CY8CKIT-016

PSoC® 1 Thermal Management Kit Guide

Doc. # 001-80790 Rev. **

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1. Introduction

1.1 Overview

Thank you for your interest in the CY8CKIT-016 PSoC® 1 Thermal Management Kit. Thermal management is a combination of temperature sensing, fan control, and the algorithms or transfer functions that map temperature to fan speed. Thermal management is a critical, system-level function, which ensures that all components in the system operate within safe temperature limits, while at the same time minimizing power consumption and acoustic noise.

The PSoC 1 Thermal Management Kit is designed to work with the CY8CKIT-001 PSoC Development Kit (DVK) and CY8CKIT-036 PSoC Thermal Management Expansion Board Kit (EBK). To evaluate the thermal management functions and capabilities of PSoC 1 devices, the CY8CKIT-001 with CY8C28 family processor module and the CY8CKIT-036 are prerequisites. You can evaluate the example project described in this guide or alter the example project provided with this kit based on your design requirement.

Typical solutions for thermal management include devices such as CPLDs, mixed-signal ASICs, and limited-functionality and inflexible discrete devices. Thermal management solutions need to be flexible enough to interface with many kinds of digital and analog temperature sensors. To maximize efficiency, they must also be able to drive a multitude of fans independently. Finally, thermal management solutions must have enough intelligence built in to reliably control the cooling systems autonomously, independent of a master control processor in the event that communications are lost or the master control processors fail or go offline.

The PSoC 1 architecture enables a flexible and unique method of thermal management in a single chip, combining analog sensing capabilities for any analog temperature sensor, such as remote diodes, thermistors, and resistance temperature detectors (RTDs). The versatile digital resource pool of PSoC 1 enables the integration of I2C bus interfaces and capture timers to support interfaces to a wide variety of digital temperature sensors such as I2C based, pulse-width-modulated (PWM) based, and other proprietary serial interface digital temperature sensors.

1.2 Prerequisites

- CY8CKIT-001 PSoC Development Kit
- CY8CKIT-036 PSoC Thermal Management EBK

1.3 Features

CY8CKIT-016 demonstrates how to develop a PSoC 1 based thermal management coprocessor solutions with the help of an example project that has the following functions:

- Temperature monitoring
- Closed-loop fan control
- Thermal zone management - relationship between temperatures and cooling functions
- Algorithms - to detect thermal and cooling failures or warnings

1.4 Kit Contents

You can download the *CY8CKIT-016 Kit Setup* executable file from http://www.cypress.com/go/CY8CKIT-016. If you already have PSoC Designer and PSoC Programmer installed, download *CY8CKIT-016 Kit Only*.

The executable file includes the following:

- PSoC Designer™ 5.2 SP1 or later
- PSoC Programmer 3.14 or later
- Thermal Management example project using the CY8CKIT-001 DVK and CY8CKIT-036 EBK
- User Guide (this document)
- Application Note (AN78920): *PSoC 1 Temperature Measurement Using Diode*
- Application Note (AN78737): *PSoC 1 - Temperature Sensing Solution using a TMP05/TMP06 Digital Temperature Sensor*
- Application Note (AN78692): *PSoC 1 - Intelligent Fan Controller*
- Application Note (AN2163): *PSoC 1 - Temperature Sensing Solution using a 1-Wire/2-Wire (I2C) Digital Temperature Sensor*

1.5 Document History

Revision	PDF Creation Date	Origin of Change	Description of Change
**	08/22/2012	PRKU	Initial version of kit guide

1.6 Documentation Conventions

Table 1-1. 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 Designer 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. Getting Started

This section provides instructions to install software and set up the hardware to run the example project provided with the kit.

2.1 Software Installation

1. Download the executable file, as described in 1.4 Kit Contents and run the file to install the PSoC 1 Thermal Management Kit software.

Figure 2-1. Kit Menu



After the installation is complete, the kit contents are available at the following location:

`C:\Program Files\Cypress\CY8CKIT-016\1.0`

When installing the PSoC 1 Thermal Management Kit software, the installer checks if your system has the required software. This includes PSoC Designer, PSoC Programmer, Windows Installer, .NET framework, and Adobe Acrobat. If these applications are not installed, then the installer prompts you to install all pre-requisite software, which is also available in the *CY8CKIT-016 ISO* file at http://www.cypress.com/go/CY8CKIT-016.

The software can be uninstalled using one of the following methods:

- Go to **Start > Control Panel > Add or Remove Programs**; select the appropriate software package; select the **Remove** button.
- Go to **Start > All Programs > Cypress > Cypress Update Manager > Cypress Update Manager**; select the **Uninstall** button for the appropriate software package.
- Run the executable file and click **Install CY8CKIT-016** button. In the CyInstaller for PSoC 1 Thermal Management Kit 1.0 window, select **Remove** from the Installation Type drop-down menu. Follow the instructions to uninstall.

  Note This method will only uninstall the kit software and not all the other material/software that may have been installed along with the kit software.

2.2 Hardware Setup

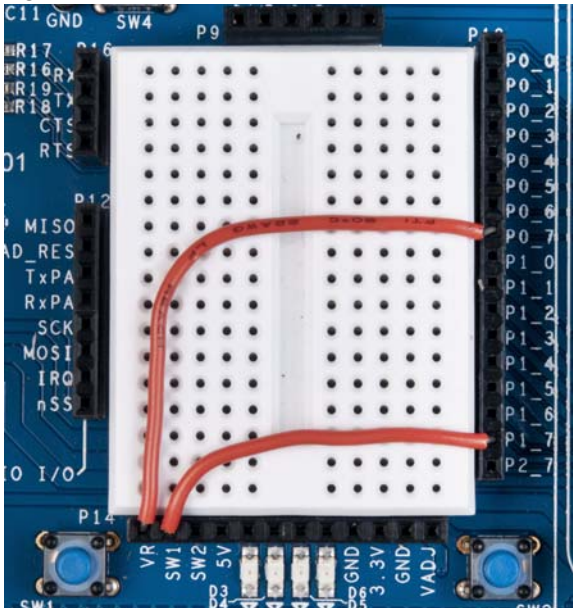
The following sections describe how to set up the hardware to run the example project. Make sure you have the hardware prerequisites before proceeding with this section.

2.2.1 CY8CKIT-001 PSoC DVK

Using the pin header/breadboard area of the PSoC DVK base board, use jumper wires to make the following connections:

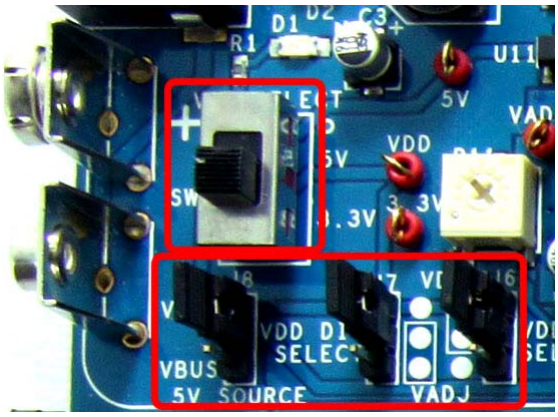
- VR to P0_7
- SW1 to P1_7

Figure 2-2. CY8CKIT-001 PSoC DVK Breadboard



Set the system to run at 3.3 V using SW3 and set J6 ‘VDD ANLG’ and J7 ‘VDD DIG’ to VDD=3.3 V, as shown in Figure 2-3.

Figure 2-3. CY8CKIT-001 PSoC DVK Power Jumpers



Attach the LCD included with the PSoC DVK and set the LCD power jumper (J12) in the ON position.

Figure 2-4. CY8CKIT-001 PSoC DVK LCD Power Jumper



Ensure that the VR_PWR jumper (J11) is installed.

Figure 2-5. CY8CKIT-001 PSoC DVK VR_PWR Jumper



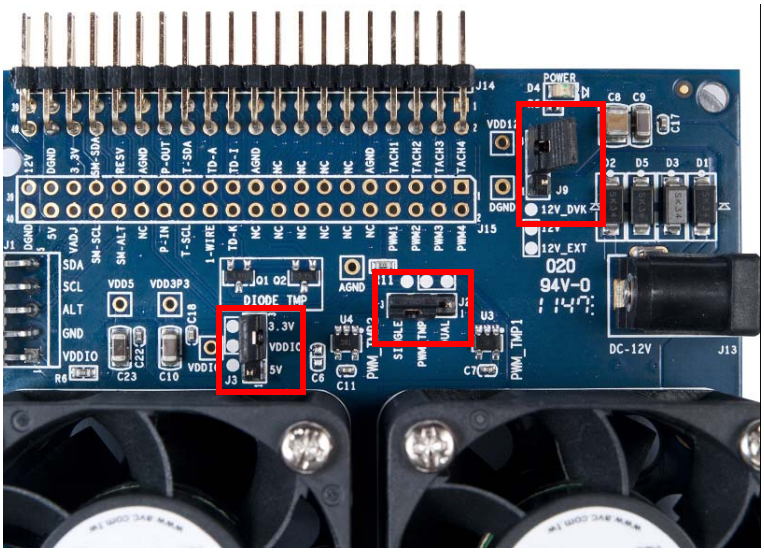
2.2.2 CY8CKIT-036 Jumper Settings:

Set the jumpers as follows:

- J2 to SINGLE
- J3 to 3.3V
- J9 to 12V_DVK
- bullet 4: Connect Fans to FAN1 (J7),FAN2(J8)

Note Ensure that the jumpers are set as provided above before proceeding to the next step. Also, ensure that the CY8CKIT-001 hardware and CY8CKIT-035 hardware are functional before starting with this example project. The corresponding kit documents can be used to verify if the hardware is functional.

Figure 2-6. Jumper Settings

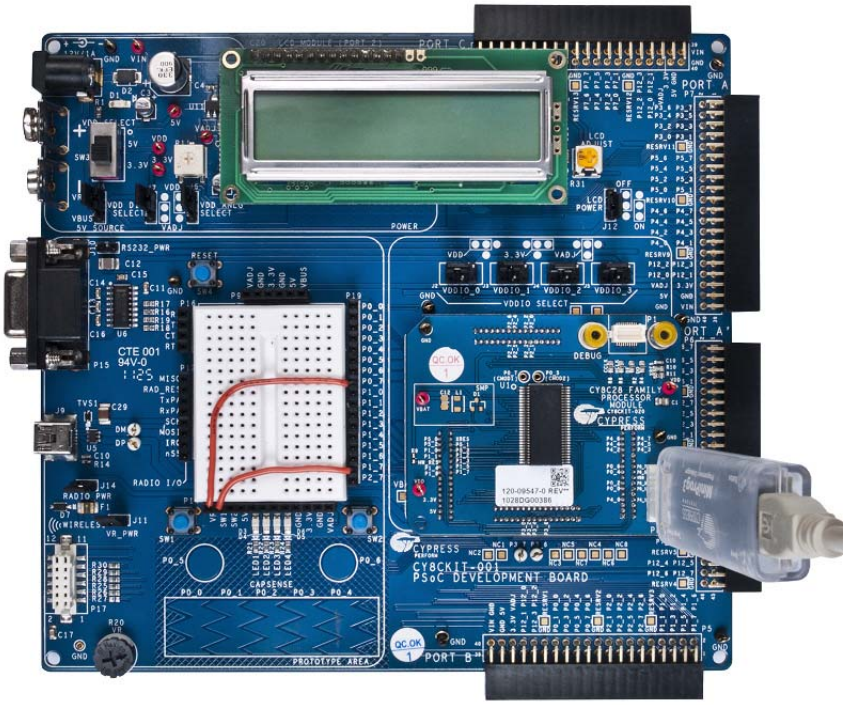


2.3 Running the Example Project

2.3.1 Programming

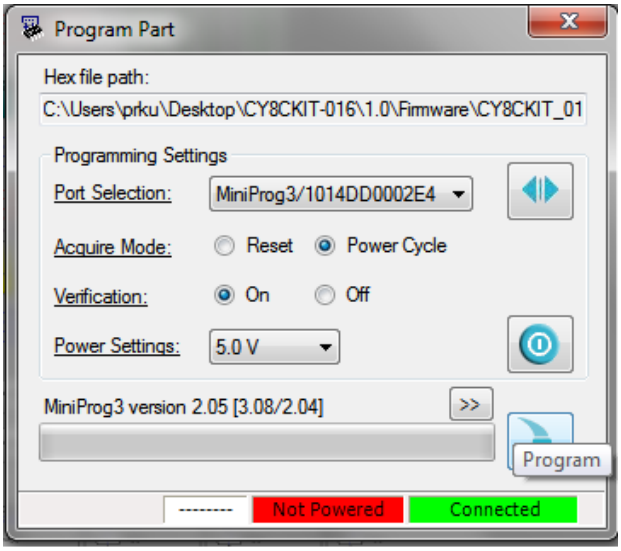
1. If this is the first time that the example project firmware is being programmed into PSoC, make sure the CY8CKIT-036 EBK is not connected to the CY8CKIT-001 DVK.
2. Ensure that the CY8C28 family processor module is connected to CY8CKIT-001.
3. Connect the MiniProg3 first to a USB port on the PC and then to the PROG port on the CY8C28 family processor module.

Figure 2-7. MiniProg3 Connected



4. Open the example project in PSoC Designer; select **Program > Program Part**.

Figure 2-8. PSoC Programmer



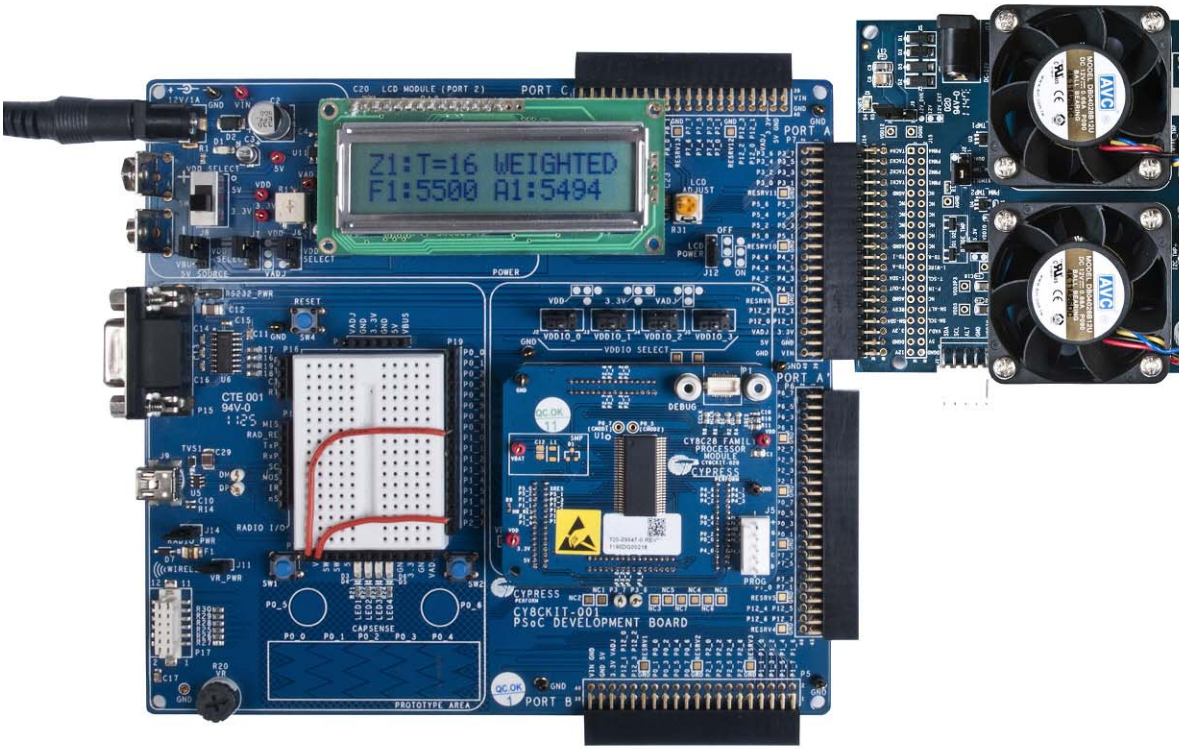
5. Ensure the programmer settings as given in Figure 2-8 and then click on the **Program** button.
6. When programming is completed successfully, remove the MiniProg3.

2.3.2 Demo Walk Through

1. Connect the CY8CKIT-036 to port A of the CY8CKIT-001 DVK.

2. Power the CY8CKIT-001 DVK using the 12-V DC high-current power supply (comes with CY8CKIT-036) that is capable of supplying the inrush current needed by the fans installed on CY8CKIT-036.
3. If the CY8CKIT-036 cannot be detected by PSoC, status debug messages will be displayed on the LCD to help rectifying the error.

Figure 2-9. CY8CKIT-001 PSoC DVK with CY8CKIT-036 Connected to Port A



The first screen shows Zone 1 temperature and fan speed set and actual. The potentiometer R20 can be used to increase or decrease Zone 1 temperature and notice how fan speed varies accordingly. SW1 can be used to navigate across different screens.

3. Example Project

3.1 Example Project: Thermal Management System

3.1.1 Overview

This example project demonstrates how the temperature sensors combined with the fans on the CY8CKIT-036 can create a complete thermal management system. The example shows how to combine temperature readings from a number of temperature sensors in a variety of ways and use the composite temperature to set desired fan speeds according to customized transfer function.

The thermal management example project uses the concept of 'Thermal Zone'. A thermal zone describes:

- How to combine multiple temperature sensor readings together to form a composite 'zone temperature'.
- How to map the zone temperature to a fan speed.

By this definition, each fan will be controlled according to its own independent thermal zone. This example has two thermal zones because CY8CKIT-036 has only two fans installed. Algorithms currently implemented to combine multiple temperature sensors into a composite zone temperature include straight average, weighted average, and maximum.

This example project uses the weighted method on both fans. A zone temperature to fan speed transfer function is then definable for each zone. Transfer functions currently implemented include linear and table driven. In this project, the transfer function used is table driven on both fans. That is, a look-up table maps composite zone temperature to fan speed.

- Two temperature zones – Zone 1 and Zone 2
- Two 4-wire BLDC fans – Fan1 and Fan2 installed in Zone 1 and Zone 2, respectively
- Four temperature sensors

Table 3-1. Zone Configuration

Label	Temperature sensor	To be installed in	Weight
U1 in CY8CKIT-036	I2C output temperature sensor - TMP175	Zone 1	10%
R20 in CY8CKIT-001	Diode temperature sensor		90%
U2 in CY8CKIT-036	One wire temperature sensor - DS1820	Zone 2	90%
U3,U4 in CY8CKIT-036	PWM output temperature sensor - TMP05		10%

This example is a simulation of a thermal management system. The first zone, Zone 1, combines temperature measurements from two temperature sensors (1 analog and 1 digital). The analog sensor is simulated using a variable potentiometer to allow easy demonstration of fan control over a wide simulated temperature range without the need for an environmental chamber to cycle through temperatures. In Zone 1, the temperature sensors are combined using a weighted average where the potentiometer is given 90% weight and the digital I2C temp sensor (U1 on CY8CKIT-036) is given 10% weight. Adjust the potentiometer (R20 on the CY8CKIT-001 DVK) to vary the simulated

temperature value in the approximate range of 15 °C to 100 °C. The Zone 1 speed transfer function is table driven and follows the profile shown in Table 3-2.

Table 3-2. Zone 1 Thermal Profile

Temperature (°C)	Fan Speed (RPM)
0–15	5000
15–35	5500
35–55	6500
55–75	8500
>75	10500

Zone 2 consists of two temperature sensors and a single fan. The Zone 2 speed transfer function is table driven and is shown in Table 3-3. Note that the temperature range is narrow and close to room temperature. This is to allow for simple testing at room by just touching a temperature sensor with a warm finger to cause a fan speed change. In Zone 2, the temperature sensors are combined using a weighted average where the 1-wire temperature sensor (U2 on CY8CKIT-036) is given approximately 90% of the weight. The TMP05 temperature sensor (U3, U4 on CY8CKIT-036) is given 10% weight. In this example, U2's temperature reading will dominate the overall zone temperature calculation.

Table 3-3. Zone 2 Thermal Profile

Temperature (°C)	Fan Speed (RPM)
0–23	5000
23–25	6000
25–27	7000
27–29	9000
>29	10000

The LCD screen displays status information about thermal management system across three screens. You can cycle through the status screens by pressing SW1 on the CY8CKIT-001 DVK.

3.1.2 Screen 1 - Zone 1 Summary

This screen displays the current status of Zone 1. Line 1 displays the zone number, the current composite zone temperature, and the zone temperature calculation algorithm used. Line 2 displays the desired fan speed and the actual fan speed for Zone 1.

Figure 3-1. Zone 1 Summary



3.1.3 Screen 2 - Zone 2 Summary

This screen displays the current status of Zone 2. Line 1 displays the zone number, the current composite zone temperature, and the zone temperature calculation algorithm used. Line 2 displays the desired fan speed and the actual fan speed for Zone 2.

Figure 3-2. Zone 2 Summary

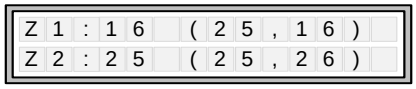


3.1.4 Screen 3 - Temperature Sensor Summary

This screen displays the current temperature sensor readings for all sensors in the system.

Line 1 displays the Zone 1 temperature sensor values. The left most temperature is the zone's composite temperature followed by the temperatures of each contributing sensor. Line 2 displays the same information for Zone 2.

Figure 3-3. Temperature Sensor Summary

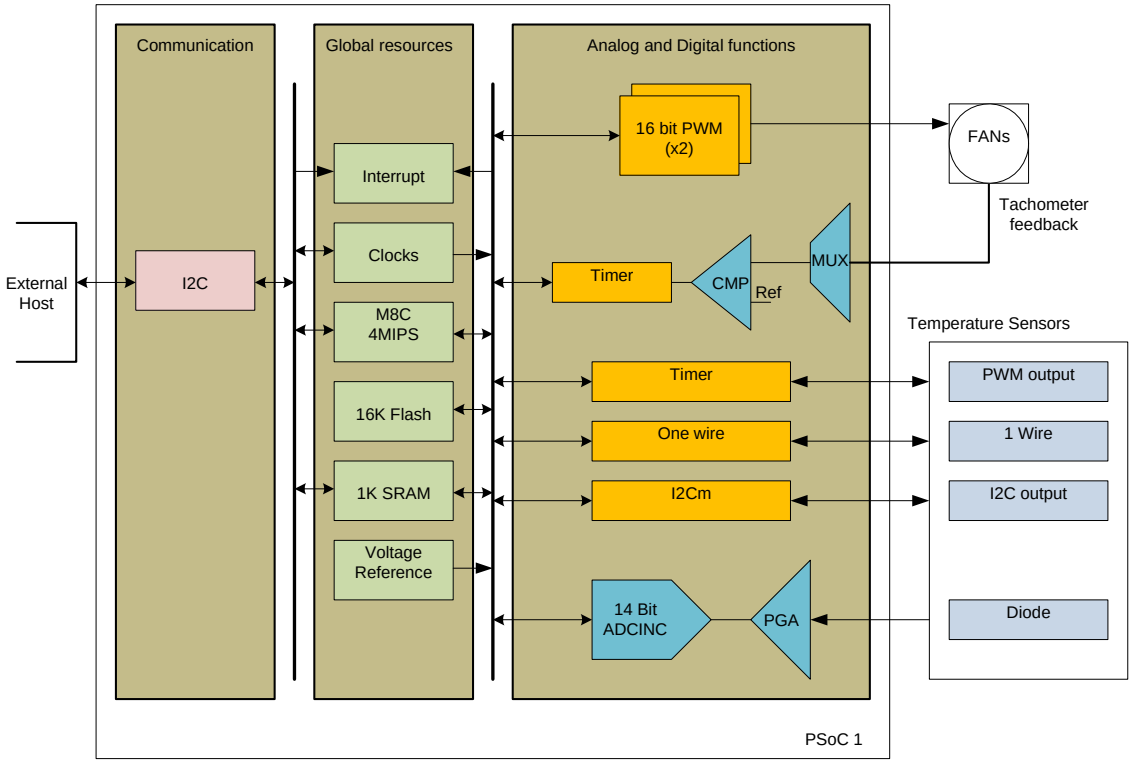


3.2 Technical Details

3.2.1 High-Level Architecture

The block diagram shows the high-level architecture inside PSoC 1.

Figure 3-4. Thermal Management Functional Block Diagram



3.2.2 PSoC 1 Resource Usage Details

The following table lists the resources used inside PSoC 1.

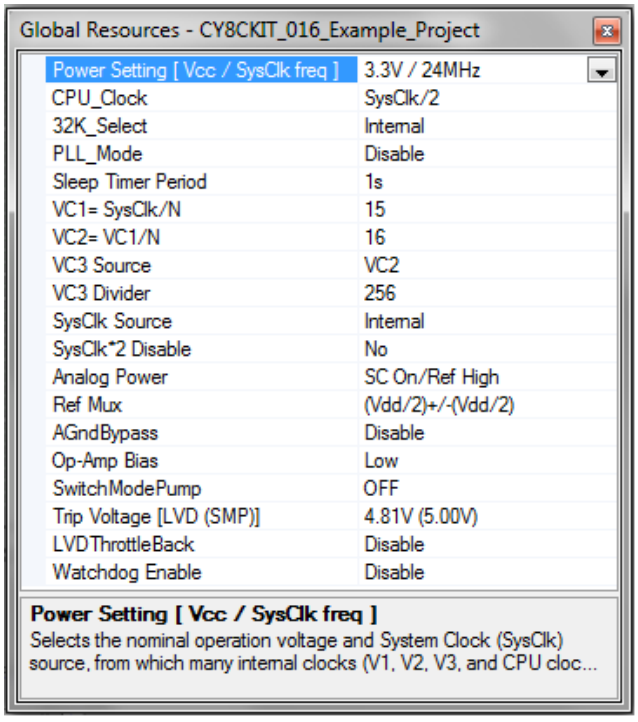
Table 3-4. Resource Usage

IP	Functions	Digital Blocks	Analog Blocks	Pins
Fan Controller	10-bit PWM (2) 16-bit Timer Hysteresis Comparator	6	1	4 (2/Fan)
TMP05	16-bit Timer	2	0	1
I2C	I2C HW	0	0	2
Analog Sensor	PGA ADC	1	2	1
OneWire	Transciever Clock	3	0	2

3.2.2.1 Global Resources

This window is used to set the global resource parameters.

Figure 3-5. Global Resource Parameters

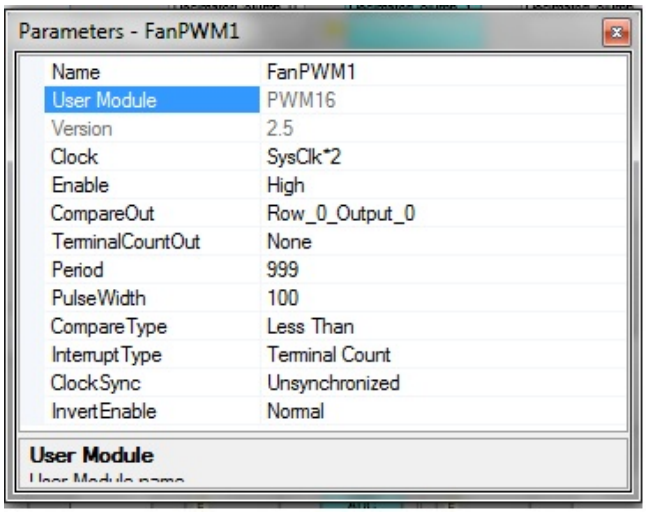


Set ADC measurement in the range 0 V to 5 V

The VC1 clock of 1.6 MHz drives the ADCINC block. This gives sample rate as 24 sps.

Figure 3-6. FanPWM1.

User Module Parameters



User Module PSoC Designer Screen

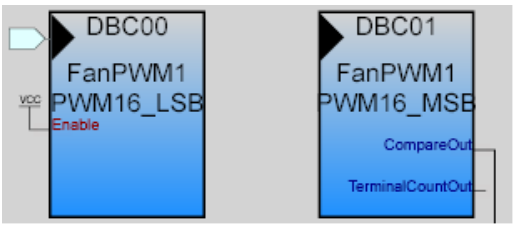
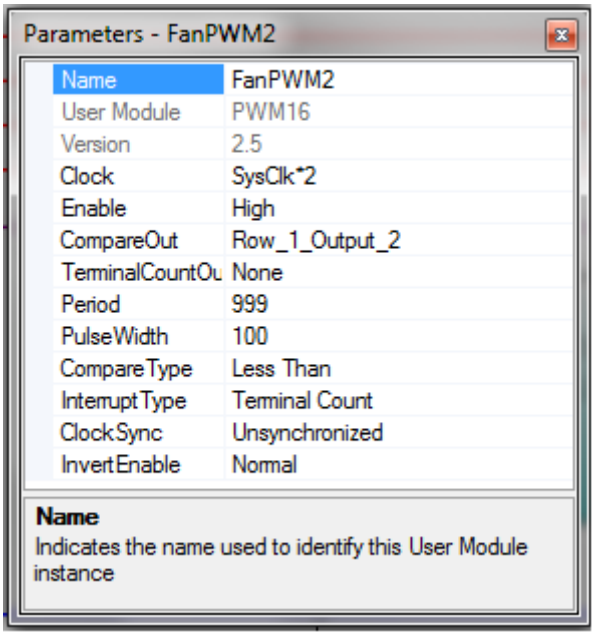
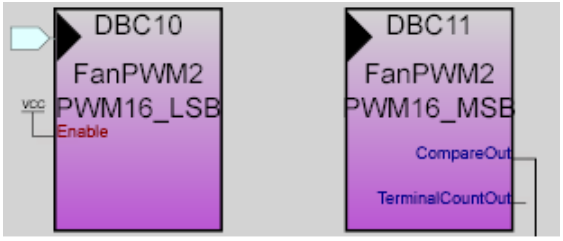


Figure 3-7. FanPWM2

User Module Parameters



User Module PSoC Designer Screen

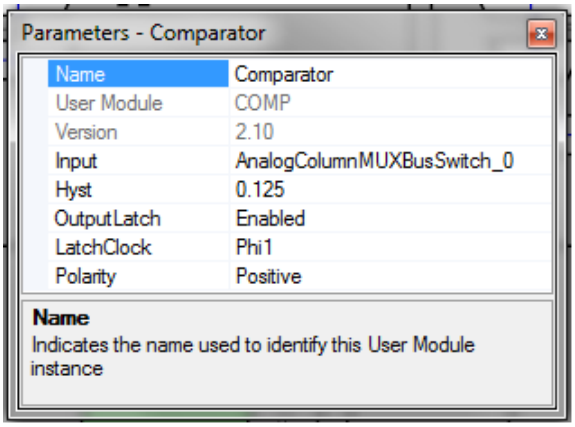


FanPWM

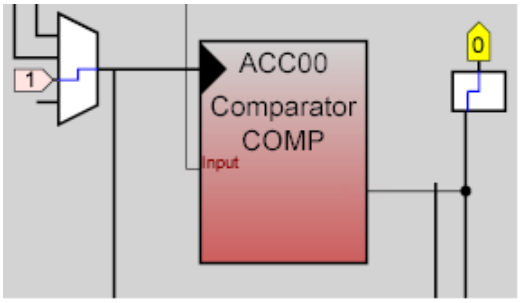
- FanPWMs are used to drive BLDC fans
- PWM frequency is set to 48 kHz
- Input clock is set to 48 MHz. This gives duty cycle resolution of 1000 counts

Figure 3-8. Comparator

User Module Parameters



User Module PSoC Designer Screen

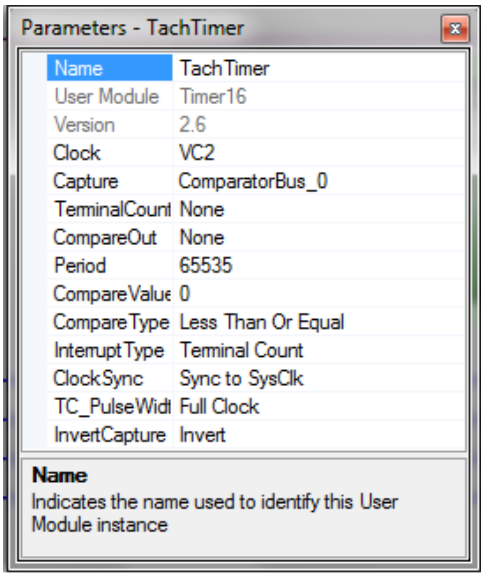


Comparator

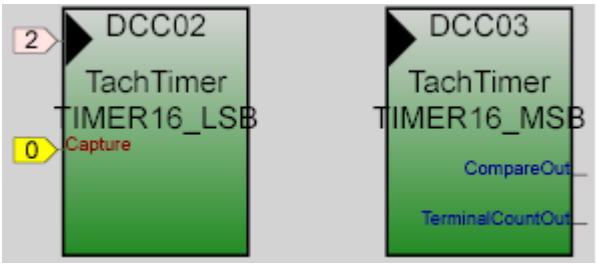
- Comparator takes the Fan tach signals and checks the level between the set hysteresis limit

Figure 3-9. Tach Timer

User Module Parameters



User Module PSoC Designer Screen

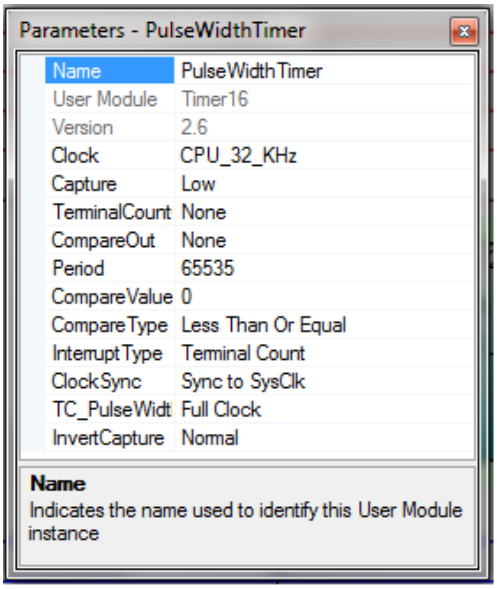


Tach Timer

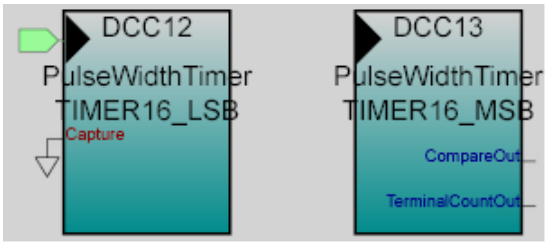
- Tach Timer is the 16-bit timer used to measure pulse width for the tach input from the BLDC fans

Figure 3-10. TMP05

User Module Parameters



User Module PSoC Designer Screen

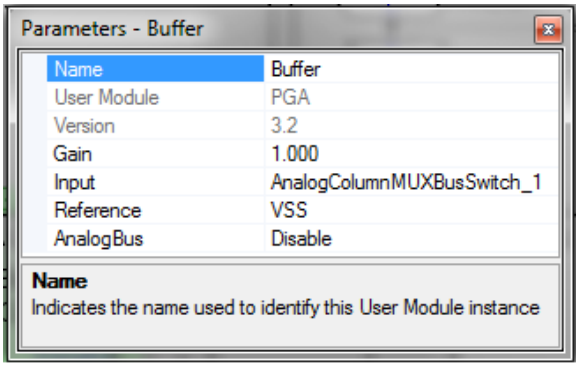


TMP05

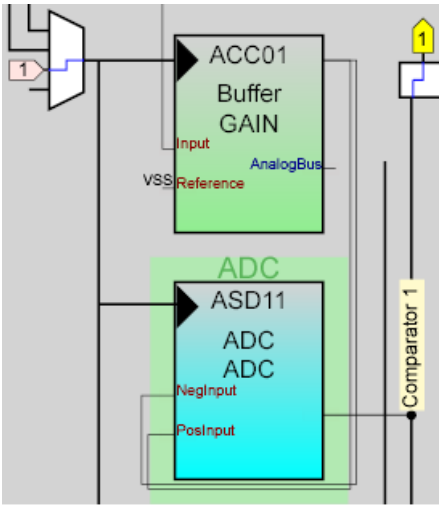
- PulseWidthTimer is the 16-bit timer used to measure pulse width for PWM based temperature sensors

Figure 3-11. PGA

User Module Parameters



User Module PSoC Designer Screen

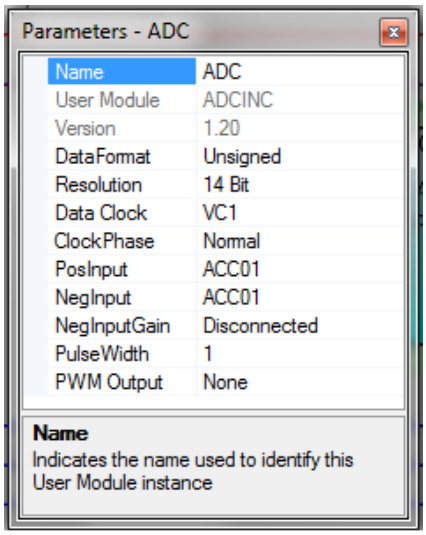


PGA

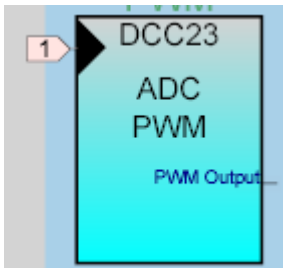
- PGA gain is set to 1
- This module takes the input from a potentiometer, which is used to simulate the diode sensor output

Figure 3-12. ADCINC

User Module Parameters



User Module PSoC Designer Screen

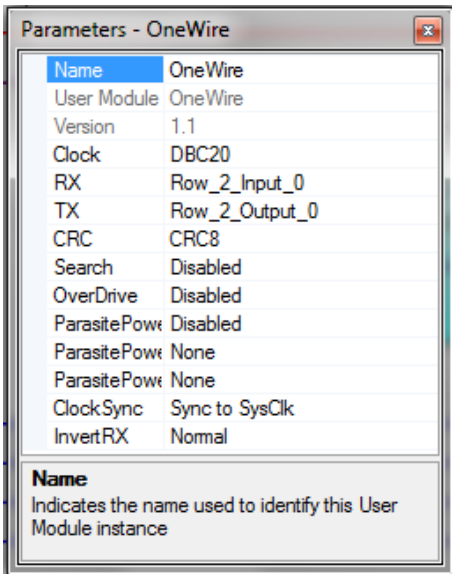


ADCINC

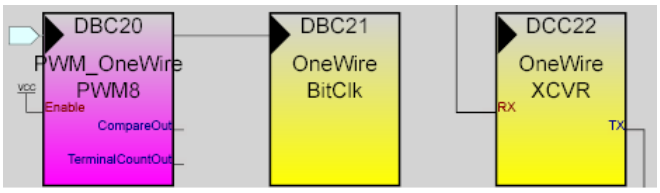
- ADCINC will read the voltage from potentiometer (simulated diode sensor)
- Resolution is set to 14 bits
- Sample rate is set to 24 sps
- The input for this user module is taken from PGA

Figure 3-13. OneWire

User Module Parameters



User Module PSoC Designer Screen

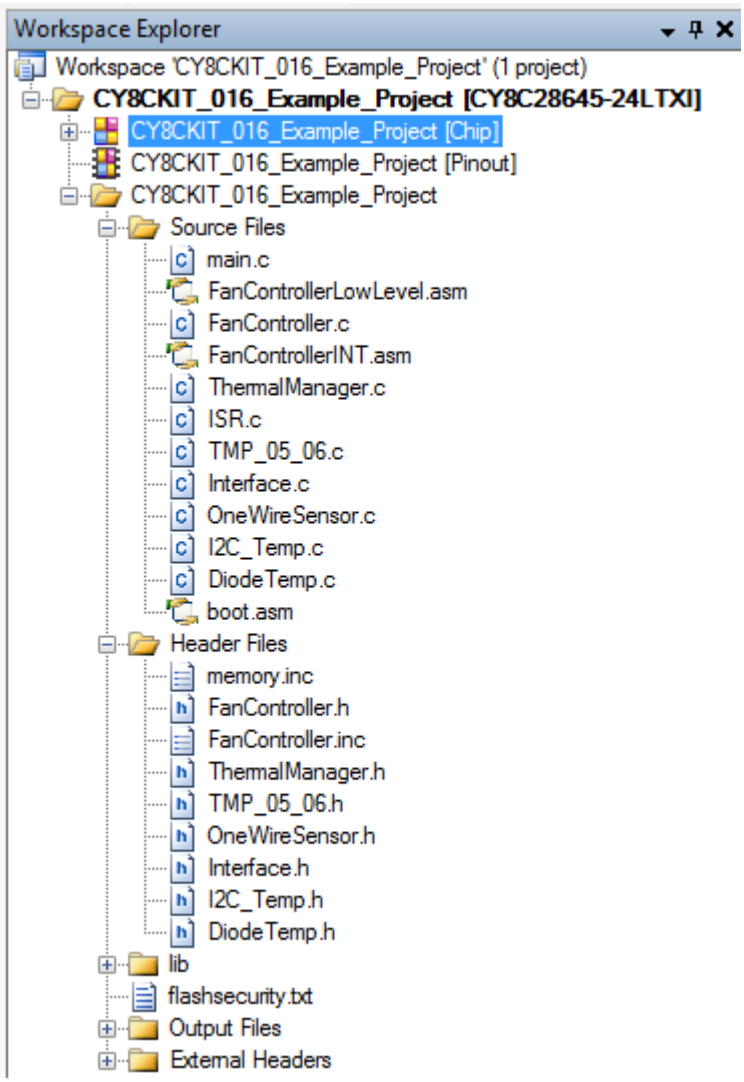


OneWire

- OneWire is the one-wire communication user module to read temperature data from one wire temperature sensor
- PWM_Onewire supplies input clock to the OneWire user module

3.2.3 Firmware Structure

Figure 3-14. Workspace Explorer

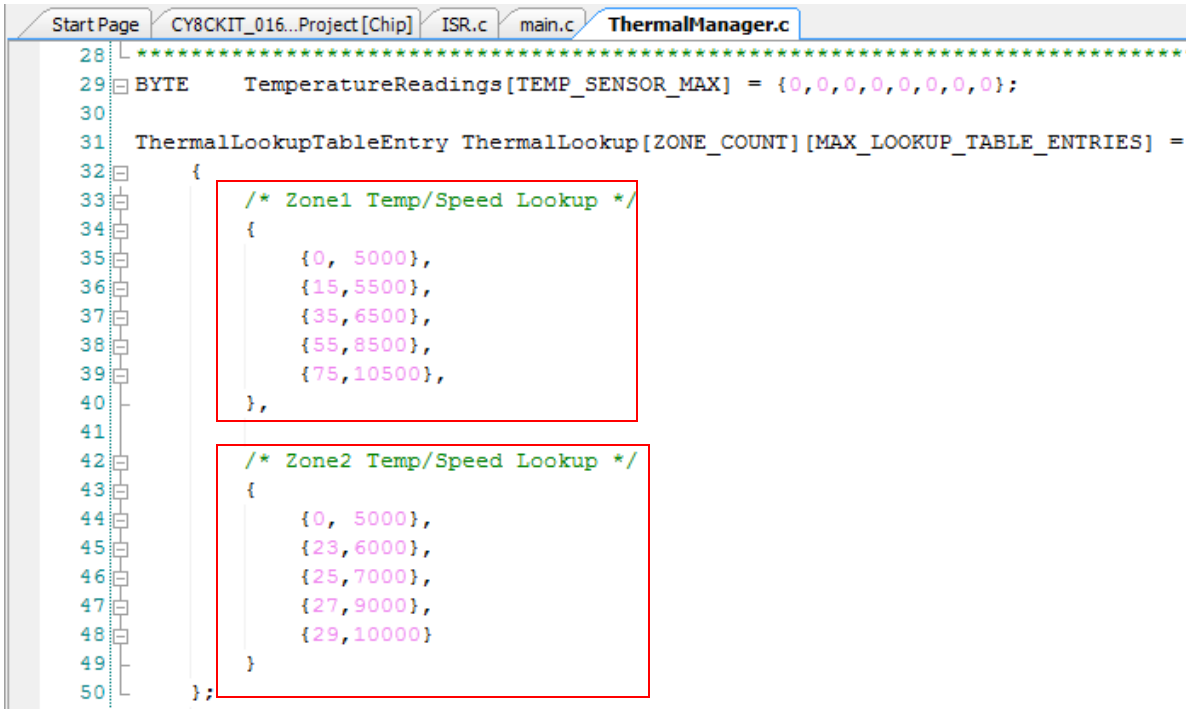


The Thermal Management System example consists of dedicated .c and .h files for every function. You can remove any function you do not need by removing the associated .c and .h file. The main application is responsible for the user interface and for periodically calling the thermal manager. The application implementation can be found in *main.c*. The thermal manager implementation can be found in ThermalManager.

The main application only needs to call ThermalManager_Start() to initialize the thermal manager and then it must periodically call ServiceThermalManager() to run temperature and speed updates.

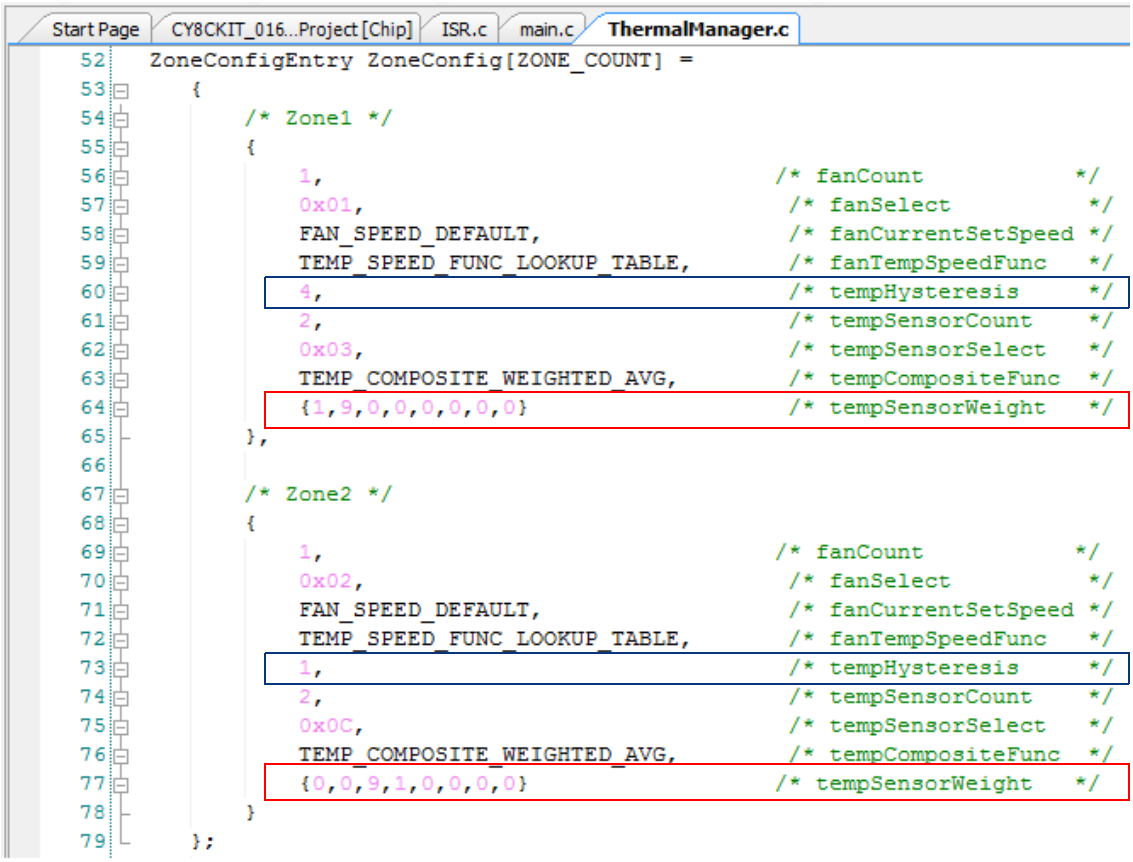
All the parameters that define the zone composite temperature sensor algorithm and the zone temperature to fan speed algorithm are defined at the top of *ThermalManager.c*. To modify these settings, refer to *ThermalManager.h* for the relevant keywords.

Figure 3-15. Zone Temperature Vs. Fan Speed Lookup Table



The entries in Table 3-2 and Table 3-3 are defined in the highlighted boxes. These entries can be changed based on design requirements.

Figure 3-16. Zone Configuration



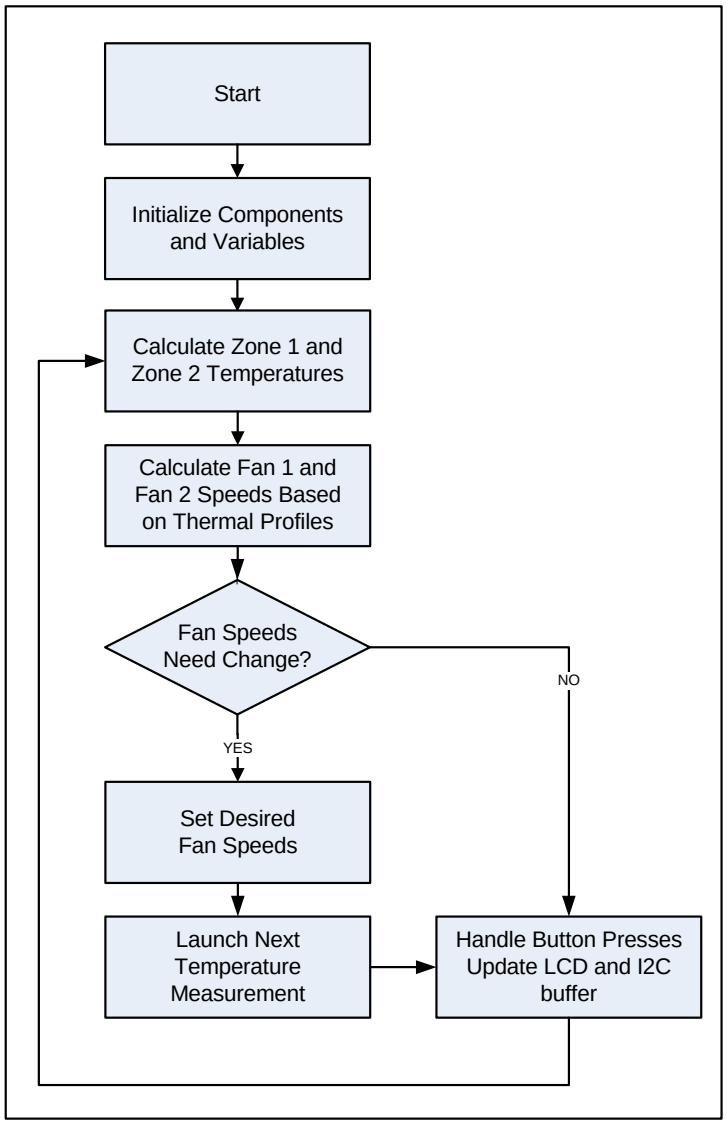

```
52  ZoneConfigEntry ZoneConfig[ZONE_COUNT] =
53      {
54          /* Zone1 */
55          {
56              1,                                  /* fanCount           */
57              0x01,                               /* fanSelect          */
58              FAN_SPEED_DEFAULT,                  /* fanCurrentSetSpeed */
59              TEMP_SPEED_FUNC_LOOKUP_TABLE,       /* fanTempSpeedFunc   */
60              4,                                  /* tempHysteresis     */
61              2,                                  /* tempSensorCount    */
62              0x03,                               /* tempSensorSelect   */
63              TEMP_COMPOSITE_WEIGHTED_AVG,        /* tempCompositeFunc  */
64              {1,9,0,0,0,0,0,0}                   /* tempSensorWeight   */
65          },
66
67          /* Zone2 */
68          {
69              1,                                  /* fanCount           */
70              0x02,                               /* fanSelect          */
71              FAN_SPEED_DEFAULT,                  /* fanCurrentSetSpeed */
72              TEMP_SPEED_FUNC_LOOKUP_TABLE,       /* fanTempSpeedFunc   */
73              1,                                  /* tempHysteresis     */
74              2,                                  /* tempSensorCount    */
75              0x0C,                               /* tempSensorSelect   */
76              TEMP_COMPOSITE_WEIGHTED_AVG,        /* tempCompositeFunc  */
77              {0,0,9,1,0,0,0,0}                   /* tempSensorWeight   */
78          }
79      };
```

- Key zone configuration parameters can be changed here based on design requirements.
- The highlighted box in red marks where the weights for different temperature sensors are entered. See Table 3-1 for details.
- The highlighted box in blue sets the hysteresis for both the zones. Hysteresis has been defined to avoid unnecessary fan speed changes in the temperature borders of the lookup table. For example, if Zone 1 temperature varies between 34.9 °C and 35.1 °C, the fan speed will be fluctuating between 5500 and 6500 RPM. To avoid this, hysteresis logic is implemented in the firmware. In this case, it is defined as '4', which means, if the temperature changes from 34.9 °C to 35 °C, the fan speed will change from 5500 to 6500 RPM, but if the temperature again falls from 35 °C, the fan speed will not change until 31 °C to avoid unnecessary speed fluctuations in the border. This entry can be changed according to design requirements.

3.2.4 Firmware Flowchart

The following flowchart shows the basic function of the thermal manager in*ThermalManager.c,* which implements the main service loop.

Figure 3-17. Thermal Manager Flowchart



4. CY8CKIT-036 Hardware

4.1 Hardware Overview

The CY8CKIT-016 uses the CY8CKIT-036 hardware for the example project. This section provides an overview of the CY8CKIT-036 Hardware. The CY8CKIT-036 contains two 4-wire, 12-V brushless DC fans with connectors to support an additional two fans for designers who need to prototype with their own specific fan models. Six temperature sensors (four different kinds) are also installed on the kit:

- TMP175 I2C digital temperature sensor
- Two TMP05 PWM output digital temperature sensors
- DS18S20 "One Wire" digital temperature sensor
- Two MMBT3094 temperature diodes.

This combination of hardware elements enables designers to rapidly prototype thermal management solutions in a variety of configurations.

CY8CKIT-036 also provides an I2C/SMBus/PMBus compatible header to support systems that have a requirement for communication with a host controller. All of this functionality is implemented on a single PSoC 1. CY8CKIT-036 routes all the input and output signals for thermal management to a PSoC 1 mounted on a development kit platform such as the CY8CKIT-001. PSoC 1 is not mounted on CY8CKIT-036.

Figure 4-1 shows a functional diagram of the PSoC 1 Thermal Management solution. This solution enables control of up to four 4-wire fans using MCU based control. Fan drive signals are generated by independent hardware PWM blocks in PSoC 1 to drive the 4-wire fans. To determine fan rotational speeds, tachometer signals from the fans are interpreted by PSoC 1. Speed control to the desired RPM is achieved by the firmware running on PSoC 1. The firmware also detects fan stall or rotor lock faults.

To support digital sensor temperature sensing, standard PSoC 1 interfaces are used where possible (such as I2C); PSoC user modules have been developed for non-typical digital sensors such as the PWM output TMP05 sensor and 1-wire temperature sensor. For analog sensors, PSoC 1 also provides on-board filtering, multiplexing for better resolution, and accurate temperature sensor measurement.

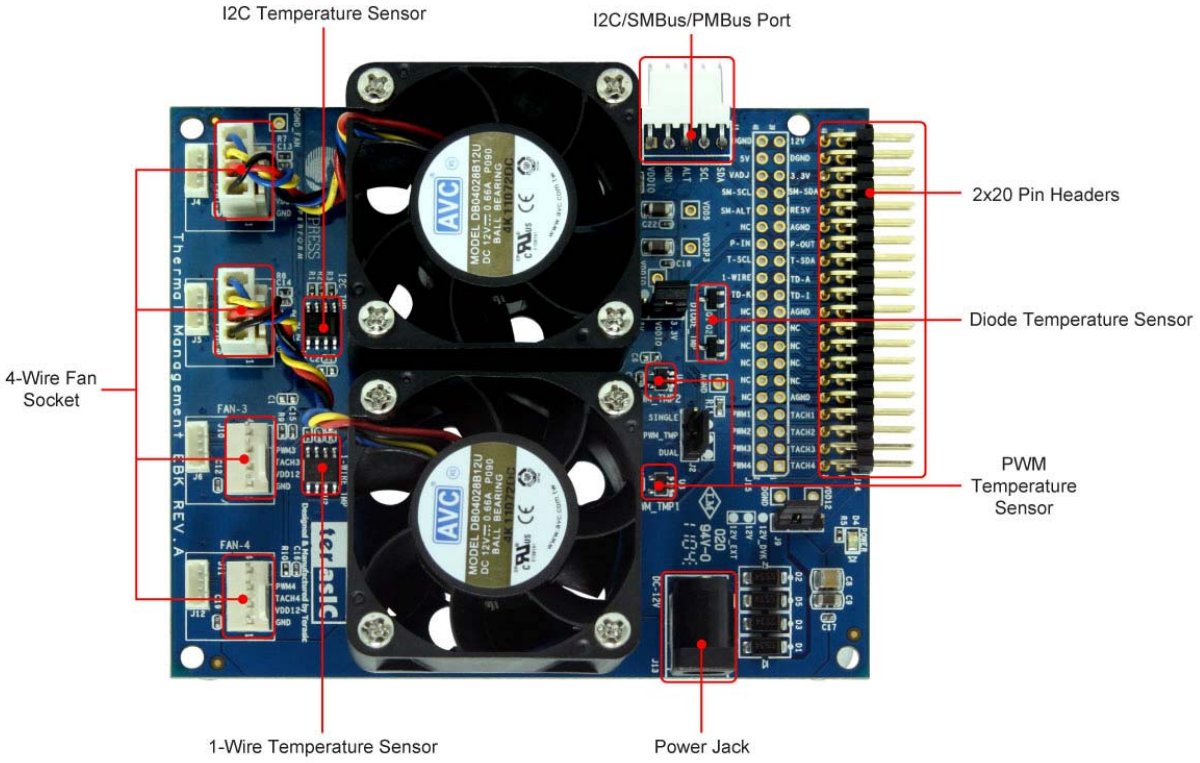
The example project provided with the CY8CKIT-036 illustrates how to aggregate temperature sensor readings using a variety of methods. The resultant "zone" temperature is used to set individual fan speeds - this is defined as a "thermal zone". The example project shows how each fan can be configured to be dependent on any of the available temperature sensors in any combination. It also demonstrates how the composite "zone temperature" can be used to determine the required fan speed to achieve system cooling needs.

Although not included in the example project, PSoC 1 devices also include nonvolatile EEPROM memory that can be used to store sensor calibration information or for event and fault logging purposes. Communication with a host controller or management processor can be achieved via I2C,

SMBus, PMBus, or a variety of other communications protocols implemented with easy-to-use PSoC 1 user modules.

Note that CY8CKIT-036 hardware limits support a maximum of four fans. The PSoC 1 Thermal Management solution can be easily extended to support up to 10 fans in a single device. Contact Cypress for further information on the full PSoC 1 Thermal Management solution.

Figure 4-1. CY8CKIT-036 Hardware Components



4.2 2×20 pin Interface Header

The 40-pin interface (2×20 pin header) provides a mechanism to connect CY8CKIT-036 to a Cypress development kit platform. Table 4-1 lists the pin assignments of the 2×20 connector.

Table 4-1. 2x20 Header (J14) Pin Definition

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	–

Table 4-1. 2x20 Header (J14) Pin Definition *(continued)*

Description	Signal	Pin	Pin	Signal	Description
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
I2C temperature sensor data	T-SDA	25	26	T-SCL	I2C 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 (I2C/SMBus/PMBus)
Serial Data (I2C/SMBus/PMBus)	SM-SDA	33	34	SM-SCL	Serial cock (I2C/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	12V	39	40	DGND	Digital ground

4.3 CY8CKIT-036 Headers and Jumpers

A number of jumpers are provided on the CY8CKIT-036. Table 4-2 lists the default jumper settings for the board.

Table 4-2. CY8CKIT-036 Jumper Settings

Headers and Jumpers	Description	Factory Default Configuration
J1	5-pin header for connecting an external host or management processor via I2C/SMBus/PMBus	Connector fitted
J2	3-pin header to choose between single sensor or dual sensor (daisy chain) connection for the PWM temperature sensors. Place jumper in 1-2 position to enable dual sensor daisy-chain mode	1-2 position (dual sensor daisy chain)
J3	3-pin header to set logic signal levels for digital temperature sensors. Place in 1-2 for 5 V interfacing; place in 2-3 position for 3.3 V interfacing	2-3 position (3.3 V interfacing)
J4	4-pin header (1.25 mm pitch) to connect Fan 1. Supplies 12-V power, ground, PWM drive, and tachometer feedback. All signals replicated on J7	Not connected
J5	4-pin header (1.25 mm pitch) to connect Fan 2. Supplies 12-V power, ground, PWM drive, and tachometer feedback. All signals replicated on J8	Not connected
J6	4-pin header (1.25 mm pitch) to connect Fan 3. Supplies 12-V power, ground, PWM drive, and tachometer feedback. All signals replicated on J10	Not connected
J7	4-pin header (2.54 mm pitch) to connect Fan 1. Supplies 12-V power, ground, PWM drive, and tachometer feedback. All signals replicated on J4	Connected to Fan 1
J8	4-pin header (2.54 mm pitch) to connect Fan 2. Supplies 12-V power, ground, PWM drive, and tachometer feedback. All signals replicated on J5	Connected to Fan 2
J9	3-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)

Table 4-2. CY8CKIT-036 Jumper Settings *(continued)*

Headers and Jumpers	Description	Factory Default Configuration
J10	4-pin header (2.54 mm pitch) to connect Fan 3. Supplies 12-V power, ground, PWM drive, and tachometer feedback. All signals replicated on J6	Not connected
J11	4-pin header (2.54 mm pitch) to connect Fan 4. Supplies 12-V power, ground, PWM drive, and tachometer feedback. All signals replicated on J12	Not connected
J12	4-pin header (1.25 mm pitch) to connect Fan 4. Supplies 12-V power, ground, PWM drive, and tachometer feedback. All signals replicated on J11	Not connected
J13	Power jack. 12-V DC nominal	Connector fitted
J14	2×20 pin header for connecting to PSoC DVK	Connector fitted
J15	2×20 pin header that replicates signals on J14 for easy connection to a logic analyzer or oscilloscope	Open

4.4 PWM Output Digital Temperature Sensors

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 high period (TH) of the PWM remains generally static over all temperatures, while the low period (TL) varies. The ratio of TH/TL provides a method for determining the temperature according to the formula, Temperature (°C) = 421 – (751 × TH/TL).

The TMP05 sensors have a 2-pin interface: CONV/IN input, which when pulsed by PSoC initiates a new temperature measurement and OUT output, which provides a PWM signal that can be decoded using the formula above to determine ambient temperature. The TMP05 sensors support a daisy chain mode of operation where 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.This sensor is generally operated in either the one-shot mode or continuous mode.

For more details, refer to the TMP05 device datasheet, which is available on the device manufacturer's website or under the datasheet folder at the install location. Application note AN78737, PSoC 1 - Temperature Sensing Solution using a TMP05/TMP06 Digital Temperature Sensor discusses more about the temperature sensor and the implementation in PSoC 1 with an example project.

4.5 I2C Digital Temperature Sensor

CY8CKIT-036 demonstrates I2C temperature sensing capability using a two-wire I2C compatible digital temperature sensor, the TMP175. I2C digital temperature sensors are common sensors for thermal management and are used in a variety of communication, computer, consumer, environmental, industrial, and instrumentation applications due to the popularity of the I2C bus. For more details, refer to its datasheet, which is available on the manufacturer's website or under the datasheet folder at the install location. Application note AN2163, PSoC 1 - Temperature Sensing Solution using a 1-Wire/2-Wire (I2C) Digital Temperature Sensor discusses more about the temperature sensor and the implementation in PSoC 1 with an example project.

4.6 1-Wire Digital Temperature Sensor

CY8CKIT-036 has a Maxim DS18S20 1-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 1-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. For more details, refer to its datasheet, which is available on the manufacturer's website or under the datasheet folder at the install location. Application note AN2163, PSoC 1 - Temperature Sensing Solution using a 1-Wire/2-Wire (I2C) Digital Temperature Sensor discusses more about the temperature sensor and the implementation in PSoC 1 with an example project.

4.7 Diode Analog Temperature Sensors

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. The delta Vbe method described in application note AN78920, PSoC 1 Temperature Measurement Using Diode can be used with CY8CKIT-036; the application note discusses the operation theory and relevant mathematical equations. The implementation is primarily driven by firmware due to the complexities associated with varying the source current fed to the BJT, filtering the ADC measurements, and calibrating the analog sub-system all of which are required to achieve sufficiently high accuracy with these low-cost temperature sensors.

4.8 4-Wire Fan Connectors

The CY8CKIT-036 provides four industry-standard 4-wire fan interface connectors and two AVC 12 V brushless DC fans. The fan speeds are controllable up to 13,000 RPM via PWM control, with tachometer output to calculate actual fan speeds. For more details, refer to its datasheet, which is available on the manufacturer's website or under the datasheet folder at the install location.

Table 4-3. Fan Connector Pinouts

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

Application note AN78692, PSoC 1 - Intelligent Fan Controller discusses more about the 4-wire fan and implementation inside PSoC 1.

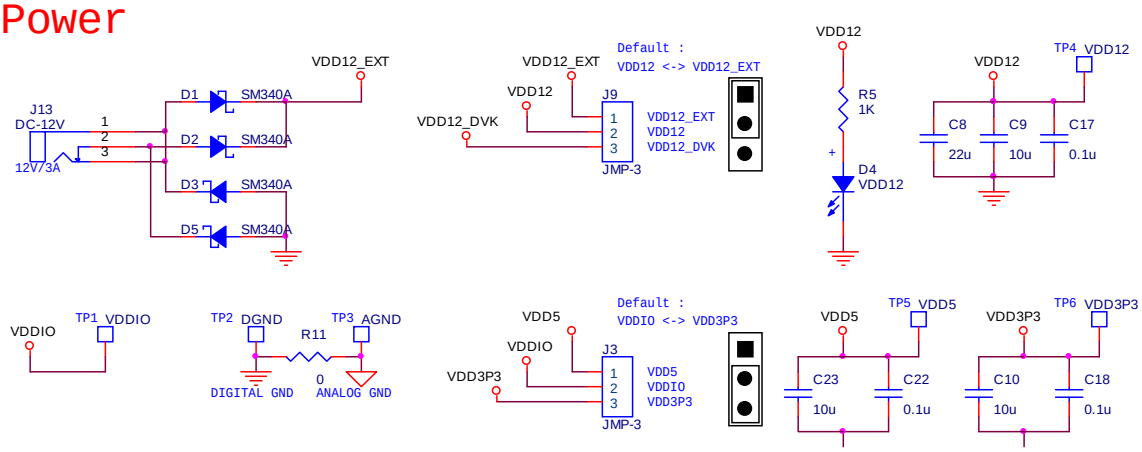
4.9 Development Kit and Expansion Board Kit Compatibility

The CY8CKIT-016 kit contains only a PSoC 1 thermal management example project. It requires the CY8CKIT-036 EBK and CY8CKIT-001 PSoC DVK.

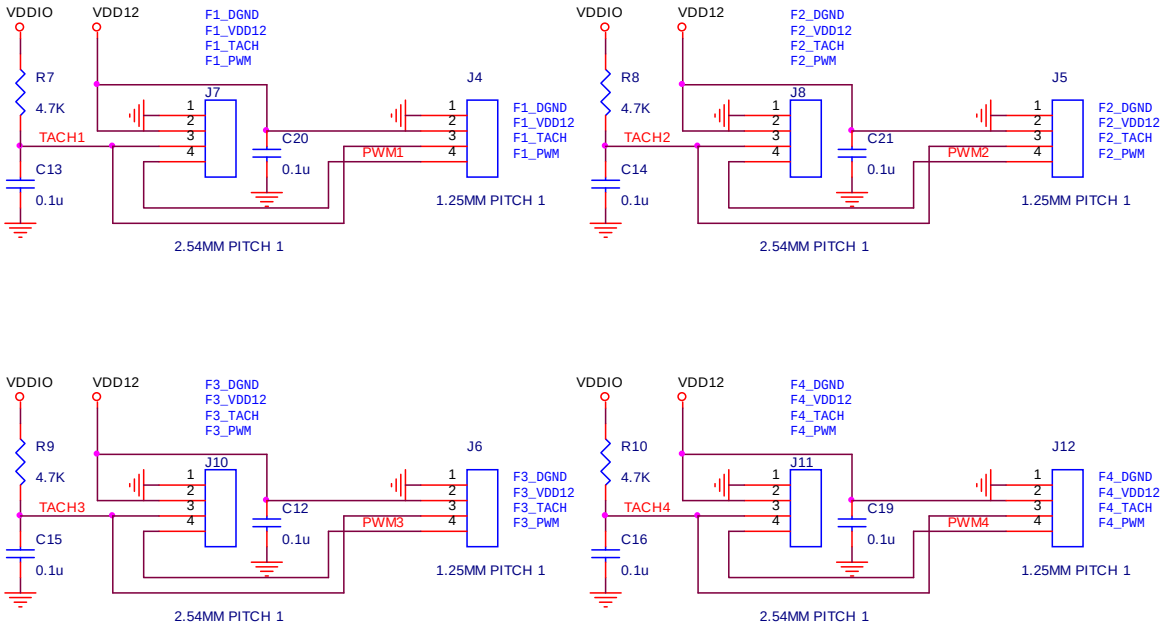
A. Appendix

A.1 CY8CKIT-036 Schematics

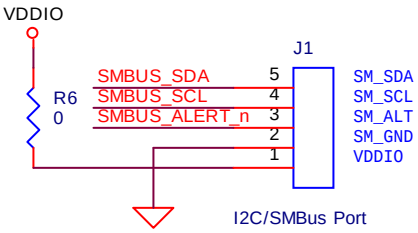
A.1.1 Power Supply



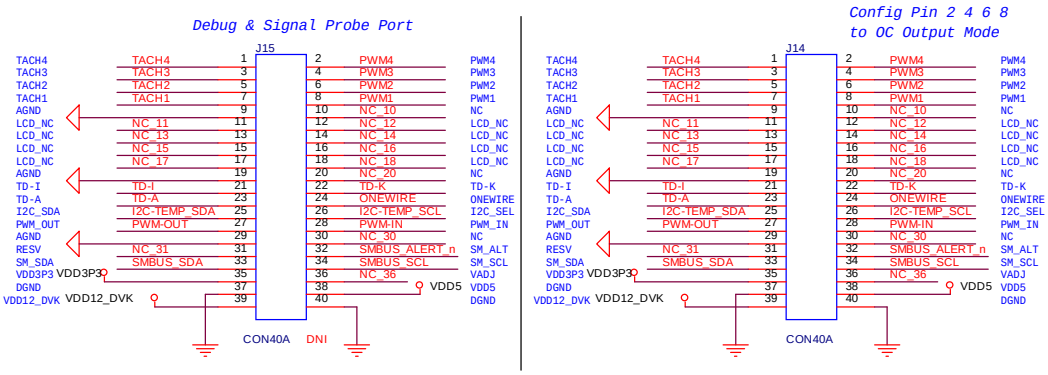
A.1.2 4-Wire Fan Sockets



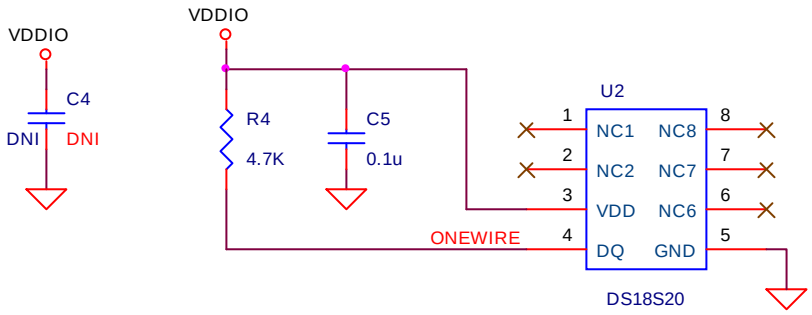
A.1.3 I2C/SMBus/PMBus Port



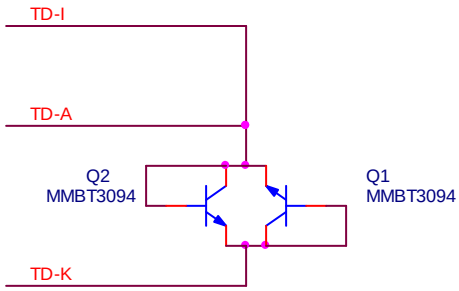
A.1.4 2x20 Pin DVK Connector and Test Points



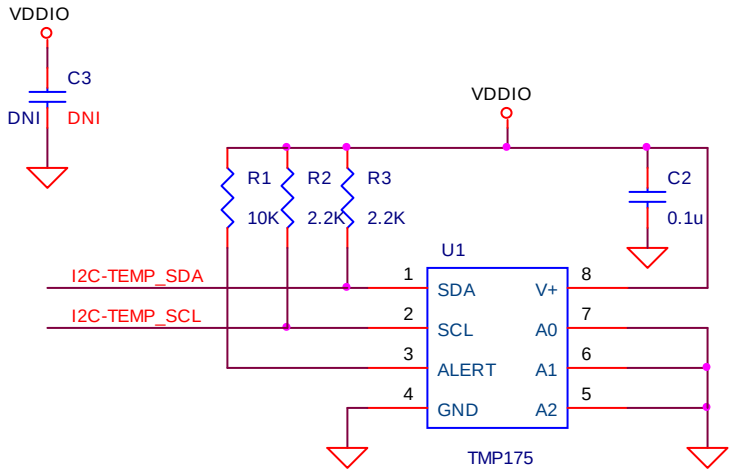
A.1.5 1-Wire Temperature Sensor



A.1.6 Temperature Diodes

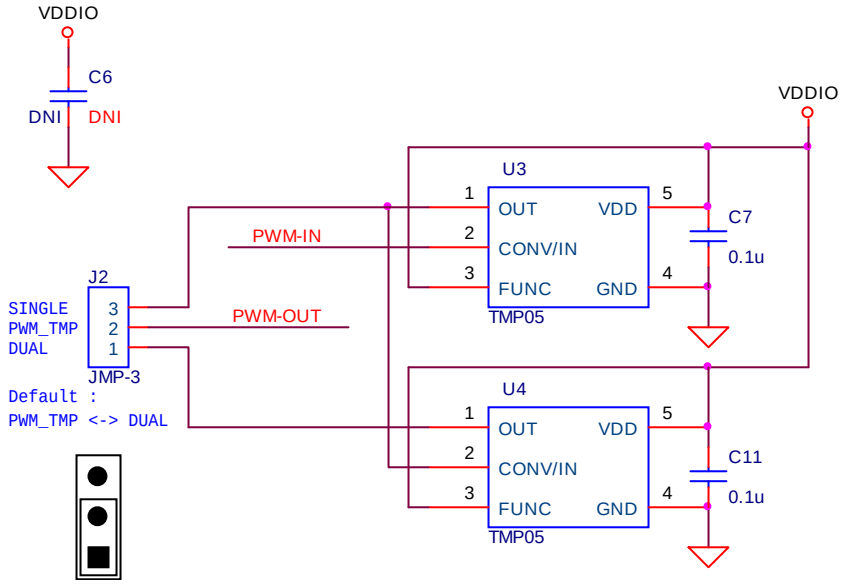


A.1.7 I2C Temperature Sensor



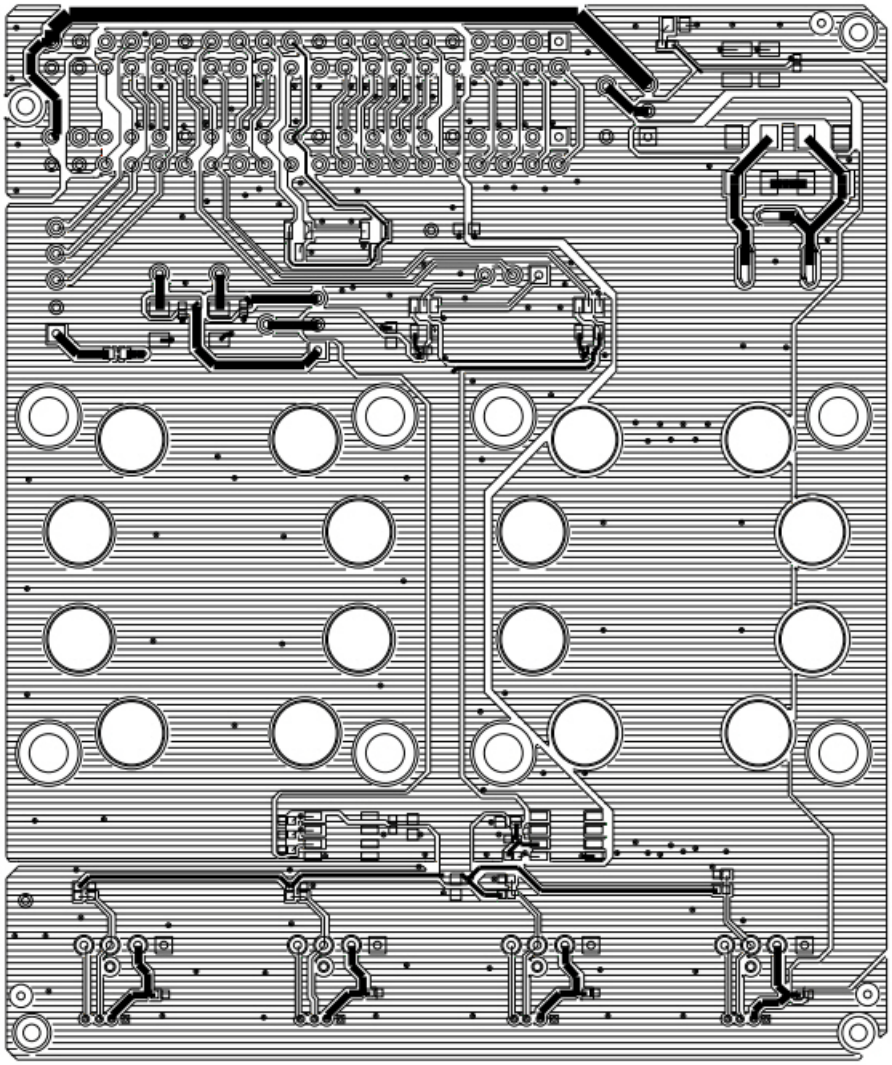
I2C Address 8'b01001000

A.1.8 PWM Temperature Sensors

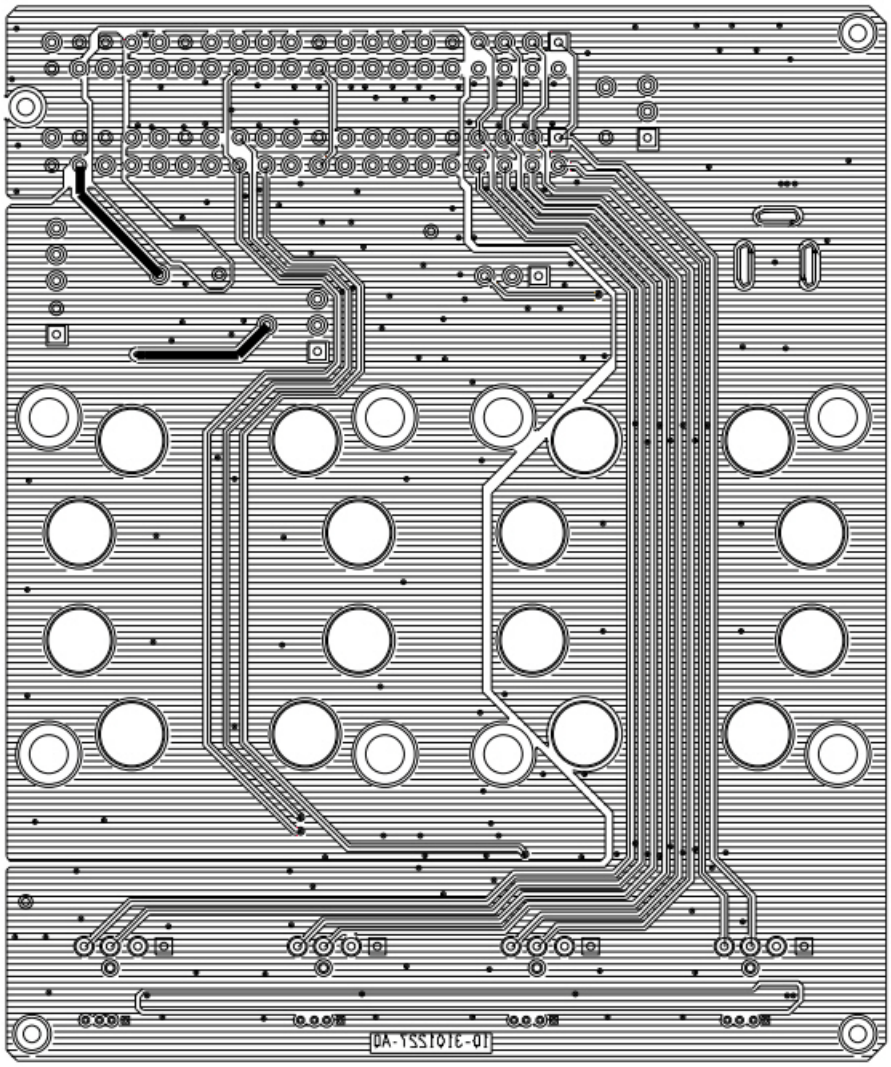


A.2 CY8CKIT-036 Board Layout

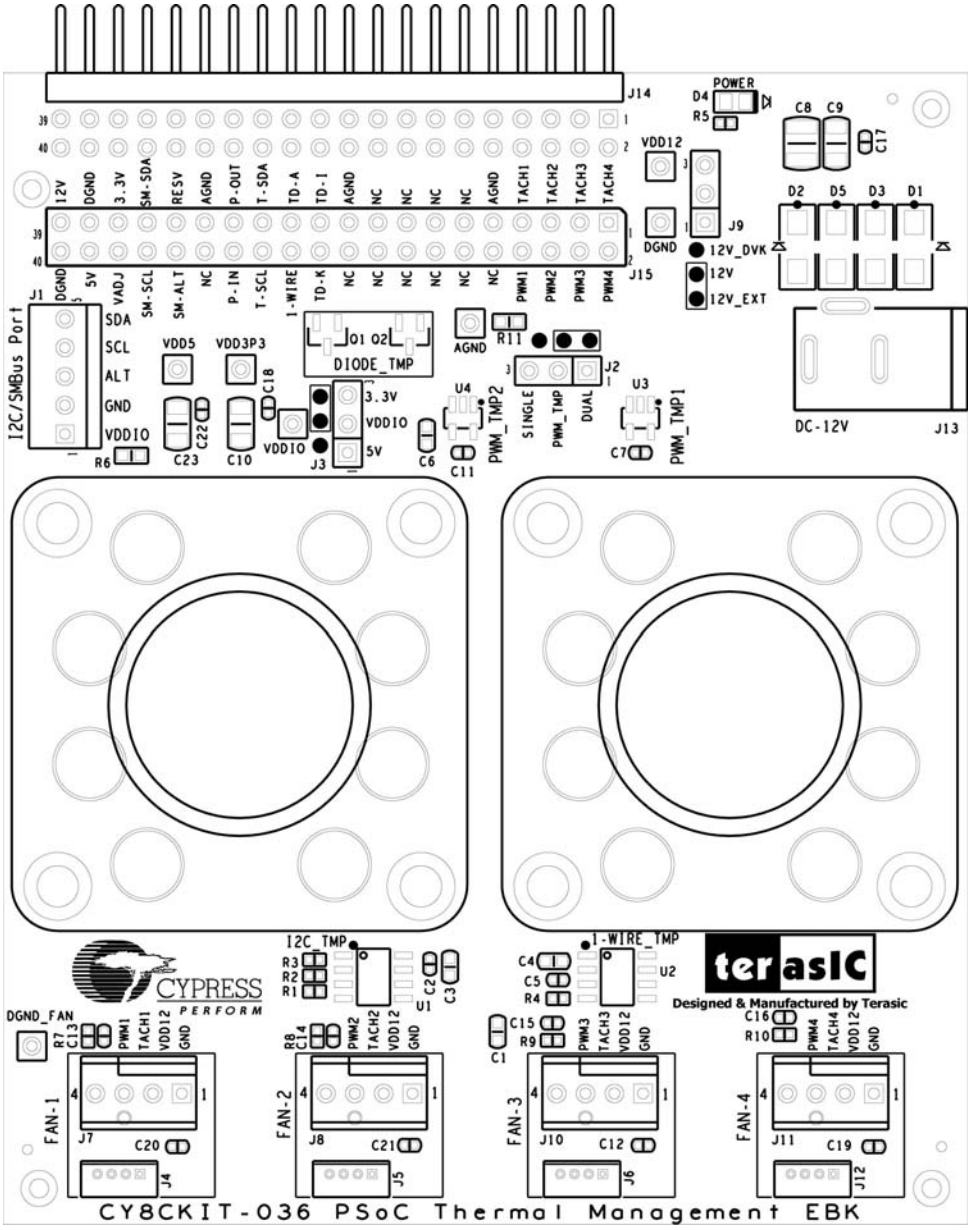
A.2.1 Top layer



A.2.2 Bottom Layer



A.2.3 Top Silkscreen



A.3 CY8CKIT-036 Bill of Materials

Item	Qty.	Designator	Value	Description	Manufacturer	Manufacturer Part No.
1	15	C2,C5,C7, C11,C12, C13,C14,C15, C16, C17,C18,C19,C20, C21,C22	0.1u	Ceramic Capacitor, 0.1uF, +/-10%, 25V, X5R(0402)	Taiyo Yuden	TMK105BJ104KV-F
2	1	C8	22u	22uF, +/-10%, 25V, X5R(1210)	MURATA	GRM32ER61E226KE15L
3	3	C9,C10,C23	10u	10uF, +/-10%, 25V, X5R(1206)	MURATA	GRM31CR61E106KA12
4	4	D1,D2,D3,D5	SM340A	Schottky Rectifier 40V/3A(SM340A)	GW	SM340A
5	1	D4	VDD12	Light Emitting Diode (Yellow)	LITEON	LTST-C170KSKT
6	1	J1	I2C/ SMBus Port	ONN HEADER 5POS .100 VERT TIN	MOLEX	22-05-3051
7	3	J2,J3,J9	JMP-3	1X3 .100"CENTER HEADER	SAMTEC	TSW-103-07-G-S
8	4	J4,J5,J6,J12	1.25MM PITCH 1	FAN socket, 1.25mm Wafer 180°	CHERNG WEEI	CCX-W125-04-DIP
9	4	J7,J8,J10,J11	2.54MM PITCH 1	FAN socket, 2.54mm Wire-to-Board Header, DIP 180° Type	CHERNG WEEI	CD-W254-(3.4)
10	1	J13	DC-12V	DC Power Socket	CHERNG WEEI	32753PA
11	1	J14	CON40A	Pin Header, 2X20, Pitch 2.54MM, male, Right Angel	NA	NA
12	2	Q1,Q2	MMBT3094	NPN General Purpose Amplifier	Fairchild	MMBT3094
13	1	R1	10K	10K ohm, +/-1%, 1/16W(0402)	YAGEO	RC0402FR-0710KL
14	2	R2,R3	2.2K	2.2K ohm, +/-1%, 1/16W(0402)_	YAGEO	RC0402FR-072K2L
15	5	R4,R7,R8,R9,R10	4.7K	4.7K ohm, +/-1%, 1/16W(0402)	YAGEO	RC0402FR-074K7L
16	1	R5	1K	1K ohm, +/-0.1%, 1/16W(0402)_	SAMSUNG	RG1005P-102-B-T5
17	2	R6,R11	0 ohm	0 ohm, Jumper, 1/10W(0603)_	WALSIN	WR06X000 PTL
18	1	U1	TMP175	Digital Temperature Sensor with Two-Wire Interface	Texas Instruments	TMP175AID
19	1	U2	DS18S20	High-Precision 1-Wire Digital Thermometer	MAXIM	DS18S20Z

Item	Qty.	Designator	Value	Description	Manufacturer	Manufacturer Part No.
20	2	U3,U4	TMP05	±0.5°C Accurate PWM Temperature Sensor	ADI	TMP05AKS-500RL7
21	4	MH1,MH2, MH3, MH4	screw holes	BUMPER CLEAR.370X.19" CYLINDER	Richco Plastic Co	RBS-35
22	3			Mini Jumper 2.54 Pitch Open Type(13.5)	CHERNG WEEI	CMJ-135BB
23	8			M3 35mm, Nickel Plated, Round Head	NA	NA
24	8			M3 Nickel Plated Hexagonal Nut	NA	NA
25	2			DC Brushless axial flow fan, 40x40mm, 4-wire, 12V	AVC	DB04028B12UP014