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## SAM E70 Xplained Ultra User's Guide

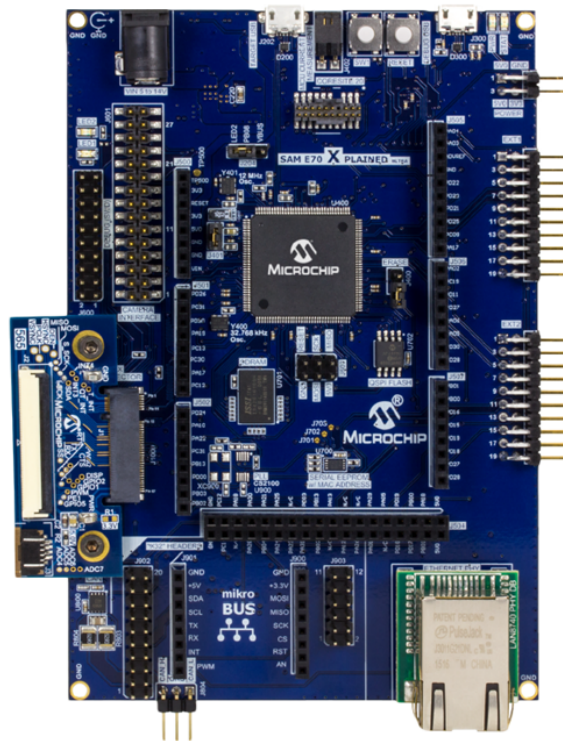
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### Introduction

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This user's guide provides detailed information about the SAM E70 Xplained Ultra Evaluation kit and its various features. Figure below illustrates the SAM E70 Xplained Ultra Evaluation kit.

**Figure 1. SAM E70 Xplained Ultra Evaluation Kit with PHY Daughter Board**



### Features

- ATSAME70Q21 Microcontroller
- One Mechanical Reset Button
- One Mechanical User Push Button
- Two User LEDs
- 12.0 MHz Oscillator (DSC6003)
- 32.768 kHz Oscillator (DSC6083)
- 2-MB SDRAM
- 4-MB QSPI Flash (SST26VF032BA)

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- Ethernet Interface with External IEEE 802.3az 10Base-T/100Base-TX Ethernet RMII PHY on a Daughter Board
  - AT24MAC402 256KB EEPROM with EUI-48 Address
  - ATA6561 CAN Transceiver
  - Micro SD Card Connector with SDIO Support
  - Camera Interface Connector
  - Two Xplained Pro Extension Headers
  - Graphics Card Interface
  - CoreSight<sup>®</sup> 20 Connector for 4-bit ETM
  - Arduino MEGA Shield Connector
  - External Debugger Connector
  - USB Interface, Device and Host Mode
  - Embedded Debugger:
    - Programming and debugging through USB interface
    - Auto-ID for board identification in Atmel Studio and MPLAB<sup>®</sup> X
    - One yellow status LED
    - One green board power LED
    - Symbolic debug of complex data types including scope information
    - Data Gateway Interface: SPI, I<sup>2</sup>C, four GPIOs
    - Virtual COM port (CDC)
  - External Power Input (5-14V) or USB Power
  - X32 Daughter Board Interface to Support Audio and Bluetooth<sup>®</sup>
  - One mikroBus<sup>™</sup> Interface

### Kit Overview

The Microchip PIC32 SAM E70 Xplained Ultra Development Kit (DM320113) provides a modular development system for Microchip's line of 32-bit Cortex<sup>®</sup> microcontrollers.

For a free Microchip demonstration code and additional information, visit the MPLAB Harmony<sup>™</sup> web page at: <http://www.microchip.com/MPLABHarmony>.

The Atmel SAM E70 Xplained Ultra Development Kit is a hardware platform to evaluate the Microchip ATSAME70Q21. The kit offers a set of features that enables the ATSAME70Q21 users to start with the SAM E70 peripherals and understand how to integrate the device in their design.

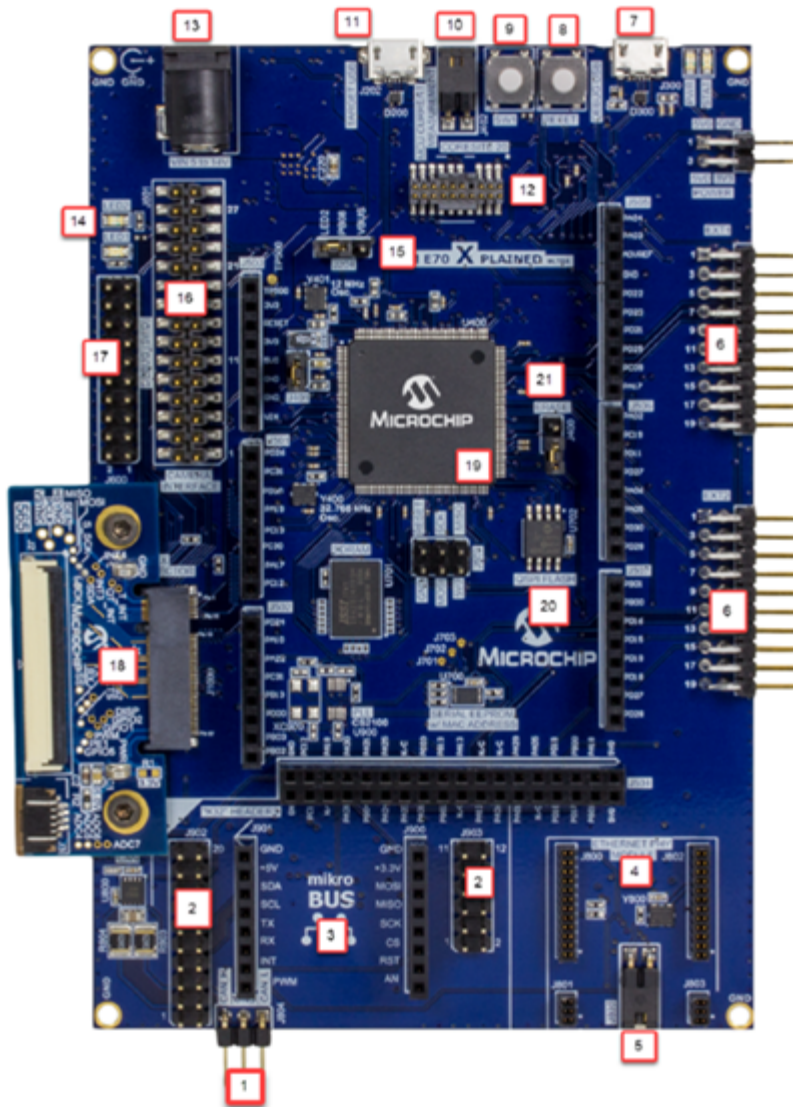
The SAM E70 Xplained Ultra kit contains the following items:

- One SAM E70 Xplained Ultra Development Kit
- One KSZ8061 Ethernet PHY
- One Graphics card set up for 565 (16-bit color) graphics

**Note:** If any items are missing in the kit, contact Microchip sales office for assistance. A list of Microchip Sales offices is provided on the last page of this document.

The figure below illustrates the SAM E70 Xplained Ultra Evaluation Kit features.

Figure 2. SAM E70 Xplained Ultra Evaluation Kit



The table below provides the SAM E70 Xplained Ultra Evaluation kit feature descriptions.

**Table 1. SAM E70 Xplained Ultra Evaluation Kit Feature and Location**

Number	Description
1	CAN interface
2	X32 Daughter Board interface
3	Mikro interface
4	Ethernet PHY interface
5	Ethernet Clock enable/disable jumper <ol style="list-style-type: none"> <li>1. Shorted = disabled</li> <li>2. Open = enabled</li> </ol>
6	EXT1/EXT2 interface
7	Debugger USB <ol style="list-style-type: none"> <li>1. Programming</li> <li>2. Power</li> <li>3. DGI</li> </ol>
8	External Reset Button
9	User Button
10	MCU current measurement jumper
11	SAM E70 Host/Device USB
12	CoreSite <sup>®</sup> 20 (SWD + ETM) debugging interface
13	Barrel power input (2.1mm)
14	User defined LEDs
15	LED2/USB detect jumper
16	Image Sensor interface
17	SWD debugger interface
18	Graphics card interface
19	ATSAME70Q21B
20	SQI external Flash memory

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# 1. Getting Started

## SAM E70 Xplained Ultra Evaluation Quick Start

Follow these steps to explore the Atmel SAM E70 Xplained Ultra evaluation kit:

1. Download and install MPLAB X.
2. Launch MPLAB X.
3. Install MPLAB Harmony 3™.

When Microchip SAM E70 Xplained Ultra is connected to the computer for the first time, the operating system will install a driver software. The driver file supports both 32-bit and 64-bit versions of Microsoft® Windows® XP/ Vista /7/8/10.

Once the kit is powered, the green power LED will be lit and MPLAB X will auto-detect the kit and identify which Xplained Pro extension boards are connected. MPLAB X will provide relevant information like data sheets and kit documentation. The SAM E70 device is programmed and debugged by the on-board Embedded Debugger, hence no external programmer or debugger tool is needed.

## Design Documentation and Relevant Links

The following list provides links to the relevant documents and software for the SAM E70 Xplained Ultra.

- Xplained Pro products
  - Atmel Xplained Pro is a series of small-sized and easy-to-use evaluation kit for Microchip microcontrollers and other Microchip products. It consists of a series of low-cost MCU boards for evaluation and demonstration of features and capabilities of different MCU families.
- Microchip MPLAB® Integrated Development Environment
  - A free Microchip MPLAB IDE for development of C/C++ and assembler code for Microchip microcontrollers.
- MPLAB Harmony™
  - A free MPLAB Harmony code base is available for user application. The latest MPLAB Harmony code is available for download at:<http://www.microchip.com/MPLABHarmony>.
- EDBG User Guide
  - This user's guide provides additional information about the on-board Embedded Debugger.
- Data Visualizer
  - Data Visualizer is a program used for processing and visualizing data. The Data Visualizer can receive data from various sources, such as the Embedded Debugger Data Gateway Interface that is found on the Xplained Pro boards and COM ports.
- IAR Embedded Workbench® for ARM®
  - A commercial C/C++ compiler that is available for ARM. A 30-day evaluation version and a code size limited kick-start version are also available for download from their web site. The code size limit is 16-KB for devices with M0, M0+, M1 cores, and 32-KB for devices with other cores.
- Keil MDK-ARM Microcontroller Development Kit
  - The MDK-ARM is a complete software development environment for Cortex® -M, Cortex-R4, ARM7™, and ARM9™ processor-based devices. The MDK-ARM is specifically designed for microcontroller applications, it is user friendly yet powerful enough for the most demanding embedded applications.
- Design Documentation

- Package containing schematics, BOM, assembly drawings, 3D plots, layer plots, and so on.
- Hardware Users Guide
  - PDF version of this user guide.



## **2. Xplained Ultra**

The SAM E70 Xplained Ultra implements several Xplained Pro standards like extension headers and connectors. Xplained Pro is an evaluation platform that provides a full Microchip microcontroller experience. The platform consists of a series of Microcontroller (MCU) boards and extension boards that are integrated with the Microchip MPLAB IDE that supports data streaming. The Xplained Pro MCU boards support a wide range of Xplained Pro extension boards, such as audio DACs/CODECs, Ethernet PHYs, graphics cards, and mikroBUS™ that are connected through a set of standardized headers and connectors. Each extension board has an identification (ID) chip to uniquely identify which boards are connected to a Xplained Pro MCU board. This information is used to present relevant user guides, application notes, data sheets, and example code through MPLAB X.

### 3. Embedded Debugger

The SAM E70 Xplained Ultra contains Microchip Embedded Debugger (EDBG) for on-board debugging. The EDBG is a composite USB device, which is based on the following interfaces:

- Debugger
- Virtual COM Port
- Data Gateway Interface (DGI)

Together with the Microchip MPLAB IDE, the EDBG debugger interface can program and debug the ATSAME70Q21. On the SAM E70 Xplained Ultra, the SWD interface is connected between the EDBG and the ATSAME70Q21.

The Virtual COM Port is connected to a UART on the ATSAME70Q21 and provides an easy way to communicate with the target application through the terminal software. It offers variable baud rate, parity, and Stop bit settings. The settings on the ATSAME70Q21 must match the settings given in the terminal software.

**Note:** If not set automatically, Data Terminal Ready (DTR) must be set in the terminal software.

The DGI consists of several physical interfaces for communication with the host computer. Communication over the interfaces is bidirectional. It can be used to send events and values from the ATSAME70Q21, or as a generic printf-style data channel. Traffic over the interfaces can be timestamped on the EDBG for accurate tracing of events. Note that timestamping imposes an overhead that reduces maximal throughput. The Data Visualizer is used to send and receive data through DGI.

The EDBG controls two LEDs on SAM E70 Xplained Ultra: a power LED and a status LED.

The following table describes how the LEDs are controlled in different operation modes.

**Table 3-1. EDBG LED Control**

Operation Mode	Power LED	Status LED
Normal operation	The power LED is lit when power is applied to the board.	Activity indicator, LED flashes when any communication happens to the EDBG.
Bootloader mode (idle)	The power LED and the status LED blinks simultaneously.	The power LED and the status LED blinks simultaneously.
Bootloader mode (firmware upgrade)	The power LED and the status LED blinks in an alternating pattern.	The power LED and the status LED blinks in an alternating pattern.

For additional information on EDBG, refer to the [EDBG User Guide](#).

#### 3.1 Hardware Identification System

All Xplained Pro-compatible extension boards have an Microchip ATSHA204 CryptoAuthentication™ chip mounted. This chip contains information that identifies the extension with its name and data. When an Xplained Pro extension is connected to an Xplained Pro MCU board, the information is read and sent to the MPLAB X IDE. The Microchip kits extension, installed with MPLAB X, provides relevant information, such as code examples, and links to relevant documents. The following table provides the data fields stored in the ID chip with content examples.

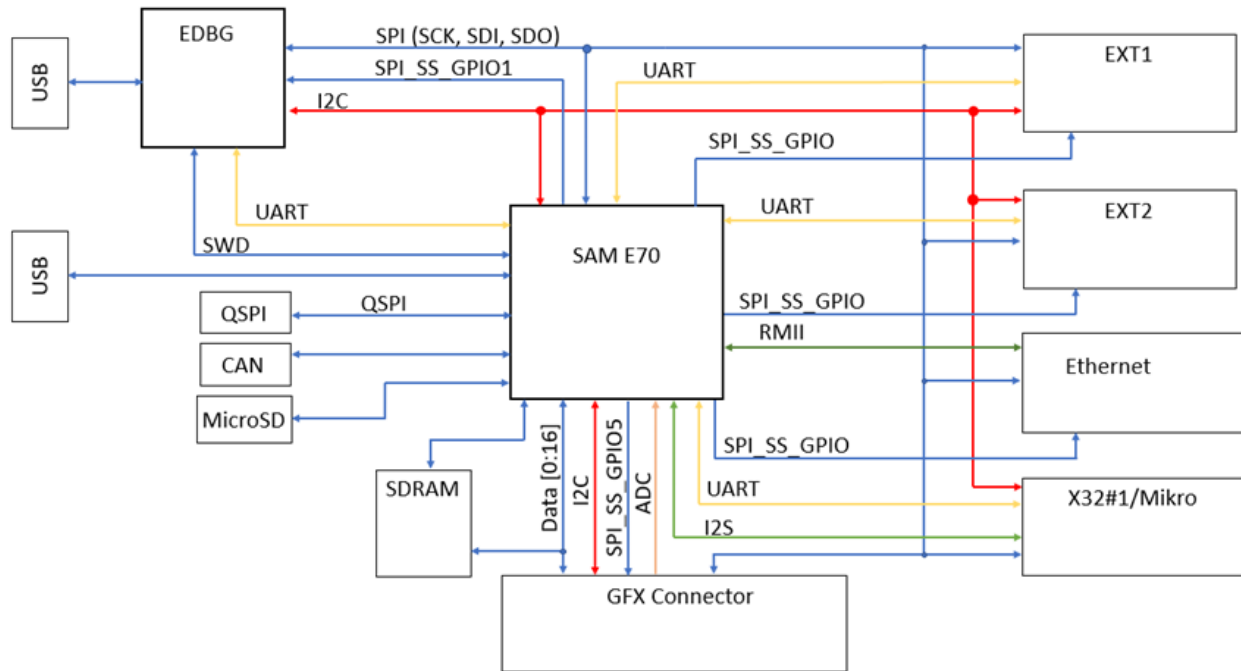
**Table 3-2. Xplained Pro ID Chip Content Example**

Data Field	Data Type	Example
Manufacture	ASCII string	Microchip'\0'
Product Name	ASCII string	
Product Revision	ASCII string	04'\0'
Product Serial number	ASCII string	1774020200000010'\0'
Minimum Voltage (mV)	uint16_t	3000
Maximum Voltage (mV)	uint16_t	3600
Maximum Current (mA)	uint16_t	30

## 4. System Level Block Diagram

The following figure illustrates the high-level signal block diagram of the SAM E70 Xplained Ultra Development Kit.

**Figure 4-1. Signal Level Block Diagram**



Wire buses that are tied together are connected together. In this system the SPI bus data and clock are shared across several interfaces. The SPI Slave selects are addressed individually with GPIO.

System I<sup>2</sup>C uses I2C0 and connects to the debugger, EXT1, EXT2, and mikroBus/X32. Touch I<sup>2</sup>C uses I2C2 and only goes from the microcontroller to the graphics connector.

The debugger has the following interfaces connected: DGI SPI, DGI I2C, DGI UART, and SWD.

UART wires from the microcontroller to the blocks are not shared with each other.

## 5. Hardware Features

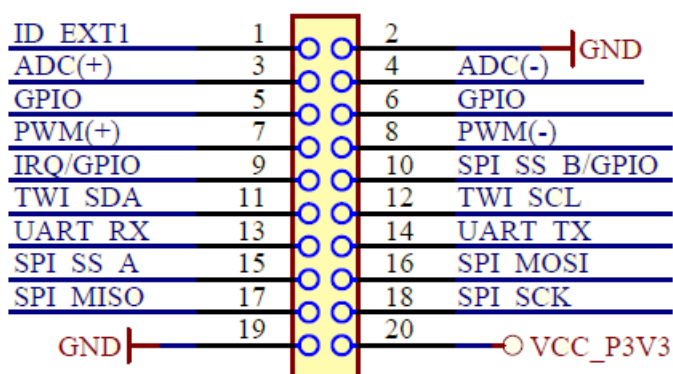
### 5.1 Xplained Pro Standard Extension Header

All Xplained Ultra Kits have many dual row, 20-pin, 100 mil extension headers. Xplained Ultra MCU boards have male headers, while Xplained Ultra extensions have their female counterparts as shown in the image below.

**Note:** All pins are not always connected.

The extension headers can be used to connect a variety of Xplained Pro extensions to Xplained Ultra MCU boards or to access the pins of the target MCU on Xplained Ultra MCU boards directly.

**Figure 5-1. Extension Headers**



All connected pins follow the defined pinout description as shown in the following table.

**Table 5-1. Xplained Pro Standard Extension Header**

Pin number	Name	Description
1	ID	Communication line to the ID chip on an extension board
2	GND	Ground
3	ADC(+)	Analog-to-Digital Converter, alternatively positive part of differential ADC
4	ADC(-)	Analog-to-Digital Converter, alternatively negative part of differential ADC
5	GPIO1	General purpose I/O
6	GPIO2	General purpose I/O
7	PWM(+)	Pulse-Width Modulation, alternatively positive part of differential PWM
8	PWM(-)	Pulse-Width Modulation, alternatively negative part of differential PWM
9	IRQ/INT/GPIO	Interrupt request line and general purpose I/O
10	SPI SS B/GPIO	SPI Slave Select or general purpose I/O
11	I <sup>2</sup> C SDA	Data line for I <sup>2</sup> C interface. Always implemented, bus type
12	I <sup>2</sup> C SCL	Clock line for I <sup>2</sup> C interface. Always implemented, bus type
13	UART RX	Receiver line of target device UART

.....continued

Pin number	Name	Description
14	UART TX	Transmitter line of target device UART
15	SPI SS A/GPIO	SPI Slave Select or general purpose I/O
16	SPI MOSI	<b>Master Out Slave In</b> line of serial peripheral interface. Always implemented, bus type.
17	SPI MISO	<b>Master In Slave Out</b> line of serial peripheral interface. Always implemented, bus type.
18	SPI SCK	Clock for serial peripheral interface. Always implemented, bus type.
19	GND	Ground
20	V <sub>CC</sub>	Power for extension boards (3.3V)

## 5.2 Graphics Connectors or GFX Card Interface

The SAM E70 Xplained Ultra Development Kit is designed to have a modular graphics interface. This interface enables using several graphics cards, which allow for expandability and different use cases. A 565 adapter card is included in the kit, which takes 16-bit parallel LCD data and converts it to 24-bit data. This card also provides access to ADC for resistive touch screens, hence an external controller is not needed. See table below for pin descriptions.

**Table 5-2. Graphics Interface Pinout**

Pin Number	Name	Description
1	GND	Ground
2	GND	Ground
3	MCLR	Master Clear, Controlled by the debuggers. Allows for a complete system reboot.
4	IRQ1 (LCD Touch)	Interrupt request line for cap touch device
5	5.0v V <sub>CC</sub>	5.0v
6	IRQ2 (Q Touch)	Interrupt request line for Q touch devices
7	LCDEN	LCD Data Enable
8	IRQ3 (Display Controllers)	Interrupt request line for external display controllers
9	LCDHSYNC/NCS3	LCD Horizontal Sync
10	IRQ4 (Resistive touch)	Interrupt request line for resistive touch controllers
11	LCDVSYNC/nWE	LEC Vertical Sync or Write enable (active-low)
12	5.0v V <sub>CC</sub>	+5.0v
13	LCDPCK/nRD	LCD pixel Clock or Read Enable (active-low)
14	I <sup>2</sup> C SDA	Data line for I <sup>2</sup> C interface. Always implemented, bus type.

.....continued		
Pin Number	Name	Description
15	LCD D0	LCD Data bit 0
16	I <sup>2</sup> C SCL	Clock line for I <sup>2</sup> C interface. Always implemented, bus type.
17	LCD D1	LCD Data bit 1
18	SPI SCK	Clock for serial peripheral interface. Always implemented, bus type.
19	LCD D2	LCD Data bit 2
20	SPI MOSI	<b>Master Out Slave In</b> line of serial peripheral interface.
21	LCD D3	LCD Data bit 3
22	SPI MISO	<b>Master In Slave Out</b> line of serial peripheral interface.
23	LCD D4	LCD Data bit 4
24	SPI SS	SPI Slave Select
25	LCD D5	LCD Data bit 5
26	UART RX	Receiver line of target device UART
27	LCD D6	LCD Data bit 6
28	UART TX	Transmitter line of target device UART. (from MCU to GFX card)
29	LCD D7	LCD Data bit 7
30	UART RTS	UART Ready To Send (from MCU to GFX card)
31	LCD D8	LCD Data bit 8
32	UART CTS	UART Clear To Send (from MCU to GFX card)
33	LCD D9	LCD Data bit 9
34	LCD PWM	LCD PWM back light control
35	LCD D10	LCD Data bit 10
36	PWM2	Pulse-Width Modulation,
37	LCD D11	LCD Data bit 11
38	GPIO1	General purpose I/O
39	LCD D12	LCD Data bit 12
40	GPIO2	General purpose I/O
41	LCD D13	LCD Data bit 13
42	GPIO3	General purpose I/O
43	LCD D14	LCD Data bit 14

.....continued		
Pin Number	Name	Description
44	STBY/RST/GPIO4	Standby/Reset or general purpose I/O. For resetting devices attached to the GFX connector.
45	LCD D15	LCD Data bit 15
46	STBY/RST/GPIO5	Standby2/Reset2 or general purpose I/O
47	LCD D16	LCD Data bit 16 (Not Implemented on this design)
48	ID pin	Communication line to the ID chip on an extension board
49	LCD D17	LCD Data bit 17 (Not Implemented on this design)
50	ADC 0	Analog-to-Digital Converter to MCU
51	LCD D18	LCD Data bit 18 (Not Implemented on this design)
52	ADC1	Analog-to-Digital Converter to MCU
53	LCD D19	LCD Data bit 19 (Not Implemented on this design)
54	ADC2	Analog-to-Digital Converter to MCU
55	LCD D20	LCD Data bit 20 (Not Implemented on this design)
56	ADC3	Analog-to-Digital Converter to MCU
57	LCD D21	LCD Data bit 21 (Not Implemented on this design)
58	ADC4	Analog-to-Digital Converter to MCU
59	LCD D22	LCD Data bit 22
60	ADC5	Analog-to-Digital Converter to MCU
61	LCD D23	LCD Data bit 23
62	ADC6	Analog-to-Digital Converter to MCU
63	3.3V V <sub>CC</sub>	+3.3V V <sub>CC</sub>
64	ADC7	Analog-to-Digital Converter to MCU
65	GND	Ground
66	3.3V V <sub>CC</sub>	+3.3V V <sub>CC</sub>
67	GND	Ground
68	GND TAB	Mounting Tab
69	GND TAB	Mounting Tab

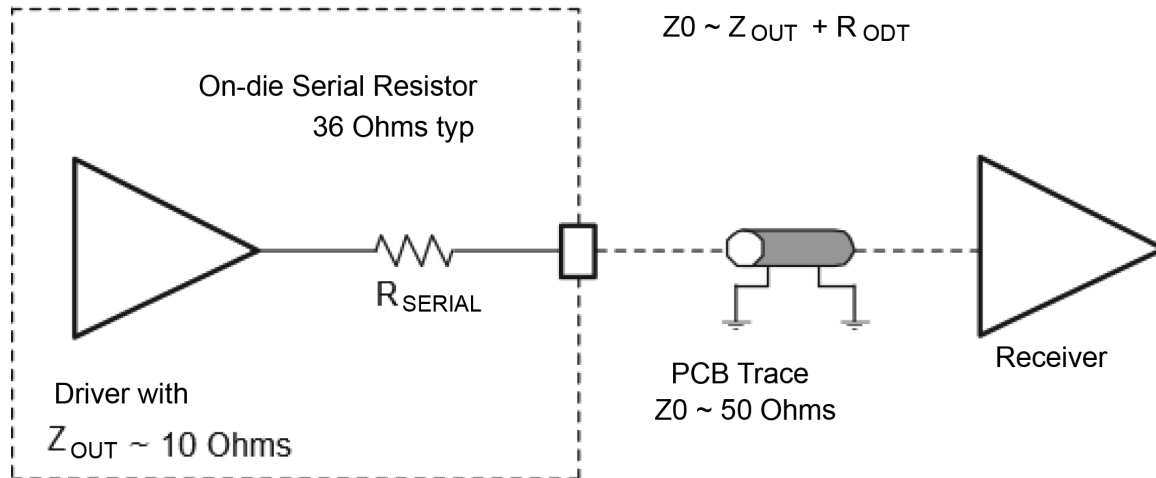


### 5.3 SDRAM and LCD Connections

The external bus interface (EBI) on SAM E71 Xplained Ultra is controlled by the static memory controller (SMC) and SDRAM controllers modules in the ATSAME70Q21B.

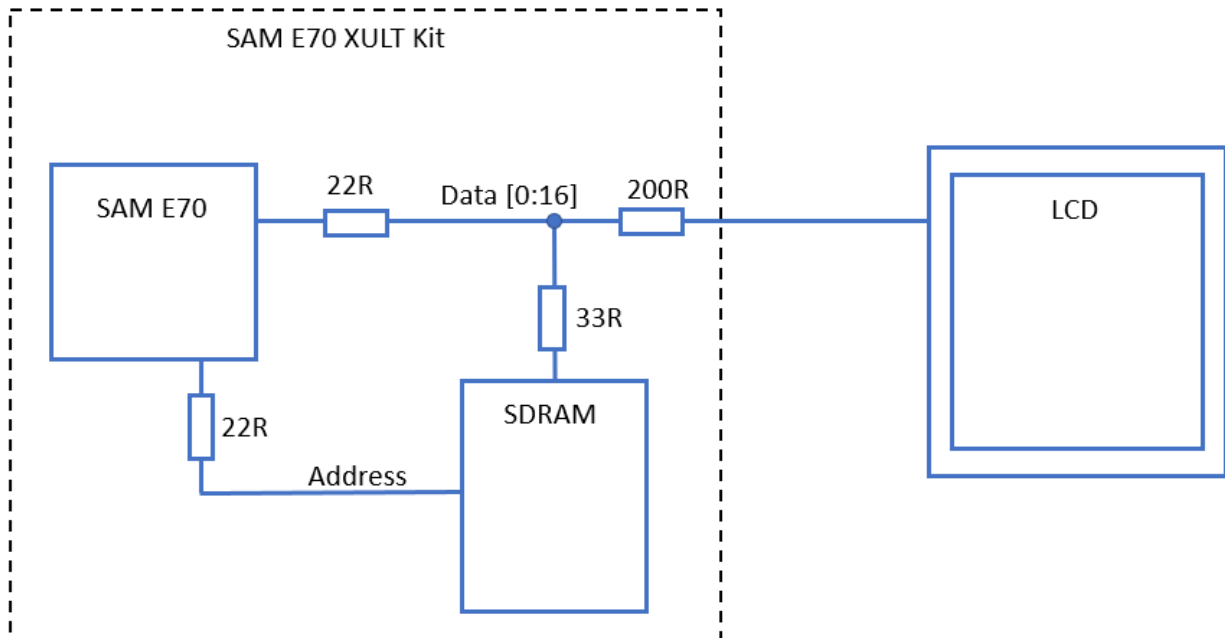
ATSAME70Q21B has on-die series termination on very I/O pin as shown in figure below.

**Figure 5-2. On-Die Termination**



The EBI is connected to the on-board SDRAM and the Xplained Pro Graphics connector. The following figure shows how the SDRAM and LCD share the same sets of data pins, and displays the location of the series termination resistors.

**Figure 5-3. LCD and SDRAM**



As the I/O pins have on-die series termination, the impedance of the drivers must be matched to the impedance of the EBI tracks on the PCB using series resistors. The EBI tracks are routed as 50Ω on SAM E70 Xplained Ultra. The clock and address lines are only driven by the ATSAME70Q21B, while the data lines are driven by the ATSAME70Q21B and the on-board SDRAM.

Simulation of the transmissions lines using IBIS files for the ATSAME70Q21B and the SDRAM gave the results are shown in the table below.

**Table 5-3. EBI Simulation Results**

Driving Circuit	Signal Type	Driver Impedance (from ibis)	Series Termination	Z <sub>0</sub>
ATSAME70Q21B	Data/Address	22Ω	24Ω ≈ 22Ω	50Ω
	Clock	21Ω	25Ω ≈ 22Ω	50Ω
SDRAM	Data	11Ω	32Ω ≈ 33Ω	50Ω

The routing of the data lines to the LCD connector causes stubs on the data lines at the SDRAM (the stubs are even longer when a cable is plugged in). The 200Ω resistors are placed close to the SDRAM to create a high-impedance path for the signal to the stubs, improving the signal integrity when communicating with the SDRAM.

**TIP:**

- The series-termination is always placed near to the driving pin.
- The 200Ω resistors are placed close to the intersection between the SDRAM routing and the routing to the LCD connector.
- All designs must be simulated using an IBIS file for the ATSAMV71Q21B and the target peripherals to check whether the signals are within the limits of the devices.

## 5.4 Camera Connector

A 2 x 15, 100 mil pin-header camera connector is implemented to provide access to the SAM E70's parallel Image Sensor Interface (ISI).

**Table 5-4. Camera Interface Pin Description**

Pin Number	Name	Function
1	V <sub>CC</sub>	+3.3v
2	GND	Ground
3	V <sub>CC</sub>	+3.3v
4	GND	Ground
5	Reset	Reset
6	PWD	ISI PWD
7	I <sup>2</sup> C SCK	Clock line for I <sup>2</sup> C interface. Always implemented, bus type.
8	I <sup>2</sup> C SDA	Data line for I <sup>2</sup> C interface. Always implemented, bus type.
9	GND	Ground
10	MCK	Master Clock
11	GND	Ground
12	VSYNC	Image Sensor Vertical Sync
13	GND	Ground
14	HSYNC	Image Sensor Horizontal Sync
15	GND	Ground
16	Pixel Clock	Image Sensor Pixel Clock
17	GND	Ground
18	ISI D0	Image Sensor Data Bit 0
19	ISI D1	Image Sensor Data Bit 1
20	ISI D2	Image Sensor Data Bit 2
21	ISI D3	Image Sensor Data Bit 3
22	ISI D4	Image Sensor Data Bit 4
23	ISI D5	Image Sensor Data Bit 5
24	ISI D6	Image Sensor Data Bit 6
25	ISI D7	Image Sensor Data Bit 7
26	ISI D8	Image Sensor Data Bit 8
27	ISI D9	Image Sensor Data Bit 9
28	ISI D10	Image Sensor Data Bit 10

.....continued

Pin Number	Name	Function
29	ISI D11	Image Sensor Data Bit 11
30	GND	Ground

## 5.5 USB Connectivity

Users can connect to the PIC32 USB microcontroller using any one of the following modes:

- **Host mode:** If connecting the device to the Type-A/B Micro connector, an adapter is required. Using this method, a maximum of 400 mA can be supplied from the debug USB port to the host port. If a full 500 mA supply is needed, an external supply must be connected to the application board.
- **Device mode:** Connect the SAM E70 to the target USB Micro-A/B port using a USB cable. This is enough to power the board as a device. If programming and debugging is required, connect the Debug USB Micro-A/B port. The other end of the cable must have a Type-A connector, to connect it to a USB host.
- **On-The-Go (OTG) mode:** Connect the starter kit to the OTG device by using an OTG Micro-A/B cable to the Micro-A/B port.

There is a 1x3, 100mil pin-header marked VBUS on the kit. The PB08 pin on the SAM E70 can be connected to the LED2 or to the target USB VBUS DETECT signal by placing a jumper between pin 1 and pin 2, or pin 2 and pin 3 on this pin-header. The USB VBUS DETECT is the target USB voltage divided by 1.64. When connected to the PB08 pin the signal can be used to detect power on the target USB connector.

**Table 5-5. USB Jumper Description**

Pin number	Name	Description
1	LED2	LED2 active-low
2	PB08	Pin and Port to microcontroller
3	VBUS_ Detect	VBUS Detect, used to detect when a device cable (micro-B) is plugged into the SAM E70

The SAM E70 Xplained Ultra has a Micro-USB connector to use with the SAM E70 USB module labeled as TARGET USB on the kit. In USB Host mode, the VBUS voltage is provided by the kit, and must be enabled by setting the VBUS Host Enable pin to low. When a USB OTG cable is plugged in, it will automatically trigger the power supply.

**Table 5-6. USB Interface Pin Description**

Pin on SAM	USB Function
PA08	VBUS Host Enable
HSDM	USB -
HSDP	USB +

### 5.6 Chip Erase Header

A 1x2 pin-header is connected to the SAM E70 chip erase pin, PB12, and 3V3 is marked ERASE. This header can be used to chip erase the SAM E70 by placing the jumper on the header and toggle power to the board. After the power is toggled, the jumper must be removed. Using the chip erase jumper may be the only way to erase a chip with the security bit set, and applications that immediately set invalid clock options, or go into deep sleep without any wake-up sources enabled.

### 5.7 Audio Connectivity

The SAM E70 provides an audio connection through the X32 interface to the two main audio modules in the chip, such as the SSC and the I<sup>2</sup>S. On this board the SSC interface is considered the main audio interface. See image below.

There is a 32-pin interface to the board to support the audio codec or DACs and Bluetooth radios. This interface has two audio supply interfaces, such as the SSC and the I<sup>2</sup>S. Addition to this other control lines and data interfaces are available.

Figure 5-4. SSC/I<sup>2</sup>S Block Diagram

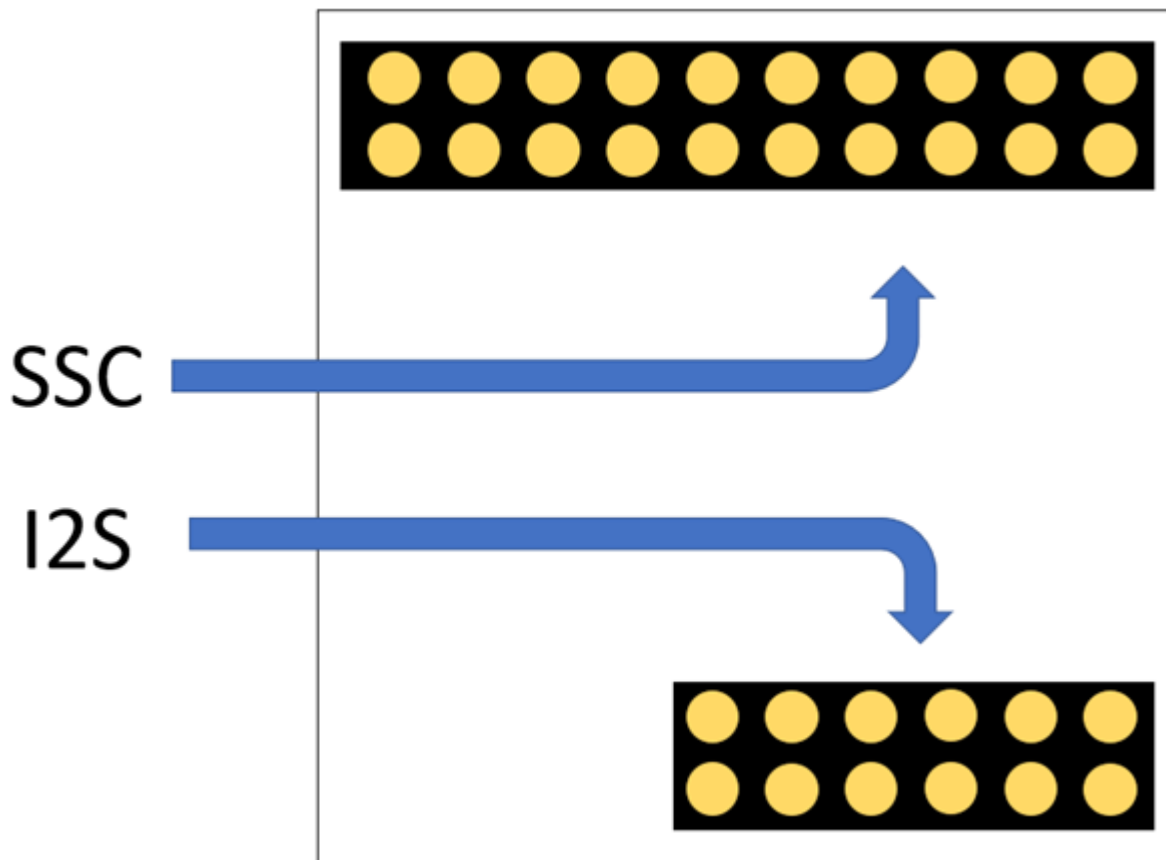


Table 5-7. X32 Audio Interface Pin Description

Pin Number	Name	Description	Interface
1	GND	Ground	Power

.....continued			
Pin Number	Name	Description	Interface
2	GND	Ground	Power
3	UART RX	UART RX, receive to MCU from DB	UART
4	UART CTS	UART Clear to send	UART
5	UART TX	UART TX, transmit from MCU to DB	UART
6	UART RTS	UART Ready to send	UART
7	I <sup>2</sup> C SCL	Clock line for I <sup>2</sup> C interface	I <sup>2</sup> C
8	STBY/RST	Standby/Reset control	GPIO
9	I <sup>2</sup> C SDA	Data line for I <sup>2</sup> C interface	I <sup>2</sup> C
10	Audio WS/LRCLK	Audio Word Select/ Left Right Clock	SSC
11	Audio In	Audio into MCU, out from CODEC	SSC
12	Audio CLK	Audio clock	SSC
13	Audio out	Audio out of MCU, in to CODEC/DAC	SSC
14	REFCLK/MCK	Reference clock #1	REFCLK
15	GND	Ground	-
16	GND	Ground	-
17	NC	Legacy hold over	-
18	+3.3v	V <sub>DD</sub>	-
19	NC	Legacy hold over	-
20	+5.0v	V <sub>DD</sub>	-
21 (1)	Audio WS/ Audio LRCLK	Audio Word Select/ Left Right Clock	I <sup>2</sup> S
22 (2)	ADC/Card ID pin	Analog-to-Digital Converter to read voltage on the daughter card	ADC
23 (3)	Audio CLK	Audio Clock	I <sup>2</sup> S
24 (4)	NC	-	-
25 (5)	Audio IN	Audio into MCU, out from CODEC	I <sup>2</sup> S
26 (6)	NC		-
27 (7)	Audio OUT	Audio out of MCU, in to CODEC/DAC	I <sup>2</sup> S
28 (8)	NC	-	-
29 (9)	REFCLK2/MCK2	Reference clock #2	REFCLK
30 (10)	NC	-	-
31 (11)	GND	Ground	-

.....continued

Pin Number	Name	Description	Interface
32 (12)	GND	Ground	-

## 5.8 mikroBUS™ Header

The mikroBUS™ interface enables using the additional click boards. For additional information and to identify the boards to be used with this development kit, visit the following web site: <https://www.mikroe.com/>.

**Table 5-8. mikroBUS™ interface Pin Description**

Pin Number	Name	Function
1	GND	Ground
2	+5V	+5.0V
3	SDA	I <sup>2</sup> C SDA
4	SCL	I <sup>2</sup> C SCL
5	TX	UART TX
6	RX	UART RX
7	INT	Interrupt request line
8	PWM	Pulse-Width Modulation
9	GND	Ground
10	+3.3V	Ground
11	MOSI	Master Out Slave In line of serial peripheral interface
12	MISO	Master In Slave Out line of serial peripheral interface
13	SCK	Clock for serial peripheral interface
14	CS	Chip Select for serial peripheral interface. (Active-low)
15	RST	Reset
16	AN	Analog-to-Digital Converter.

## 5.9 CAN

The development kit provides access to the a CAN-FD interface that is post transceiver. The SAM E70 Xplained Ultra has two MCAN modules that perform communications according to ISO11898-1 (Robert Bosch GmbH CAN specification 2.0 part A and B). Bosch CAN FD specification V1.0. MCAN1 is connected to an on-board ATA6561 CAN physical-layer transceiver. These connections are described in the following table.

Table 5-9. Connections Between the ATSAME70Q21 and the ATA6561

Pin Number	Name	Description
1	CAN_H	CAN High Signal
2	GND	Ground
3	CAN_L	CAN Low Signal

### 5.10 Ethernet

The SAM E70 Xplained Ultra kit has a modular Ethernet PHY system that allows for different PHYs to be plugged into the board. This interface is set up to use a Reduced Media-Independent Interface (RMII), as well as a SPI bus interface with GPIO.

Figure 5-5. Ethernet PHY Header Configuration

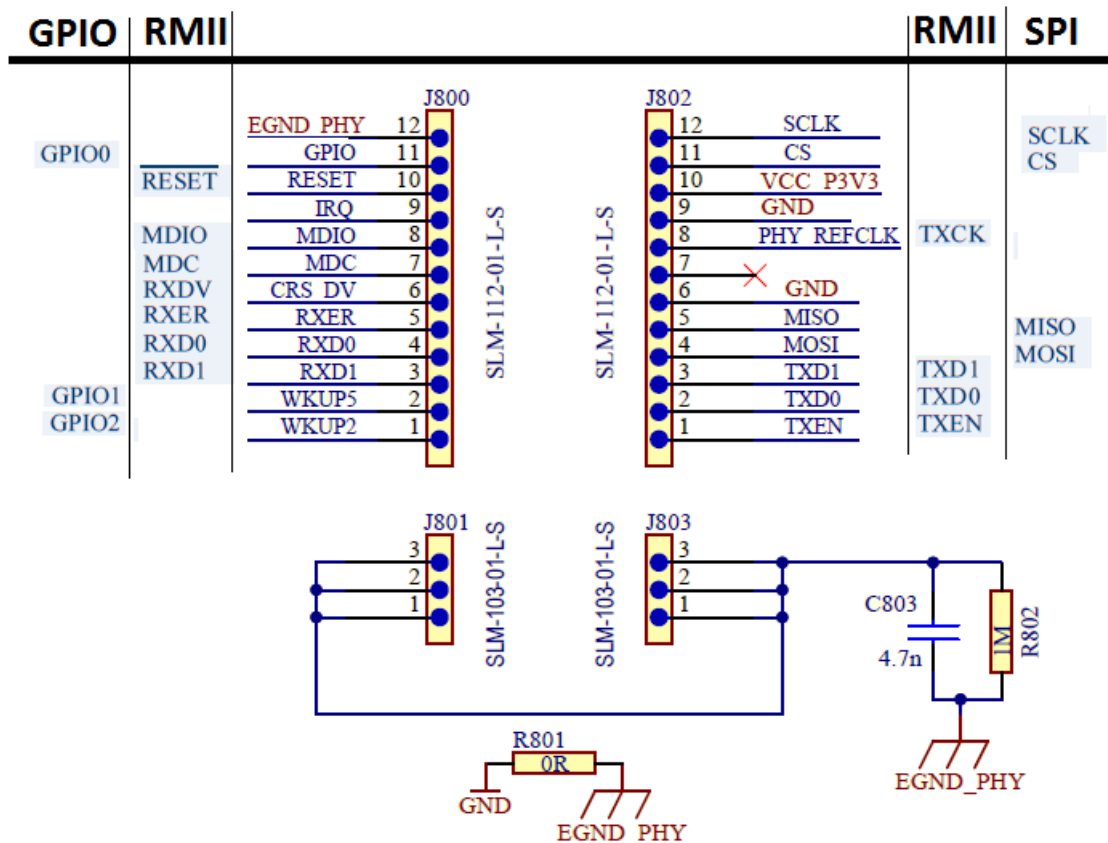


Table 5-10. Ethernet Interface Pinout Description

Pin Number	Name	Description
1	GPIO	General purpose I/O
2	GPIO	General purpose I/O
3	RXD1	Receive Data 1
4	RXD0	Receive Data 0



.....continued		
Pin Number	Name	Description
5	RXER	Receive Error
6	RXDV	Receive Data Valid
7	MDC	-
8	MDIO	-
9	IRQ	Interrupt request line
10	RESET	Reset control to the Ethernet PHY
11	GPIO	General purpose I/O
12	EGND	Shield Ground
13 (1)	TXEN	Transmit Enable
14 (2)	TXD0	Transmit Data
15 (3)	TDX1	Transmit Data
16 (4)	MOSI	Master Out Slave In line of serial peripheral interface
17 (5)	MISO	Master In Slave Out line of serial peripheral interface
18 (6)	GND	Ground
19 (7)	NC	No Connect
20 (8)	REFCLK (in)	Reference Clock input (50 MHz)
21 (9)	GND	GND
22 (10)	+3.3v V <sub>DD</sub>	+3.3V V <sub>DD</sub>
23 (11)	CS	Chip Select for serial peripheral interface
24 (12)	SCK	Clock for serial peripheral interface
25 -30	EGND	Shield Ground

### 5.11 Debug USB Connectivity

The starter kit includes an EDBG USB microcontroller that provides debugger connectivity over the USB. The EDBG MCU is hard-wired to the SAM E70 device to provide protocol translation.

An external programmer, such as MPLAB ICD4, may be used with the development kit through either the SWD interface or through the Coresite 20 interface.

### 5.12 Switches

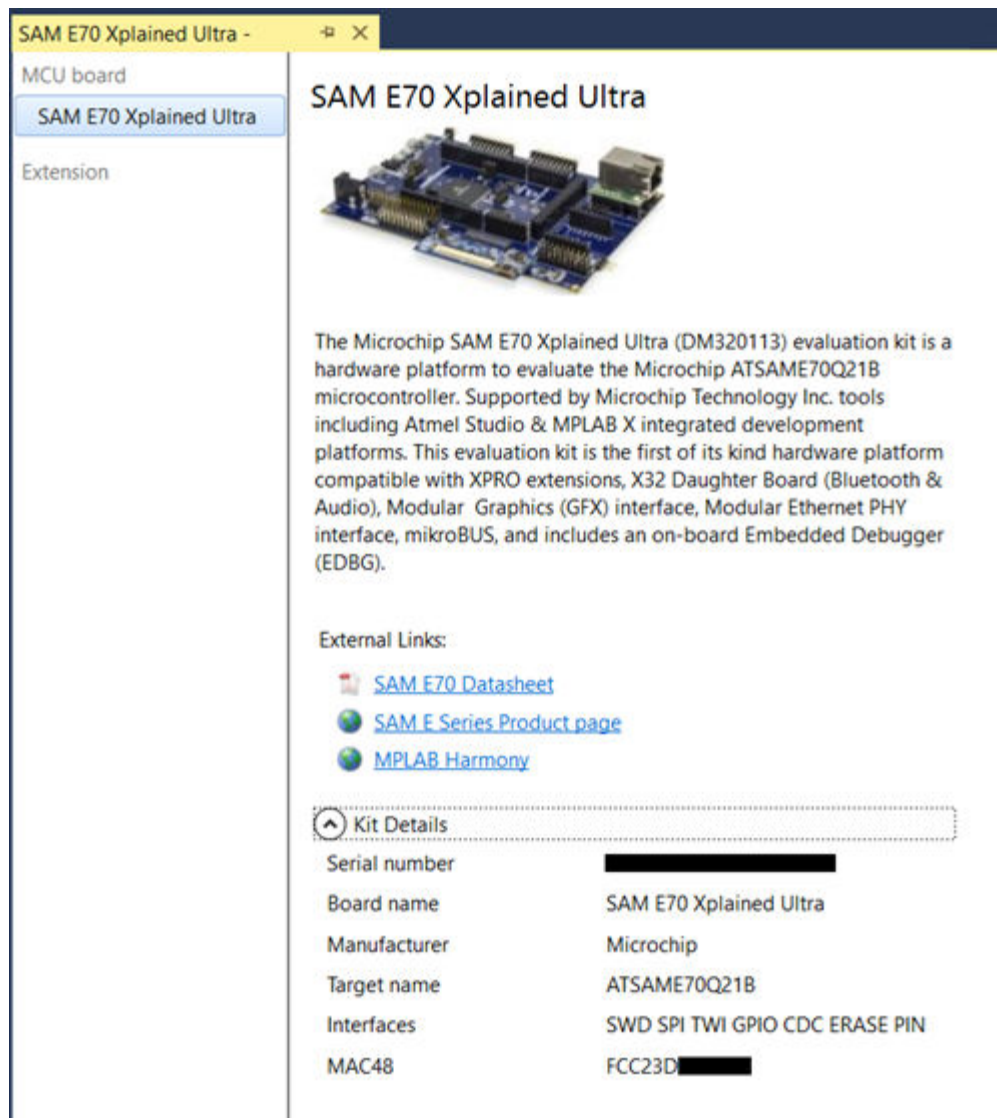
The starter kit provides the following two push button switches. The push button switches do not have any debounce circuitry and require the use of internal pull-up resistors. This enables the user to investigate the software debounce techniques. When Idle, the switches are pulled high (+3.3V,) and when pressed, they are grounded.

- User switch
- Reset switch

### 5.13 AT24MAC402 Serial EEPROM

The development board has an on-board 2-Kbit I<sup>2</sup>C serial EEPROM which is available for user applications. This serial EEPROM has a unique EUI-48, EUI-64, and 128-bit serial number. The unique number can be seen in the Microchip MPLAB Xplained window or Atmel Studio Xplained window after the kit has been plugged into the PC.

**Figure 5-6. SAM E70 Xplained Ultra Window**



**Note:** The above figure provides an example of the Xplained window with the MAC48 address.

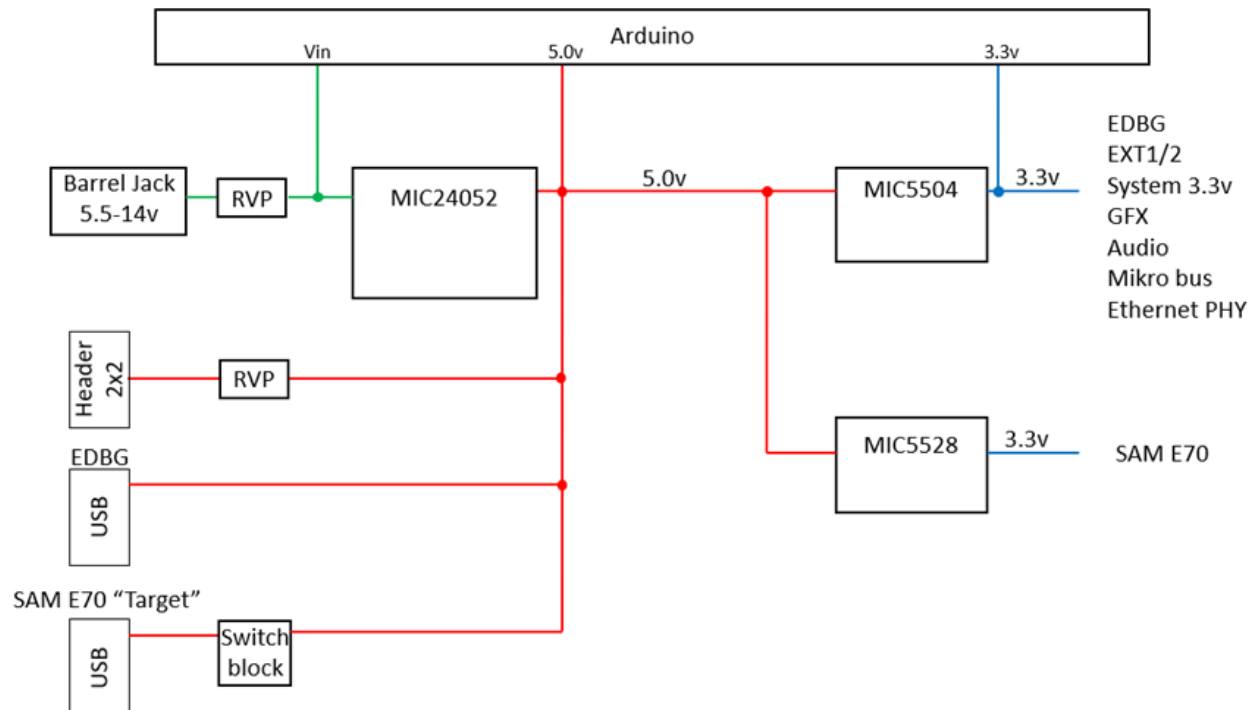
Users can change the device address using the solder pads on the board, but all address bits have been defaulted to one, refer to schematics for additional information. For additional usage information of on this part, refer to “AT24MAC402 and AT24MAC602 data sheet”, which is available for download from the

following location: <http://ww1.microchip.com/downloads/en/DeviceDoc/Atmel-8807-SEEPROM-AT24MAC402-602-Datasheet.pdf>.

## 5.14 Power Sources

The SAM E70 Xplained Ultra evaluation kit has several power systems to it. This section covers the power sub system in detail. Figure below shows a high-level block diagram of the power system.

**Figure 5-7. Power Sources Block Diagram**



The following options can be used to power the development kit:

- Using the Micro-USB connector that is connected to the EDBG known as Debug USB.
- Using the Micro-USB connector which is known as Target USB.
- Using the Barrel Jack. This input can take a large range of power inputs from 5.5V to 19V.
- Using the Arduino headers. This has several options one must be careful of when using this method. Not all power rails are protected from the user error.  $V_{IN}$  connects to the input side of the main buck supply (step down), and it is similar to the barrel jack (2.1 mm).
- Using the 2 x 2 x 0.1 header, located on the side of the board, which has a 3.3v and 5.0v capable inputs.

The SAM E70 Xplained Ultra kit can be powered by several power sources as described in the following table.

**Table 5-11. Power Sources for SAM E70 Xplained Ultra**

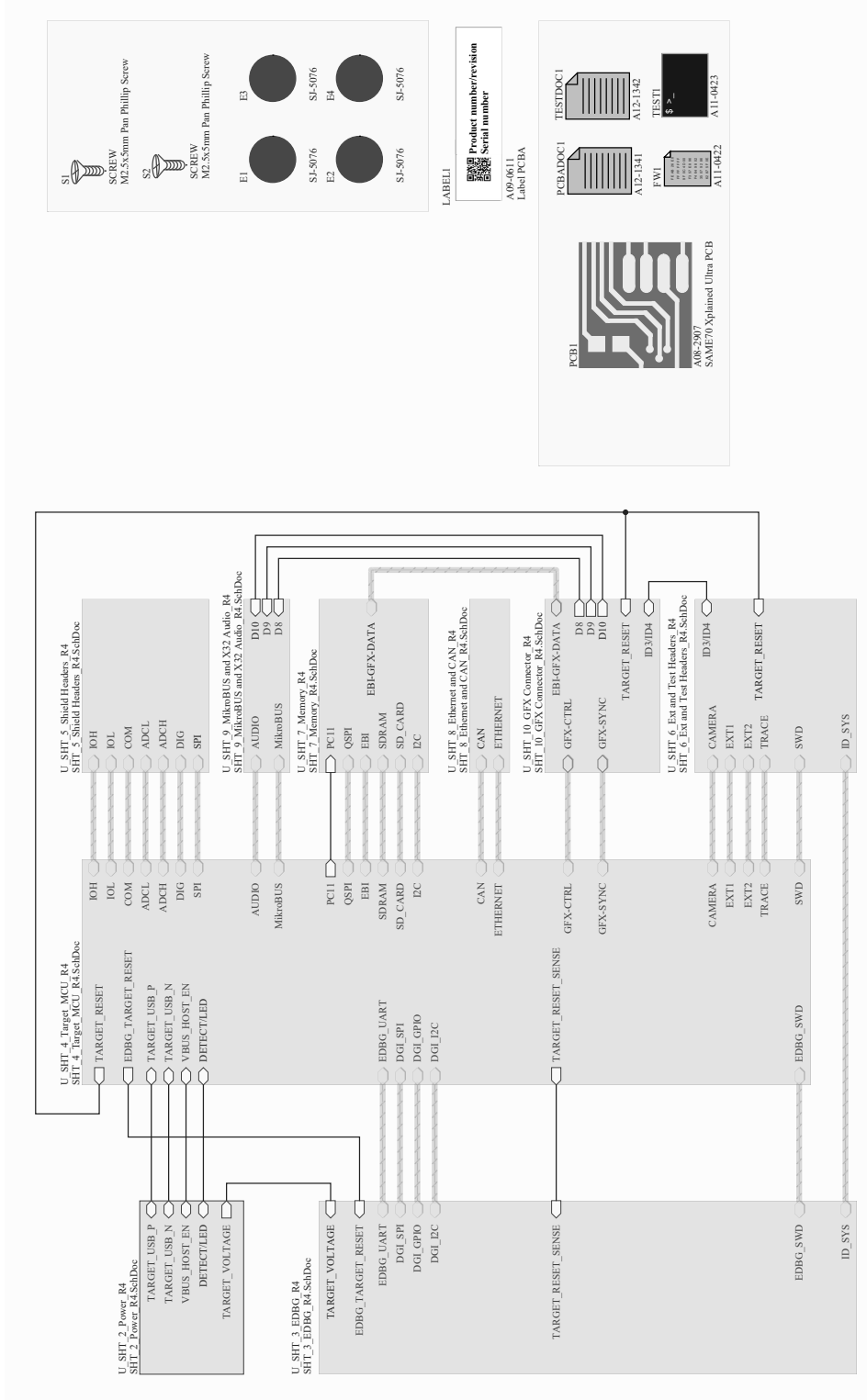
Power Input	Voltage Requirements	Current Requirements	Connector Marking
External Power	5V $\pm$ 2% ( $\pm$ 100 mV) for USB host operation. 4.3V to 5.5V if USB host operation is not required.	Recommended minimum current is 1A to be able to provide enough current for the connected USB devices and the board. Recommended maximum current is 2A due to the input protection maximum current specification.	5V0
Embedded Debugger USB	4.4V to 5.25V (according to USB spec.)	500 mA (according to USB spec.)	DEBUG USB
Target USB	4.4V to 5.25V (according to USB spec.)	500 mA (according to USB spec.)	TARGET USB
External Jack Input	5.5v to 19V	1A minimum, 2.5A is recommended. 6A maximum.	VIN

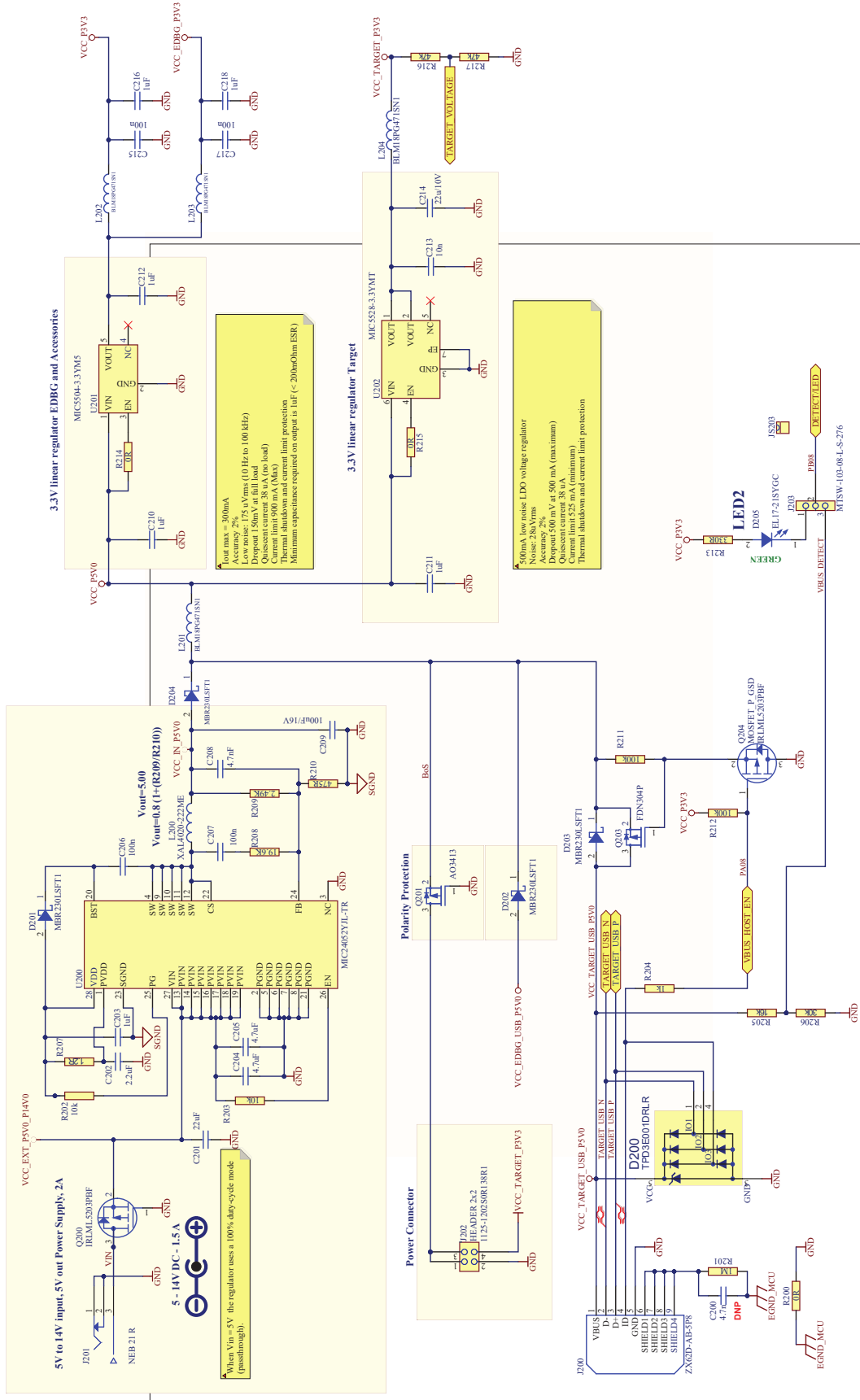
The development kit will detect and choose the available power sources based on the following options:

- External jack input
- External power
- Embedded debugger USB
- Target USB

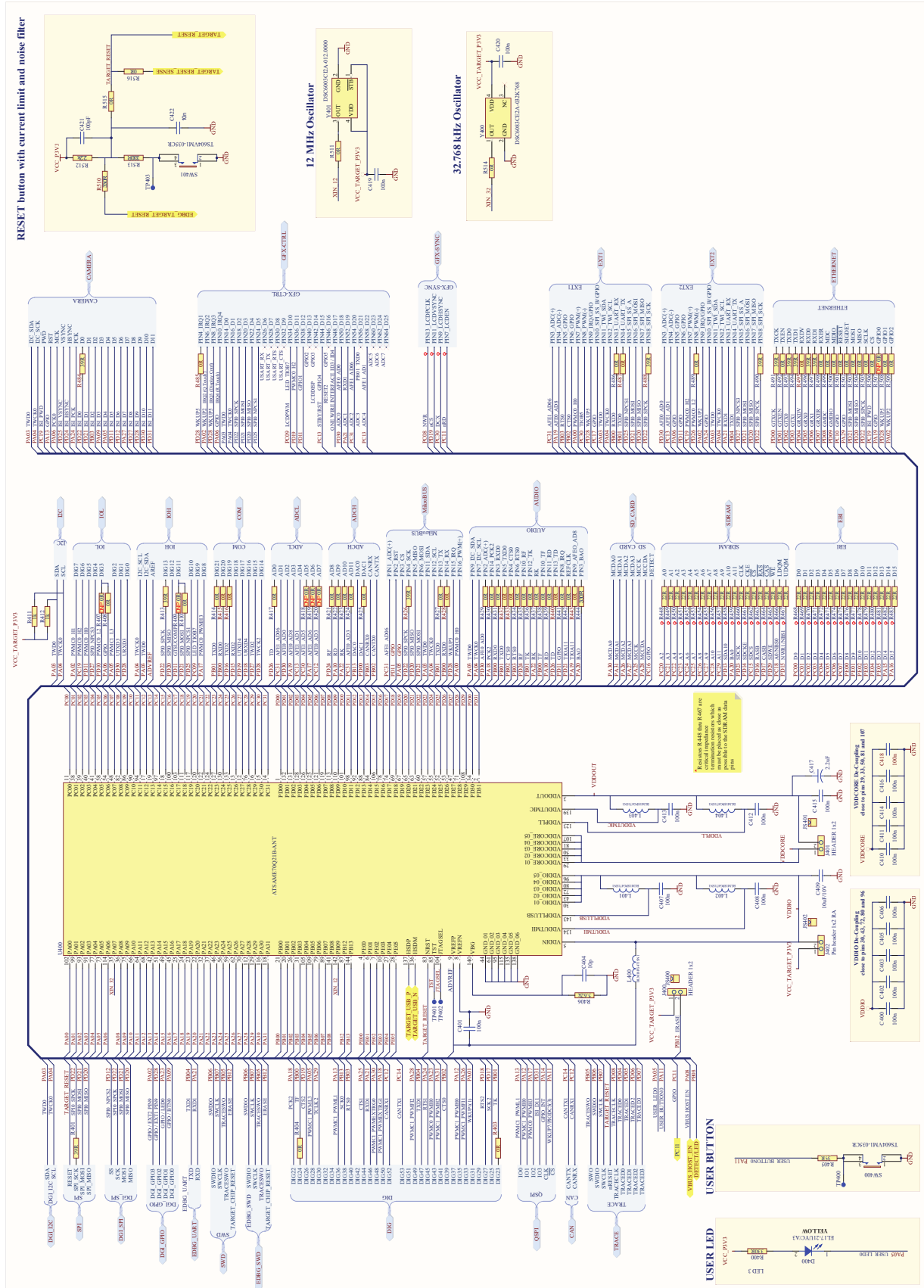
## 6. Hardware

### 6.1 SAM E70 Xplained Ultra Development Board Schematics

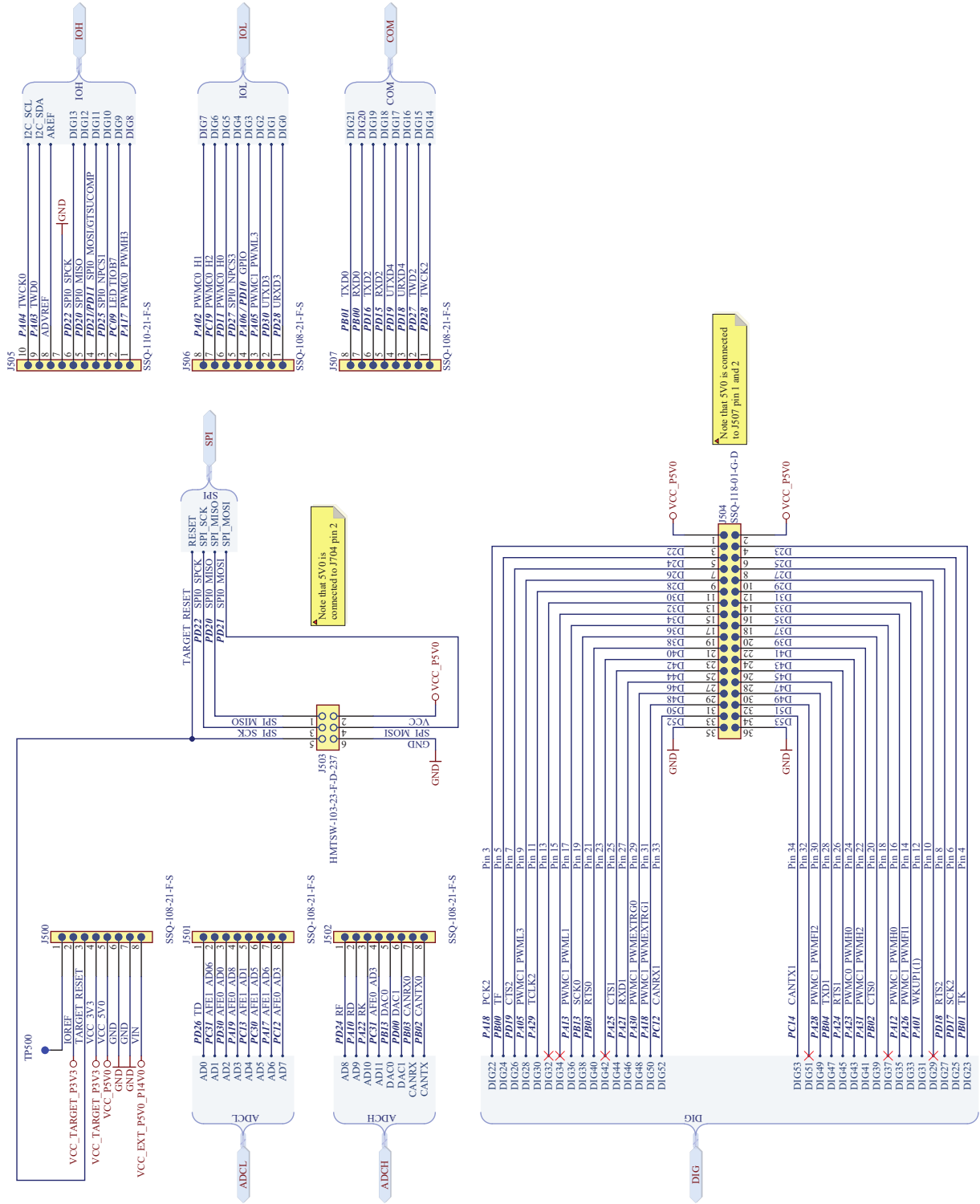






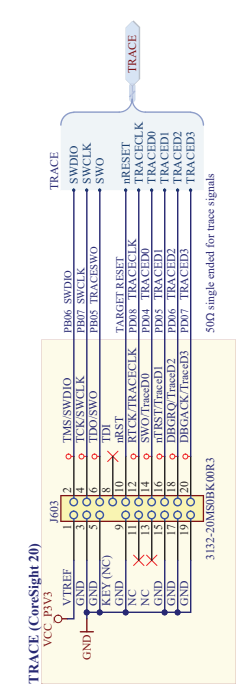
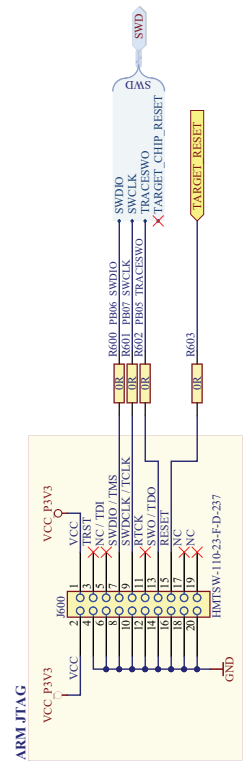
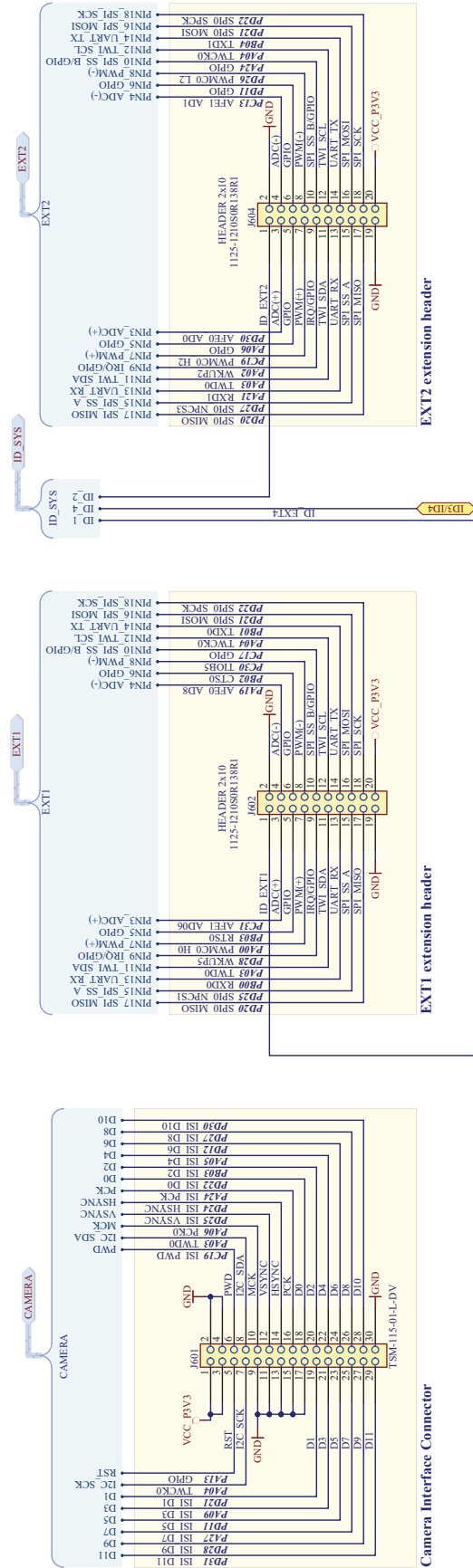


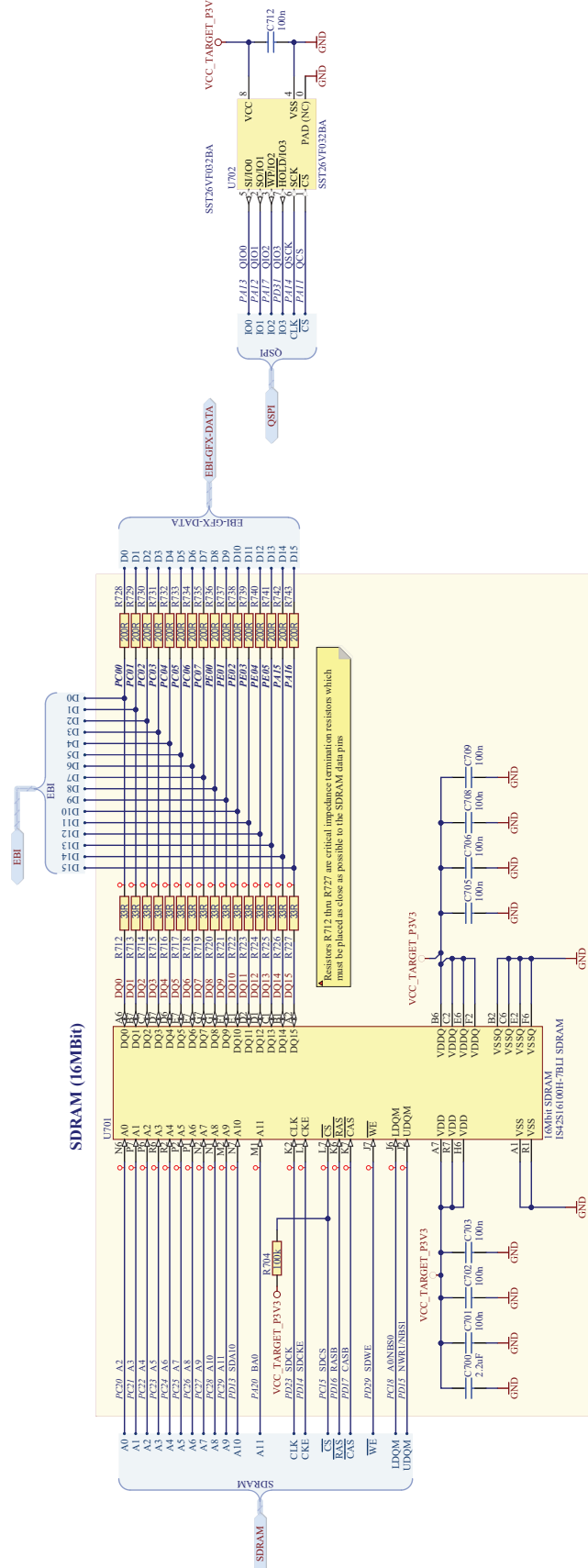
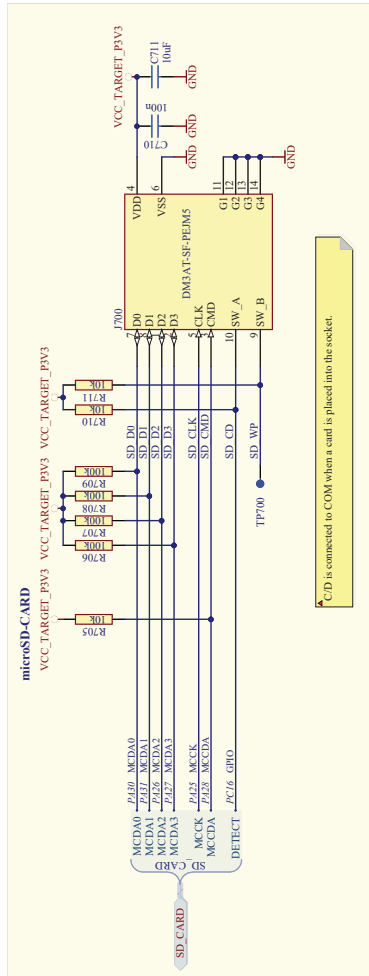
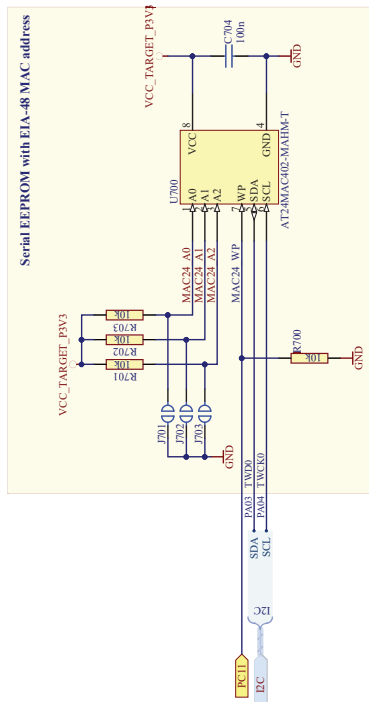


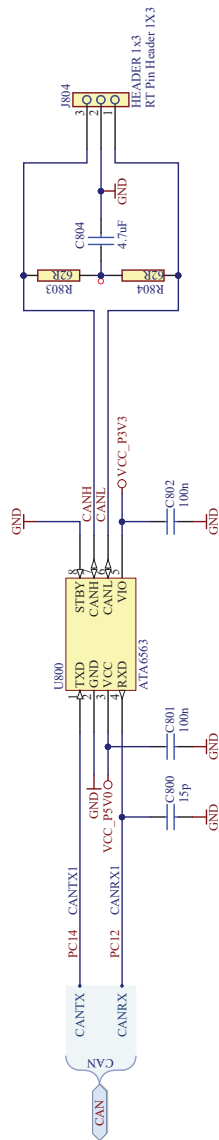
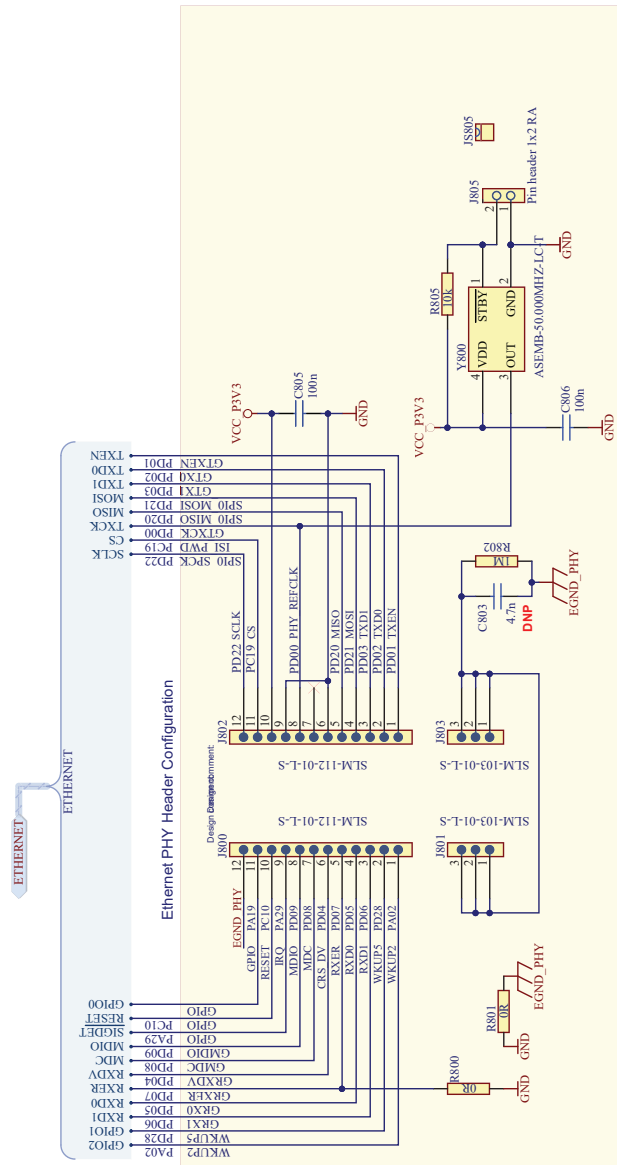


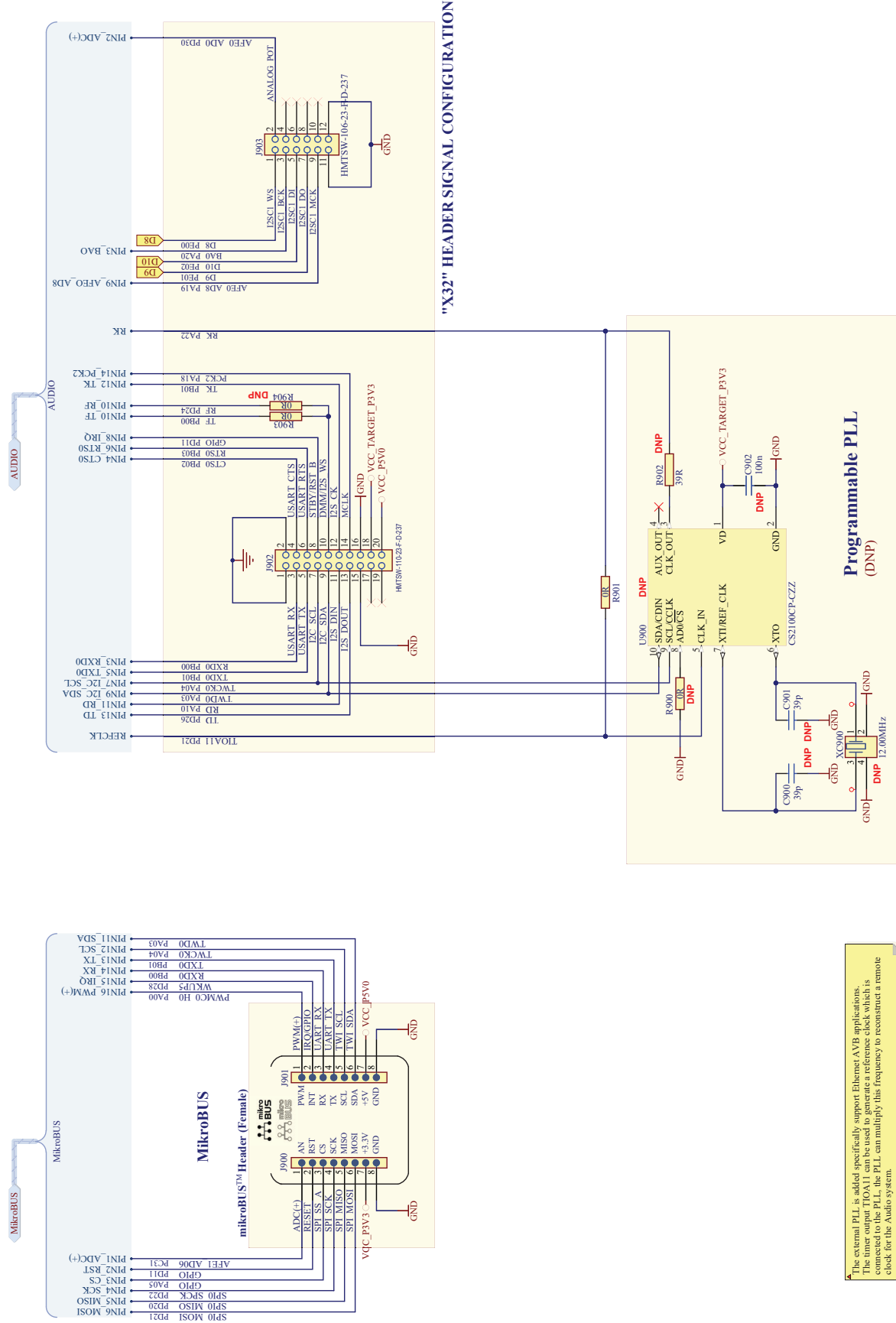
Note that 5V0 is connected to J507 pin 1 and 2

Note that 5V0 is connected to J104 pin 2

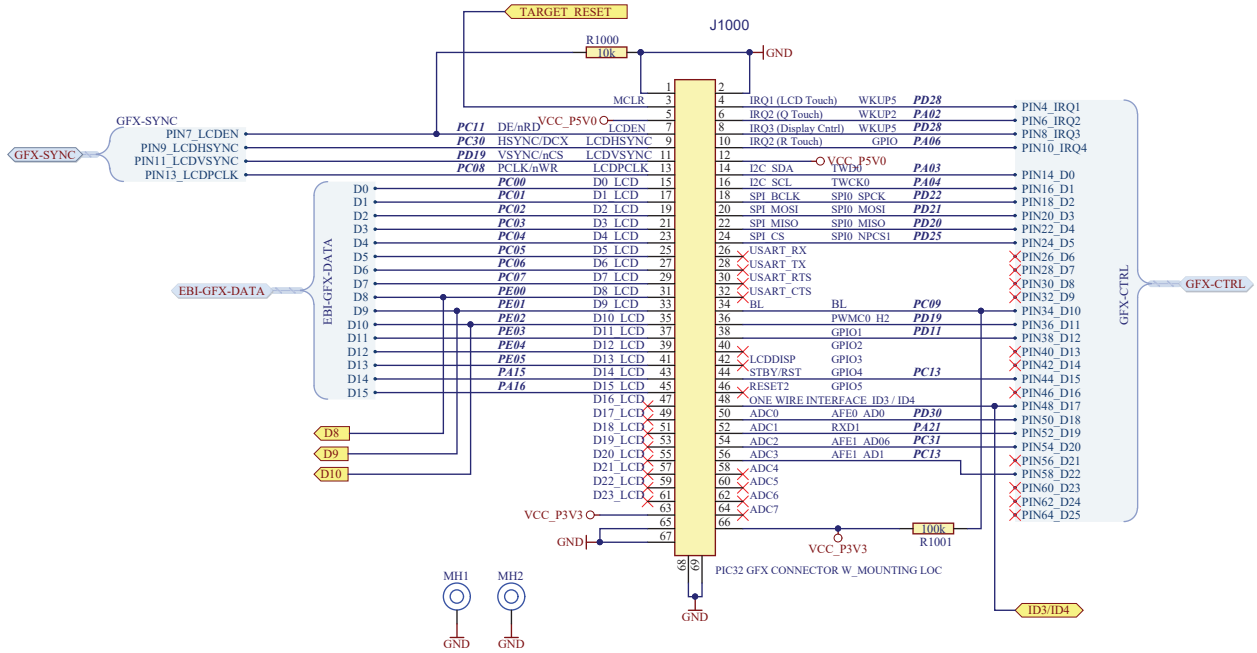


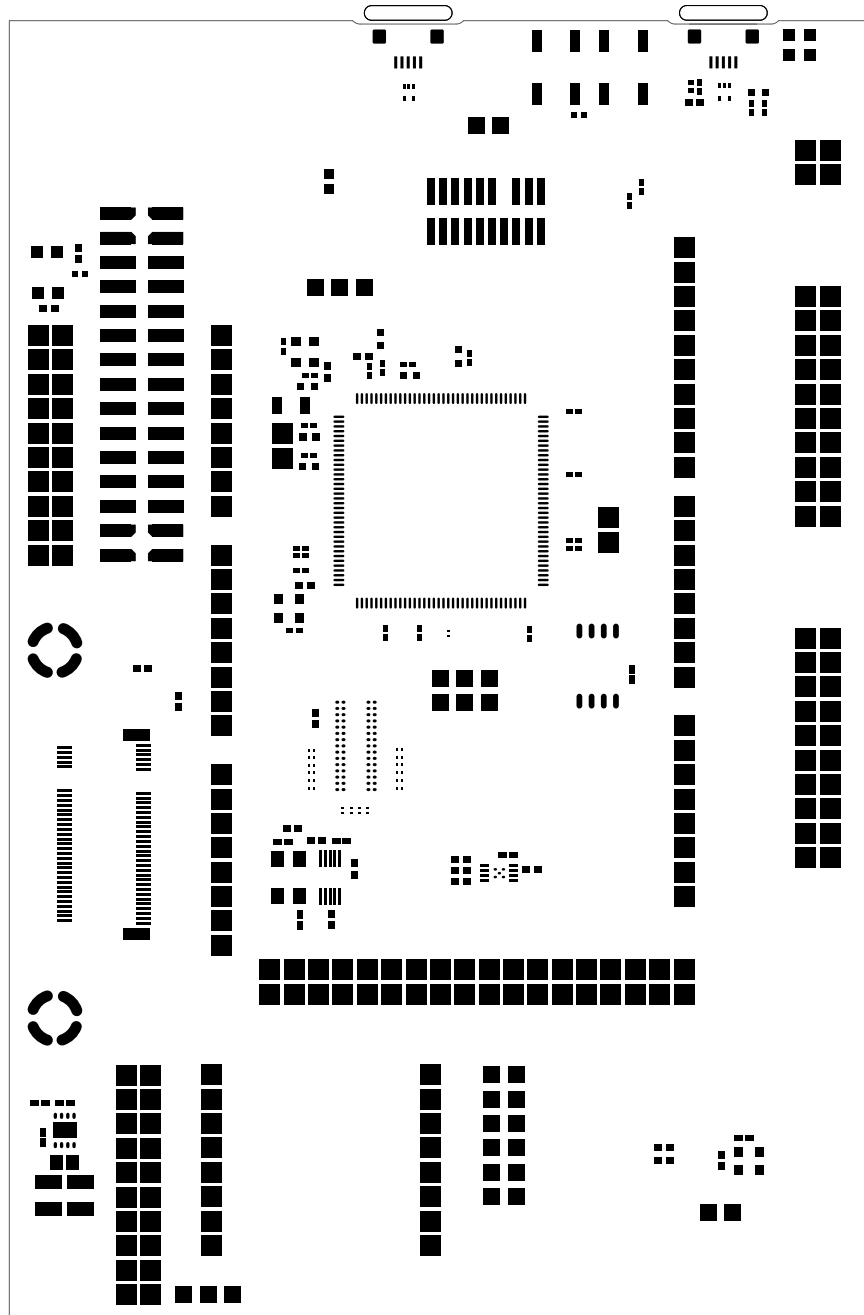


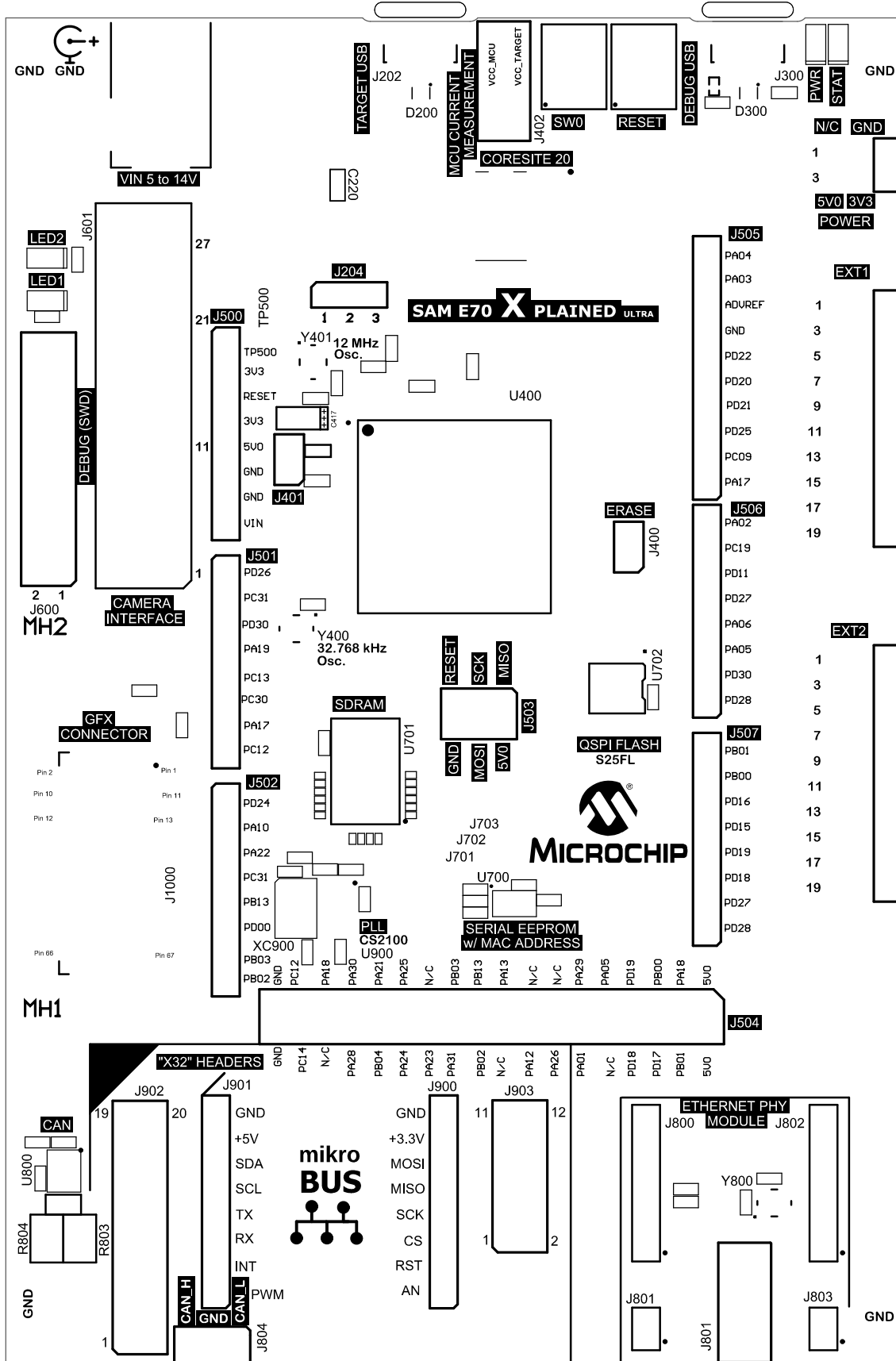




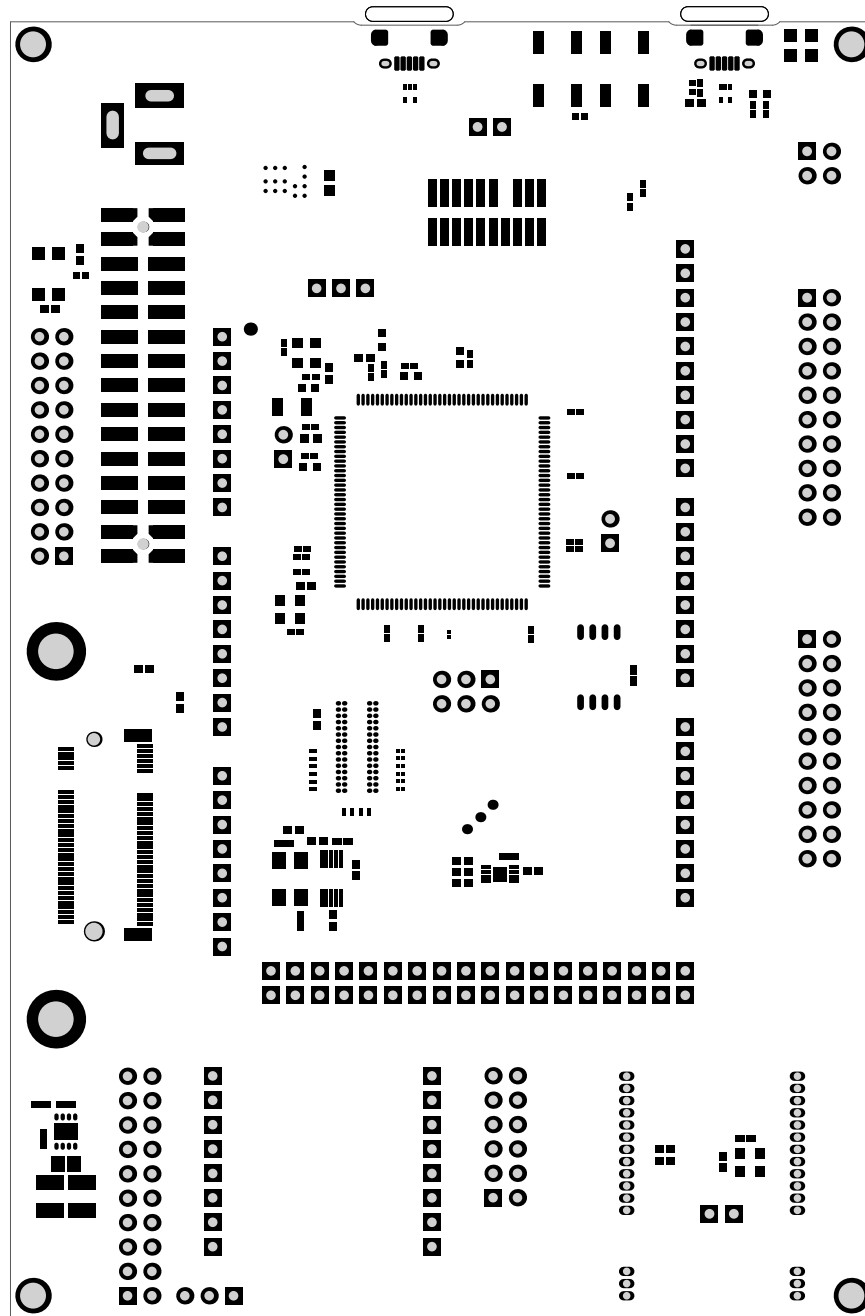
The external PLL is added specifically support Ethernet AVB applications. The timer output TIOA11 can be used to generate a reference clock which is connected to the PLL. The PLL can multiply this frequency to reconstruct a remote clock for the Audiosystem.

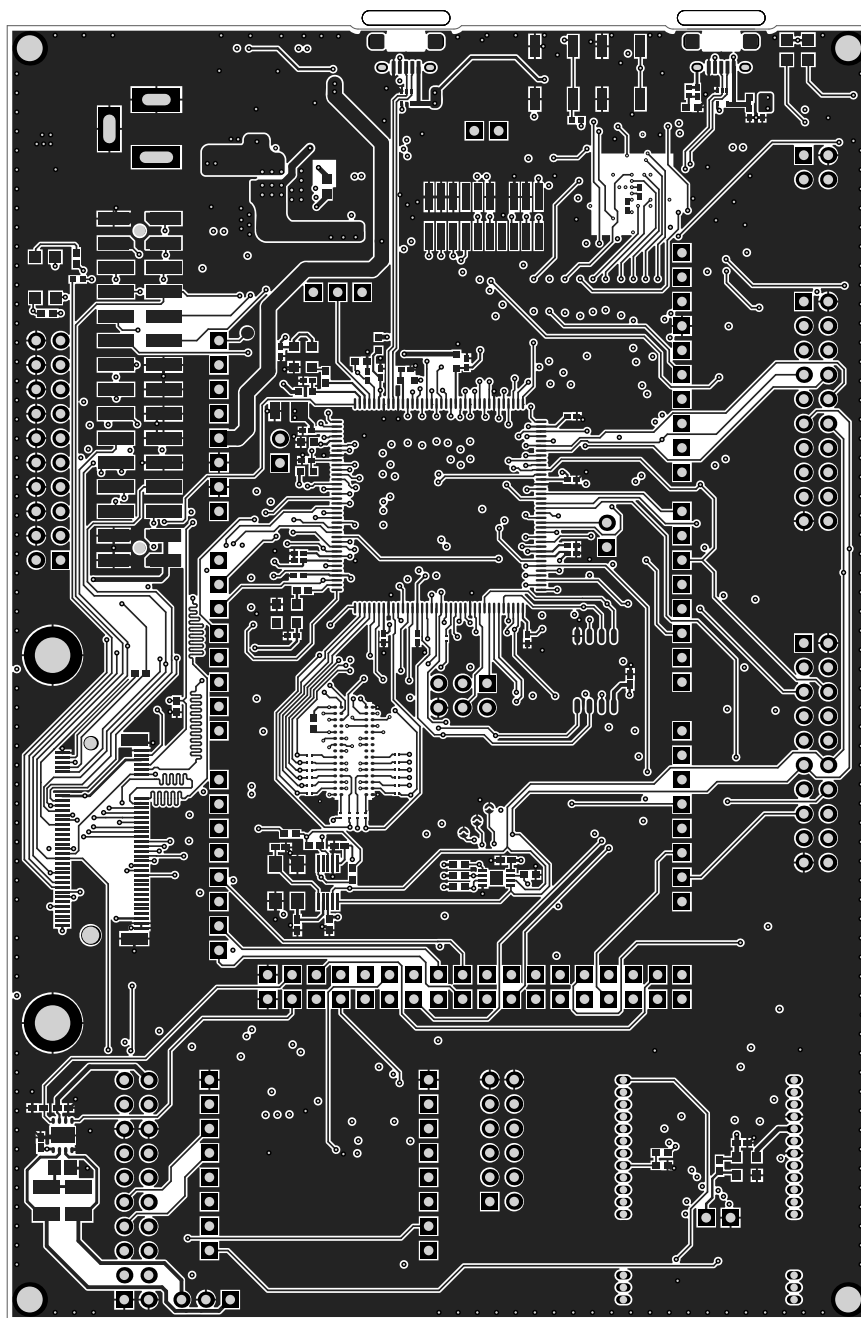


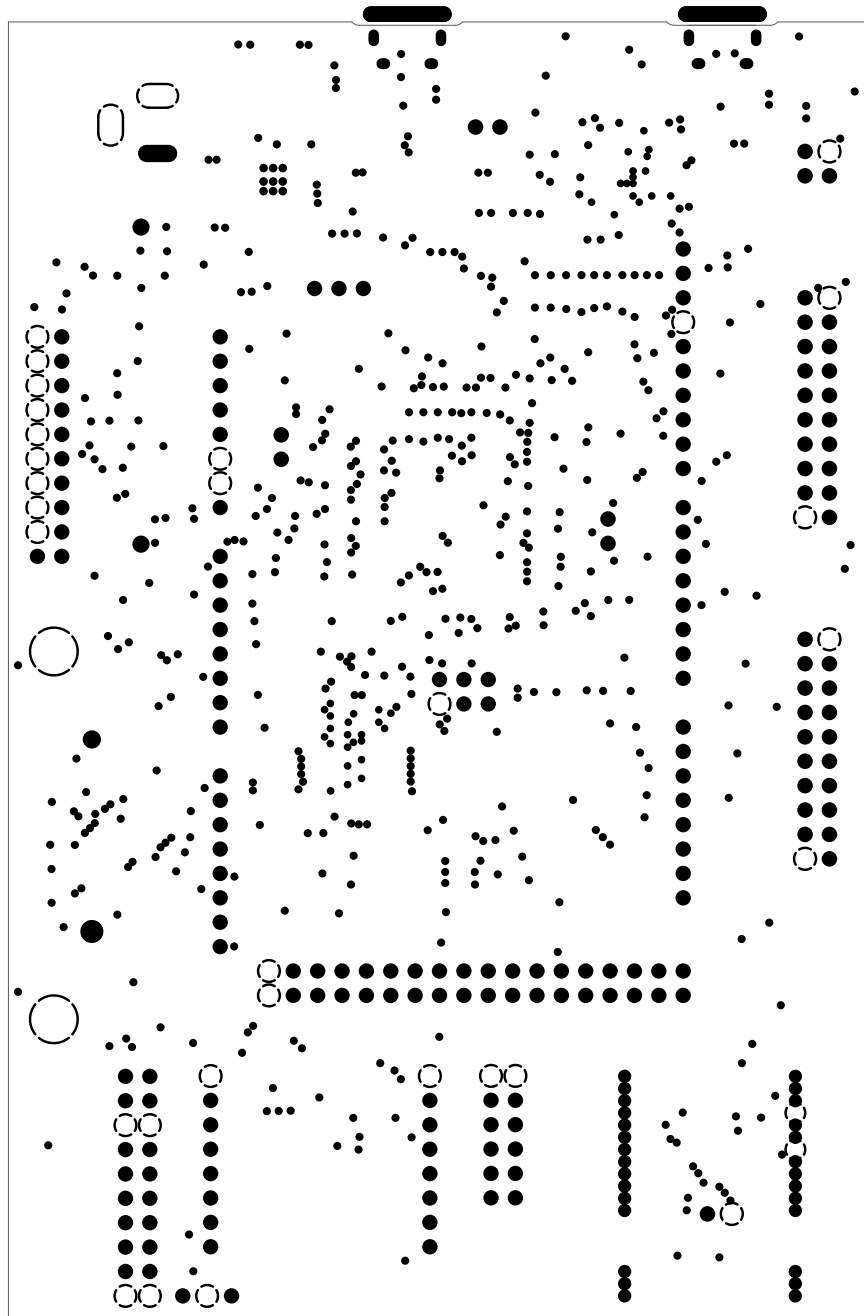


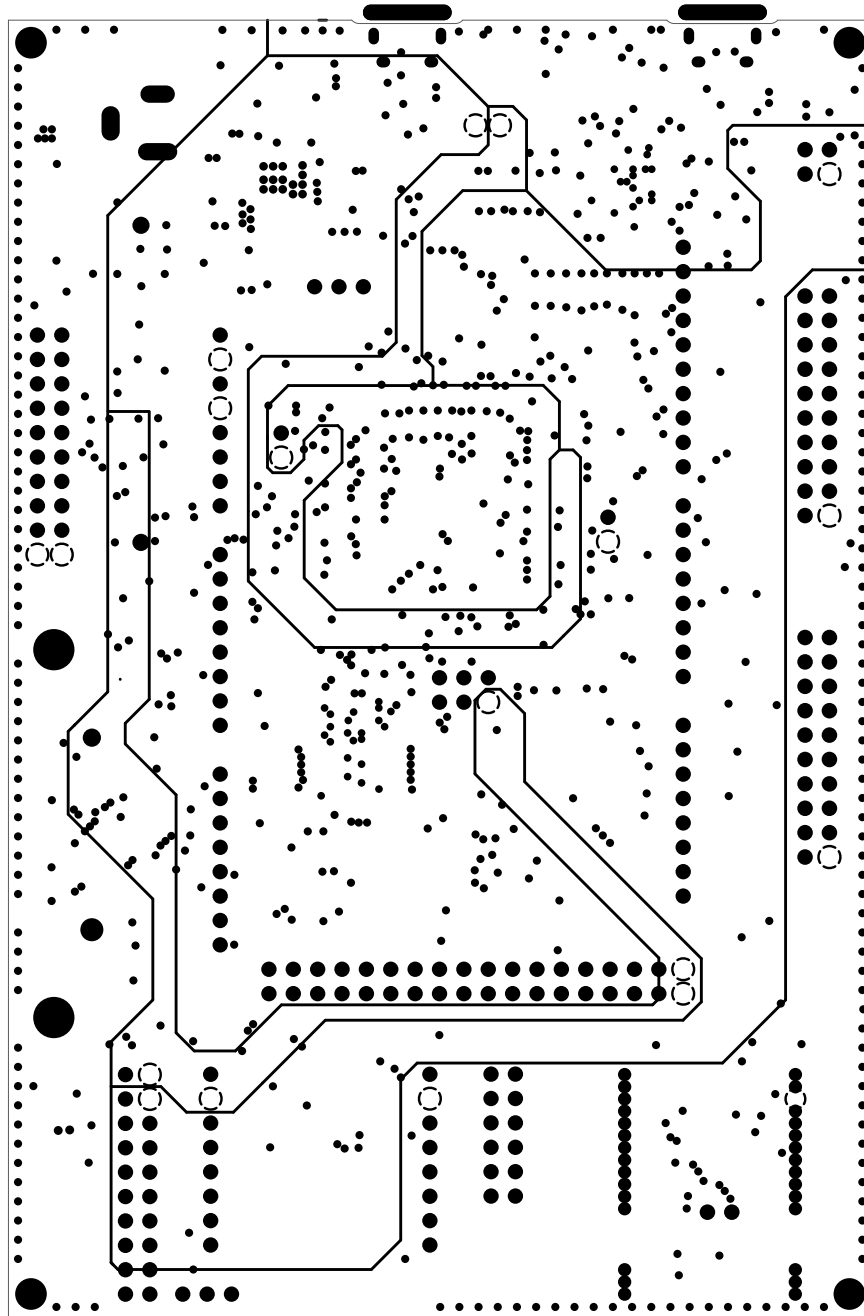


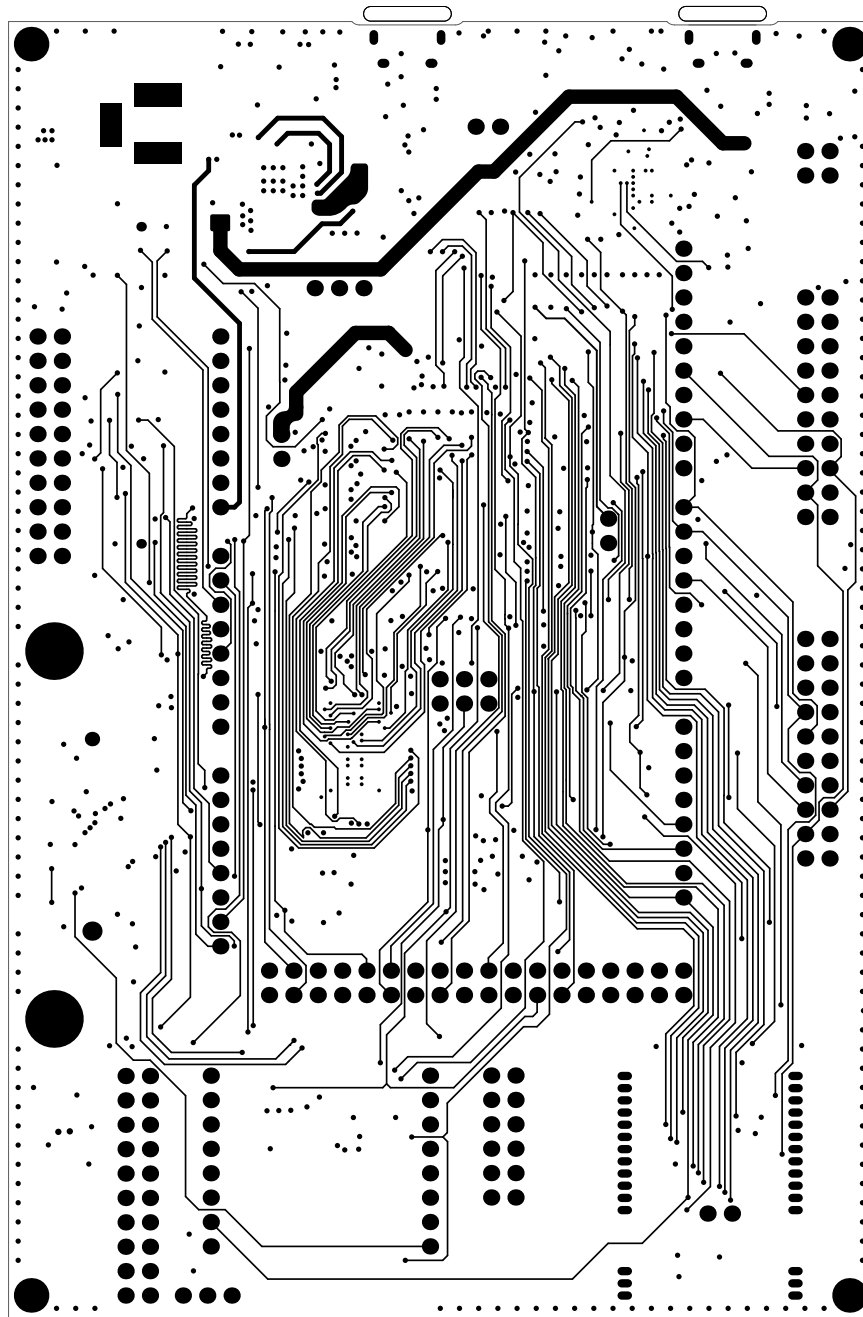


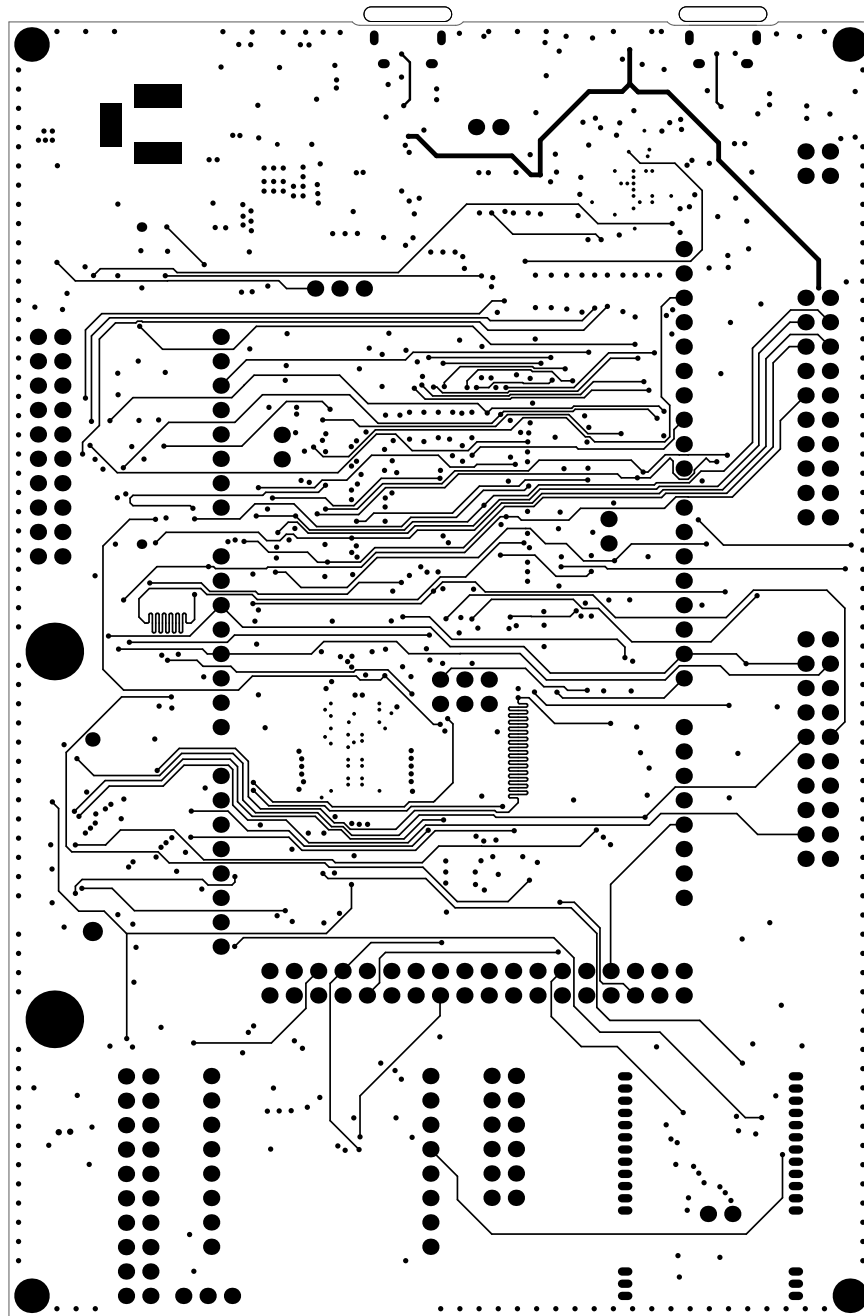


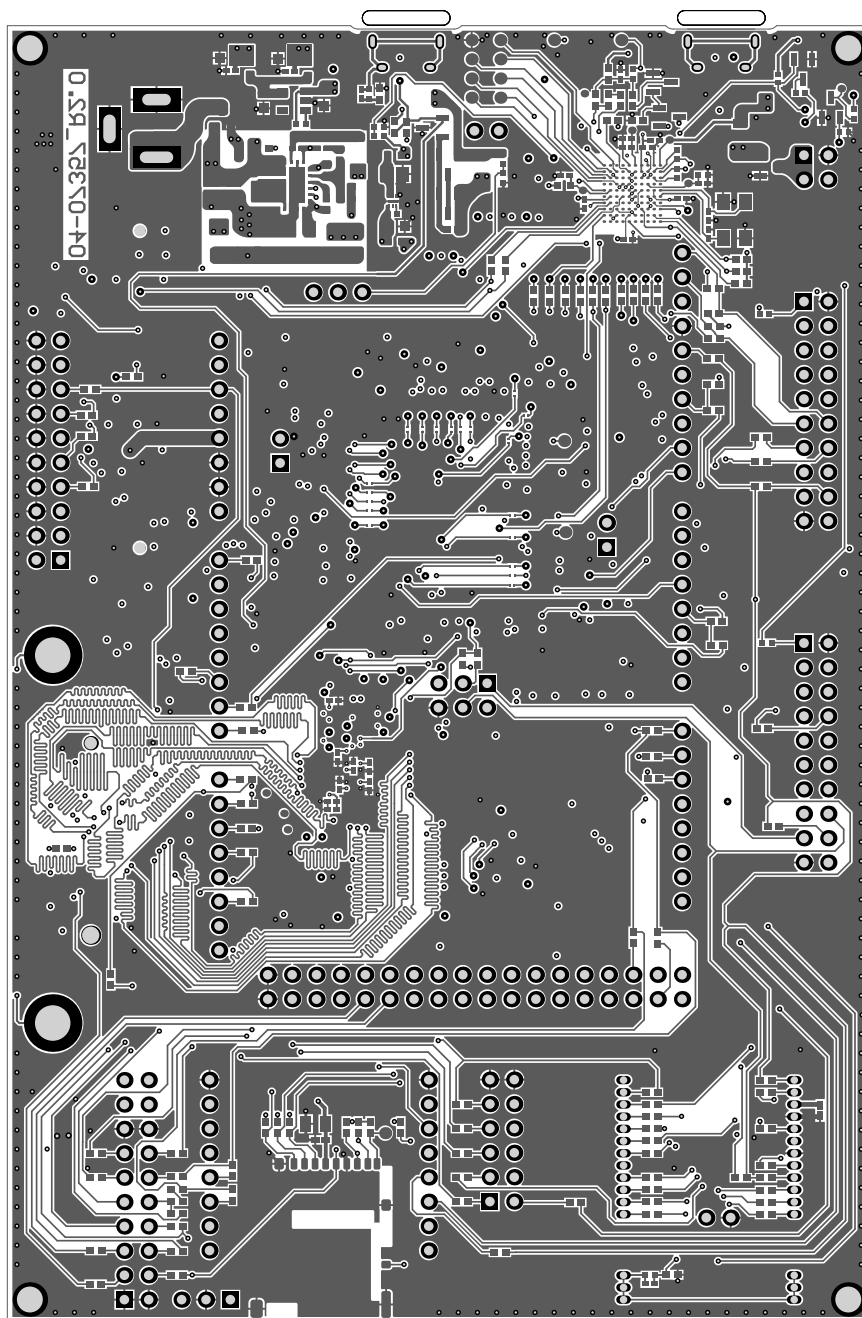


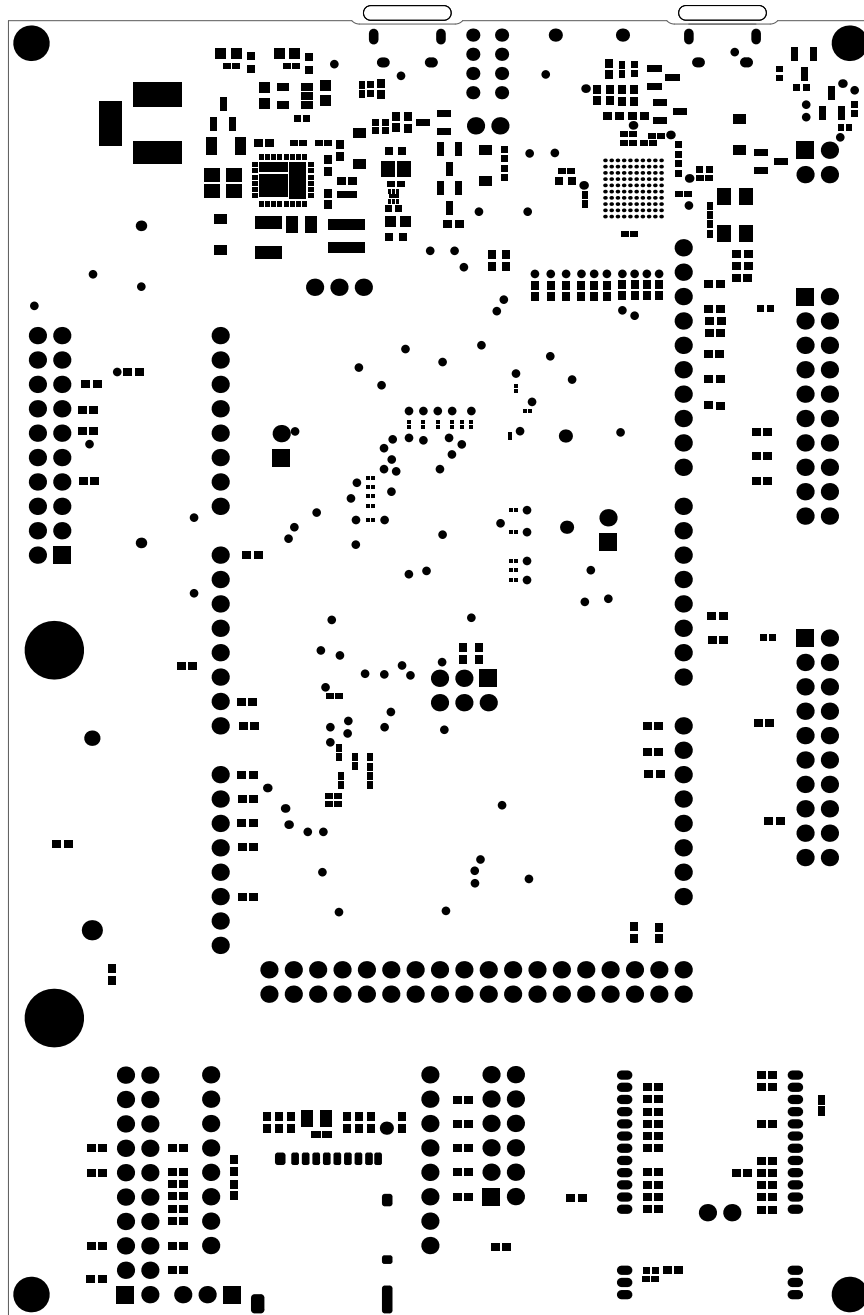






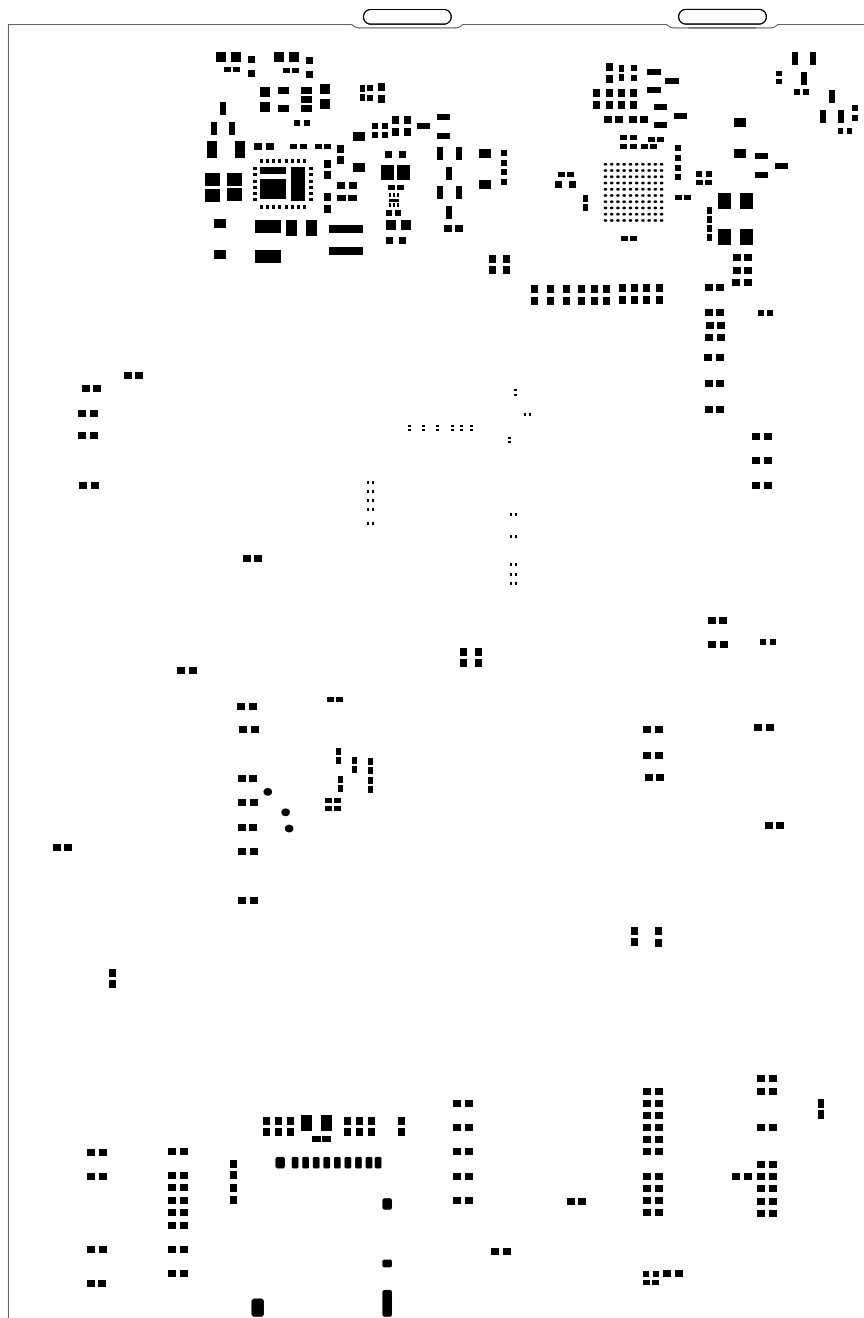












## 6.2 Bill of Materials

Qty	Designator	Description
1	C200	Ceramic capacitor, 22 uF, SMD 1206, X5R, 25V, 10%
1	C201	Ceramic capacitor, 2.2 uF, SMD 0805, X5R, 25V, 10%, (de20024)
3	C202, C203, C804	Ceramic capacitor, 4.7 uF, SMD 0805, X5R, 25V, $\pm 10\%$
6	C204, C206, C207, C212, C213, C220	Ceramic capacitor 1 UF 16V 10% X5R 0603
1	C205	Ceramic capacitor, 100 uF, SMD 1210, X5R, 16V, 20%
1	C208	Ceramic capacitor, 10 nF, SMD 0402, X7R, 25V, +/-10%
1	C209	Ceramic capacitor, 22 uF, SMD 0805, X5R, 10V, $\hat{A}\pm 20\%$
4	C214, C219, C300, C803	Ceramic capacitor, 4.7 uF, SMD 0402, X7R, 25V
3	C301, C302, C307	Ceramic capacitor, 1 nF, SMD 0402, C0G, 50V, +/-5%
2	C303, C404	Ceramic capacitor, 10 pF, SMD 0402, NP0, 50V, +/-5%
2	C304, C309	Ceramic capacitor, 22 pF, SMD 0402, NP0, 50V, +/-5%
5	C306, C308, C314, C315, C700	Ceramic capacitor, 2.2 uF, SMD 0402, X5R, 6.3V, +/-20%
42	C210, C211, C215, C217, C218, C305, C310, C311, C312, C313, C400, C401, C402, C403, C405, C406, C407, C408, C410, C411, C412, C413, C414, C415, C416, C418, C419, C420, C701, C702, C703, C704, C705, C706, C707, C708, C709, C711, C801, C802, C805, C806	Ceramic capacitor, 100 nF, SMD 0402, X7R, 16V, +/-10%
1	C409	Ceramic capacitor, 10 uF, SMD 0603, X5R, 10V, $\pm 20\%$
1	C417	Capacitor Tantalum 10V 2.2 uF 10% ESR = 6 ohm, 1206
1	C710	Ceramic capacitor, 10 uF, SMD 0805, X5R, 10V, 10%, (de19441)
1	C800	Ceramic capacitor, 15 pF, SMD 0402, NP0, 50V, +/-5%
2	D200, D300	TVS Diode Low-Capacitor 3-CH ESD-Protection for HS Data Interfaces SOT553
4	D201, D202, D203, D204	2A, 30V, Vf = 0.43V, Schottky diode, SOD-123 FL
2	D205, D301	LED, Green, Wave length = 575nm, SMD 0805, $\pm 70^\circ$
2	D302, D400	LED, Yellow, Wave length = 591nm, SMD 0805, $\pm 70^\circ$

.....continued		
Qty	Designator	Description
1	J200	Through-hole DC jack 2.1 mm, 12V, 3A
1	J201	Pin header, 2 x 2, Right Angle, 2.54 mm, THT, Pin-in-Paste
1	J202	CONN RCPT USB MICRO AB SMD
1	J300	mikroBUS™ USB 2.0 Receptacle Connector 5 Position Surface Mount, Right Angle; through- hole
1	J204	1 x 3 pin header, 2.54 mm pitch, THM
2	J400, J401	1 x 2 pin header, 2.54 mm pitch, Pin-in-Paste THM
2	J402, J805	1 x 2 pin header, right angle, 2.54 mm pitch, through-hole
7	J500, J501, J502, J506, J507, J900, J901	1 x 8 receptacle pin header, low- insertion force, 2.54 mm pitch THM, Pin-in-Paste
1	J503	2 x 3 pin header, 2.54 mm pitch, Pin-in-Paste THM
1	J504	2 x18 female pin header, 2.54 mm pitch, THM
1	J505	1 x 10 receptacle pin header, low insertion force, 2.54 mm pitch THM, Pin-in-Paste
2	J600, J902	2 x 10 pin header, 2.54 mm pitch, Pin-in-Paste THM, 1 mm hole
1	J601	Samtec TSM series, 2 x 15 pin header, straight, 2.54 mm pitch SMD
2	J602, J604	Pin header, 2 x 10, Right Angle, 2.54 mm, THM, Pin-in-Paste
1	J603	50-mil header, shrouded, pin 7 removed, SMD
1	J700	Micro SD Card Connector, (8 + 2) Position Push - Push, SMT, Right Angle Gold
2	J800, J802	1 x 12 - THM - Female Receptacle - 0.05 pitch
2	J801, J803	1 x 3 - THM - Female Receptacle - 0.05 pitch
1	J804	1 x 3 pin header, 2.54 mm pitch, Right angle THM, Pin-in-Paste
1	J903	2 x 6 pin header, 2.54 mm pitch, Pin-in-Paste, 1 mm hole
1	J1000	PIC32 GFX Connector W_MOUNTING LOC_2199230-3
5	JS204, JS400, JS401, JS402, JS805	Jumper cap for 2.54 mm pin header
11	L201, L202, L203, L204, L300, L301, L400, L401, L402, L403, L404	SMD RF inductor 0603. Z = 470 Ohm (@100 MHz), Max R(dc)=0.65 Ohm, Max current = 1A
1	L200	2.2 ÂµH Shielded Power Inductor, 4 x 4 x 2 mm, Isat = 5.6A , Irms = 4 .0A , DCR = 35.2 mÎ©
2	MH1, MH2	Round Standoff Threaded M2.5 x 0.45 Steel 0.098 (H2.50 mm)

.....continued		
Qty	Designator	Description
3	Q200, Q204, Q206	P-ch. MOSFET. -30V, -3.0A continuous, -24A Peak. RDS(ON) = 0.098 Ohm@VGS = -10V, RDS(ON) = 0.165 Ohm@VGS = -4.5V, -2.5V<VGS(th)<-1.0V
1	Q201	P-CH MOSFET, SOT-23, 20V, 3A, Rds(on) = 0.097 mOhm@3A, 4.5V
2	Q202, Q203	P-Channel Power MOSFET 20V 2.4A continuous 10A peak
1	Q205	N-channel MOSFET, SOT23, 20V, 4.2A
2	Q300, Q301	N-Channel MOSFET. 60V, 0.300A continuous, 1.2A Peak. RDS(ON) = 3.8 Ohm@VGS = 4.5V, VGS(th) < 2.5V
11	R200, R201, R700, R701, R702, R703, R705, R710, R711, R805, R1000	Thick film resistor, SMD 0402, 1/16W, 1%
1	R202	RES 19.6 kOhm 1% 1/16W 0402
1	R203	RES SMD 2.49 kOhm 1% 1/16W 0402
76	R204, R207, R208, R220, R221, R301, R302, R303, R304, R305, R311, R312, R319, R325, R327, R403, R404, R408, R410, R414, R415, R416, R417, R421, R422, R423, R424, R425, R427, R428, R429, R430, R431, R432, R433, R434, R435, R436, R437, R438, R439, R440, R441, R442, R443, R444, R445, R446, R447, R485, R486, R487, R489, R492, R495, R498, R499, R500, R501, R502, R503, R504, R505, R506, R508, R509, R511, R514, R600, R601, R602, R603, R800, R801, R901, R903	RES 0.0 Ohm 1/16W 0402 SMD
5	R205, R300, R328, R330, R802	Thick film resistor, 1M, SMD 0402, 1/16W, 1%
6	R206, R313, R314, R315, R411, R412	Thick film resistor, 1K, SMD 0402, 1/16W, 1%
3	R209, R210, R215	Thick film resistor, 47K, SMD 0402, 1/16W, 1%

.....continued		
Qty	Designator	Description
10	R211, R212, R216, R218, R704, R706, R707, R708, R709, R1001	Thick film resistor, 100K, SMD 0402, 1/16W, 1%
15	R213, R217, R306, R307, R308, R309, R310, R320, R321, R322, R323, R324, R329, R331, R400	Thick film resistor, 330R, SMD 0402, 1/16W, 1%
1	R214	Thick film resistor, 30K, SMD 0402, 1/16W, 1%
16	R219, R316, R317, R326, R401, R405, R413, R426, R484, R488, R490, R491, R493, R494, R496, R497	Thick film resistor, 39R, SMD 0402, 1/16W, 1%
1	R222	RES SMD 475 Ohm 1% 1/16W 0402
1	R318	Thick film resistor, 6.81K, SMD 0402, 1/16W, 1%
1	R406	Thick film resistor, 5.62K, SMD 0402, 1/16W, 1%
36	R448, R449, R450, R451, R452, R453, R454, R455, R456, R457, R458, R459, R460, R461, R462, R463, R464, R465, R466, R467, R468, R469, R470, R471, R472, R473, R474, R475, R476, R477, R478, R479, R480, R481, R482, R483	RES 22 Ohm 1/20W 5% 0201 SMD
2	R803, R804	Thick film resistor, 62R, SMD 1210, 0.5W, 1%
1	U200	Microchip Buck Regulator 12V 6A MIC24052 QFN-28
1	U201	LDO 3.3V 0.3A SOT-23-5
1	U202	LDO 3.3V 0.5A 6TDFN
1	U300	EDBG controller
1	U400	ARM <sup>®</sup> Cortex <sup>®</sup> -M7 microcontroller, LQFP144
1	U700	2 Kbit I <sup>2</sup> C EEPROM, single EUI-48 MAC, 1.7-5.5V, 2 x 3 mm UDFN (8MA2)
1	U701	16 Mbit SDRAM (512K Words x 16 Bits x 2 Banks), 143 MHz 3,3V
1	U702	FLASH 32MBIT_8SOIC (W5.3 mm) SST26VF032BAT-104I/SM
1	U800	High-speed CAN Transceiver with Standby mode CAN FD Ready
1	XC300	Fox FQ5032B 12.0000 MHz 20pF SMD crystal 738B-12, Fox FQ5032B 12.0 MHz SMD crystal 738B-12

.....continued

Qty	Designator	Description
1	Y400	Oscillator 32.768 KHz 1.71-3.3V DSC60xxL3.2xW2.5H0.9
1	Y401	Oscillator 12.000 MHz 1.71-3.3V DSC60xxL3.2xW2.5H0.9
1	Y800	Oscillator 50 MHz 1.71-3.3V DSC60xxL3.2xW2.5H0.9
2	SW201, SW400	SWITCH, SMD, 260 gf, 6.4 mm X 6.2 mm
4	E1, E2, E3, E4	2.8 mm adhesive feet, diam 8.0 mm
2	S1, S2	M2.5 x 5 mm Pan Phillip Screw

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- Microchip is willing to work with the customer who is concerned about the integrity of their code.



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