CY8CKIT-036

PSoC® Thermal Management Expansion Board Kit Guide

Doc. No. 001-89649 Rev. **

Cypress Semiconductor
198 Champion Court
San Jose, CA 95134-1709
Phone (USA): +1.800.858.1810
Phone (Intnl): +1.408.943.2600
www.cypress.com

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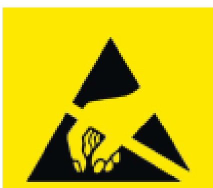
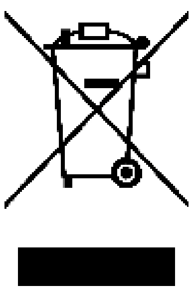
Contents

Safety Information

The CY8CKIT-036 PSoC Thermal Management Expansion Board Kit is intended for use as a development platform for hardware or software in a laboratory environment. The board is an open system design, which does not include a shielded enclosure. Due to this reason the board may cause interference to other electrical or electronic devices in close proximity. In a domestic environment, this product may cause radio interference. In such cases, the user may be required to take adequate preventive measures. Also, this board should not be used near any medical equipment or RF devices.

Attaching additional wiring to this product or modifying the product operation from the factory default may affect its performance and cause interference with other apparatus in the immediate vicinity. If such interference is detected, suitable mitigating measures should be taken.

	The CY8CKIT-036 contains electrostatic discharge (ESD) sensitive devices. Electrostatic charges readily accumulate on the human body and any equipment, and can discharge without detection. Permanent damage may occur on devices subjected to high-energy discharges. Proper ESD precautions are recommended to avoid performance degradation or loss of functionality. Store unused CY8CKIT-036 boards in the protective shipping package.
	End-of-Life / Product Recycling This kit has an end-of-life cycle of five years from the date of manufacturing mentioned on the back side of the box. Please contact your nearest recycler for discarding the kit.

General Safety Instructions

Electrostatic Discharge Protection

Electrostatic Discharge (ESD) can damage boards and associated components. Cypress recommends that the user perform procedures only at an ESD workstation. If ESD workstation is not available, use appropriate ESD protection by wearing an antistatic wrist strap attached to the chassis ground (any unpainted metal surface) on the board when handling parts.

Handling Boards

CY8CKIT-036 boards are sensitive to ESD. Hold the board only by its edges. After removing the board from its box, place it on a grounded, static free surface. Use a conductive foam pad if available. Do not slide board over any surface.

Working with the Fans

Some fans run at very high rotational speeds (30,000 revolutions per minute, or RPM) and the motors can provide significant torque. The blades on this type of fan are often deeply angled and large enough for a finger to penetrate. This can cause a lot of pain if the finger accidentally comes into contact with the fan blade.

Under no circumstances should the user attempt to stop or slow down the fan using a finger or any other object. To test the PSoC ability to detect and react to fan speed changes, airflow can be modulated by forcing air into the fan using an air gun, another fan, or some other appropriate means.

The safest way to test the PSoC chip's ability to detect fan stall events (no rotation) is to disconnect the tachometer feedback by removing either the tachometer wire, or the power to the fan, or by disconnecting the fan altogether.

1. Introduction

Thank you for your interest in the CY8CKIT-036 PSoC® Thermal Management Expansion Board Kit (EBK). This kit is intended for creating thermal management solutions using PSoC products.

The CY8CKIT-036 supports the following thermal management features:

- Interfacing with four-wire fans. The kit comes with two fans installed onboard and has a provision for connecting two additional fans.
- Temperature measurement of analog temperature sensors. The kit includes two general purpose transistors configured as diodes for measuring temperature.
- Temperature measurement of digital temperature sensors. The digital temperature sensors on the kit include an I^2C interface sensor, a one-wire sensor, and two pulse-width modulator (PWM) based sensors.

This kit guide provides details on the kit contents, hardware, schematics, and BOM.

1.1 Kit Contents

The PSoC Thermal Management Expansion Board Kit (CY8CKIT-036 EBK) includes:

- Thermal Management Expansion Board
- Quick Start Guide
- Power DC Adaptor 12 V/2 A

1.2 Getting Started

This section provides details on the hardware requirements, software requirements, and associated application notes for using CY8CKIT-036 with various PSoC devices. Refer to the kit webpage www.cypress.com/go/CY8CKIT-036 for the latest information on using CY8CKIT-036 with various PSoC devices. The webpage will be updated as new PSoC devices and development kits that work with CY8CKIT-036 are released to the market.

1.2.1 Beginner Resources

An overview of various PSoC devices is available at www.cypress.com/psoc/. The webpage includes a comparison of PSoC devices, software IDE information, and associated development kits. In addition, refer to the following application notes to get started with PSoC devices:

- AN79953 – Getting Started with PSoC® 4
- AN54181 – Getting Started with PSoC® 3
- AN77759 – Getting Started with PSoC® 5LP
- AN75320 – Getting Started with PSoC® 1

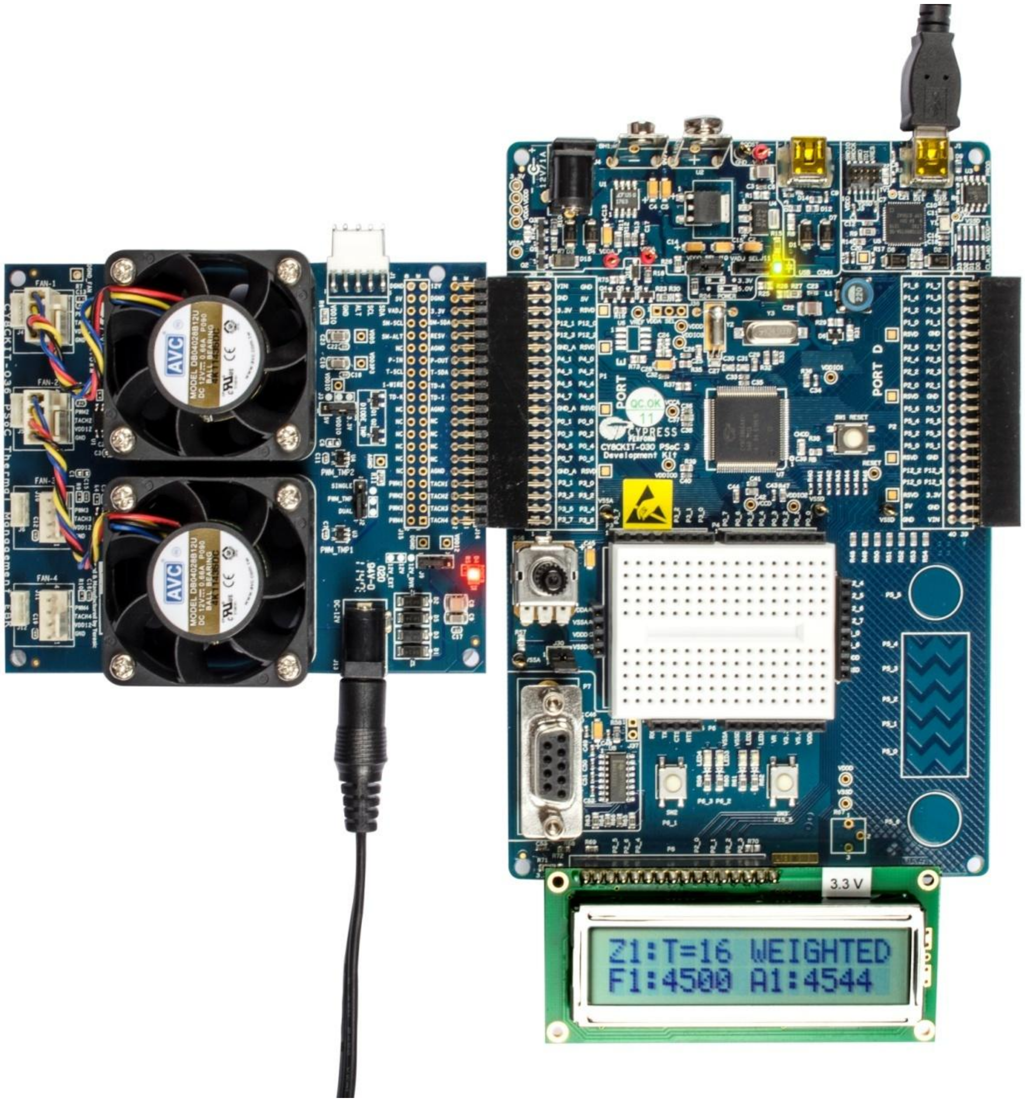
1.2.2 Hardware Requirements

CY8CKIT-036 is designed to connect with the expansion ports of the various PSoC development kits so you can use one EBK to evaluate the entire portfolio of PSoC devices. Table 1-1 lists the hardware requirements for using CY8CKIT-036 with various PSoC devices. Figure 1-1 shows how the CY8CKIT-036 connects to CY8CKIT-030, a PSoC 3 DVK.

Table 1-1. CY8CKIT-036 Hardware Requirement

PSoC Device	Hardware Requirement
PSoC 1	CY8CKIT-001 PSoC DVK fitted with a PSoC CY8C28 Family Processor Module
PSoC 4	CY8CKIT-042 PSoC 4 Pioneer Kit fitted with a CY8CKIT-019 Pioneer to EBK Shield
PSoC 3	CY8CKIT-001 PSoC DVK fitted with a PSoC CY8C38 Family Processor Module Or CY8CKIT-030 PSoC 3 DVK
PSoC 5LP	CY8CKIT-001 PSoC DVK fitted with a PSoC CY8C58LP Family Processor Module Or CY8CKIT-050 PSoC 5LP DVK

Figure 1-1. CY8CKIT-036 Connected to Port E of CY8CKIT-030 PSoC 3 DVK



1.2.3 Software Requirements

- PSoC Creator™ is an integrated design environment (IDE) that allows concurrent hardware and application firmware design of PSoC 3, PSoC 4, and PSoC 5LP systems. PSoC systems are designed using classic, familiar schematic capture technology supported by preverified, production-ready PSoC Components.
- PSoC Components™ are analog and digital virtual chips, represented by an icon that users can drag and drop into a design and configure to suit a broad array of application requirements. Each component in the rich mixed-signal Cypress Component Catalog is configured with a component customizer and includes a full set of dynamically generated API libraries. After the PSoC system has been configured, firmware can be written, compiled, and debugged within PSoC Creator or exported to top IDEs from IAR, Keil, and Eclipse.
- Download the latest version of PSoC Creator software from www.cypress.com/psoccreator.
- PSoC Designer™ is an IDE that allows concurrent hardware and application firmware design of PSoC 1 systems. PSoC Designer has a library of production-ready PSoC Components, which are referred to as user modules. Each user module has a wizard for configuration and a set of dynamically generated APIs associated with the user module.
- Download the latest version of PSoC Designer software from www.cypress.com/psocdesigner.

1.2.4 Application Notes and Projects

Cypress offers many application notes that pertain to CY8CKIT-036. Application notes cover the topics of four-wire fan control and temperature sensing using PSoC devices; they also provide associated projects. The Kit Operation section of this guide lists related application notes. In a thermal management application, the PSoC chip senses the temperature and controls the fan; the measured temperature is used to determine the fan speed based on thermal management algorithms. Table 1-2 lists applications notes that provide the complete thermal management project for the respective PSoC devices.

Table 1-2. Application Notes That Contain the Thermal Management Project

PSoC Device	Application Note
PSoC 1	AN78692 – PSoC 1 – Intelligent Fan Controller
PSoC 4	AN89346 – PSoC 4 – Intelligent Fan Controller
PSoC 3, PSoC 5LP	AN66627 – PSoC 3 and PSoC 5LP – Intelligent Fan Controller

1.3 Technical Support

For assistance, visit Cypress Support or contact customer support at +1(800) 541-4736 Ext. 8 (in the USA), or +1 (408) 943-2600 Ext. 8 (International).

1.4 Document Conventions

Table 1-3. Document Conventions for Guides

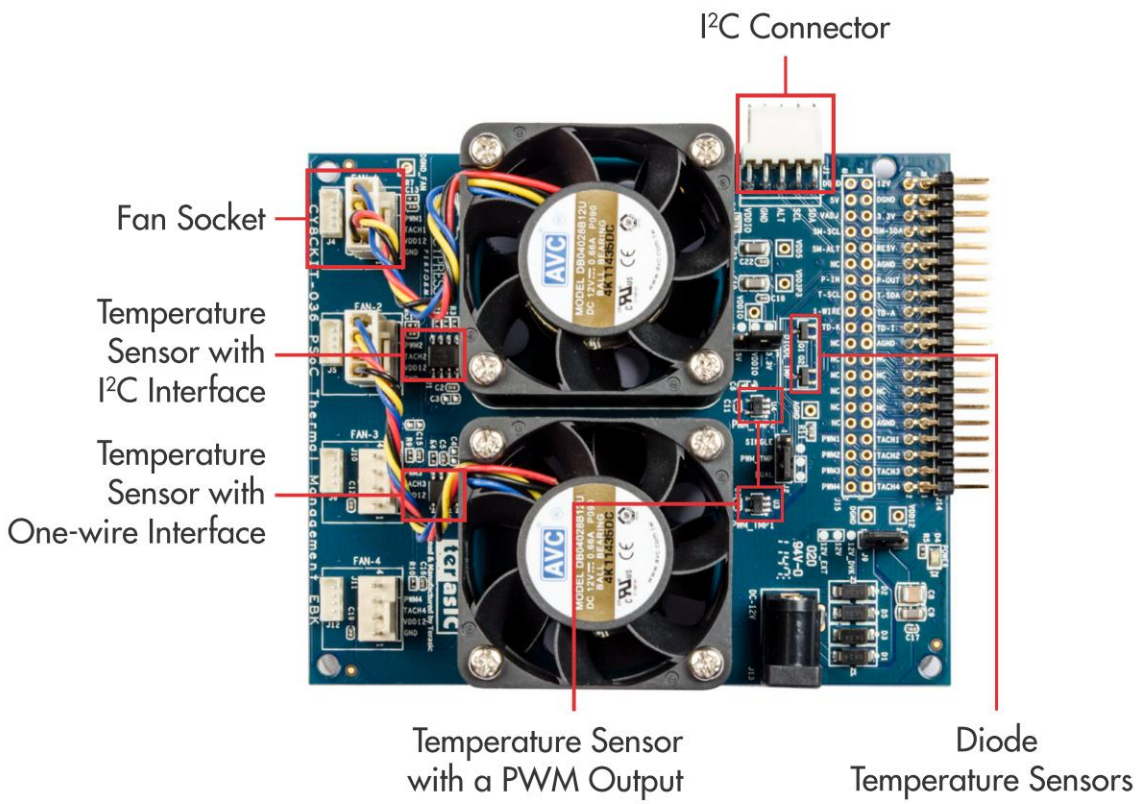
Convention	Usage
`Courier New`	Displays file locations, user entered text, and source code: `C:\ ...cd\icc\`
Italics	Displays file names and reference documentation: Read about the *sourcefile.hex* file in the *PSoC Creator User Guide*.
[**Bracketed, Bold**]	Displays keyboard commands in procedures: [**Enter**] or [**Ctrl**] [**C**]
File > Open	Represents menu paths: File > Open > New Project
Bold	Displays commands, menu paths, and icon names in procedures: Click the **File** icon and then click **Open**.
Times New Roman	Displays an equation: $2 + 2 = 4$
Text in gray boxes	Describes cautions or unique functionality of the product.

2. Kit Hardware

2.1 Kit Overview

Figure 2-1 shows the CY8CKIT-036 EBK. The circuits associated with each sensor are boxed and labeled in the figure. The kit has two onboard four-wire fans, PWM temperature sensors, transistors connected in diode configuration, an I^2C temperature sensor, and a one-wire temperature sensor. The kit also provides sockets for plugging in additional four-wire fans, an I^2C/SMBus/PMBus port for connecting to an external host, and a 2x20 pin connector for connecting the EBK to one of the PSoC development kits.

Figure 2-1. CY8CKIT-036 EBK



2.2 Four-Wire Fans

The CY8CKIT-036 EBK has two four-wire fans onboard. The fans are from the vendor AVC, and the part number is DB04028B12UP090. These DC brushless axial flow fans can spin at speeds of up to 13,000 rpm via PWM-based speed control. These fans also have a tachometer output to calculate the fan speeds. For specifications, see the manufacturer's fan datasheet on the kit webpage.

The CY8CKIT-036 EBK has a provision for interfacing up to four four-wire fans. Two sets of industry-standard connector slots are available for each fan: One is the four-pin header with a 2.54-mm pitch, and the other is a four-pin header with a 1.25-mm pitch. The four 2.54-mm headers are labeled J7, J8, J10, J11 respectively. The four 1.25-mm headers are labeled J4, J5, J6, J12 respectively. The two fans provided along with the EBK are connected to the J7 and J8 headers by default. They can be connected to any of the 2.54-mm headers, depending on the requirements. You can connect two additional fans to the remaining two connection headers.

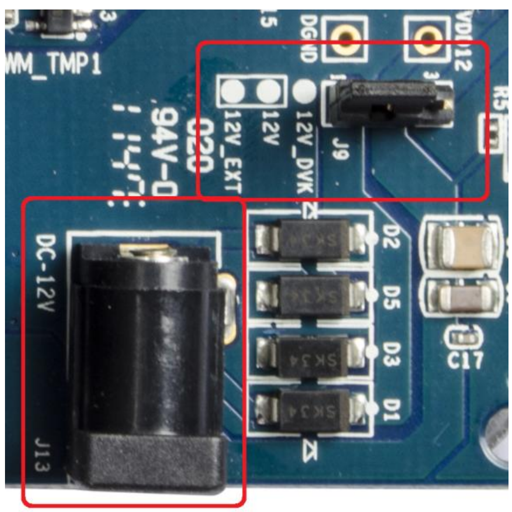
Table 2-1 shows the pin assignment of the four-pin fan headers (both 2.54 mm and 1.25 mm) and the color coding of the wires used for connecting the two fans on the kit to these headers.

Table 2-1. Fan Connector Pinouts

Pin Number	Name	Colors	Description
1	GND	Black	GND
2	POWER	Red	12 V DC power
3	TACH	Yellow	Frequency generator signal
4	PWM	Blue	PWM control signal

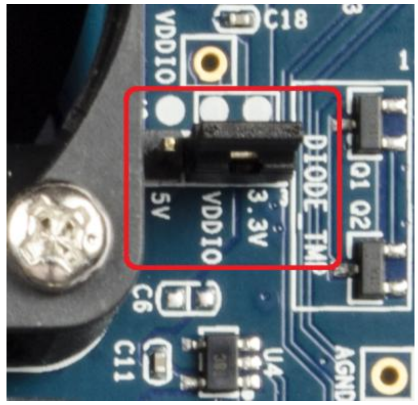
The fans require a 12-V power supply and usually take about 0.5 A of input current. The CY8CKIT-036 EBK includes a 12-V DC high-current power supply that is capable of providing the inrush current needed by the fans installed on the kit. Connect the high-current power supply to the power connector (J13), and set the power jumper (J9) on the CY8CKIT-036 EBK board to 12V_EXT (the default setting).

Figure 2-2. 12 V Power Supply Selection (Jumper J9)



The tachometer signals from the fans have an onboard external pull-up resistor (4.7 K) to VDDIO for interfacing with PSoC. The value of the VDDIO power supply is controlled by jumper J3 (3.3 V or 5 V). The VDDIO selection (see Figure 2-3) should be the same as the VDD operating voltage of the PSoC chip.

Figure 2-3. VDDIO Selection on KIT-036 Using Jumper J3



2.3 Temperature Sensors

2.3.1 I^{2}C Temperature Sensor

The CY8CKIT-036 EBK demonstrates I^{2}C temperature-sensing capability using a two-wire I^{2}C-compatible digital temperature sensor, the TMP175. I^{2}C digital temperature sensors are common for thermal management and are used in a variety of communication, computer, consumer, environmental, industrial, and instrumentation applications due to the popularity of the I^{2}C bus.

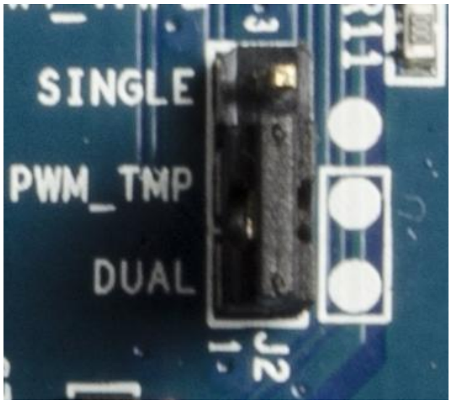
The sensor is powered by the VDDIO power supply, and the value of the VDDIO power supply is controlled by jumper J3 (3.3 V or 5 V), as shown in Figure 2-3. The VDDIO selection should be the same as the VDD operating voltage of the PSoC chip. For details, refer to the temperature sensor datasheet, which is available on the manufacturer’s website or on the kit webpage.

2.3.2 PWM Output Digital Temperature Sensors

The CY8CKIT-036 EBK has two TMP05 PWM-based temperature sensors onboard. The TMP05 is a monolithic temperature sensor that generates a modulated serial digital output (PWM) signal. The duty cycle of this PWM signal is proportional to the ambient temperature measured by the device. The TMP05 sensor has a two-pin interface. The CONV/IN input pin, when pulsed by PSoC, initiates a new temperature measurement. The output (OUT) pin provides a PWM signal; and the logic-high duration, logic-low duration of the PWM signal is used to determine the ambient temperature.

The TMP05 sensors support a daisy-chain mode of operation, in which the OUT signal of the first sensor can be connected directly to the CONV/IN input of the subsequent sensor. The OUT signal of the second sensor carries the PWM signals from both sensors. Many sensors can be daisy-chained in this fashion, with the final OUT signal carrying the PWM temperature encoding from all sensors in the daisy chain. Jumper J2 on the CY8CKIT-036 EBK, as shown in Figure 2-4, is used to select between the single PWM temperature sensor (PWM_TMP1) or the daisy-chain mode of operation (PWM_TMP1 followed by PWM_TMP2). This sensor generally is operated either in one-shot mode or in continuous mode.

Figure 2-4. TMP05 Sensors with Daisy-Chain Mode or Single-Sensor Mode Selection Using Jumper J2



The sensor is powered by the VDDIO power supply, and the value of the VDDIO power supply is controlled by jumper J3 (3.3 V or 5 V), as Figure 2-3 shows. The VDDIO selection should be the same as the VDD operating voltage of the PSoC chip. For details, refer to the TMP05 device datasheet, which is available on the manufacturer's website or on the kit webpage.

2.3.3 One-Wire Digital Temperature Sensor

The CY8CKIT-036 EBK has a Maxim DS18S20 one-wire, high-precision digital temperature sensor installed. The DS18S20 digital thermometer provides 9-bit resolution Celsius temperature measurements and has an alarm function with nonvolatile user-programmable upper and lower trigger points. The DS18S20 communicates over a proprietary one-wire bus that by definition requires only one data line (and ground) to communicate with a host microprocessor. It has an operating temperature range of –55° C to +125° C.

The sensor is powered by the VDDIO power supply, and the value of the VDDIO power supply is controlled by jumper J3 (3.3 V or 5 V), as Figure 2-3 shows. The VDDIO selection should be the same as the operating voltage of the PSoC chip. For details, refer to the datasheet, which is available on the manufacturer's website or on the kit webpage.

2.3.4 Diode Analog Temperature Sensors

The CY8CKIT-036 EBK has two onboard MMBT3904 transistors for temperature measurement. MMBT3904 is a bipolar junction transistor (BJT) designed as a general-purpose amplifier and switch. The useful dynamic range extends to 100 mA as a switch and to 100 MHz as an amplifier. For measuring the temperature, the transistor is connected in the diode configuration by shorting the collector and base terminals of the transistor. The temperature measurement is based on the principle of diode forward voltage drop dependence on temperature.

For details on the transistor characteristics, refer to the datasheet, which is available on the manufacturer's website or on the kit webpage.

2.4 Communication Interface

The CY8CKIT-036 EBK has an I^2C/SMBus/PMBus Port J1 that can be used by an external I^2C/SMBus/PMBus host to communicate with the PSoC chip. PSoC will act as the I^2C/PMBus/SMBus slave, and the host can send commands to the PSoC device and receive status information about the thermal management zone (fan speed, sensor temperature).

2.5 CY8CKIT-036 EBK 2x20 Pin Header

The 40-pin interface (2x20 pin header) provides a mechanism to connect CY8CKIT-036 EBK to a Cypress development kit platform. Table 2-2 lists the pin assignments of the 2x20 connector.

Table 2-2. 2x20 Connector Pin Assignments

Description	Signal	Pin	Pin	Signal	Description
Tachometer signal from Fan 4	TACH4	1	2	PWM4	PWM speed control for Fan 4
Tachometer signal from Fan 3	TACH3	3	4	PWM3	PWM speed control for Fan 3
Tachometer signal from Fan 2	TACH2	5	6	PWM2	PWM speed control for Fan 2
Tachometer signal from Fan 1	TACH1	7	8	PWM1	PWM speed control for Fan 1
Analog ground	AGND	9	10	NC	–
–	NC	11	12	NC	–
–	NC	13	14	NC	–
–	NC	15	16	NC	–
–	NC	17	18	NC	–
Analog ground	AGND	19	20	NC	–
Temperature diode current source	TD-I	21	22	TD-K	Temperature diode cathode
Temperature diode anode	TD-A	23	24	1-WIRE	One-wire temperature sensor
I^2C temperature sensor output	T-SDA	25	26	T-SCL	I^2C temperature sensor clock
PWM temperature sensor output	P-OUT	27	28	P-IN	PWM temperature sensor input
Analog ground	AGND	29	30	NC	–
Reserved	RESV	31	32	SM-ALT	Alert signal (I^2C/SMBus/PMBus)
Serial data (I^2C/SMBus/PMBus)	SM-SDA	33	34	SM-SCL	Serial clock (I^2C/SMBus/PMBus)
3.3-V power from DVK	3.3 V	35	36	VADJ	Unused
Digital ground	DGND	37	38	5 V	5 V-power from DVK
Optional 12-V power from DVK	12 V	39	40	DGND	Digital ground

2.6 CY8CKIT-036 EBK Headers and Jumpers

The CY8CKIT-036 EBK provides numerous jumpers. Table 2-3 lists the default jumper settings for the board.

Table 2-3. CY8CKIT-036 EBK Jumper Settings

Headers and Jumpers	Description	Factory Default Configuration
J1	Five-pin header for connecting an external host or management processor via I2C/SMBus/PMBus.	Connector fitted
J2	Three-pin header to choose between a single-sensor or a dual-sensor (daisy chain) connection for the PWM temperature sensors. Place the jumper in 1-2 position to enable dual-sensor daisy-chain mode.	1-2 position (dual-sensor daisy chain)
J3	J3 three-pin header to set logic signal levels for digital temperature sensors. Place in 1-2 position for 5-V interfacing; place in 2-3 position for 3.3-V interfacing.	2-3 position (3.3-V interfacing)
J4	Four-pin header (1.25 mm pitch) to connect Fan 1. Supplies 12-V power, ground, PWM drive, and tachometer feedback. All signals are replicated on J7.	Not connected
J5	Four-pin header (1.25 mm pitch) to connect Fan 2. Supplies 12-V power, ground, PWM drive, and tachometer feedback. All signals are replicated on J8.	Not connected
J6	Four-pin header (1.25 mm pitch) to connect Fan 3. Supplies 12-V power, ground, PWM drive, and tachometer feedback. All signals are replicated on J10.	Not connected
J7	Four-pin header (2.54 mm pitch) to connect Fan 1. Supplies 12-V power, ground, PWM drive, and tachometer feedback. All signals are replicated on J4.	Connected to Fan 1
J8	Four-pin header (2.54 mm pitch) to connect Fan 2. Supplies 12-V power, ground, PWM drive, and tachometer feedback. All signals are replicated on J5.	Connected to Fan 2
J9	Three-pin header for fan power supply. Place in 1-2 position to source external power from the power jack (J13); place in 2-3 position to source 12-V power from the DVK.	1-2 position (fan power from J13)
J10	Four-pin header (2.54 mm pitch) to connect Fan 3. Supplies 12-V power, ground, PWM drive, and tachometer feedback. All signals are replicated on J6.	Not connected
J11	Four-pin header (2.54 mm pitch) to connect Fan 4. Supplies 12-V power, ground, PWM drive, and tachometer feedback. All signals are replicated on J12.	Not connected
J12	Four-pin header (1.25 mm pitch) to connect Fan 4. Supplies 12-V power, ground, PWM drive, and tachometer feedback. All signals are replicated on J11.	Not connected
J13	Power jack. 12-V DC nominal.	Connector fitted
J14	2×20 pin header for connecting to the PSoC DVK.	Connector fitted
J15	2×20 pin header that replicates signals on J14 for easy connection to a logic analyzer or oscilloscope.	Open

3. Kit Operation

3.1 System Block Diagram and Theory of System Operation

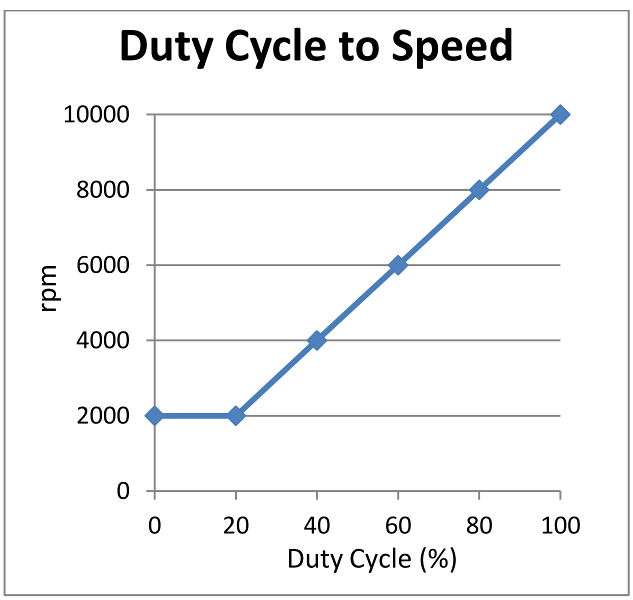
The Appendix contains a schematic of the CY8CKIT-036 EBK, along with circuits associated with the four-wire fans and the different onboard temperature sensors. This section describes the theory of operation for each of those hardware sub-blocks in the EBK.

3.2 Four-Wire Fan Control

A four-wire fan has two wires for power supply (VDD, ground); the other two wires are used for speed control (PWM signal) and speed monitoring (tachometer signal), respectively. Fans come in standard sizes—with 40 mm, 80 mm, and 120 mm being the most common sizes. One of the important specifications when selecting a fan for a cooling application is how much air the fan can move. This is specified either as cubic feet per minute (ft^3/min) or cubic meters per minute (m^3/min). The size, shape, and pitch of the fan blades all contribute to the fan's capability to move air.

With four-wire fans, speed control is made possible through the use of a PWM control signal. Increasing the duty cycle of the PWM control signal will increase fan speed. Fan manufacturers specify how the PWM duty cycle relates to nominal fan speed. This is provided either through a table of data points or a graph that shows the relationship. Figure 3-1 shows an example of such a chart, with the PWM control duty cycle (as a percentage) displayed on the horizontal axis and the fan speed (in rpm) displayed on the vertical axis.

Figure 3-1. Example of a Duty-Cycle-to-Speed Chart



Designers can enter duty cycle data in the graphical user interface (GUI) of the fan controller component in PSoC Creator; this component automatically configures and optimizes the firmware and hardware inside PSoC to control fans with these parameters.

It is important to note that fans don't always behave in the same way at low duty cycles. Some fans stop rotating as the duty cycle approaches 0 percent, whereas others rotate at a nominal specified minimum rpm. In both cases, the duty-cycle-to-speed relationship can be nonlinear or unspecified. When entering duty-cycle-to-speed data in the fan controller component customizer interface, select two data points from the linear region where the behavior of the fan is well defined.

Four-wire DC fans include Hall-effect sensors that sense the rotating magnetic fields generated by the rotor as it spins. The output of the Hall-effect sensor is a pulse train that has a period inversely proportional to the rotational speed of the fan. The number of pulses that are produced per revolution depends on how many poles are used in the electromechanical construction of the fan.

For the most common four-pole brushless DC fan, the tachometer output from the Hall-effect sensor will generate two high and low pulses per fan revolution. If the fan stops rotating due to mechanical failure or other fault, the tachometer output signal will remain static at either a logic-low level or a logic-high level.

The fan controller component measures the period of the tachometer pulse train for all fans in the system using a custom hardware implementation. The firmware APIs provided convert the measured tachometer periods into revolutions per minute to enable development of fan control algorithms that are firmware based. The same hardware block can generate alerts when it detects that a fan has stopped rotating—a condition referred to as a stall event.

For details on implementing four-wire fan control using various PSoC devices, read the following application notes.

- AN78692 – PSoC 1 – Intelligent Fan Controller
- AN89346 – PSoC 4 – Intelligent Fan Controller
- AN66627 – PSoC 3 and PSoC 5LP – Intelligent Fan Controller

These application notes provide example projects that demonstrate different usage modes of four-wire fan control. In addition, they include a thermal management example project that uses the temperature sensors on the CY8CKIT-036 EBK to control the speed of the fans associated with a thermal zone.

3.3 PWM Output Digital Temperature Sensor

There are two PWM output TMP05 temperature sensors on the CY8CKIT-036 EBK. TMP05 is a monolithic temperature sensor that generates a PWM serial digital output. The duty cycle of the PWM output varies in direct proportion to the ambient temperature of the devices. The high period (T_H) of the PWM remains static over all temperatures, whereas the low period (T_L) varies. It offers a high temperature accuracy of ±1° C (from 0° C to 70° C), with excellent transducer linearity. The ratio of T_H/T_L provides a method for determining the temperature according to the formula:

$$\text{Temperature (°C)} = 421 - (751 \times T_H/T_L)$$

The TMP05 sensor has a two-pin interface. The CONV/IN input, when pulsed by the PSoC chip, initiates a new temperature measurement. The output provides a PWM signal that can be decoded using the formula above to determine the ambient temperature. TMP05 sensors support a daisy-chain mode of operation in which the OUT signal of the first sensor can be directly connected to the CONV/IN input of the subsequent sensor. The OUT of the second sensor carries the PWM signals from both sensors. Many sensors can be daisy-chained in this fashion, with the final OUT signal carrying the PWM temperature encoding from all sensors in the daisy chain.

For details on interfacing with a TMP05 temperature sensor using various PSoC devices, read the following application notes:

- AN78737 – PSoC 1 – Temperature Sensing Solution Using a TMP05/TMP06 Digital Temperature Sensor
- AN65977 – PSoC 3 and PSoC 5LP: Creating an Interface to a TMP05/TMP06 Digital Temperature Sensor

3.4 Diode Analog Temperature Sensors

The CY8CKIT-036 EBK has two transistors connected in the diode configuration that can be used for temperature measurement. This section briefly describes the principle behind diode temperature measurement.

The following equation gives the current I, through a forward-biased diode:

$$I = I_s e^{\frac{V}{\eta V_T}} \qquad \text{Equation 1}$$

Where:

V is the diode-forward voltage drop

I_s is the reverse saturation current

η is a constant (called ideality factor) that has a value between 1 and 2, depending on the material and the physical structure of the diode

V_T is the thermal voltage given by the equation:

$$V_T = \frac{kT}{q} \qquad \text{Equation 2}$$

Where:

k is the Boltzmann's constant $(1.38 \times 10^{-23}\ joules/kelvin)$

T is the absolute temperature in Kelvin

q is the magnitude of electronic charge $(1.602 \times 10^{-19}\ coulomb)$

By passing two currents I1 and I2 and measuring the respective voltages V1 and V2, the temperature can be calculated using the following equation:

$$T\ (in\ Kelvin) = \frac{q}{k\,\eta}\left(\frac{(V2-V1)}{\ln\left(\frac{I2}{I1}\right)}\right) \qquad \text{Equation 3}$$

For details on interfacing with a diode temperature sensor using various PSoC devices, read the following application notes:

- AN78920 – PSoC 1 – Temperature Measurement Using a Diode
- AN60590 – PSoC 3, PSoC 4 and PSoC 5LP – Temperature Measurement with a Diode

The code examples in the application note use an external calibration resistor for measuring the current ratio accurately. The calibration resistor is not part of CY8CKIT-036 and needs to be connected externally on the PSoC DVK used. Refer to the respective PSoC application notes for the value of the calibration resistor and for connection details.

3.5 One-Wire Temperature Sensor

The CY8CKIT-036 EBK has an onboard Maxim DS18S20 one-wire, high-precision digital temperature sensor. The one-wire interface is a bidirectional, half-duplex, serial signaling protocol designed by Dallas Semiconductor. This compact communication interface for ICs does not require high-speed communication. It uses a single wire for reading and writing, and has no clock signal. One-wire devices have the ability to operate in parasitic mode, in which the connected devices can draw power from the one-wire bus itself. A one-wire interface is relatively slow, with a typical data rate of 16 kbps. It is perfect for slow sensors, such as thermometers, that do not need to be polled frequently.

For using PSoC 1 to interface with a one-wire temperature sensor, refer to the application note: AN2163 – Interfacing to One-Wire/Two-Wire Digital Temperature Sensors Using PSoC 1. Currently, there is no support for one-wire temperature sensors in the PSoC Creator IDE for PSoC 3, PSoC 4, or PSoC 5LP devices. Contact Cypress Technical Support if you need one-wire temperature sensor support for these PSoC devices.

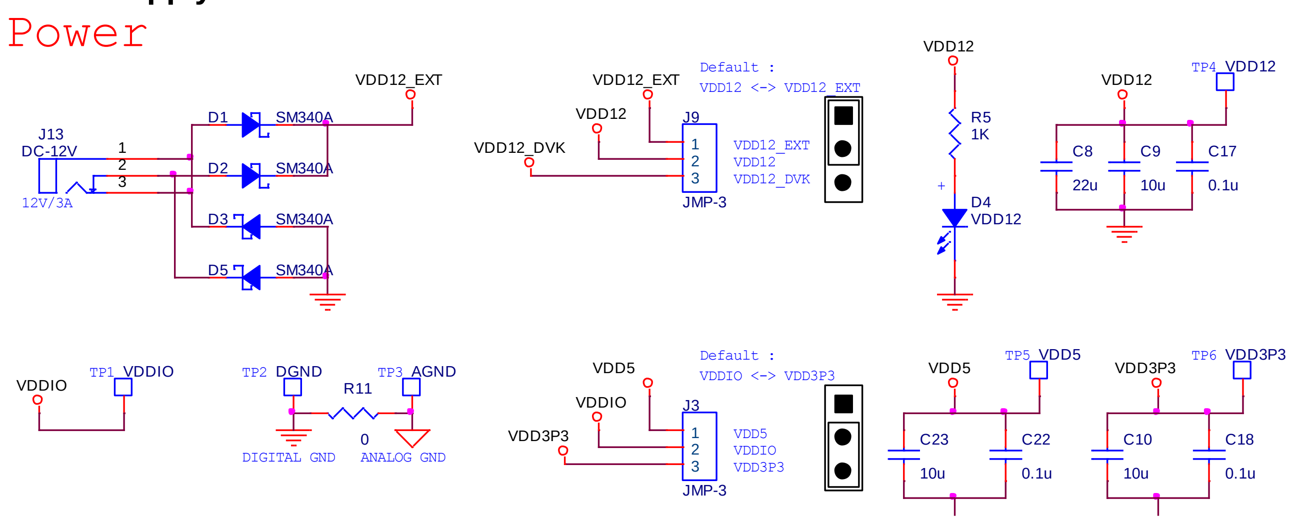
3.6 I²C Temperature Sensor

The CY8CKIT-036 EBK has an onboard TMP175 I²C temperature sensor. The TMP175 is compatible with two-wire and SMBus interfaces and is specified for a temperature range of −40° C to +125° C. The TMP175 features three address pins, allowing up to eight devices to be connected per bus. In the CY8CKIT-036 EBK, the three address pins (A2, A1, A0) are tied to ground, and the sensor address is 7'b1001000. The I²C master (PSoC) initiates a read transaction on the I²C bus to read the two-byte temperature value from the TMP175 sensor. The first byte read contains the integer part of the temperature, and the second byte contains the fractional part of the temperature value. Refer to the TMP175 datasheet for details on the output format, configuration options, and electrical specifications. The thermal management example projects provided as part of the four-wire fan control application notes listed in the Four-Wire Fan Control section have the firmware code to interface with a TMP175 temperature sensor.

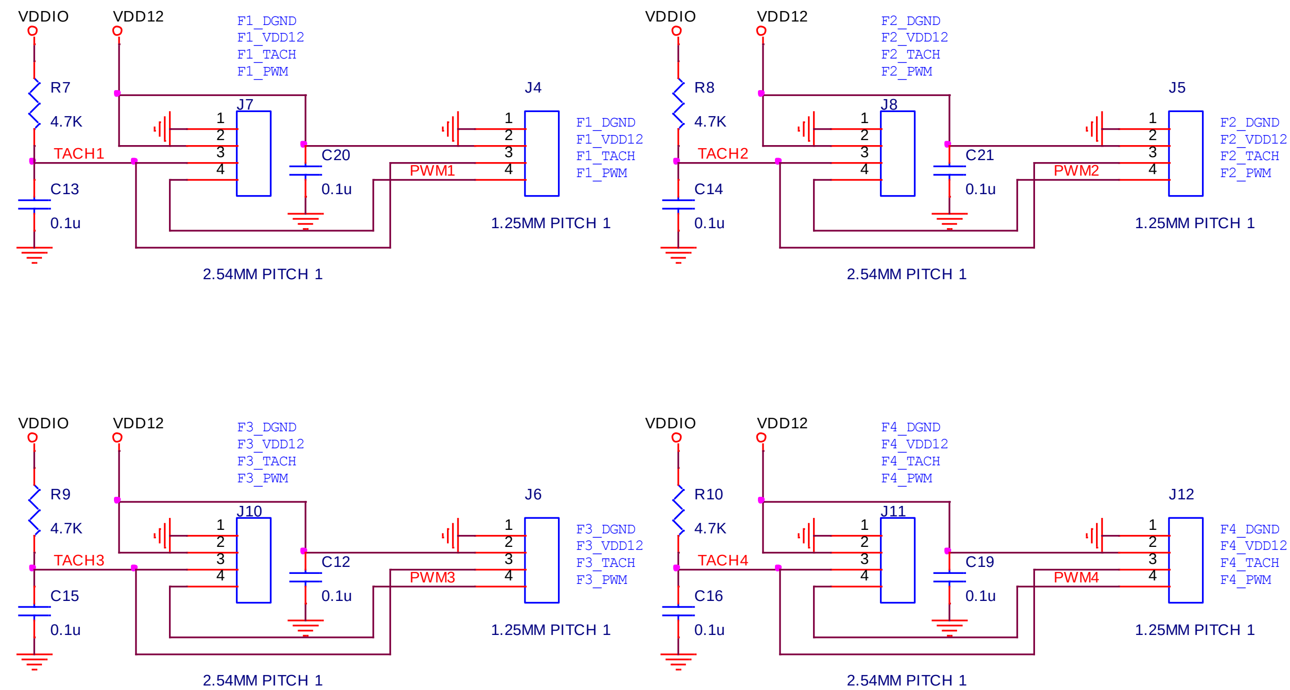
A. Appendix

A.1. Schematics

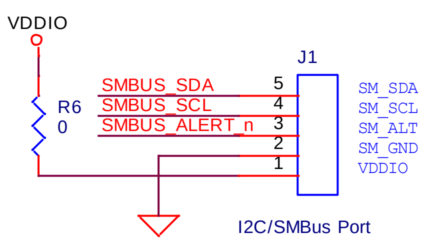
Power Supply



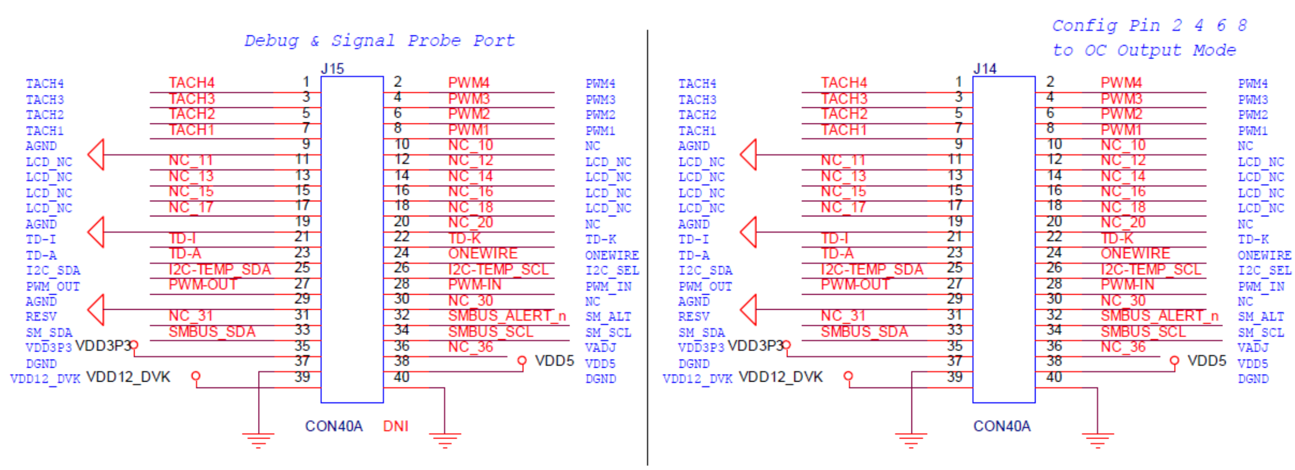
Four-Wire Fan Sockets



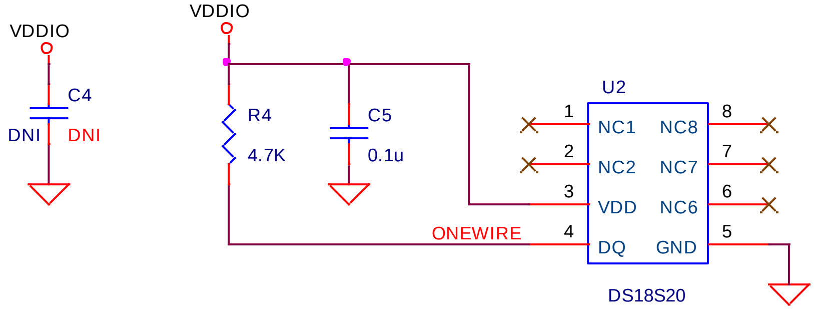
I2C/SMBus/PMBus Port



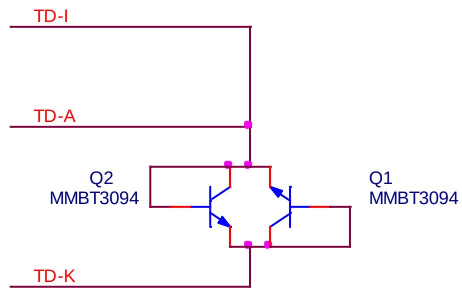
2x20 Pin DVK Connector and Test Points



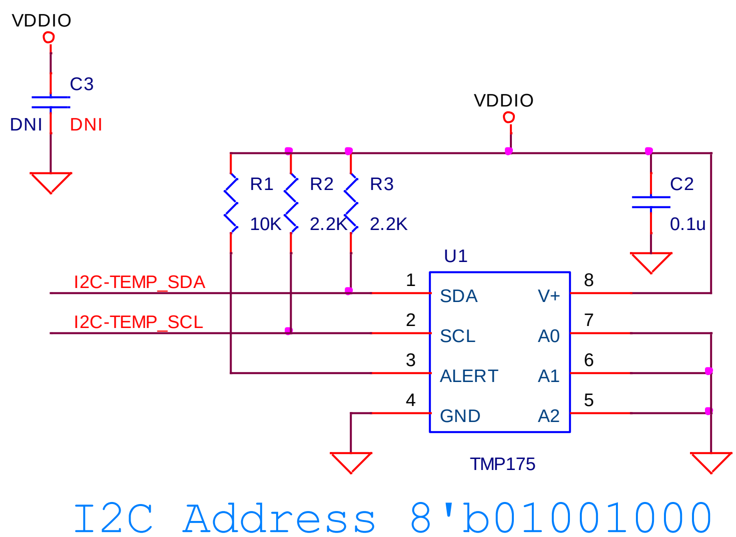
One-Wire Temperature Sensor



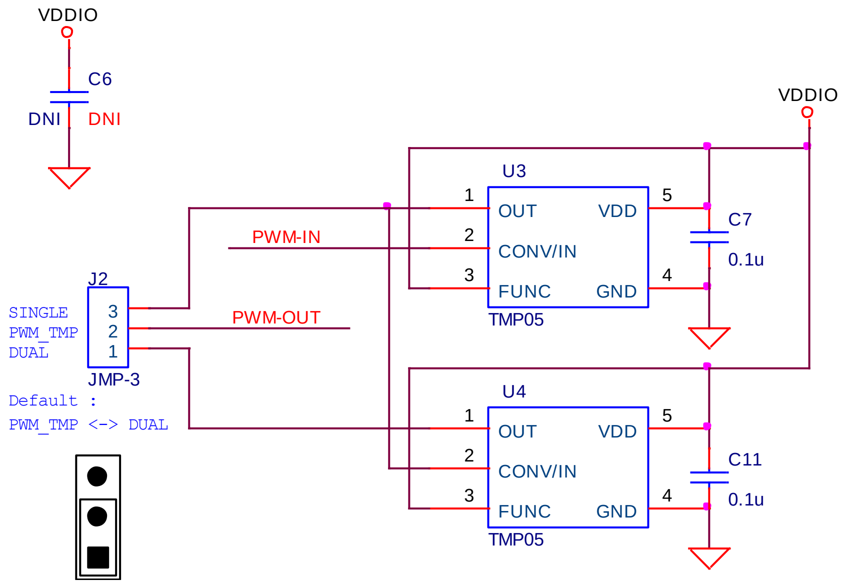
Temperature Diodes



I^{2}C Temperature Sensor

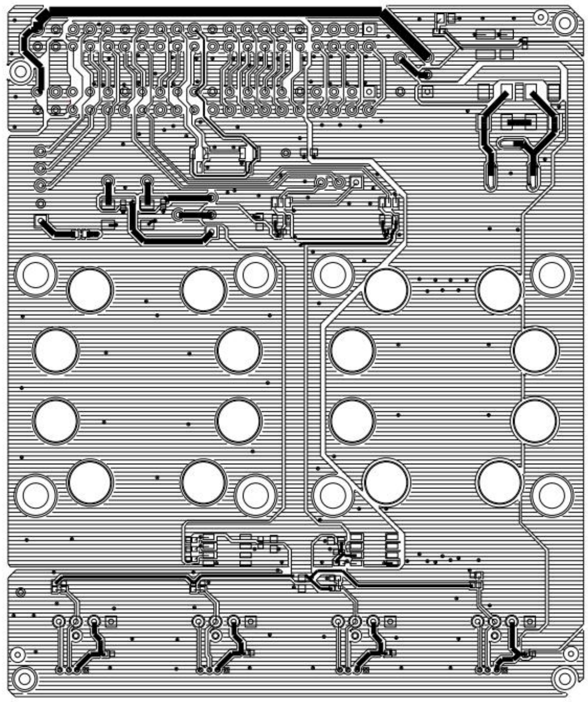


PWM Temperature Sensors

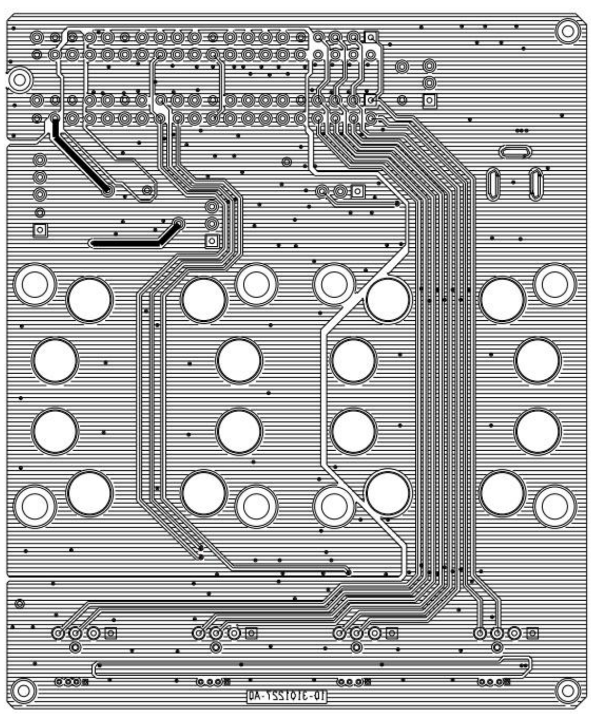


A.2. Board Layout

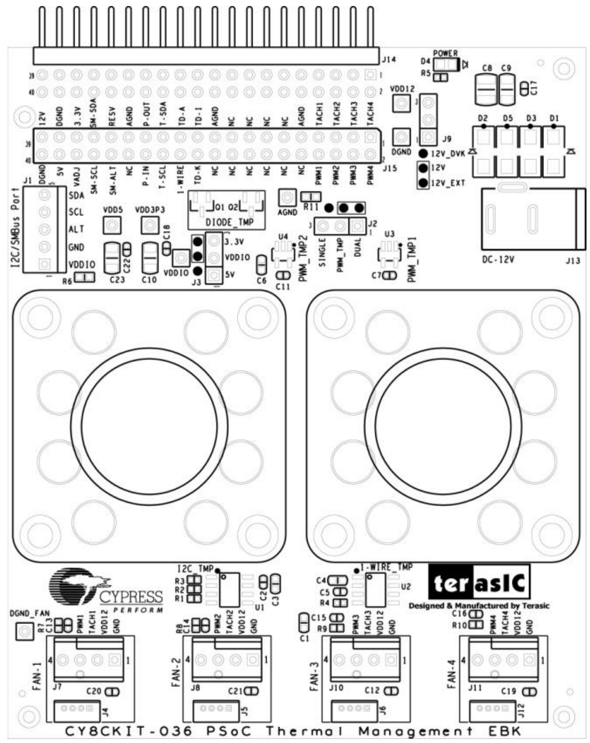
Top Layer



Bottom Layer



Top Silkscreen



A.3. Bill of Materials

Item	Description	Designator	Qty	Value	Manufacturer	Manufacturer Part#
1	Ceramic capacitor, 0.1uF, +/-10%, 25 V, X5R (0402)	C2,C5,C7,C11, C12,C13,C14, C15,C16,C17, C18,C19,C20, C21,C22	15	0.1u	Taiyo Yuden	TMK105BJ104KV-F
2	22uF, +/-10%, 25 V, X5R (1210)	C8	1	22u	MURATA	GRM32ER61E226KE15L
3	10uF, +/-10%, 25 V, X5R (1206)	C9,C10,C23	3	10u	MURATA	GRM31CR61E106KA12
4	Schottky rectifier 40 V/3 A (SM340A)	D1,D2,D3,D5	4	SM340A	GW	SM340A
5	Light-emitting diode (yellow)	D4	1	VDD12	LITEON	LTST-C170KSKT
6	ONN header 5POS .100 VERT TIN	J1	1	I2C/SMBus Port	MOLEX	22-05-3051
7	1X3 .100" center header	J2,J3,J9	3	JMP-3	SAMTEC	TSW-103-07-G-S
8	Fan socket, 1.25-mm wafer 180°	J4,J5,J6,J12	4	1.25MM PITCH 1	CHERNG WEEI	CCX-W125-04-DIP
9	Fan socket, 2.54-mm wire-to-board header, DIP 180° type	J7,J8,J10,J11	4	2.54MM PITCH 1	CHERNG WEEI	CD-W254-(3.4)
10	DC power socket	J13	1	DC-12V	CHERNG WEEI	32753PA
11	Pin header, 2x20, pitch 2.54 mm, male, right angle	J14	1	CON40A	NA	NA
12	NPN general purpose amplifier	Q1,Q2	2	MMBT3094	Fairchild	MMBT3094
13	10K ohm, +/-1%, 1/16 W (0402)	R1	1	10K	YAGEO	RC0402FR-0710KL
14	2.2K ohm, +/-1%, 1/16 W (0402)_	R2,R3	2	2.2K	YAGEO	RC0402FR-072K2L
15	4.7K ohm, +/-1%, 1/16 W (0402)	R4,R7,R8,R9, R10	5	4.7K	YAGEO	RC0402FR-074K7L
16	1K ohm, +/-0.1%, 1/16 W (0402)_	R5	1	1K	SAMSUNG	RG1005P-102-B-T5
17	0 ohm, jumper, 1/10 W (0603)_	R6,R11	2	0 ohm	WALSIN	WR06X000 PTL
18	Digital temperature sensor with two-wire interface	U1	1	TMP175	Texas Instruments	TMP175AID
19	High-precision 1-wire digital thermometer	U2	1	DS18S20	MAXIM	DS18S20Z
20	±0.5° C accurate PWM temperature sensor	U3,U4	2	TMP05	ADI	TMP05AKS-500RL7
21	Bumper clear.370X.19" cylinder	MH1,MH2, MH3,MH4	4	screw holes	Richco Plastic Co	RBS-35

Item	Description	Designator	Qty	Value	Manufacturer	Manufacturer Part#
22	Mini jumper 2.54 pitch open type (13.5)		3		CHERNG WEEI	CMJ-135BB
23	M3 35 mm, nickel-plated, round head		8		NA	NA
24	M3 nickel-plated hexagonal nut		8		NA	NA
25	DC brushless axial flow fan, 40 x 40 mm, four-wire, 12 V		2		AVC	DB04028B12UP014

4. Revision History

Document Revision History

Document Title: PSoC® Thermal Management Expansion Board Kit Guide

Document Number: 001-89649

Revision	Issue Date	Origin of Change	Description of Change
**	12/2/2013	VVSK	Initial version of the kit guide