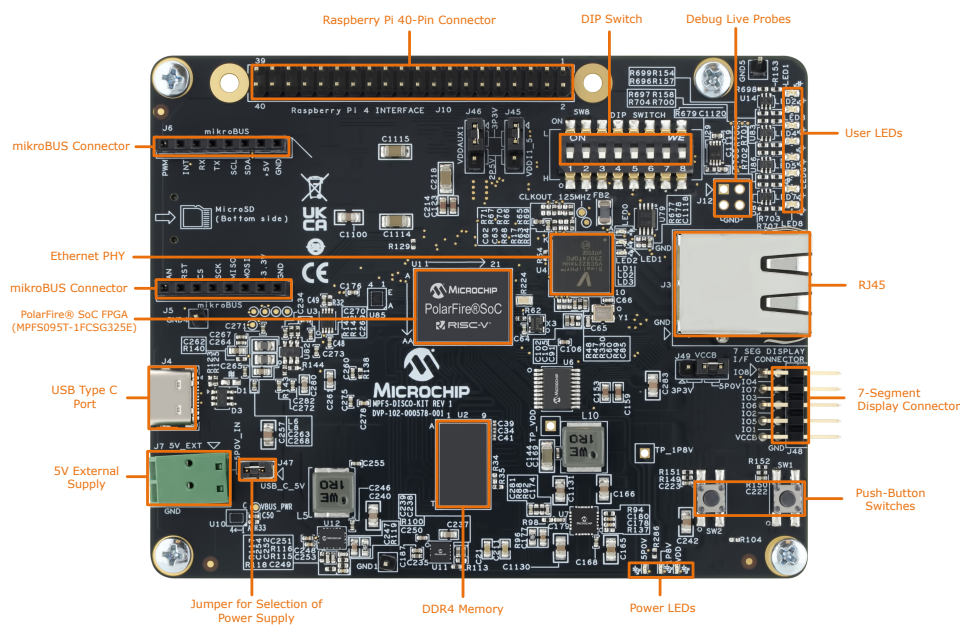


Introduction [\(Ask a Question\)](#)

The PolarFire® SoC Discovery Kit (MPFS-DISCO-KIT) is an RoHS-compliant, cost-optimized kit with general-purpose interfaces that enables you to evaluate features of the MPFS095T-1FCSG325E FPGA device.

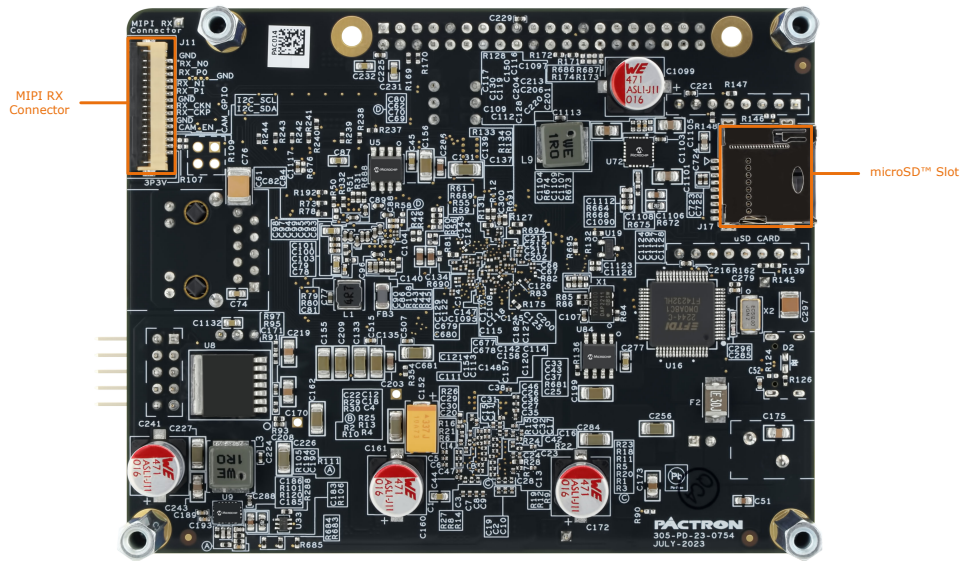
The following image highlights the top view of the PolarFire SoC Discovery Kit.

Figure 1. Board Callout (Top View)



The following image highlights the bottom view of the PolarFire SoC Discovery Kit.

Figure 2. Board Callout (Bottom View)



For more information about the PolarFire SoC Discovery Kit, see the [MPFS-DISCO-KIT](#) page.

Table of Contents

Introduction.....	1
1. Getting Started.....	4
1.1. Kit Contents.....	4
1.2. Block Diagram.....	4
1.3. Board Overview.....	5
1.4. Handling the Board.....	6
1.5. Operating Temperature.....	6
1.6. Powering Up the Board.....	6
2. Installation and Settings.....	7
2.1. Software Settings.....	7
2.2. Hardware Settings.....	7
3. Board Component and Operations.....	10
3.1. DDR4 Memory Interface.....	10
3.2. microSD Interface.....	10
3.3. Communication Interfaces.....	10
3.4. Expansion Capabilities.....	10
3.5. Debug Circuitry.....	11
3.6. Programming Scheme.....	11
3.7. Form Factor.....	11
3.8. System Reset.....	11
3.9. 50 MHz Oscillator.....	11
3.10. Pin List.....	12
4. Board Components Placement.....	13
5. Demo Design.....	15
6. Appendix: Programming the PolarFire SoC FPGA Using the Onboard FlashPro5.....	16
7. Revision History.....	20
Microchip FPGA Support.....	21
Microchip Information.....	21
The Microchip Website.....	21
Product Change Notification Service.....	21
Customer Support.....	21
Microchip Devices Code Protection Feature.....	21
Legal Notice.....	22
Trademarks.....	22
Quality Management System.....	23
Worldwide Sales and Service.....	24

1. Getting Started [\(Ask a Question\)](#)

The Discovery Kit supports the following interfaces:

- microSD™ card
- DDR4
- SGMII
- USB-UART
- mikroBUS
- 40-pin Raspberry Pi 4 interface connector

The PolarFire SoC device is programmed using the onboard FlashPro5 programmer. FlashPro5 programmer is also used to debug the FPGA fabric using Identify or SmartDebug and to debug embedded applications using SoftConsole.

1.1 Kit Contents [\(Ask a Question\)](#)

The following table lists the contents of the PolarFire SoC Discovery Kit.

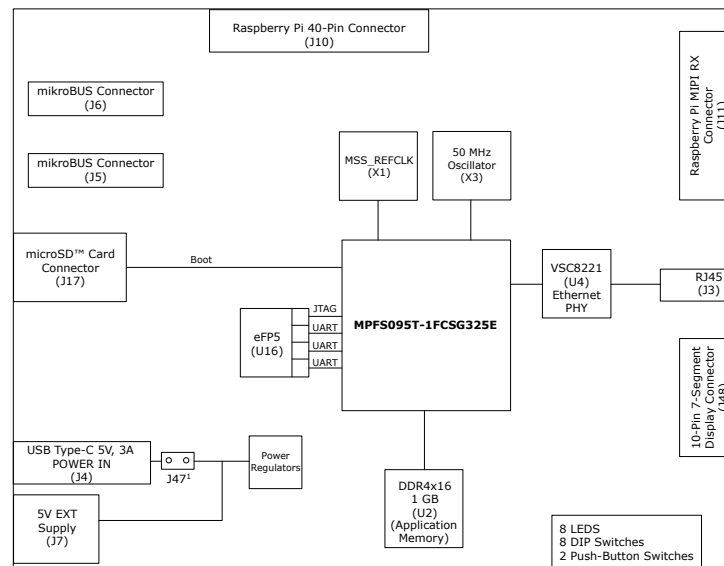
Table 1-1. Kit Contents

Item	Quantity
PolarFire® SoC Discovery Kit Board with MPFS095T-1FCSG325E	1
USB 2.0 Cable C Male to C Male 3.28' (1.00m) Shielded	1
Quickstart card	1

1.2 Block Diagram [\(Ask a Question\)](#)

The following block diagram shows the key components of the PolarFire SoC Discovery Kit.

Figure 1-1. Block Diagram



Note: 1. The PolarFire® SoC Discovery Kit receives power from the Type-C Port (J4) or the 5V External, 2 Position Terminal Block (J7). The J47 jumper setting determines which power source is used.

1.3 Board Overview [\(Ask a Question\)](#)

The PolarFire SoC Discovery Kit features an MPFS095T-1FCSG325E FPGA device. The kit supports the following capabilities:

- VSC8221 with an RJ45 connector for 10/100/1000 Mbps Ethernet
- DDR4 memory
- microSD card interface
- 40-pin Raspberry Pi 4 interface connector
- mikroBUS expansion port
- 7-Segment display connector

The following table lists the key components of the PolarFire SoC Discovery Kit.

Table 1-2. Board Components

Component	Label on Board	Description
Featured Device		
PolarFire® SoC FPGA MPFS095T-1FCSG325E FPGA	U1	See PolarFire SoC Datasheet .
Power Supply		
5V/3A power supply (USB Type-C)	J4	The Discovery Kit receives power from the USB Type-C port (J4) or the 2-Position Terminal Block (J7). The J47 jumper setting determines which power source is used. See 2.2.1. Jumper Settings .
5V external supply (2 Position Terminal Block ¹)	J7	
Clocks		
50 MHz oscillator	X3	50 MHz clock oscillator with single-ended output.
125 MHz Oscillator	X1	125 MHz oscillator (differential LVDS output) which is the input to the MSS Reference clock.
FPGA Programming and Debugging		
Embedded FlashPro5 (eFP5)	U16	On-board FlashPro5 to program and debug the device through USB-to-JTAG channel.
Communication Interfaces		
Gigabit Ethernet	J3	Ethernet (RJ45) jack with built-in magnetics interfacing with VSC8221 in SGMII mode.
USB-UART	U16	FT4232HL is a USB to quad UART bridge controller. This device supports 3 UART interfaces on the board.
Memory Chips		
DDR4	U2	MT40A512M16TB-062E: R is used for DDR4 interface.
microSD™ card	J17	microSD connector
General Purpose I/O		
Debug- push buttons	SW1 to SW2	For debugging.
Dip Switches	SW8	8 dip switches for debugging.
Light Emitting Diodes (LEDs)	LED1 to LED8	Eight active-high LEDs are connected for debugging.
Expansion Interfaces		
mikroBUS	J5, J6	mikroBus connector.
Raspberry Pi 4	J10	Raspberry Pi 4 interface connector.
Raspberry Pi MIPI RX Connector	J11	Facilitates interfacing with the MIPI CSI-2 camera module.
7-Segment Display	J48	A 10-pin interface connector to support a serial 7-Seg 8-Digit Board.

Note:

1. This will be replaced by a 5V Power Jack in the PolarFire SoC Discovery Kit REV 2.0.

1.4 Handling the Board [\(Ask a Question\)](#)

Handle the board with Electrostatic Discharge (ESD) precautions to avoid damage. For information about handling the board with ESD precautions, see [Understanding Product Handling and ESD Precautions](#).

1.5 Operating Temperature [\(Ask a Question\)](#)

To be updated in a future revision.

1.6 Powering Up the Board [\(Ask a Question\)](#)

The PolarFire SoC Discovery Kit receives power from the Type-C Port (J4) or the 5V external supply, 2-Position Terminal Block (J7). The J47 jumper setting determines which power source is used, see [2.2.1. Jumper Settings](#). By default, the board receives the power from Type-C port J4 (as the J47 jumper 1 and 2 pins are closed).

To power up the board, connect the Cable C Male to C Male cable from the USB Type-C port (J4) on the Discovery Kit to the Type-C compatible (5V, 3A) port on the Host PC. The power status LEDs 5P0V, VDD, and 1P8V glow indicating that the board is powered-up.



Important: To use the 5V external supply (J7) to power-up the board, the pins 1 and 2 of the J47 jumper must be open.

The following table lists the probing points for power rails.

Table 1-3. Voltage Measurement

S. No	Power Rail	Probing Point Label on the Board	Tolerance Allowed	Expected Voltage
1	5P0V_IN	C175	±5%	5V
2	5P0V	C165	±5%	5V
3	3P3V	C123	±5%	3.3V
4	VDD	C144	±3%	1V
5	VDDA	C134	±3%	1V
6	2P5V	C153	±3%	2.5V
7	1P8V	C227	±5%	1.8V
8	1P2V_DDR4	C284	±3%	1.2V
9	0P6V_VREF_DDR4	C250	±3%	0.6V
10	3P3V_FT	C277	±5%	3.3V
11	1P8V_FT	C280	±5%	1.8V

2. Installation and Settings [\(Ask a Question\)](#)

This section provides information about the software and hardware settings required to run the pre-programmed demo design on the Discovery Kit.

2.1 Software Settings [\(Ask a Question\)](#)

Download and install the latest release of Microchip's [Liberio® SoC](#) software from the Microchip website and register for a free Silver License to the Liberio software. The Liberio SoC installer includes the required device programmer drivers. See the following references:

1. For more information about the instructions about licensing and installing Liberio SoC, see the [Liberio SoC Documentation](#).
2. For more information about installing SoftConsole, see the [SoftConsole](#) page.
3. For more information about downloading and installing Microchip's DirectCores on the Host PC where Liberio SoC is installed, see the [IP Core Tools](#).
4. For more information about downloading and installing Microchip's firmware drivers on the Host PC where Liberio SoC is installed, see the [Firmware Catalog Documentation](#).

2.2 Hardware Settings [\(Ask a Question\)](#)

This section provides information about jumper settings, test points, and Power LEDs available on the Discovery Kit.

2.2.1 Jumper Settings [\(Ask a Question\)](#)

Connect the jumpers according to the settings specified in the following table.

Table 2-1. Jumper Settings

Jumper	Description	Pin	Default Setting
J45	Jumper to select Bank 1 and Bank 5 voltages (VDDI1_5)	<ul style="list-style-type: none"> • Close pins 1 and 2 for 3.3V (For Rpi GPIO and mikroBus operation). • Close pins 2 and 3 for 2.5V (For MIPI RX and Ethernet operation). 	1 and 2 closed
J46	Jumper to select the VDDAUX1 Voltage	<ul style="list-style-type: none"> • Close pins 1 and 2 for 3.3V. • Close pins 2 and 3 for 2.5V. 	1 and 2 closed
J47	Jumper to select the power source for the board	<ul style="list-style-type: none"> • Close pins 1 and 2 to receive power from the USB Type-C port (J4). • Open pins 1 and 2 to receive power from the 5V External, 2 Position Terminal Block (J7). 	1 and 2 closed
J49	Jumper to select the voltage for 7-Segment display	<ul style="list-style-type: none"> • Close pins 1 and 2 for 3.3V. • Close pins 2 and 3 for 5V. 	2 and 3 closed



Important:

If VDDI1_5 is set to 2.5V by closing 2 and 3 pins of J45, VDDAUX1 must also be set to 2.5V by closing 2 and 3 pins of J46.

2.2.2 Power Supply LEDs [\(Ask a Question\)](#)

The following table lists the power supply LEDs available on the Discovery Kit.

Table 2-2. Power Supply LEDs

LED	Description
VDD	1V rail (Core voltage)
1P8V	1.8V rail
5P0V	5V rail

2.2.3 Test Points [\(Ask a Question\)](#)

The following table lists the test points available on the PolarFire SoC Discovery Kit.

Table 2-3. Test Points

Test Point	Description
GND1	Test point for GND
GND4	Test point for GND
GND5	Test point for GND
TP_VDD	Test point for 1V (core voltage rail)
TP_1P8V	Test point for 1.8V

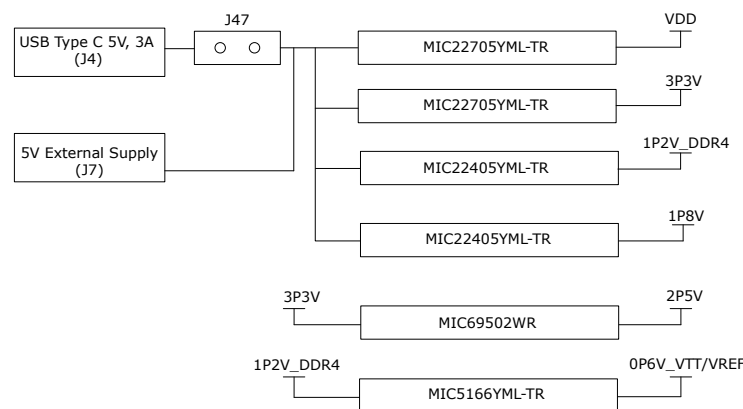
2.2.4 Power Sources [\(Ask a Question\)](#)

The PolarFire SoC Discovery uses Microchip power supply devices. For more information about these power supply devices, see Microchip's [Power Management Devices](#). The following table lists the key voltage rails required for a normal operation of the PolarFire SoC Discovery kit.

Table 2-4. I/O Voltage Rails

Bank	I/O Rail	Voltage
Bank 0 (HSIO)	1P8V	1.8V
Bank 1 (GPIO)	VDDI1_5	2.5V, 3.3V
Bank 2 (MSS I/O)	3P3V	3.3V
Bank 3 (JTAG)	3P3V	3.3V
Bank 4 (MSS SD)	1P8V	1.8V
Bank 5 (MSS SGMII)	VDDI1_5	2.5V, 3.3V
Bank 6 (MSS DDR)	1P2V_DDR4	1.2V

The following figure shows 5V, 3.3V, 2.5V, 1.8V, 1.2V, and 1.0V (VDD) voltage rails available on the Discovery Kit.

Figure 2-1. Power Supply Topology

The following table lists the power regulators recommended for PolarFire SoC Discovery kit voltage rails.

Table 2-5. Power Regulators

Voltage Rail	Part Number	Description	Current
VDD (1.0V)	MIC22705YML-TR	IC REG BUCK ADJUSTABLE 7A	7A
1P2V_DDR4	MIC22405YML-TR	IC REG BUCK ADJUSTABLE 3A	4A
1P8V	MIC22405YML-TR	IC REG BUCK ADJUSTABLE 3A	4A
2P5V	MIC69502WR	IC REG LINEAR POS ADJ 5A	5A
3P3V	MIC22705YML-TR	IC REG BUCK ADJUSTABLE 7A	7A
VTT/VREF	MIC5166YML-TR	IC PWR SUP 3A HS DDR TERM 10MLF	3A

3. Board Component and Operations [\(Ask a Question\)](#)

This section describes the key components of the PolarFire SoC Discovery kit and provides information about important board operations. For more information, see the [PolarFire SoC Datasheet](#).

3.1 DDR4 Memory Interface [\(Ask a Question\)](#)

The DDR4 memory is connected to MSS BANK 6. The DDR4 memory specification is as follows:

- Part number: MT40A512M16TB-062E: R
- Manufacturer: Micron
- Frequency range: 800 MHz
- Memory size: 1 GB

3.2 microSD Interface [\(Ask a Question\)](#)

The Kit has one microSD card connector and it is interfaced to MSS BANK 4 I/Os. The microSD card connector specification is as follows:

- Part number: MEM2075-00-140-01-A
- Manufacturer: GCT

The microSD interface is connected using a voltage translator between the SD card connector and FPGA silicon.

3.3 Communication Interfaces [\(Ask a Question\)](#)

The Discovery Kit supports the following interfaces for communication:

- Ethernet - SGMII interface: The Kit supports a low-power single-port Ethernet 10/100/1000BASE-T PHY device and the part number of the PHY device is VSC8221. The PHY SGMII signals connected on MSS SGMII Bank 5.
- USB-to-UART interface: The Kit supports a USB-to-quad UART bridge controller device, which supports 3 UART interfaces. The specifications are as follows:
 - Part number: FT4232HL
 - Manufacturer: FTDI
 - UART_B and UART_C interfaces are connected to MSS BANK 2 I/Os.
 - UART_D interface hooked to HSIO BANK 0.



Important: To detect and view the UART COM ports in your **Host PC > Device Manager**, install the [FT4232H drivers](#).

3.4 Expansion Capabilities [\(Ask a Question\)](#)

PolarFire SoC Discovery Kit has the following expansion capabilities.

3.4.1 Raspberry Pi 40-Pin Connector [\(Ask a Question\)](#)

The PolarFire SoC Discovery kit has a 40-pin Raspberry connector.

- Raspberry Pi signals are interfaces to GPIO BANK 1 and MSS I/O Bank 2
- SPI, I2C Signals (7) are interfaced to MSS I/O Bank 2
- UART, one pair of I2C, and other GPIO Signals (21) are connected to GPIO Bank 1.
- Part number: 61204021621

- Manufacturer: Würth Elektronik

3.4.2 mikroBUS Connector [\(Ask a Question\)](#)

The PolarFire SoC Discovery kit has a 16-pin mikroBUS interface connector. It supports interfaces like UART, SPI, and I2C. mikroBUS signals are interfaced to GPIO BANK 1. For more information on available Click Boards, see www.mikroe.com/.

3.4.3 7-Segment Display [\(Ask a Question\)](#)

The PolarFire SoC Discovery kit has a 10-pin interface connector to support a [Serial 7-Seg 8-Digit Board](#). Display signals are connected to HSIO Bank 0.

3.5 Debug Circuitry [\(Ask a Question\)](#)

The Kit is equipped with 2 push button switches, eight dip switches, and eight debug LEDs. Switches and LEDs (1-7) are connected to HSIO BANK 0, and LED 8 is connected to MSS I/O Bank 2. Three LEDs are for power indication and eight LEDs are for debugging purposes.

The Kit also has provision for live probes access (J12) and debug Reset. Debug live probes are connected to GPIO Bank and the debug Reset signal is connected to Bank 3.

3.6 Programming Scheme [\(Ask a Question\)](#)

The Discovery kit supports the JTAG programming through an on-board FlashPro5 programmer. For more information about programming the PolarFire SoC device, see [6. Appendix: Programming the PolarFire SoC FPGA Using the Onboard FlashPro5](#).

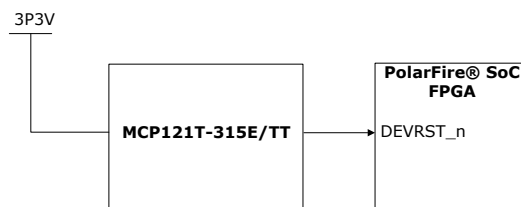
3.7 Form Factor [\(Ask a Question\)](#)

The form factor of the PolarFire SoC Discovery Kit is 4.15 x 3.3 inches approximately.

3.8 System Reset [\(Ask a Question\)](#)

DEVRST_n is an input-only reset pad that allows a full reset of the chip to be asserted. The following figure shows a sample reset circuit that uses a Microchip MCP121T-315E/TT device.

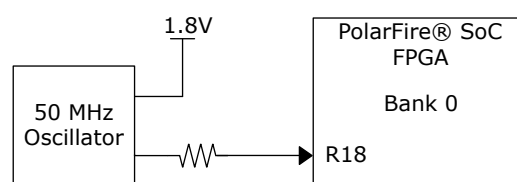
Figure 3-1. Reset Circuit



3.9 50 MHz Oscillator [\(Ask a Question\)](#)

A 50 MHz clock oscillator with an accuracy of ± 10 ppm is available on the board. This clock oscillator is connected to the FPGA fabric through the R18 pin to provide a system reference clock as shown in the following figure.

Figure 3-2. 50 MHz Oscillator



For more information, see the board-level schematics on the [PolarFire SoC Discovery Kit Documentation](#).

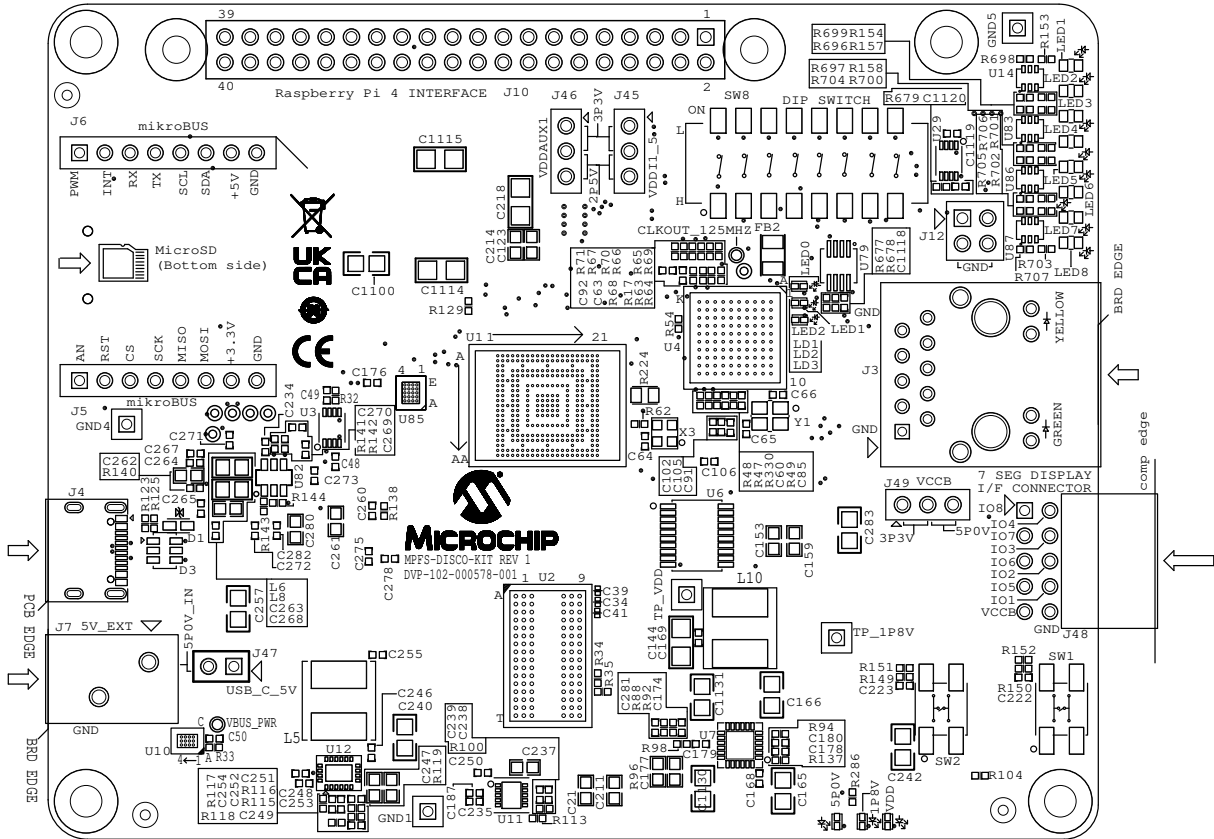
3.10 Pin List [\(Ask a Question\)](#)

For more information about all PolarFire SoC package pins, see [Package Pin Assignment Tables \(PPATs\)](#).

4. Board Components Placement [\(Ask a Question\)](#)

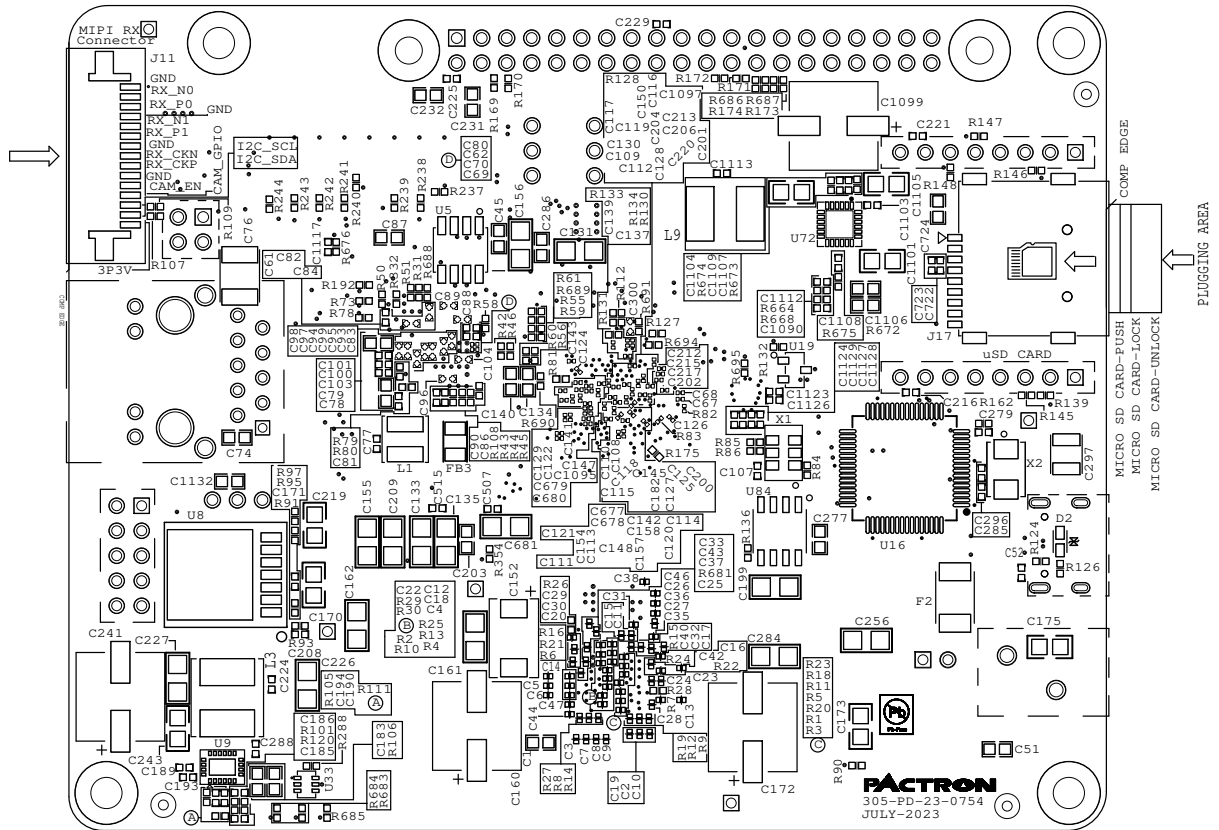
The following silkscreen shows the top view of the placement of various components on the board.

Figure 4-1. Silkscreen (Top View)



The following silkscreen shows the bottom view of the placement of various components on the board.

Figure 4-2. Silkscreen (Bottom View)



5. Demo Design [\(Ask a Question\)](#)

The PolarFire SoC Discovery Kit is pre-loaded with a Finite Impulse Response (FIR) Filter demo design. For information about the demo design and running it, see [AN5165: PolarFire SoC DSP FIR Filter Demo](#).

6. Appendix: Programming the PolarFire SoC FPGA Using the Onboard FlashPro5 [\(Ask a Question\)](#)

The PolarFire SoC Discovery Kit includes an onboard FlashPro5 programmer. Therefore, external programming hardware is not required to program the PolarFire SoC device. The device is programmed with a programming job file using the FlashPro Express software installed on the host PC. As a prerequisite, ensure to download the latest version of [FlashPro Express](#) on the host PC.

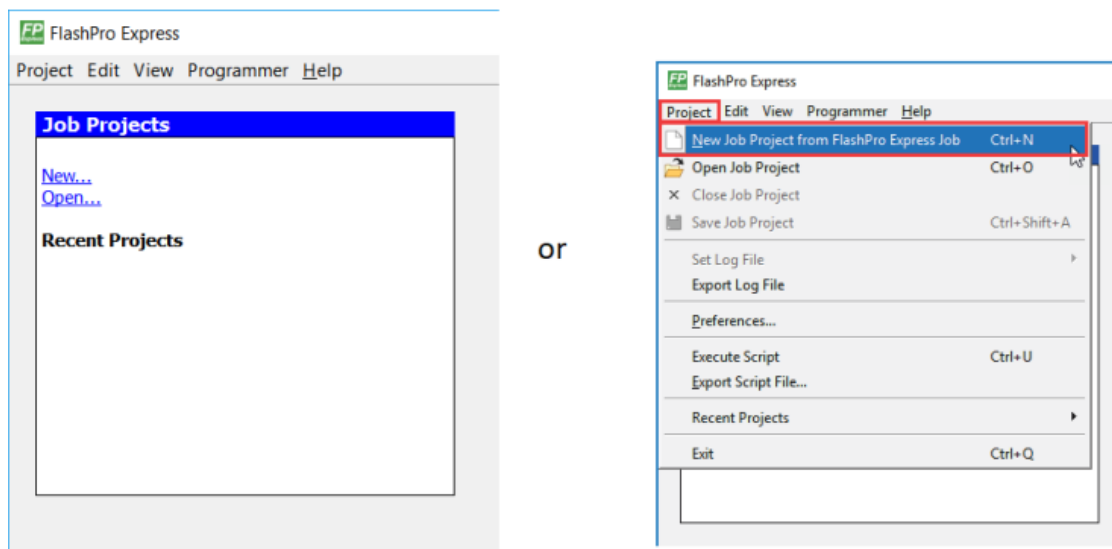
To program the PolarFire SoC device, perform the following steps:

1. Connect the USB Type-C cable from the host PC to the J4 connector on the board.
2. Ensure that the desired power source is selected for the board using the J47 jumper setting.
3. When the board is successfully powered up, the power status LEDs glow.

Follow these steps to program the PolarFire SoC device:

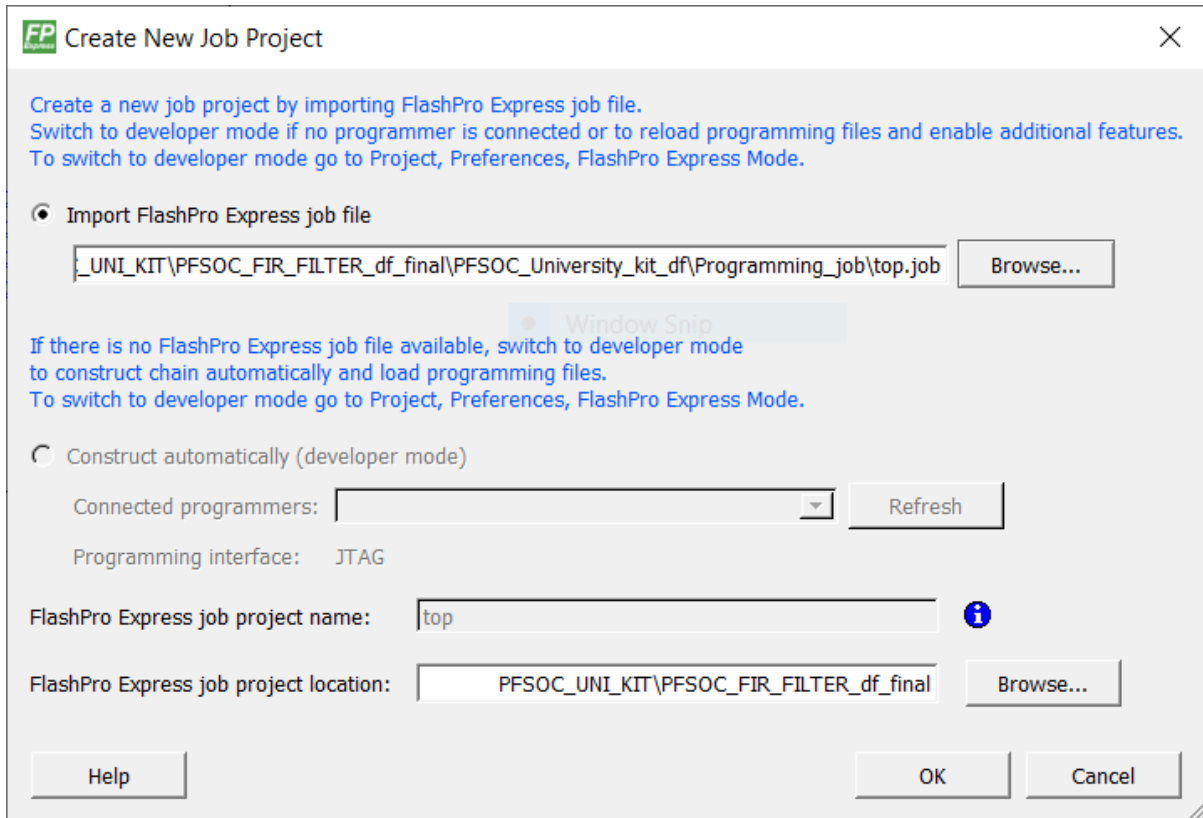
1. On the host PC, launch FlashPro Express.
2. Click **New** or select **Project > New Job Project from FlashPro Express Job** to create a new job project as shown in the following figure.

Figure 6-1. New Job Project Creation



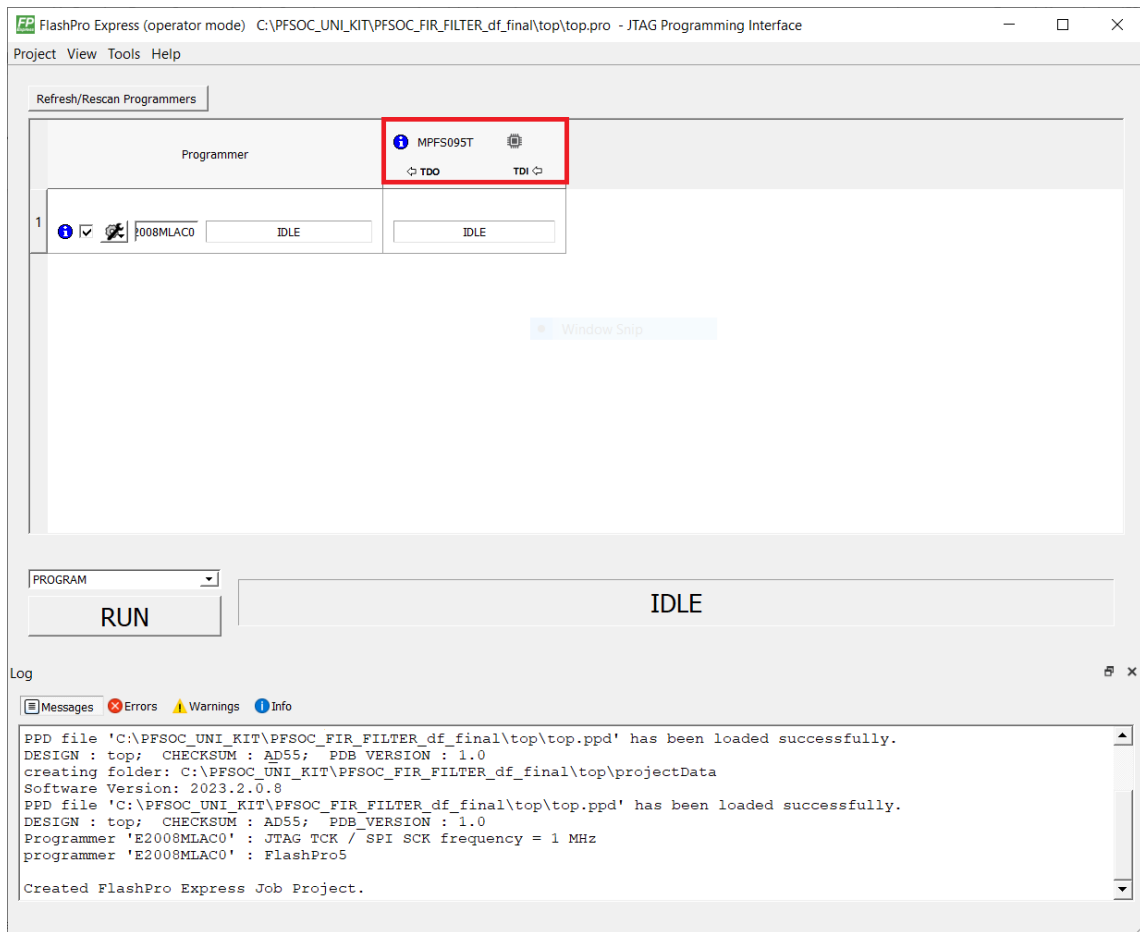
3. **Create New Job Project** dialog box appears, enter the following:
 - In **Import FlashPro Express job file:**
 - i. Click **Browse**.
 - ii. Select the `.job` file
 - In **FlashPro Express job project location:**
 - i. Click **Browse**.
 - ii. Select the location to save the project.

Figure 6-2. Selecting the Programming Job File



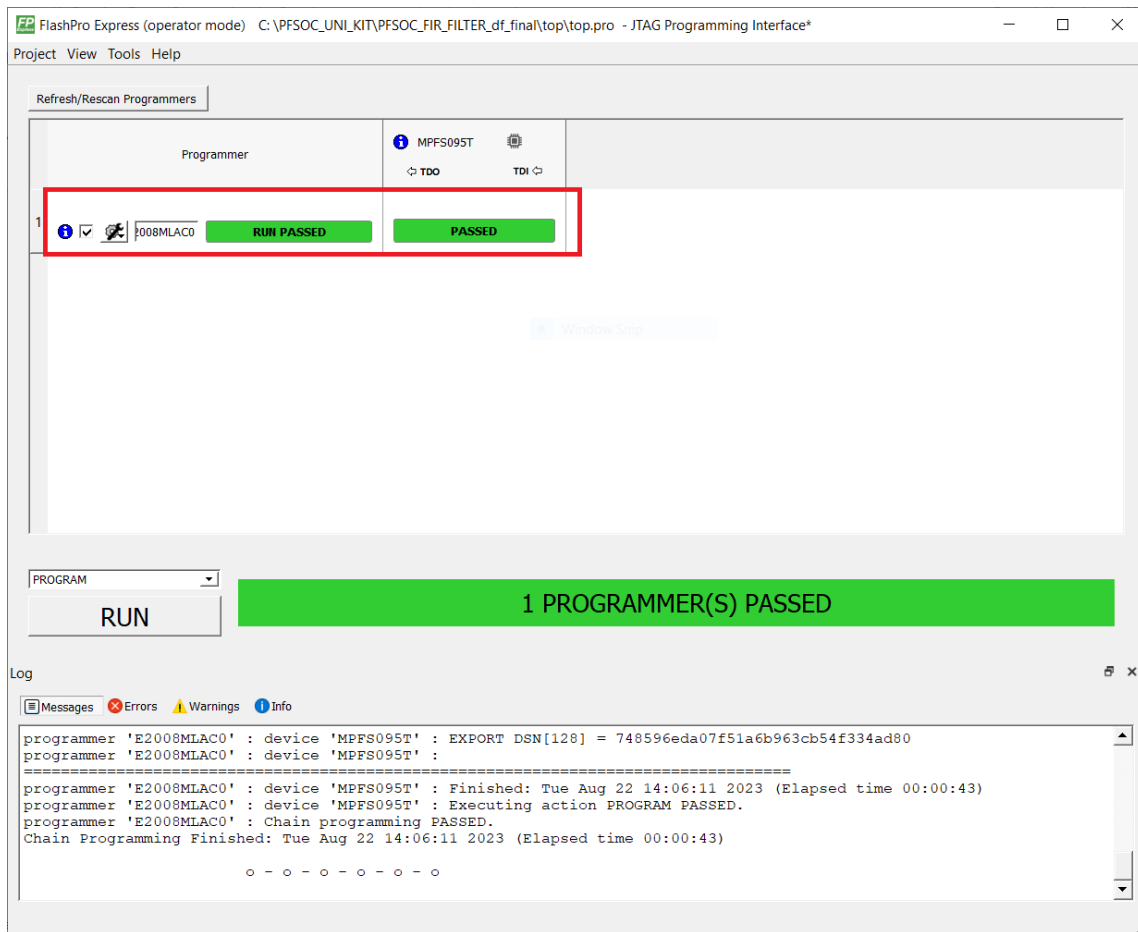
4. Click **OK**. The required programming file is selected and ready to be programmed in the device. The FlashProExpress window appears.
5. Verify that a programmer number appears in the **Programmer** box. If it does not show, verify the board connections, and click **Refresh/Rescan Programmers**.

Figure 6-3. Refresh/Rescan Programmiers



- Click **RUN** to program the device. When the device is programmed successfully, a **RUN PASSED** status is displayed as shown in the following figure.

Figure 6-4. RUN PASSED



This concludes programming the PolarFire SoC device.

7. Revision History [\(Ask a Question\)](#)

The revision history describes the changes that were implemented in the document. The changes are listed by revision, starting with the most current publication.

Revision	Date	Description
A	12/2023	Initial Revision

Microchip FPGA Support

Microchip FPGA products group backs its products with various support services, including Customer Service, Customer Technical Support Center, a website, and worldwide sales offices. Customers are suggested to visit Microchip online resources prior to contacting support as it is very likely that their queries have been already answered.

Contact Technical Support Center through the website at www.microchip.com/support. Mention the FPGA Device Part number, select appropriate case category, and upload design files while creating a technical support case.

Contact Customer Service for non-technical product support, such as product pricing, product upgrades, update information, order status, and authorization.

- From North America, call **800.262.1060**
- From the rest of the world, call **650.318.4460**
- Fax, from anywhere in the world, **650.318.8044**

Microchip Information

The Microchip Website

Microchip provides online support via our website at www.microchip.com/. This website is used to make files and information easily available to customers. Some of the content available includes:

- **Product Support** – Data sheets and errata, application notes and sample programs, design resources, user's guides and hardware support documents, latest software releases and archived software
- **General Technical Support** – Frequently Asked Questions (FAQs), technical support requests, online discussion groups, Microchip design partner program member listing
- **Business of Microchip** – Product selector and ordering guides, latest Microchip press releases, listing of seminars and events, listings of Microchip sales offices, distributors and factory representatives

Product Change Notification Service

Microchip's product change notification service helps keep customers current on Microchip products. Subscribers will receive email notification whenever there are changes, updates, revisions or errata related to a specified product family or development tool of interest.

To register, go to www.microchip.com/pcn and follow the registration instructions.

Customer Support

Users of Microchip products can receive assistance through several channels:

- Distributor or Representative
- Local Sales Office
- Embedded Solutions Engineer (ESE)
- Technical Support

Customers should contact their distributor, representative or ESE for support. Local sales offices are also available to help customers. A listing of sales offices and locations is included in this document.

Technical support is available through the website at: www.microchip.com/support

Microchip Devices Code Protection Feature

Note the following details of the code protection feature on Microchip products:

- Microchip products meet the specifications contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is secure when used in the intended manner, within operating specifications, and under normal conditions.
- Microchip values and aggressively protects its intellectual property rights. Attempts to breach the code protection features of Microchip product is strictly prohibited and may violate the Digital Millennium Copyright Act.
- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of its code. Code protection does not mean that we are guaranteeing the product is “unbreakable”. Code protection is constantly evolving. Microchip is committed to continuously improving the code protection features of our products.

Legal Notice

This publication and the information herein may be used only with Microchip products, including to design, test, and integrate Microchip products with your application. Use of this information in any other manner violates these terms. Information regarding device applications is provided only for your convenience and may be superseded by updates. It is your responsibility to ensure that your application meets with your specifications. Contact your local Microchip sales office for additional support or, obtain additional support at www.microchip.com/en-us/support/design-help/client-support-services.

THIS INFORMATION IS PROVIDED BY MICROCHIP "AS IS". MICROCHIP MAKES NO REPRESENTATIONS OR WARRANTIES OF ANY KIND WHETHER EXPRESS OR IMPLIED, WRITTEN OR ORAL, STATUTORY OR OTHERWISE, RELATED TO THE INFORMATION INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTIES OF NON-INFRINGEMENT, MERCHANTABILITY, AND FITNESS FOR A PARTICULAR PURPOSE, OR WARRANTIES RELATED TO ITS CONDITION, QUALITY, OR PERFORMANCE.

IN NO EVENT WILL MICROCHIP BE LIABLE FOR ANY INDIRECT, SPECIAL, PUNITIVE, INCIDENTAL, OR CONSEQUENTIAL LOSS, DAMAGE, COST, OR EXPENSE OF ANY KIND WHATSOEVER RELATED TO THE INFORMATION OR ITS USE, HOWEVER CAUSED, EVEN IF MICROCHIP HAS BEEN ADVISED OF THE POSSIBILITY OR THE DAMAGES ARE FORESEEABLE. TO THE FULLEST EXTENT ALLOWED BY LAW, MICROCHIP'S TOTAL LIABILITY ON ALL CLAIMS IN ANY WAY RELATED TO THE INFORMATION OR ITS USE WILL NOT EXCEED THE AMOUNT OF FEES, IF ANY, THAT YOU HAVE PAID DIRECTLY TO MICROCHIP FOR THE INFORMATION.

Use of Microchip devices in life support and/or safety applications is entirely at the buyer's risk, and the buyer agrees to defend, indemnify and hold harmless Microchip from any and all damages, claims, suits, or expenses resulting from such use. No licenses are conveyed, implicitly or otherwise, under any Microchip intellectual property rights unless otherwise stated.

Trademarks

The Microchip name and logo, the Microchip logo, Adaptec, AVR, AVR logo, AVR Freaks, BesTime, BitCloud, CryptoMemory, CryptoRF, dsPIC, flexPWR, HELDO, IGLOO, JukeBlox, KeeLoq, Klear, LANCheck, LinkMD, maXStylus, maXTouch, MediaLB, megaAVR, Microsemi, Microsemi logo, MOST, MOST logo, MPLAB, OptoLyzer, PIC, picoPower, PICSTART, PIC32 logo, PolarFire, Prochip Designer, QTouch, SAM-BA, SenGenuity, SpyNIC, SST, SST Logo, SuperFlash, Symmetricom, SyncServer, Tachyon, TimeSource, tinyAVR, UNI/O, Vectron, and XMEGA are registered trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

AgileSwitch, ClockWorks, The Embedded Control Solutions Company, EtherSynch, Flashtec, Hyper Speed Control, HyperLight Load, Libero, motorBench, mTouch, Powermite 3, Precision Edge, ProASIC, ProASIC Plus, ProASIC Plus logo, Quiet-Wire, SmartFusion, SyncWorld, TimeCesium, TimeHub, TimePictra, TimeProvider, and ZL are registered trademarks of Microchip Technology Incorporated in the U.S.A.

Adjacent Key Suppression, AKS, Analog-for-the-Digital Age, Any Capacitor, AnyIn, AnyOut, Augmented Switching, BlueSky, BodyCom, Clockstudio, CodeGuard, CryptoAuthentication, CryptoAutomotive, CryptoCompanion, CryptoController, dsPICDEM, dsPICDEM.net, Dynamic

Average Matching, DAM, ECAN, Espresso T1S, EtherGREEN, EyeOpen, GridTime, IdealBridge, IGaT, In-Circuit Serial Programming, ICSP, INICnet, Intelligent Paralleling, IntelliMOS, Inter-Chip Connectivity, JitterBlocker, Knob-on-Display, MarginLink, maxCrypto, maxView, memBrain, Mindi, MiWi, MPASM, MPF, MPLAB Certified logo, MPLIB, MPLINK, mSiC, MultiTRAK, NetDetach, Omniscient Code Generation, PICDEM, PICDEM.net, PICKit, PICtail, Power MOS IV, Power MOS 7, PowerSmart, PureSilicon, QMatrix, REAL ICE, Ripple Blocker, RTAX, RTG4, SAM-ICE, Serial Quad I/O, simpleMAP, SimpliPHY, SmartBuffer, SmartHLS, SMART-I.S., storClad, SQI, SuperSwitcher, SuperSwitcher II, Switchtec, SynchroPHY, Total Endurance, Trusted Time, TSHARC, Turing, USBCheck, VariSense, VectorBlox, VeriPHY, ViewSpan, WiperLock, XpressConnect, and ZENA are trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

SQTP is a service mark of Microchip Technology Incorporated in the U.S.A.

The Adaptec logo, Frequency on Demand, Silicon Storage Technology, and Symmcom are registered trademarks of Microchip Technology Inc. in other countries.

GestIC is a registered trademark of Microchip Technology Germany II GmbH & Co. KG, a subsidiary of Microchip Technology Inc., in other countries.

All other trademarks mentioned herein are property of their respective companies.

© 2023, Microchip Technology Incorporated and its subsidiaries. All Rights Reserved.

ISBN: 978-1-6683-3693-9

Quality Management System

For information regarding Microchip's Quality Management Systems, please visit www.microchip.com/quality.

Worldwide Sales and Service

AMERICAS	ASIA/PACIFIC	ASIA/PACIFIC	EUROPE
<p>Corporate Office 2355 West Chandler Blvd. Chandler, AZ 85224-6199 Tel: 480-792-7200 Fax: 480-792-7277 Technical Support: www.microchip.com/support Web Address: www.microchip.com</p> <p>Atlanta Duluth, GA Tel: 678-957-9614 Fax: 678-957-1455</p> <p>Austin, TX Tel: 512-257-3370</p> <p>Boston Westborough, MA Tel: 774-760-0087 Fax: 774-760-0088</p> <p>Chicago Itasca, IL Tel: 630-285-0071 Fax: 630-285-0075</p> <p>Dallas Addison, TX Tel: 972-818-7423 Fax: 972-818-2924</p> <p>Detroit Novi, MI Tel: 248-848-4000</p> <p>Houston, TX Tel: 281-894-5983</p> <p>Indianapolis Noblesville, IN Tel: 317-773-8323 Fax: 317-773-5453 Tel: 317-536-2380</p> <p>Los Angeles Mission Viejo, CA Tel: 949-462-9523 Fax: 949-462-9608 Tel: 951-273-7800</p> <p>Raleigh, NC Tel: 919-844-7510</p> <p>New York, NY Tel: 631-435-6000</p> <p>San Jose, CA Tel: 408-735-9110 Tel: 408-436-4270</p> <p>Canada - Toronto Tel: 905-695-1980 Fax: 905-695-2078</p>	<p>Australia - Sydney Tel: 61-2-9868-6733</p> <p>China - Beijing Tel: 86-10-8569-7000</p> <p>China - Chengdu Tel: 86-28-8665-5511</p> <p>China - Chongqing Tel: 86-23-8980-9588</p> <p>China - Dongguan Tel: 86-769-8702-9880</p> <p>China - Guangzhou Tel: 86-20-8755-8029</p> <p>China - Hangzhou Tel: 86-571-8792-8115</p> <p>China - Hong Kong SAR Tel: 852-2943-5100</p> <p>China - Nanjing Tel: 86-25-8473-2460</p> <p>China - Qingdao Tel: 86-532-8502-7355</p> <p>China - Shanghai Tel: 86-21-3326-8000</p> <p>China - Shenyang Tel: 86-24-2334-2829</p> <p>China - Shenzhen Tel: 86-755-8864-2200</p> <p>China - Suzhou Tel: 86-186-6233-1526</p> <p>China - Wuhan Tel: 86-27-5980-5300</p> <p>China - Xian Tel: 86-29-8833-7252</p> <p>China - Xiamen Tel: 86-592-2388138</p> <p>China - Zhuhai Tel: 86-756-3210040</p>	<p>India - Bangalore Tel: 91-80-3090-4444</p> <p>India - New Delhi Tel: 91-11-4160-8631</p> <p>India - Pune Tel: 91-20-4121-0141</p> <p>Japan - Osaka Tel: 81-6-6152-7160</p> <p>Japan - Tokyo Tel: 81-3-6880-3770</p> <p>Korea - Daegu Tel: 82-53-744-4301</p> <p>Korea - Seoul Tel: 82-2-554-7200</p> <p>Malaysia - Kuala Lumpur Tel: 60-3-7651-7906</p> <p>Malaysia - Penang Tel: 60-4-227-8870</p> <p>Philippines - Manila Tel: 63-2-634-9065</p> <p>Singapore Tel: 65-6334-8870</p> <p>Taiwan - Hsin Chu Tel: 886-3-577-8366</p> <p>Taiwan - Kaohsiung Tel: 886-7-213-7830</p> <p>Taiwan - Taipei Tel: 886-2-2508-8600</p> <p>Thailand - Bangkok Tel: 66-2-694-1351</p> <p>Vietnam - Ho Chi Minh Tel: 84-28-5448-2100</p>	<p>Austria - Wels Tel: 43-7242-2244-39 Fax: 43-7242-2244-393</p> <p>Denmark - Copenhagen Tel: 45-4485-5910 Fax: 45-4485-2829</p> <p>Finland - Espoo Tel: 358-9-4520-820</p> <p>France - Paris Tel: 33-1-69-53-63-20 Fax: 33-1-69-30-90-79</p> <p>Germany - Garching Tel: 49-8931-9700</p> <p>Germany - Haan Tel: 49-2129-3766400</p> <p>Germany - Heilbronn Tel: 49-7131-72400</p> <p>Germany - Karlsruhe Tel: 49-721-625370</p> <p>Germany - Munich Tel: 49-89-627-144-0 Fax: 49-89-627-144-44</p> <p>Germany - Rosenheim Tel: 49-8031-354-560</p> <p>Israel - Ra'anana Tel: 972-9-744-7705</p> <p>Italy - Milan Tel: 39-0331-742611 Fax: 39-0331-466781</p> <p>Italy - Padova Tel: 39-049-7625286</p> <p>Netherlands - Drunen Tel: 31-416-690399 Fax: 31-416-690340</p> <p>Norway - Trondheim Tel: 47-72884388</p> <p>Poland - Warsaw Tel: 48-22-3325737</p> <p>Romania - Bucharest Tel: 40-21-407-87-50</p> <p>Spain - Madrid Tel: 34-91-708-08-90 Fax: 34-91-708-08-91</p> <p>Sweden - Gothenberg Tel: 46-31-704-60-40</p> <p>Sweden - Stockholm Tel: 46-8-5090-4654</p> <p>UK - Wokingham Tel: 44-118-921-5800 Fax: 44-118-921-5820</p>