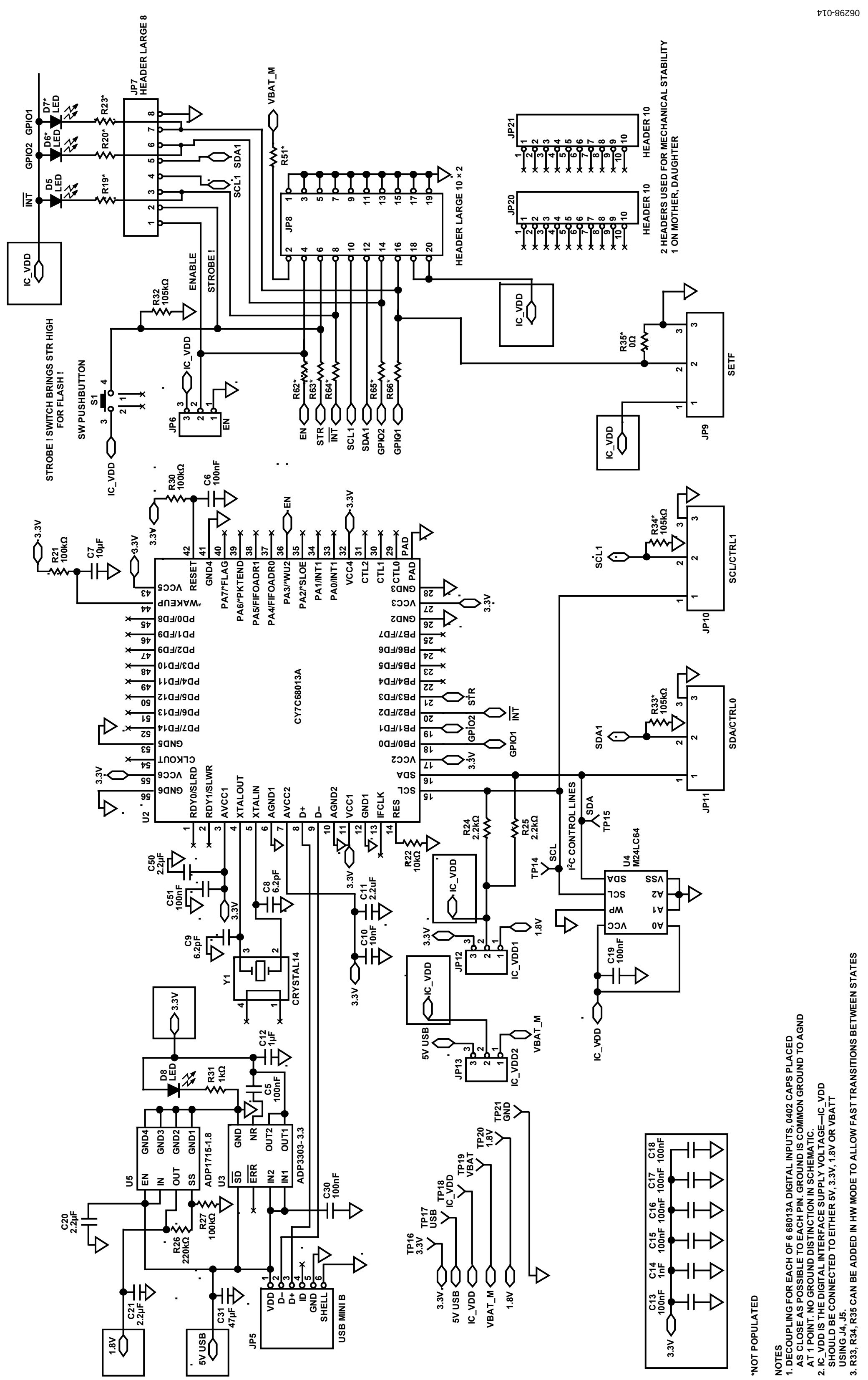


Figure 14. Motherboard Schematics

DAUGHTERBOARD

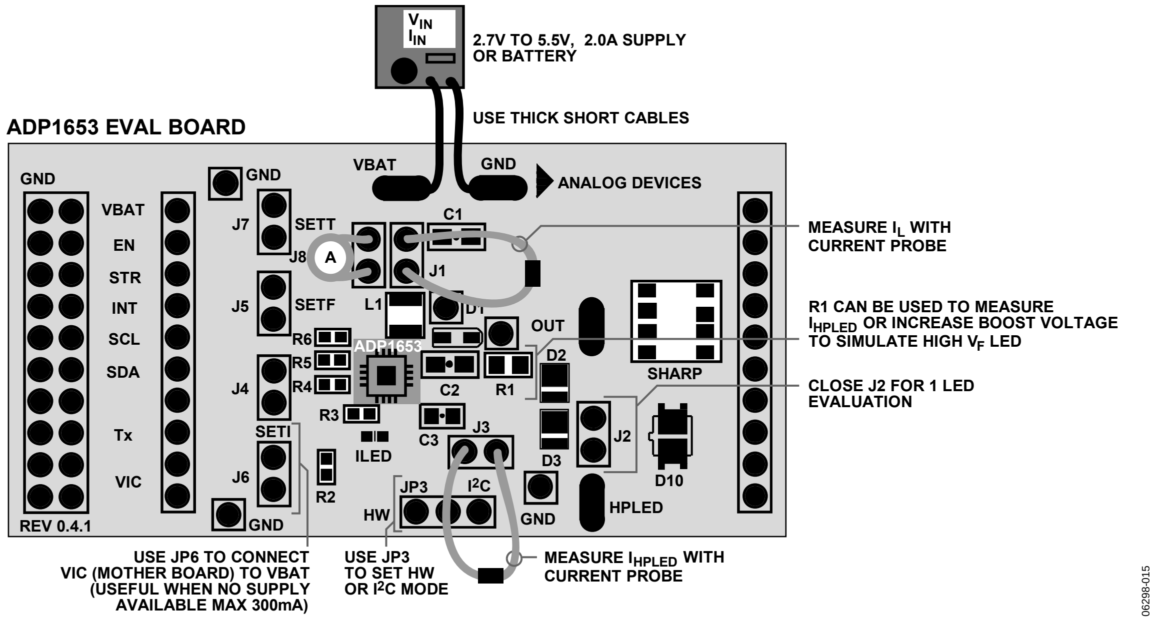


Figure 15. Daughterboard

The ADP1653 evaluation daughterboard is designed to quickly evaluate key parameters of the ADP1653 IC. The board layout footprint is extended so that parts can be exchanged easily, and headers are available to measure currents using a current probe or ammeter.

Connect a power supply or Li-Ion battery with 2 A capability to VBAT. Up to 1.8 A (nominal) can be drawn from the battery; therefore, short thick cables are recommended to minimize the IR drops. A high current can cause a big IR drop, and VBAT can be low enough to put the part into UVLO.

I_Q

I_Q is the supply current and can be measured by using an ammeter across J8.

I_L

I_L is the inductor current and can be measured by using a current loop across J1.

I_{LED}

I_{LED} is the LED current and can be measured by using an ammeter or current loop across JP3.

High V_F LEDs

By default, R1 is 0 Ω. It can be replaced with another resistor for current measurement or for increasing the OUT voltage (to simulate a higher boost ratio for a high V_F LED).

One-LED Evaluation

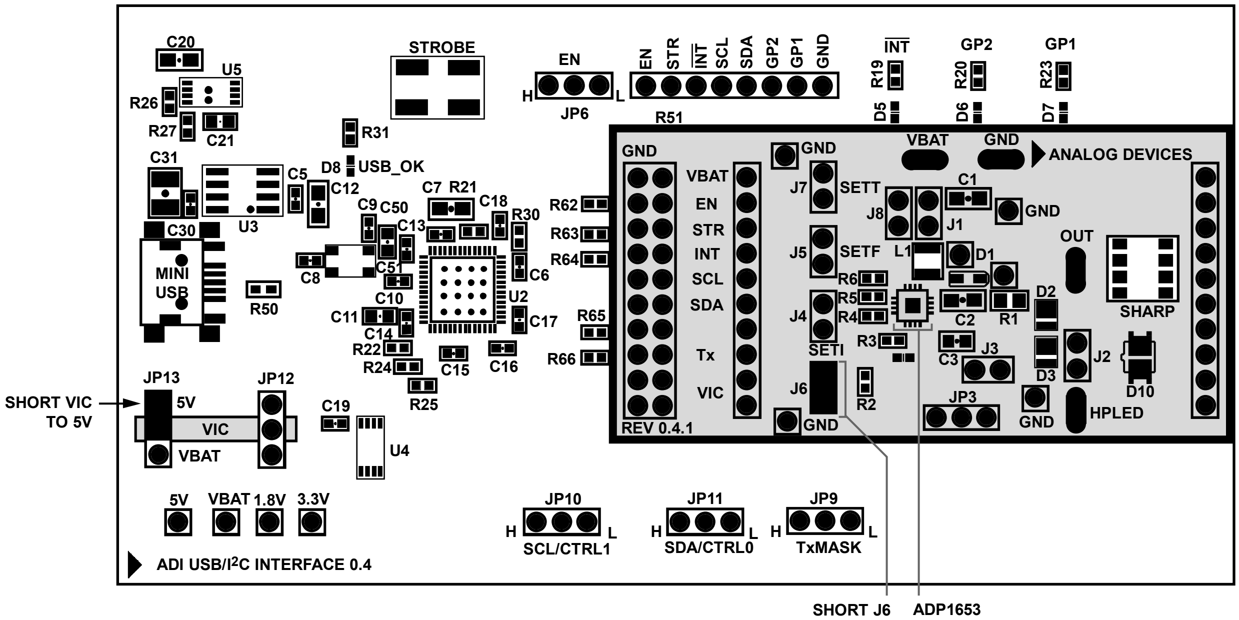
The J2 jumper can be placed to short D3 for the evaluation of the one-LED solution.

HW Mode or I²C

JP3 is used to select the hardware mode or I²C mode. Shorting the INTF pin to VBAT selects the hardware mode, whereas shorting it to GND selects the I²C mode.

Power Board from USB Port Only

To power the board via the USB without using an external supply, short Jumper J6 on the daughterboard and short VIC to 5 V on JP13 on the motherboard. Figure 16 illustrates these two jumpers. Ensure that the LED current is less than 200 mA to avoid exceeding the 500 mA current limit of the USB.



06298-016

Figure 16. Evaluation Board Setup to Run from USB Power

DAUGHTERBOARD SCHEMATICS

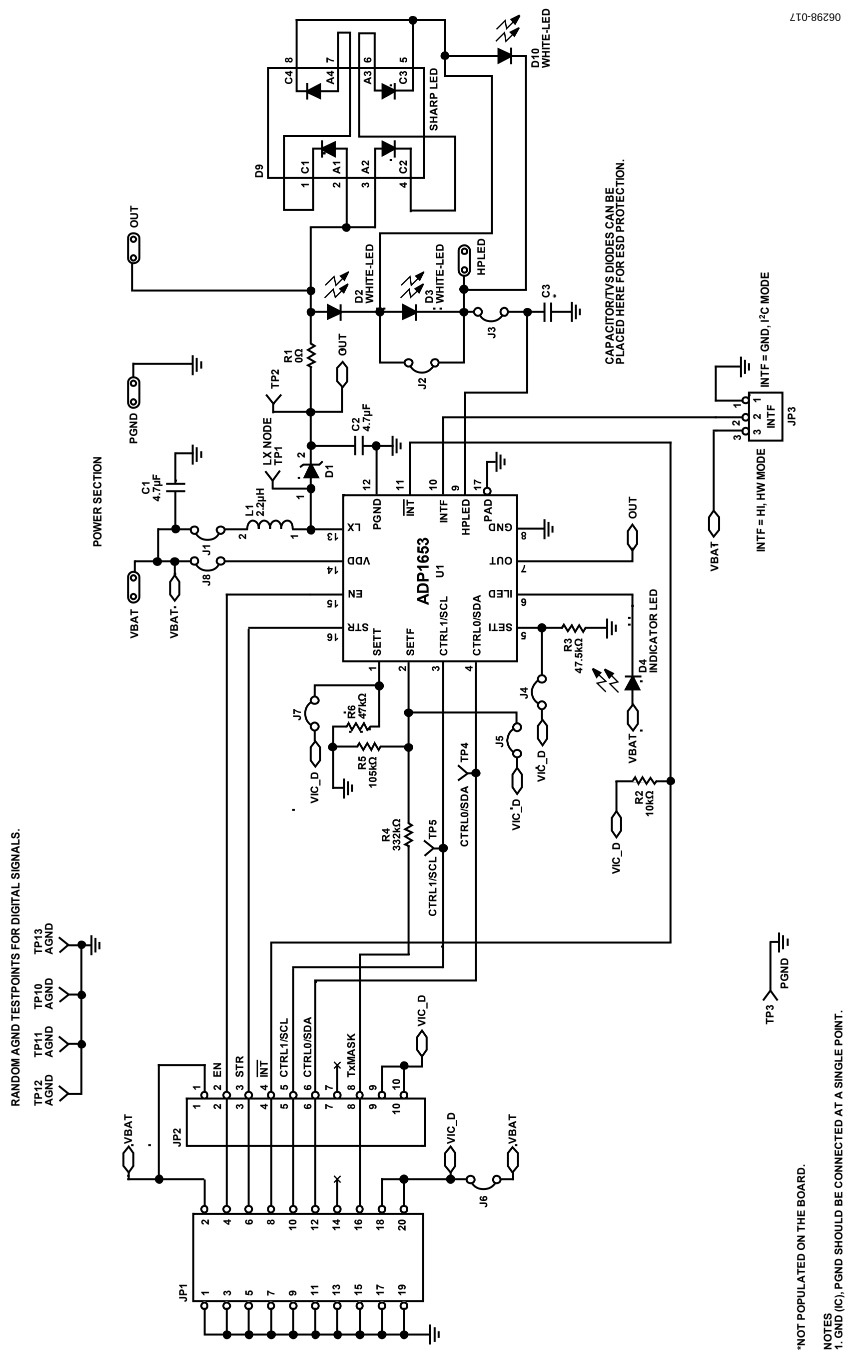


Figure 17. Daughterboard Schematics

TEST RESULTS USING EVALUATION BOARD

Table 4. Current Limit—Typical Part, OUT = 6.9 V

V_{BAT} (V)	Temp (°C)	Current Limit (A)	Maximum Output Current (mA), Two LEDs
2.9	−40	2.1	500
	0	2.08	486
	+25	2.03	470
	+85	1.93	440
	+125	1.86	415
3.6	−40	N/A	500
	0	N/A	500
	+25	N/A	500
	+85	N/A	500
	+125	N/A	500

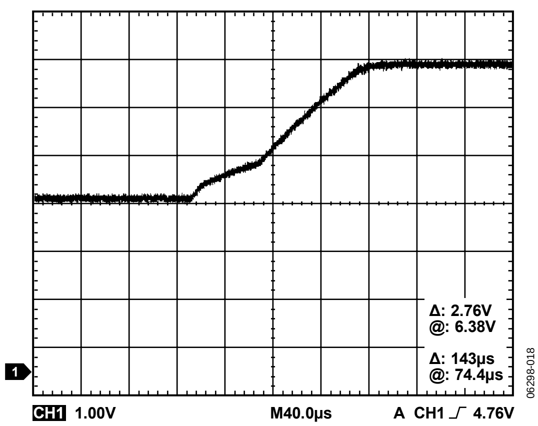


Figure 18. Soft Start Ramp, Two LEDs, VBAT = 3.6 V, T_A = 25°C

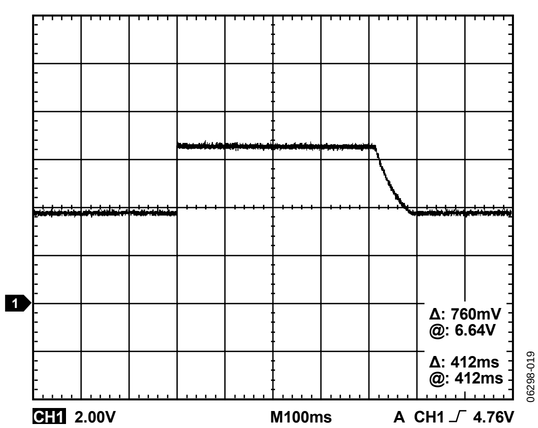


Figure 19. OUT Voltage—Timed Flash Mode, STR Glitch (Write 0 × 10 to Reg 1, Glitch STR, Capture Transient on Scope and Measure Period) T_A = 25°C (Design = 410 ms, Measure = 412 ms)

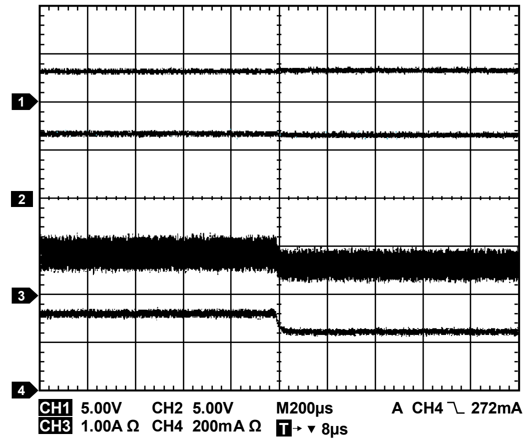


Figure 20. Tx Masking—0 V to 3.3 V
Channel 1— Input Voltage
Channel 2—Output Voltage
Channel 3—Input (Inductor) Current
Channel 4—Output Current

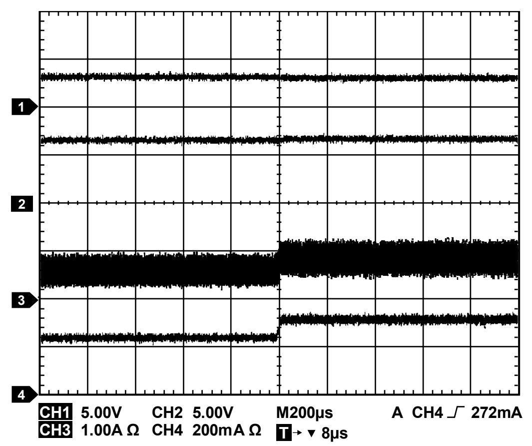


Figure 21. Tx Masking—3.3 V to 0 V
Channel 1—Input Voltage
Channel 2—Output Voltage
Channel 3—Input (Inductor) Current
Channel 4—Output Current

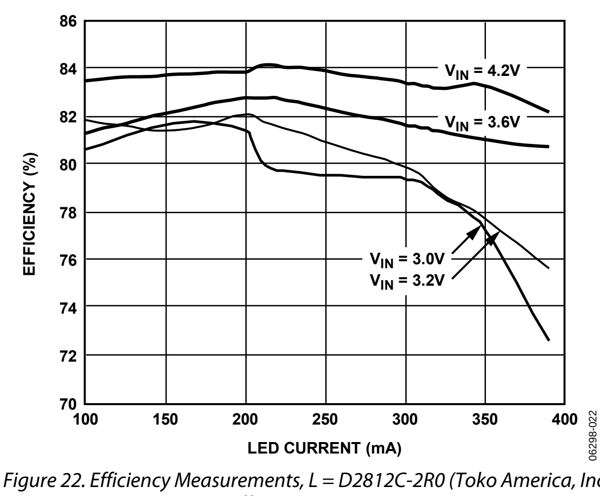


Figure 22. Efficiency Measurements, L = D2812C-2R0 (Toko America, Inc.)
Efficiency = P_{LED}/P_{IN}

PCB LAYOUT

The evaluation kit contains two boards. One board is for easy evaluations and contains a large footprint and layout size. The other is a reference design that shows a small layout solution. Both boards utilize a 4-layer design with minimum traces.

Evaluation Board Layout

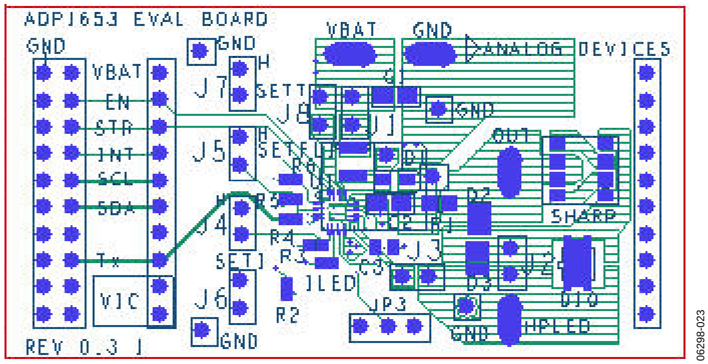


Figure 23. Evaluation Daughterboard, Top Layer

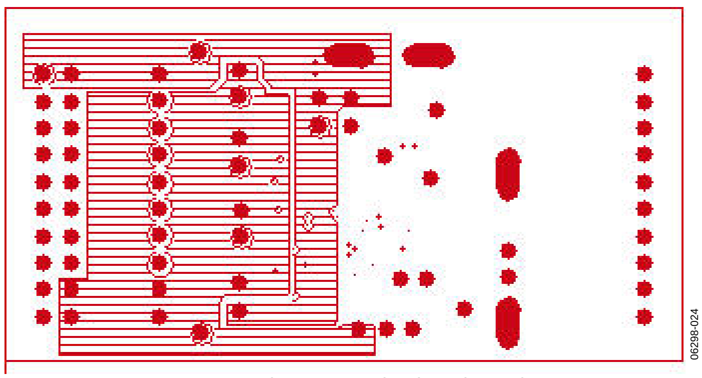


Figure 24. Evaluation Daughterboard, V_{DD} Plane

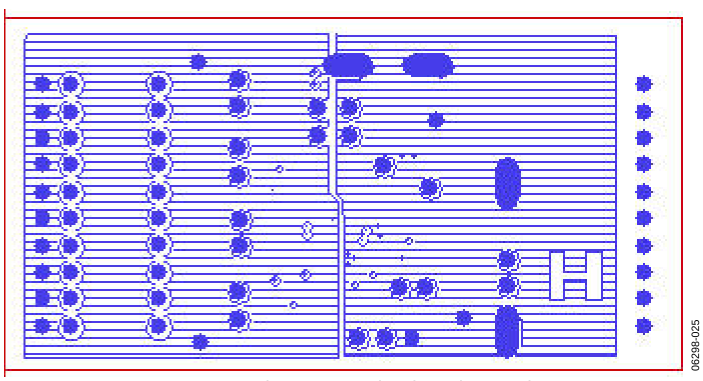


Figure 25. Evaluation Daughterboard, GND Plane

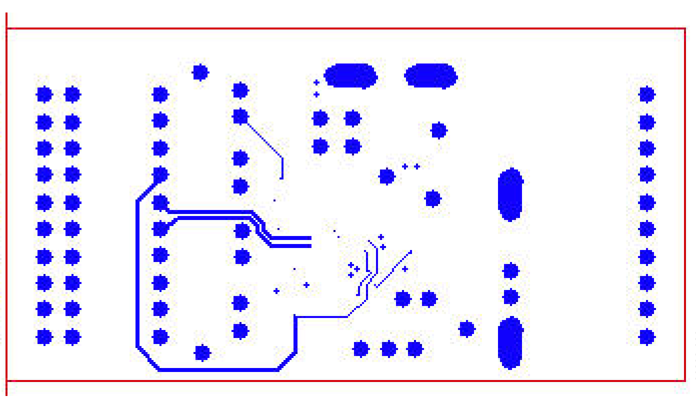


Figure 26. Evaluation Daughterboard, Bottom Layer

Reference Board Layout

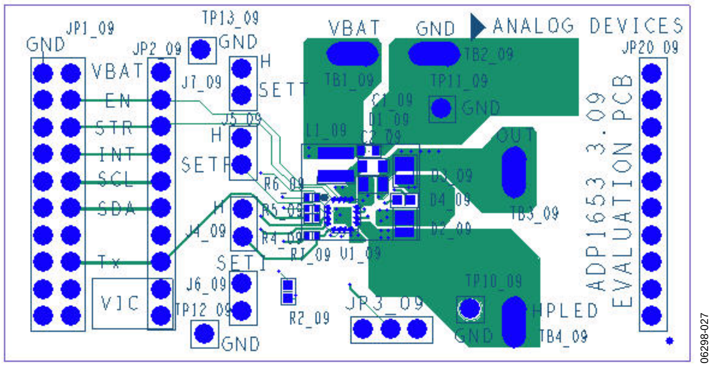


Figure 27. Reference Daughterboard, Top Layer

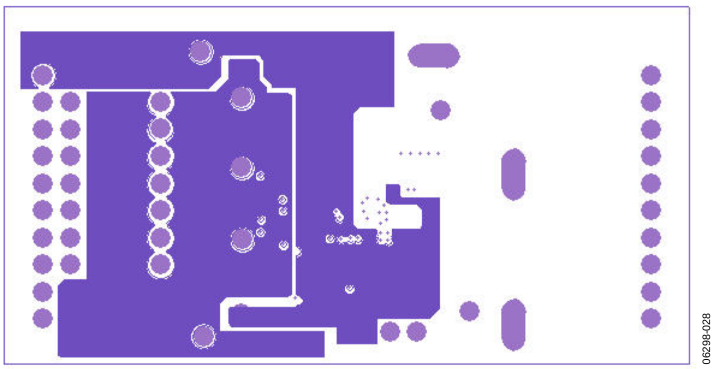


Figure 28. Reference Daughterboard, V_{DD} Plane

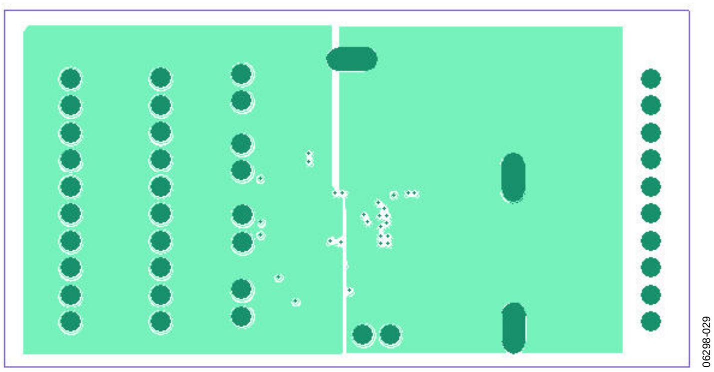


Figure 29. Reference Daughterboard, GND Plane

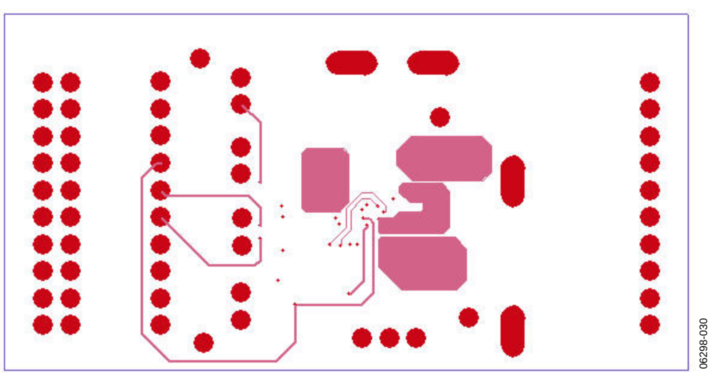


Figure 30. Reference Daughterboard, Bottom Layer

FAQS

Why does the solution size seem bigger than was expected?

This board (4.0.1) is intended as an evaluation board, with easy access to test points and current measurements and the ability to switch components easily. The LFCSP and all other pads are extended so that parts can be exchanged and hand-soldered easily. The 0 Ω resistor between the diode and the LEDs can be replaced with either a current-sensing resistor to measure current or a larger resistor to simulate a system with a larger HPLED V_F.

The evaluation kit includes a 9 mm × 9 mm reference (including the two LEDs), but several alternative reference design*s* are available.

Why is the logic level of INTF equal to VBAT/2, whereas all others are 1.8 V?

It is not envisaged that customers will change between HW and I^2C modes during operation; therefore, 1.8 V logic levels are not necessary on this pin.

Can I use an ammeter to measure HPLED currents?

Yes, but it is not recommended due to the internal resistance of the ammeter. It can be used in the torch mode. However, measuring the battery current with an ammeter causes the part to hit undervoltage lockout (UVLO) at a lower battery voltage due to the IR drop. If an ammeter is used, ensure that its range is *not* set to auto, because the resistance can change during the measurement and result in a perturbation of the control loop.

ORDERING INFORMATION

BILL OF MATERIALS

Table 5.

Description	Reference Designator	Qty	Manufacturer/Vendor	Vendor P/N
Daughterboard				
Capacitor, MLCC, 4.7 μF, 6.3 V, 0603, X5R	C1	1	Murata Manufacturing Co., Ltd.	GRM188R60J475K
Capacitor, MLCC, 4.7 μF, 16 V, 0805, X5R[1]	C2	1	Murata Manufacturing Co., Ltd.	GRM219R61A475K or GRM21BR61C475K[1]
Capacitor, MLCC, 0603[2]	C3	1		
Diode, Schottky	D1	1	Diodes, Inc.	BAT20J
White LED	D2, D3	2	Philips Lumileds Lighting Company	LXCL-PWF3
Red LED, 0402 SMD	D4 (ILED)	1	Lumex Inc.	SML-LX0402SIC-TR
White LED[2]	D10	1		
SharpLED[2]	D9	1	Sharp Corporation	GM5BW05340AC
Inductor, 2.2 μH	L1	1	Toko America, Inc.	FDSE0312-2R2
Resistor, 0 Ω, 1%, 0402	R1	1	Vishay Dale	CRCW04020R00F
Resistor, 10 kΩ, 1%, 0402	R2	1	Vishay Dale	CRCW04021002F
Resistor, 47.5 kΩ, 1%, 0402	R3, R6	2	Vishay Dale	CRCW04024752F
Resistor, 332 kΩ, 1%, 0403	R4	1	Vishay Dale	CRCW04023323F
Resistor, 105 kΩ, 1%, 0404	R5	1	Vishay Dale	CRCW04021053F
ADP1653, 16-Lead LFCSP, 3 mm × 3 mm	U1	1	Analog Devices, Inc.	ADP1653
Header 0.100, Single, STR, 2 Pins	J1 to J8	8	Sullins Electronics Inc./3M	S1012-36-ND
Header 0.100, Single, STR, 2 Pins	GND, VBAT, HPLED, OUT	4	Sullins Electronics Inc./3M	S1012-36-ND
Header 0.100, Single, STR, 1 Pins	GND (4), TP (close to D1)	6	Sullins Electronics Inc./3M	S1012-36-ND
Header 0.100, Single, STR, 3 Pins	JP3	1	Sullins Electronics Inc./3M	S1012-36-ND
Header 0.100, Single, STR, 10 Pins	Mounting Header	1	Sullins Electronics Inc./3M	S1012-36-ND
Header, Female 0.100, Single, STR, 20 Pins	GND, left bottom side	1	Samtec, Inc./3M	SSW-110-03-G-D
Header, Female 0.100, Single, STR, 10 Pins	Mounting Header	1	3M	929974-01-36-ND
Motherboard				
Capacitor, MLCC, 100 nF, 10 V, 0402, X5R	C5, C6, C13, C15 to C19, C30, C51	10	Murata Manufacturing Co., Ltd.	GRM155R61A104K
Capacitor, MLCC, 10 μF, 6.3 V, 0805, X5R	C7	1	Murata Manufacturing Co., Ltd.	GRM21BR60J106K
Capacitor, MLCC, 6.2 pF, 0402, NP0	C8, C9	2	Vishay/Panasonic	ECJ-OEC1H0600
Capacitor, MLCC, 10 nF, 0402	C10	1	Vishay Vitramon or equivalent	VJ0402Y103KXXA
Capacitor, MLCC, 2.2 μF, 10 V, 0603, X5R	C11, C20, C21, C50	4	Murata Manufacturing Co., Ltd.	GRM188R61A225K
Capacitor, MLCC, 1 μF, 25 V, 0805, X7R	C12	1	Murata Manufacturing Co., Ltd.	GRM21BR71E105K
Capacitor, MLCC, 1 nF, 0402	C14	1	Vishay Vitramon or equivalent	VJ0402Y102KXXA
Capacitor, MLCC, 47 μF, 6.3 V, 1206, X5R	C31	1	Murata Manufacturing Co., Ltd.	GRM32ER61C476K
Red LED, 0402, SMD[2]	D5, D7	2	Lumex Inc.	SML-LX0402SIC-TR
Green LED, 0402, SMD[2]	D8, D6	2	Lumex Inc.	SML-LX0402SUGC-TR
Resistor, 0402, SMD[2]	R20, R23, R33 to R35, R51, R62 to R66	11		
Resistor, 1 kΩ, 1%, 0402, SMD	R19, R20, R31	3	Vishay Dale or equivalent	CRCW04021001F
Resistor, 100 kΩ, 1%, 0402, SMD	R21, R27, R30	3	Vishay Dale or equivalent	CRCW04021003F
Resistor, 105 kΩ, 1%, 0402, SMD	R32	1	Vishay Dale or equivalent	CRCW04021053F

Description	Reference Designator	Qty	Manufacturer/Vendor	Vendor P/N
Resistor, 10 kΩ, 1%, 0402, SMD	R22	1	Vishay Dale or equivalent	CRCW040210022F
Resistor, 2.2 kΩ, 1%, 0402, SMD	R24, R25	2	Vishay Dale or equivalent	CRCW040222021F
Resistor, 220 kΩ, 1%, 0402, SMD	R26	1	Vishay Dale or equivalent	CRCW0402203F
SW Push Button	S1 (STROBE)	1	ITT Industries	KT11P3JM
IC MCU USB Periph High SPD-56QFN	U2	1	Cypress Semiconductor Corporation	CY7C68013A
Microchip Serial EEPROM-64K, MSOP8	U4	1	Nu Horizons Electronics Corp.	M24LC64 or 24AA64
IC LDO Regulator, SO-8	U3	1	Analog Devices, Inc.	ADP3303-3.3
IC LDO Regulator, 500 mA, 8-Lead MSOP	U5	1	Analog Devices, Inc.	ADP1715-1.8
CRYSTAL14	Y1	1	CTS Corporation	CTX651CT
USB Connector USB Mini B, 5p	JP5	1	Delphi Corporation/ Molex	15430262-110 or 5679-0588
SW SPDT On-Off-On	JP6, JP9 to JP11	4	ITT Industries, Cannon	TS03CBE
Header, Male 0.100, Dual, STR, 20 Pins	JP8 on schematic (no silk), location: center top side	1	3M	S1012-36, S2012-36-ND
Header 0.100, Single, STR, 10 Pins	JP2	1	3M	S1012-36
Header 0.100, Single, STR, 3 Pins	JP12	1	3M	S1012-36
Header 0.100, Single, STR, 3 Pins	JP13	1	3M	S1012-36
Header 0.100, Single, STR, 8 Pins	JP7 (EN, STR, $\overline{\text{INT}}$, SCL, SDA, GP2, GP1, GND)	8	3M	S1012-36

[1] For one-LED applications or higher current two-LED applications, a 16 V output capacitor is recommended to achieve good stability. See the ADP1653 data sheet for more information.
[2] Not inserted.

ORDERING GUIDE

Model	Description
ADP1653-EVALZ[1]	Evaluation Board

[1] Z = RoHS Compliant Part.

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.

EB06298-0-3/07(A)