



AppBox C21 System User's Guide



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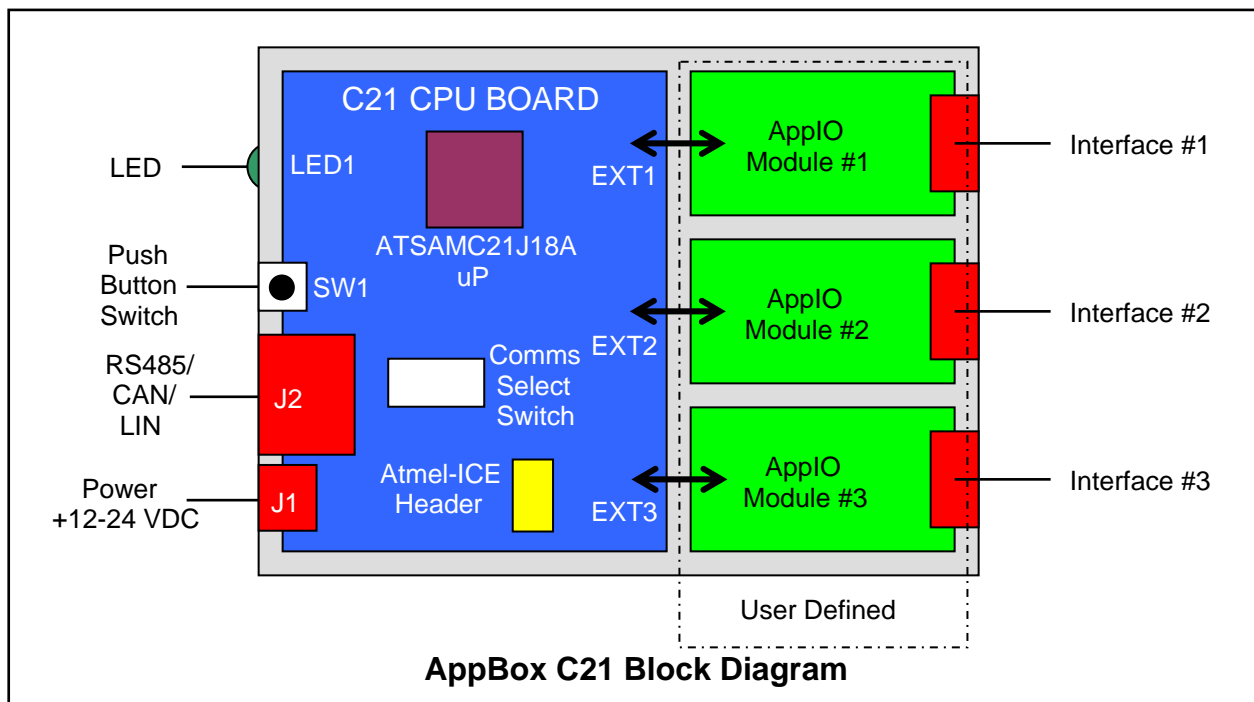
1.0 Introduction

This document describes the features of the AppBox C21. The AppBox C21 is designed to be used in an industrial environment with a CAN, RS-485, or LIN interface and provide flexible, modular I/O (AppIO) for specific applications. These AppIO Modules allow customized solutions to be integrated for a wide variety of applications that need to go into a CAN, RS-485, or LIN communications environment.

1.1 AppBox C21 Features

This AppBox C21 has the following features:

- Atmel ATSAMC21J18A processor (ARM Cortex-M0+), maximum frequency 48 MHz.
- Operates on +12 to +24 volts DC, uses less than 500 Ma. at +12
- CAN interface for industrial systems
- RS-485 communications for industrial systems
- LIN interface for automotive systems
- Communication interface expansion via Distribution Box (sold separately)
- Modular I/O expansion via up to three (3) AppIO Modules, Atmel X PLAINED compatible
- Fully enclosed system with knock out panels for AppIO Modules (sold separately)
- Convenient enclosure mounting holes
- Vented enclosure for cooling
- Front panel push button switch
- Front panel programmable LED
- Atmel-ICE debug header present for development
- Operates 0 - +70C



1.2 AppBox C21 Applications

The AppBox C21 can be used in the following applications:

- Low cost process/industrial control
- Automation
- Metering
- Motor control
- Systems operating in noisy environments
- Communications converter (CAN-RS485-LIN)
- Operates with industrial voltage levels
- Reconfigurable applications with AppIO Modules
- Entry level microcontroller educational tool

1.3 What's Included In the AppBox C21

The Spectrum Digital AppBox C21 product (Part/SKU #: 703909-0001) includes:

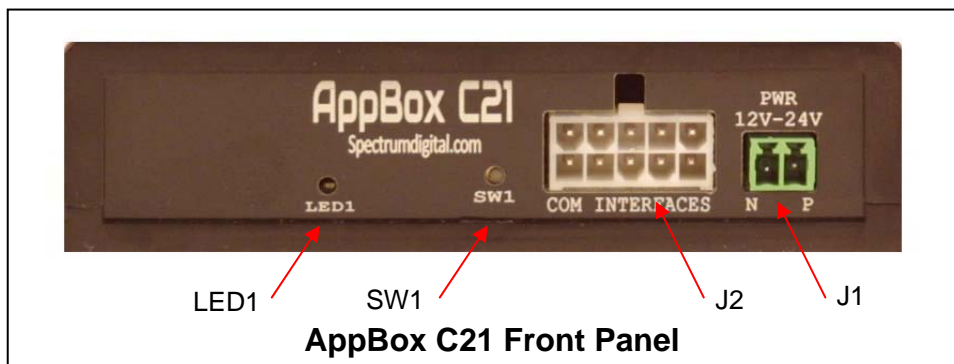
- AppBox C21 in anti-static bag
- Terminal block header for power input
- Product information card

NOTE: This product does not include any software or drivers. Development tools (Atmel-ICE and Software code generation suite) can be obtained from Microchip/Atmel at:

<https://www.microchip.com/development-tools/>.

1.4 AppBox C21 Front Panel

The features of the front panel on the AppBox C21 are shown in the figure below:



1.5 AppBox C21 Accessories

The following accessories for the AppBox C21 can be ordered from Spectrum Digital or authorized resellers:

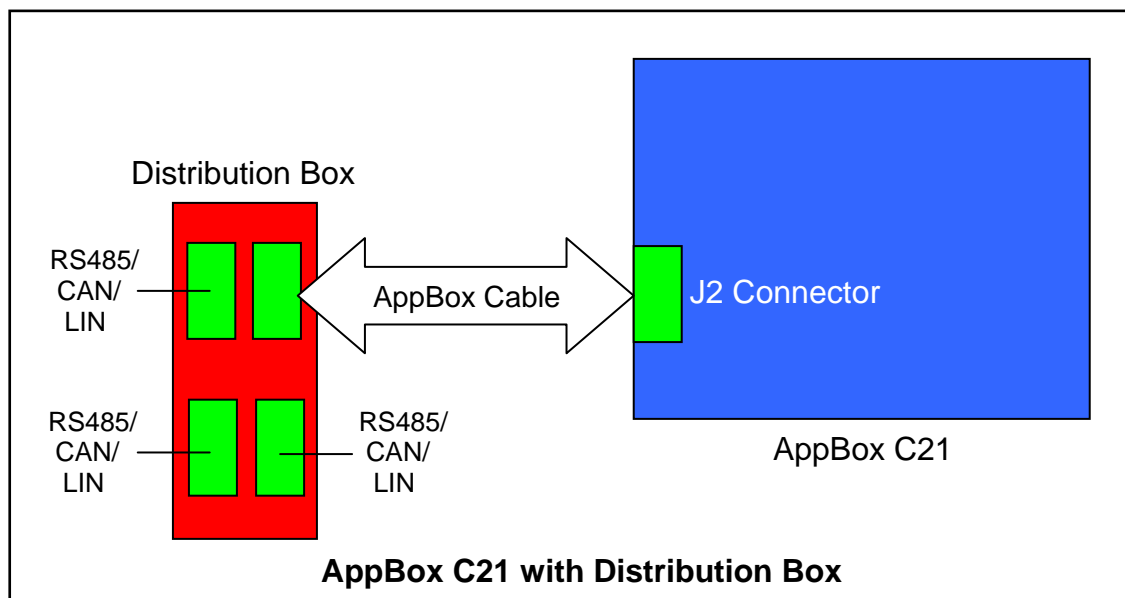
Accessory Description	Part/SKU Number
AppBox Power Supply with cable, 110/220 VAC to 12V, 1.5A	703925-0001
Distribution Box	703924-0001
AppBox cable	703923-0001
RS485 Cable	703917-0001
CAN Cable	703912-0001
LIN cable	703922-0001

1.6 AppBox C21 Communication Expansion

The J2 connector on the AppBox C21 presents multiple communication interfaces. The standard factory cables only support one interface at a time. To have access to multiple communication interfaces, a Distribution Box (Part/SKU #: 703924-0001) and AppBox cable (Part/SKU #:703923-0001) are required. The Distribution Box expands the J2 connector to four (4) images of the AppBox C21 J2 connector. The AppBox cable bridges **all** signals on the AppBox C21 J2 connector to a connector on the Distribution Box. Be **aware** that **one** (1) of the Distribution Box connectors will be used for the AppBox bridging cable leaving three (3) connectors available for communication interfaces. All AppBox interface cables that can be used on the AppBox J2 connector are also compatible with the Distribution Box.

The user should enable all interfaces they want to use with the Distribution Box by setting the switch positions on Switch SW2, positions 1, 2, or 3. See section 3.3.

The AppBox C21 and Distribution Box system configuration is shown in the figure below:



1.7 AppBox C21 Software Development Tools

The AppBox C21 is compatible with the software and hardware development tools from Microchip/Atmel. These tools are described on the Microchip/Atmel website:

<https://www.microchip.com/development-tools/>

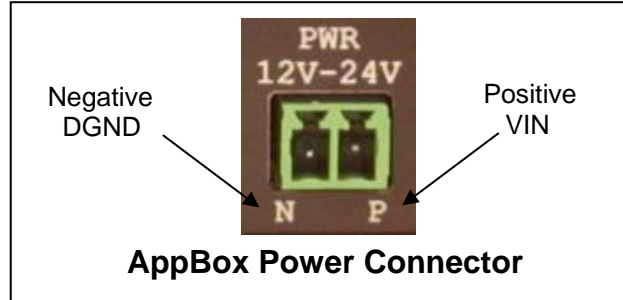
These tools include the following:

- Editor
- Compiler/assembler/linker
- Libraries
- Operating System
- Debugger
- JTAG Emulator

2.0 Installation

2.1 Attaching Power to the AppBox C21

Power can be provided to the AppBox C21 by two different means; the AppBox power supply with cable (Part/SKU #: 703925-0001), or wiring the 2 position terminal block header (included with AppBox C21) that plugs into the C21 CPU Board's power input connector. See the figure below.

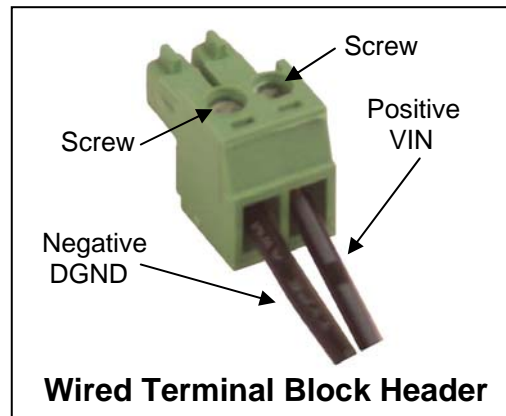


Listed below are the steps to install the terminal block header power connector (included in kit) into the AppBox C21.

1. Cut 2 pieces of wire (preferably 1 red for positive-VIN, 1 black for negative-DGND) to the desired length for your application. This wire should be 22 gauge or heavier
2. Strip $\frac{1}{4}$ inch (6-7 mm) of insulation from one end of each wire.
3. Position the terminal block header on a flat surface with the key stubs up and away from you. See the figure below.



4. Insert the negative/DGND wire (black) into the left wire hole and tighten the screw.
5. Insert the positive/VIN wire (red or black with stripe) into the right wire hole and tighten the screw.
6. The terminal header should look like the figure below.



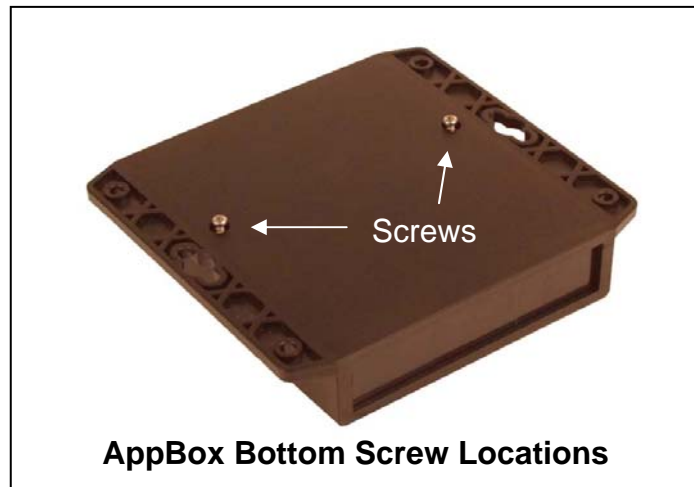
7. Pull/tug on the wires to insure they are secure in the terminal block.

8. Attach the loose end of the wires to a +12 – 24 VDC power source. Be sure of the polarity. This power source should supply at least 1 amp of current. This requirement will vary depending on the current requirements of the C21 CPU Board and the AppIO Modules.
9. Turn on the power source.
10. With a multi-meter or oscilloscope measure the voltage at the terminal block header to verify +12 -24 VDC is present. Place the meter/scope probes on the 2 screws to measure.
11. Turn off the power source
12. Insert the terminal block header into the power input of the AppBox C21.
13. Turn on the power source.

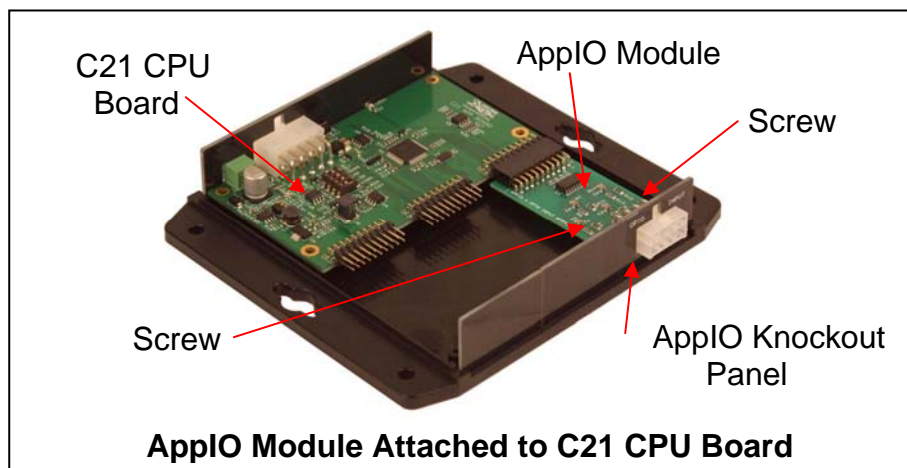
2.2 Installation of AppIO Modules

Listed below are the steps to install AppIO Modules in the AppBox C21:

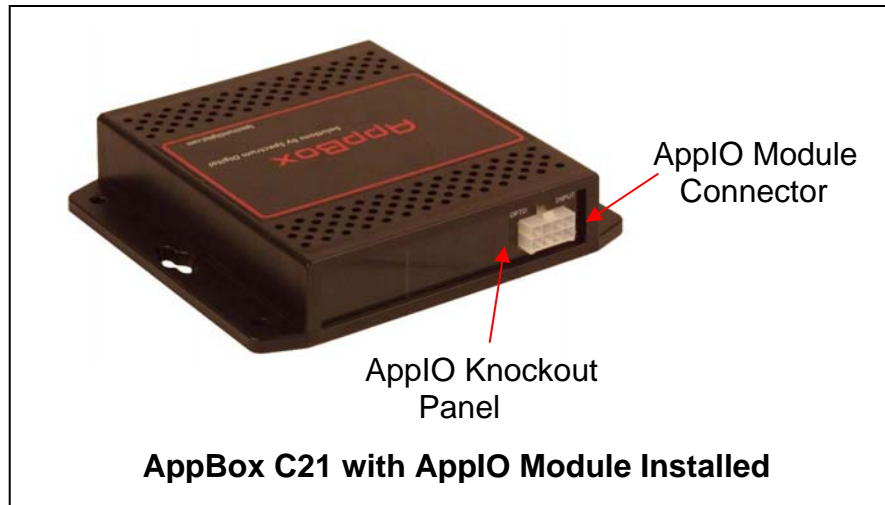
1. Remove **ALL** power to the AppBox enclosure
2. Remove all interface connections attached to the installed AppIO Modules
3. Remove the CAN/RS-485/LIN cables attached to the C21 processor board
4. Turn the AppBox over and remove the 2 screws from the bottom of the enclosure as shown below



5. Turn the AppBox back over (label showing) and lift the top off the enclosure being careful not to lose the knockout panels
6. If necessary remove one or more existing AppIO Modules and associated knockout panels by unscrewing the 2 screws
7. If the AppIO modules require configuration or jumper settings, do it now.
8. Plug the new AppIO Module(s) into EXT1, EXT2, or EXT3 on the C21 CPU Board



9. Insert the included knock out panel associated with this AppIO Module
10. Secure the AppIO Modules to the AppBox base with the 2 provided screws
11. Insert the blank knock out panels in any unused positions
12. Place the cover back over the C21 CPU Board and AppIO Modules. Make sure the cover closes tight on both sides
13. Turn the AppBox over and insert the 2 screws back in and tighten until snug, do not over tighten/strip the screws

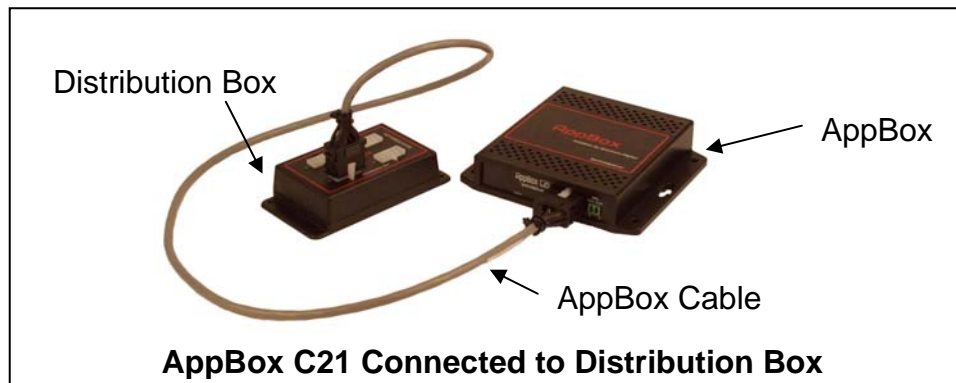


14. Re-attach the CAN/RS-485/LIN connections to the processor board
15. Re-attach all interface connections to the AppIO Modules
16. Apply power to the AppBox C21

2.3 Attachment of Distribution Box to the AppBox C21

Listed below are the steps to attach the Distribution Box (Part/SKU #: 703924-0001) to the AppBox C21:

1. Remove **ALL** power to the AppBox C21 enclosure
2. Remove any communication cables attached to the J2 connector on the AppBox C21
3. Plug one end of the AppBox cable (Part/SKU #: 703923-0001) into the J2 connector on the AppBox C21
4. Plug the other end of the AppBox cable into one of the connectors on the Distribution Box

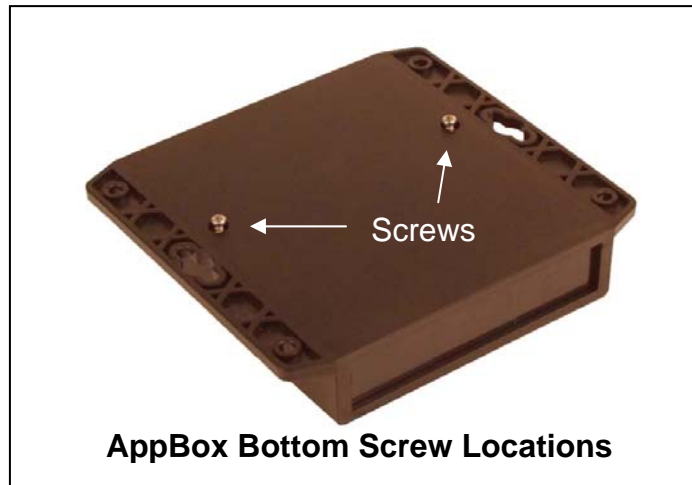


5. Plug the desired communication cables into the Distribution Box
6. Make all other connections before powering
7. Apply power to the AppBox C21

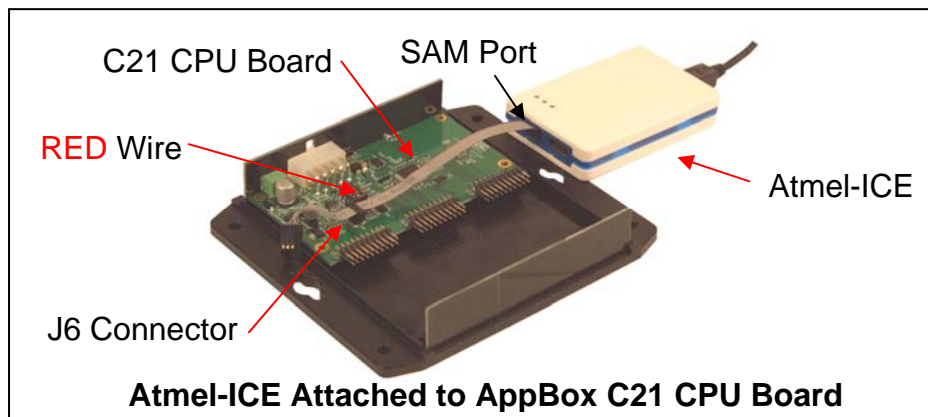
2.4 Installation of Atmel-ICE emulator

Listed below are the steps to install Atmel-ICE emulator:

1. Remove **ALL** power to the AppBox C21 enclosure
2. Remove all interface connections attached to the AppIO Modules
3. Remove the CAN/RS-485/LIN connections to the processor Module
4. Turn the AppBox over and remove the 2 screws from the bottom of the enclosure as shown below



5. Turn the AppBox back over (label showing) and lift the top off the enclosure being careful not to lose the knockout panels
6. Plug the emulator end of the ribbon cable into the "SAM" Port on the emulator
7. Plug in the Atmel-ICE debug into connector J6 on the AppBox C21 CPU board. Visually inspect the connection to insure all the board pins are in the female cable connector.

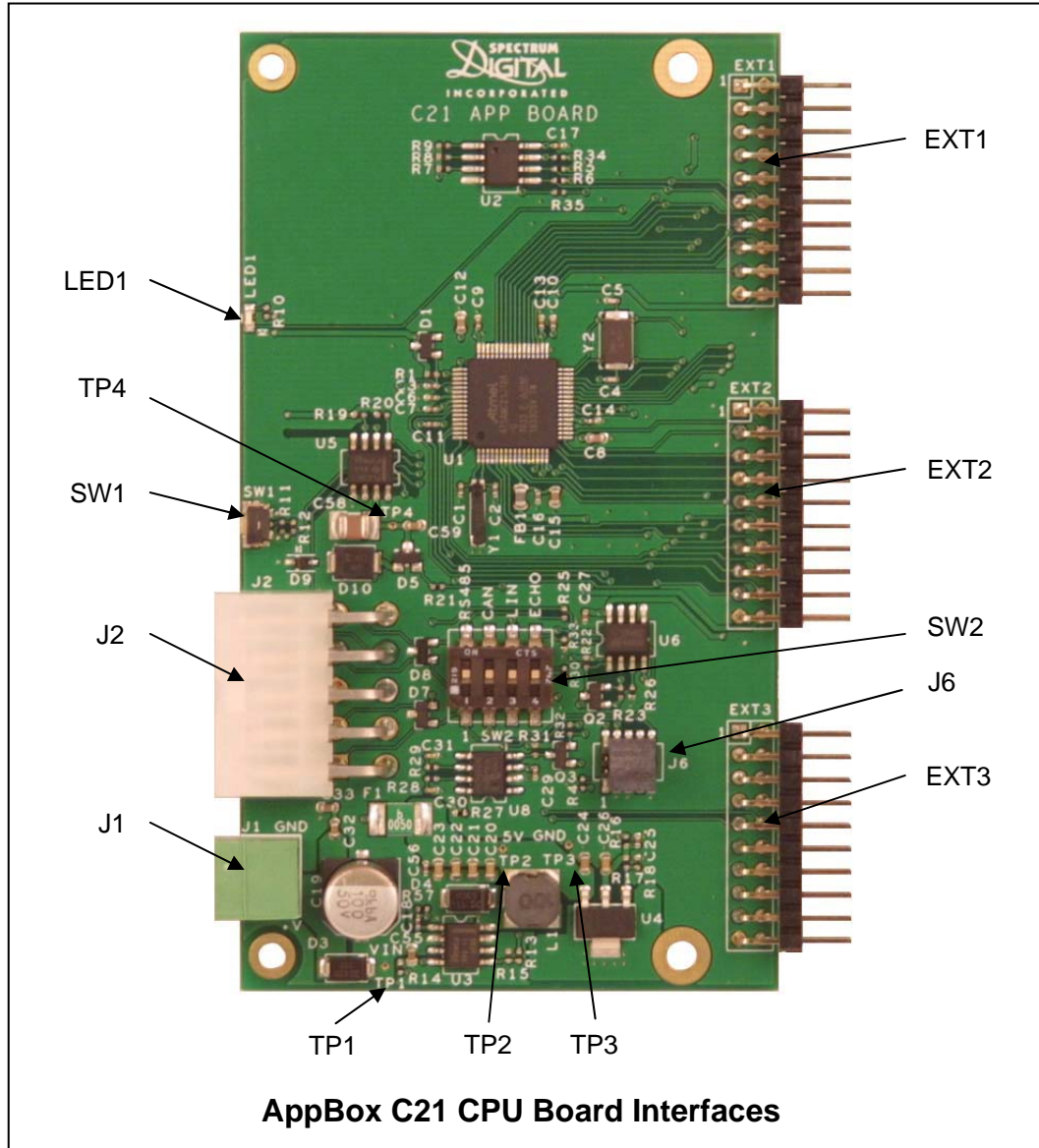


8. Re-attach the CAN/RS-485/LIN connections to the processor board
9. Re-attach all interface connections to the AppIO Modules
10. Apply power to the AppBox C21
11. Start debug session on the host computer

3.0 Interfaces

This section describes the interfaces on the AppBox C21 CPU Board. These interfaces include the connectors, jumpers, switches, LEDs, and test points.

The location of each of these interfaces is shown in the figure below:



The table below lists all the interfaces on the AppBox C21 CPU Board.

AppBox C21 CPU BOARD INTERFACES	
INTERFACE NAME	TYPE OF INTERFACE
J1	Connector for power input
J2	Connector for RS485/CAN/LIN
J6	Connector for header 5x2 Cortex-M Debug
EXT1	Connector to AppIO Module
EXT2	Connector to AppIO Module
EXT3	Connector to AppIO Module
JP1	SMT jumper(bottom)
JP2	SMT jumper(bottom)
JP3	SMT jumper(bottom)
JP4	SMT jumper(bottom)
JP5	SMT jumper(bottom)
JP6	SMT jumper(bottom)
JP7	SMT jumper(bottom)
JP8	SMT jumper(bottom)
JP9	SMT jumper(bottom)
SW1	Pushbutton switch
SW2	4 position DIP switch
LED1	Green LED
TP1	Test point
TP2	Test point
TP3	Test point
TP4	Test point

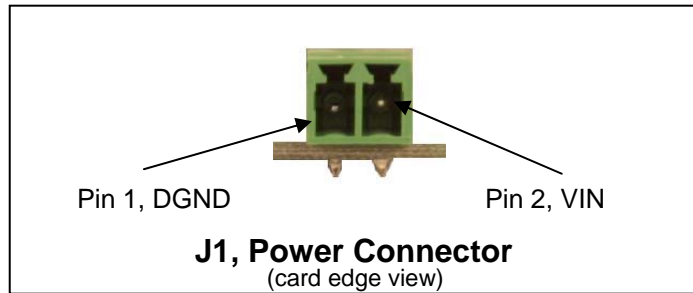
3.1 Connectors

The following section describes the connectors on the AppBox C21 CPU Board.

INTERFACE NAME	TYPE OF INTERFACE	MATING CONNECTOR
J1	Connector for power input, 2 position	Amphenol Anytek Terminal Block Plug, 2 pos TJ0231530000G TS02315A0000G
J2	Connector for RS-485/CAN/LIN, 10 position, 2 x 5	Molex 10 Position Rectangular Housing Connector Receptacle Natural 0.165" (4.20mm) 0039012100, 0039000038
J6	Connector for header 5x2	Cortex-M Debug tail
EXT1	Connector to AppIO Module #1, 20 position, 2 x 10	
EXT2	Connector to AppIO Module #2, 20 position, 2 x 10	
EXT3	Connector to AppIO Module #3, 20 position, 2 x 10	

3.1.1 J1, Power Connector

This section describes J1, the power connector. Shown below is a physical diagram of the J1 connector.

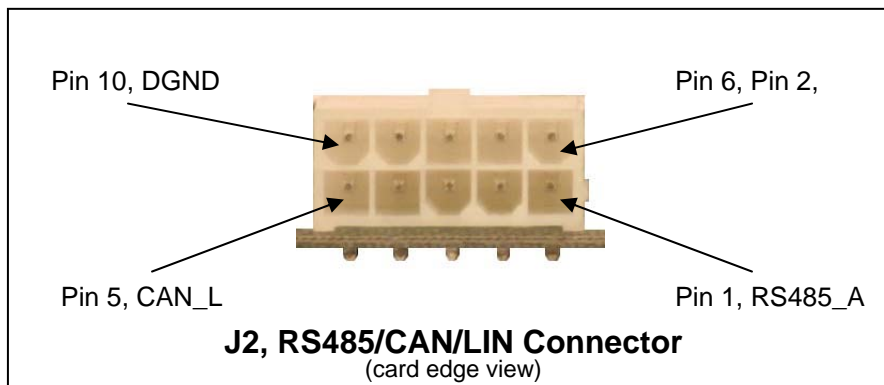


The following table shows the signals present on the J1 connector.

J1, Power Connector	
Pin number	Signal name
1	DGND
2	VIN, (+12-24 VDC)

3.1.2 J2, RS485 / CAN / LIN Connector

This section describes J2, the RS485 / CAN / LIN connector. The diagram below shows the physical layout of the J2 connector.



The following table shows the signals present on the J2 connector.

J2, RS-485 / CAN / LIN Connector	
Pin number	Signal name
1	RS485_A
2	RS485_B
3	DGND
4	CAN_H
5	CAN_L
6	VDD_5V if JP7 shorted
7	DGND
8	LIN_PWR In
9	LIN
10	DGND

3.1.3 J6, Cortex-M Debug Connector

The following table shows the signals on the J6 connector.

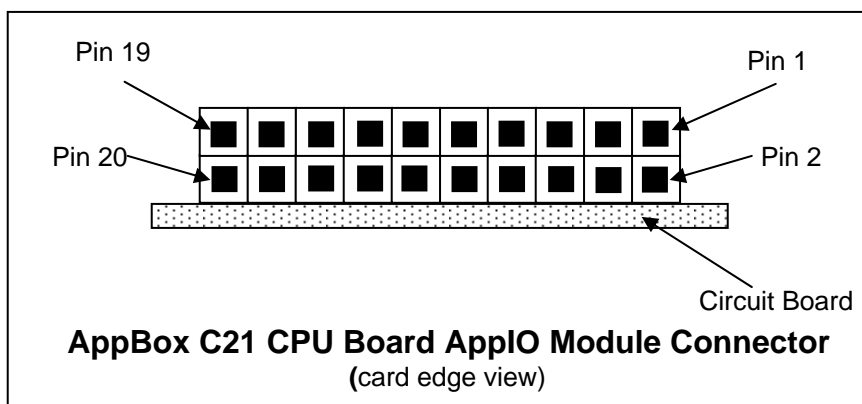
J6, Cortex-M Debug Connector	
Pin number	Signal name
1	VDD_3V3, +3.3 volts
2	PA31_SWDIO
3	DGND
4	PA30_SWCLK/TCK
5	DGND
6	No Connect
7	No Connect
8	No Connect
9	DGND
10	RESETn

3.1.4 AppIO Module Connectors

The AppBox C21 CPU Board has 3 connectors which allow the AppBox C21 to be customized to meet specific application requirements. By using function specific AppIO Modules, the user can tailor their system configuration to meet their unique requirements. The AppIO Modules can be plugged into any of the 3 connectors (EXT1, EXT2, EXT3). These 3 connectors are 20 pin, 2 x 10 double row, right angle connectors with pins on 0.1 inch (2.54 mm) centers.

Note: The user should be aware that several signals from the AppBox C21 CPU are shared and present on all 3 connectors. If the signals are used by one connector (AppIO Module) they should not be used on the other connectors.

The following diagram shows the physical layout of the EXT1, EXT2, and EXT3 connectors.



3.1.4.1 EXT1, AppIO Module Connector

The following table shows the signals present on the EXT1 connector.

EXT1, AppIO Module Connector			
Pin #	Signal Name	Function	Shared Functionality
1	Pin 2, JP1, VDD_5V if shorted	+5 volts to AppIO Module if shorted	VDD_5V
2	DGND	Ground	Ground
3	PB09_ADC(P)	A/D converter, alternatively positive part of differential ADC	
4	PB08_ADC(N)	A/D converter, alternatively negative part of differential ADC	
5	PA20_GPIO	General purpose I/O	
6	PA21_GPIO	General purpose I/O	
7	PB12_PWM(P)	PWM, alternatively positive part of differential PWM	
8	PB13_PWM(N)	PWM, alternatively negative part of differential PWM	
9	PB14_IRQ/GPIO	Interrupt request line and/or GPIO	
10	PB15_SPI_SS_B/GPIO	Slave select for SPI and/or GPIO	
11	PA12_TWI_SDA	Data line for I ² C interface, always implemented, bus type	Pin 11 on EXT2, EXT3, Pin 5, U2
12	PA13_TWI_SCL	Clock line for I ² C interface, always implemented, bus type	Pin 12 on EXT2, EXT3, Pin 6, U2
13	PA23_UART_RX	Receiver line of target device UART	Pin 13 on EXT2, EXT3
14	PA22_UART_TX	Transmitter line of target device UART	Pin 14 on EXT2, EXT3
15	PA17_SPI_SS_A	Slave select for SPI	
16	PA18_SPI_MOSI	Master out slave out line of serial peripheral interface, always implemented, bus type	
17	PA16_SPI_MISO	Master in slave out line of serial peripheral interface, always implemented, bus type	
18	PA19_SPI_SCK	Clock for serial peripheral interface, always implemented, bus type	
19	DGND	Ground	Ground
20	VDD_3V3	Power for the AppIO Module	Power for the AppIO Module

3.1.4.2 EXT2, AppIO Module Connector

The following table shows the signals present on the EXT2 connector.

EXT2, AppIO Module Connector			
Pin #	Signal Name	Function	Shared Functionality
1	Pin 2, JP2, VDD_5V if shorted	+5 volts to AppIO Module if shorted	VDD_5V
2	DGND	Ground	Ground
3	PA08_ADC(P)	A/D converter, alternatively positive part of differential ADC	
4	PA09_ADC(N)	A/D converter, alternatively negative part of differential ADC	
5	PA10_GPIO	General purpose I/O	
6	PA11_GPIO	General purpose I/O	
7	PB30_PWM(P)	PWM, alternatively positive part of differential PWM	
8	PB31_PWM(N)	PWM, alternatively negative part of differential PWM	
9	PB16_IRQ/GPIO	Interrupt request line and/or GPIO	
10	PB17_SPI_SS_B/GPIO	Slave select for SPI and/or GPIO	
11	PA12_TWI_SDA	Data line for I ² C interface, always implemented, bus type	Pin 11 on EXT1, EXT3, Pin 5, U2
12	PA13_TWI_SCL	Clock line for I ² C interface, always implemented, bus type	Pin 12 on EXT1, EXT3, Pin 6, U2
13	PA23_UART_RX	Receiver line of target device UART	Pin 13 on EXT1, EXT3
14	PA22_UART_TX	Transmitter line of target device UART	Pin 14 on EXT1, EXT3
15	PB03_SPI_SS_A	Slave select for SPI	
16	PB00_SPI_MOSI	Master out slave out line of serial peripheral interface, always implemented, bus type	
17	PB02_SPI_MISO	Master in slave out line of serial peripheral interface, always implemented, bus type	
18	PB01_SPI_SCK	Clock for serial peripheral interface, always implemented, bus type	
19	DGND	Ground	Ground
20	VDD_3V3	Power for the AppIO Module	Power for the AppIO Module

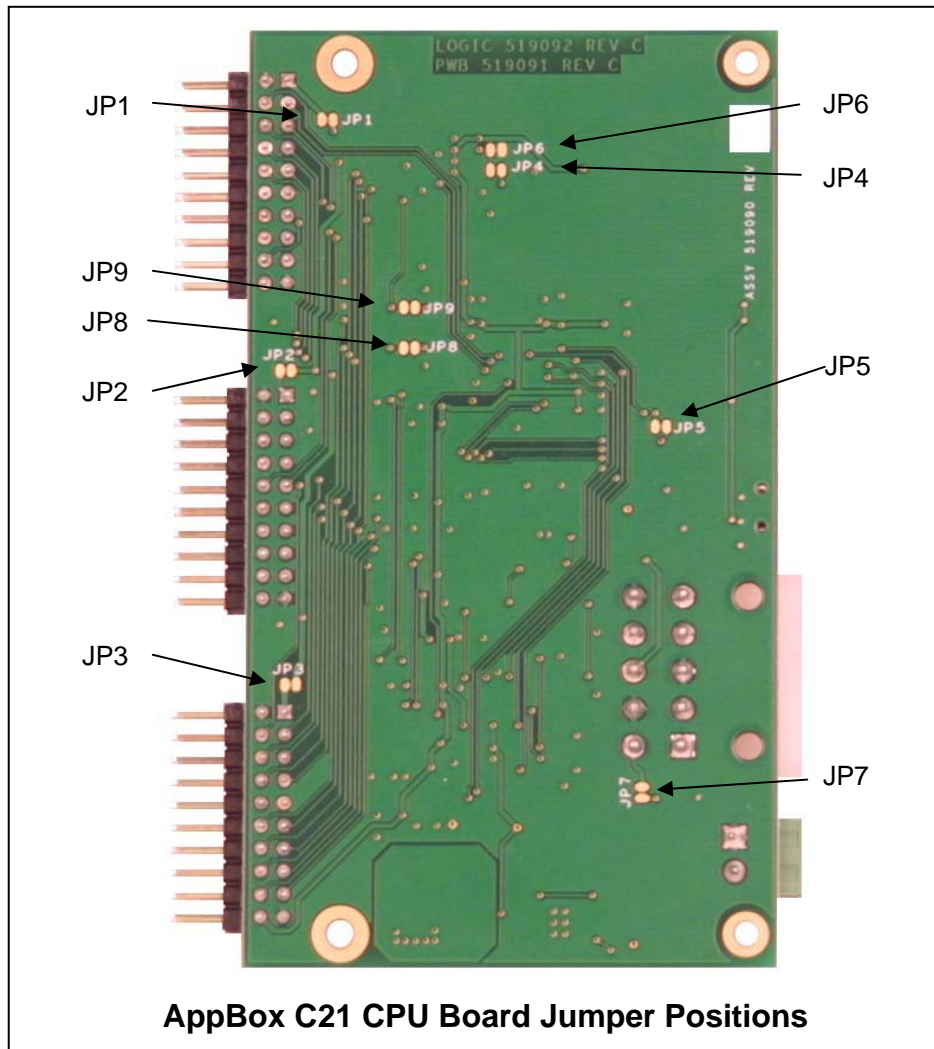
3.1.4.3 EXT3, AppIO Module Connector

The following table shows the signals present on the EXT3 connector.

EXT3, AppIO Module Connector			
Pin #	Signal Name	Function	Shared Functionality
1	Pin 2, JP3, VDD_5V if shorted	+5 volts to AppIO Module if shorted	VDD_5V
2	DGND	Ground	Ground
3	PB07_ADC(P)	A/D converter, alternatively positive part of differential ADC	
4	PB06_ADC(N)	A/D converter, alternatively negative part of differential ADC	
5	PB04_GPIO	General purpose I/O	
6	PB05_GPIO	General purpose I/O	
7	PA14_PWM(P)	PWM, alternatively positive part of differential PWM	16 Mhz. crystal, Y2
8	PA15_PWM(N)	PWM, alternatively negative part of differential PWM	Green LED, 16 Mhz. crystal, Y2
9	PA28_IRQ/GPIO	Interrupt request line and/or GPIO	SW1
10	PA27_SPI_SS_B/GPIO	Slave select for SPI and/or GPIO	
11	PA12_TWI_SDA	Data line for I ² C interface, always implemented, bus type	Pin 11 on EXT1, EXT2, Pin 5, U2
12	PA13_TWI_SCL	Clock line for I ² C interface, always implemented, bus type	Pin 12 on EXT1, EXT2, Pin 6, U2
13	PA23_UART_RX	Receiver line of target device UART	Pin 13 on EXT1, EXT2
14	PA22_UART_TX	Transmitter line of target device UART	Pin 14 on EXT1, EXT2
15	PA02_SPI_SS_A	Slave select for SPI	
16	PB00_SPI_MOSI	Master out slave out line of serial peripheral interface, always implemented, bus type	
17	PB02_SPI_MISO	Master in slave out line of serial peripheral interface, always implemented, bus type	
18	PB01_SPI_SCK	Clock for serial peripheral interface, always implemented, bus type	
19	DGND	Ground	Ground
20	VDD_3V3	Power for the AppIO Module	Power for the AppIO Module


3.2 Jumpers

This section describes the jumpers on the AppBox C21 CPU board. All jumpers are located on the bottom side of the circuit board. All jumpers are surface mount jumpers. The figure below shows the location of each jumper.



The table below describes the jumpers on the AppBox C21 CPU Board.

JUMPER NAME	POSITION DESCRIPTION	FACTORY SHIPPED POSITION
JP1	Installed = +5 V power to pin 1, EXT1	Installed
JP2	Installed = +5 V power to pin 1, EXT2	Installed
JP3	Installed = +5 V power to pin 1, EXT3	Installed
JP4	Installed = connects PA04_WP to Pin 7, U2, WP3 EEPROM write protect enable	Open – see warning 1
JP5	Installed = connects VDD_3V3 to PA05_WAKE/FAULT, and Pin3, U5 LIN WAKE/FAULT enable	Installed
JP6	Installed = connects DGND to Pin 7, U2, WP3 EEPROM write protect disable	Installed – see warning 1
JP7	Installed = connect VDD_5V to Pin 1, J2, +5 volt output	Open
JP8	Installed = connects PA14_XIN to PA14_PWM(P) XTAL/PWM option	Installed
JP9	Installed = connects PA15_XOUT to PA14_PWM(N), XTAL/PWM option	Installed



WARNING 1 !

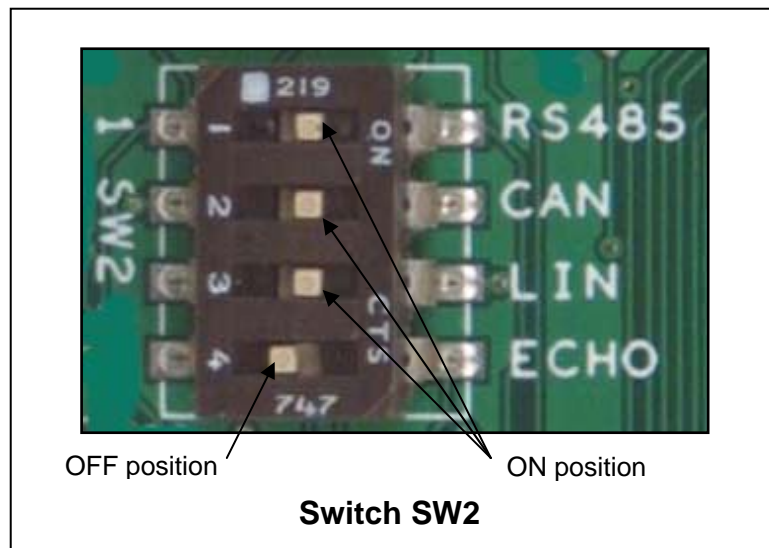
Jumpers JP4 and JP6 are used in the same circuit. Only 1 should be installed. If both are installed the circuit could be damaged.

3.3 Switches

The table below describes the switches on the AppBox C21 CPU board.

SWITCH NAME	TYPE OF SWITCH	FUNCTION	FACTORY DEFAULT POSITION
SW1	Pushbutton switch	PA28_IRQ/GPIO	Open
SW2, position 1, on	Rocker switch	Connects RS485_A to RS485_B RS485 terminator on	X
SW2, position 1, off	Rocker switch	Disconnects RS485_A from RS485_B RS485 terminator off	
SW2, position 2, on	Rocker switch	Connects CAN_H to CAN_L CAN terminator on	X
SW2, position 2, off	Rocker switch	Disconnects CAN_H from CAN_L CAN terminator off	
SW2, position 3, on	Rocker switch	Connects LIN to LIN_PU, LIN pull up	X
SW2, position 3, off	Rocker switch	Disconnects LIN from LIN_PU No LIN pull up	
SW2, position 4, on	Rocker switch	Connects PB23_RS485_EN to RS485_ECHO, RS485 echo	
SW2, position 4, off	Rocker switch	Disconnects PB23_RS485_EN to RS485_ECHO, No RS485 echo	X

The figure below shows the switch, SW2, in the “Factory Default Position”. Switch positions 1, 2, and 3 are in the “ON” position (slide moved to the right). Switch position 4 is in the “OFF” position (slide moved to the left).



3.4 LEDs

The table below describes the LED on the AppBox C21 CPU Board.

LED NAME	COLOR	MEANING
LED1	Green	User control, PA15_PWM(N)

3.5 Test Points

This section discusses the test points on the AppBox C21 CPU Board. All test points are on the top side of the circuit board. Their location is shown in the diagram in section 3.0. The table below describes the test points on the AppBox C21 CPU board.

TEST POINT NAME	SIGNAL PRESENT
TP1	Input DC voltage, (+12-24 vdc)
TP2	VDD_5V, +5 volts
TP3	DGND
TP4	Pin 7, U5, LIN_VSUP

4.0 Physical Characteristics

The physical characteristics of the AppBox C21 are described below:

Enclosure (with flanges): 5.83 in(148.26 mm) x 5.13 in(130.5 mm) x 1.10 in(27.94 mm)

C21 CPU Board (without connectors): L: 4.15 in(105 mm) x W: 2.36 in(60 mm)

C21 CPU Board (width with connectors): W: 2.77 in (70.5 mm)

C21 CPU board (maximum height): H: 0.59 in (15 mm)

Weight of enclosure with controller Module: 6 ounces (.17 kg)

Operating Temperature: -0C to +70C

Storage Temperature: -40C to +85 C

Relative Humidity: 0 to 90% (non-condensing)

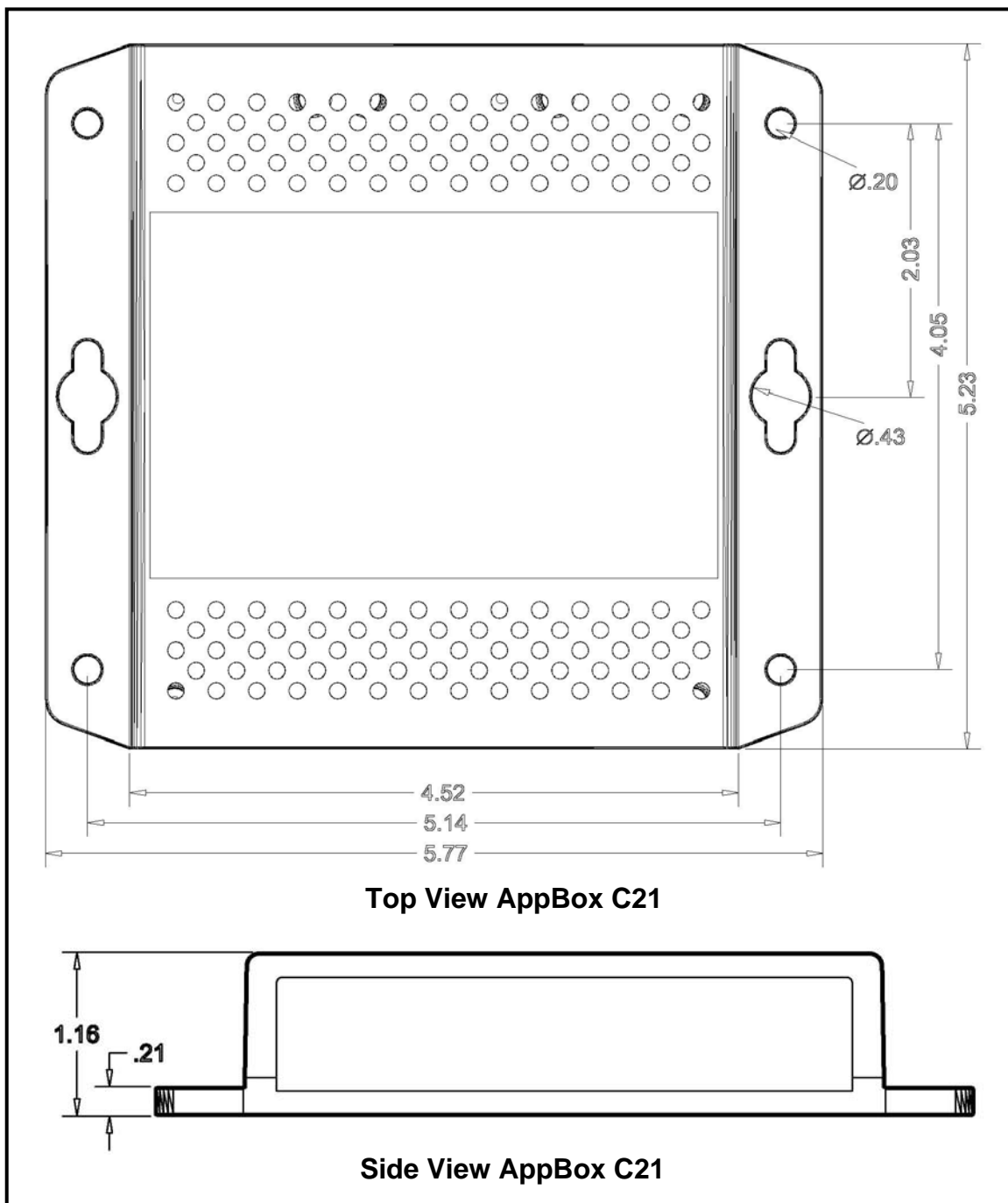
Maximum power consumption of controller Module: 1 amp at +12 volts

RoHS Compliant: Yes

5.0 Mechanical Information

The following drawing provides the mechanical information for the AppBox C21. All dimensions are in inches.

Note: Drawing is **NOT** to scale.



6.0 Schematics

The following pages include the schematics for the AppBox C21 CPU Board inside the AppBox C21.

Notes:

1.

10	9	8	7	6
5	4	3	2	1

J2

Shared Pins	
PA12_TWI_SDA	EXTI-3, CAT24C512
PA13_TWI_SCL	EXTI-3, CAT24C512
PA14_PWM(P)	EXTI3, 16Mhz Crystal
PA15_PWM(N)	EXTI3, Green Led, 16Mhz Crystal
PA28_IRQ/GPIO	EXTI3, SW1 Switch

SWITCH	Pos	Function
SW2-1	On	RS458 Termination
SW2-2	On	CAN Termination
SW2-3	On	LIN Pullup
SW2-4	Off	RS485 Echo

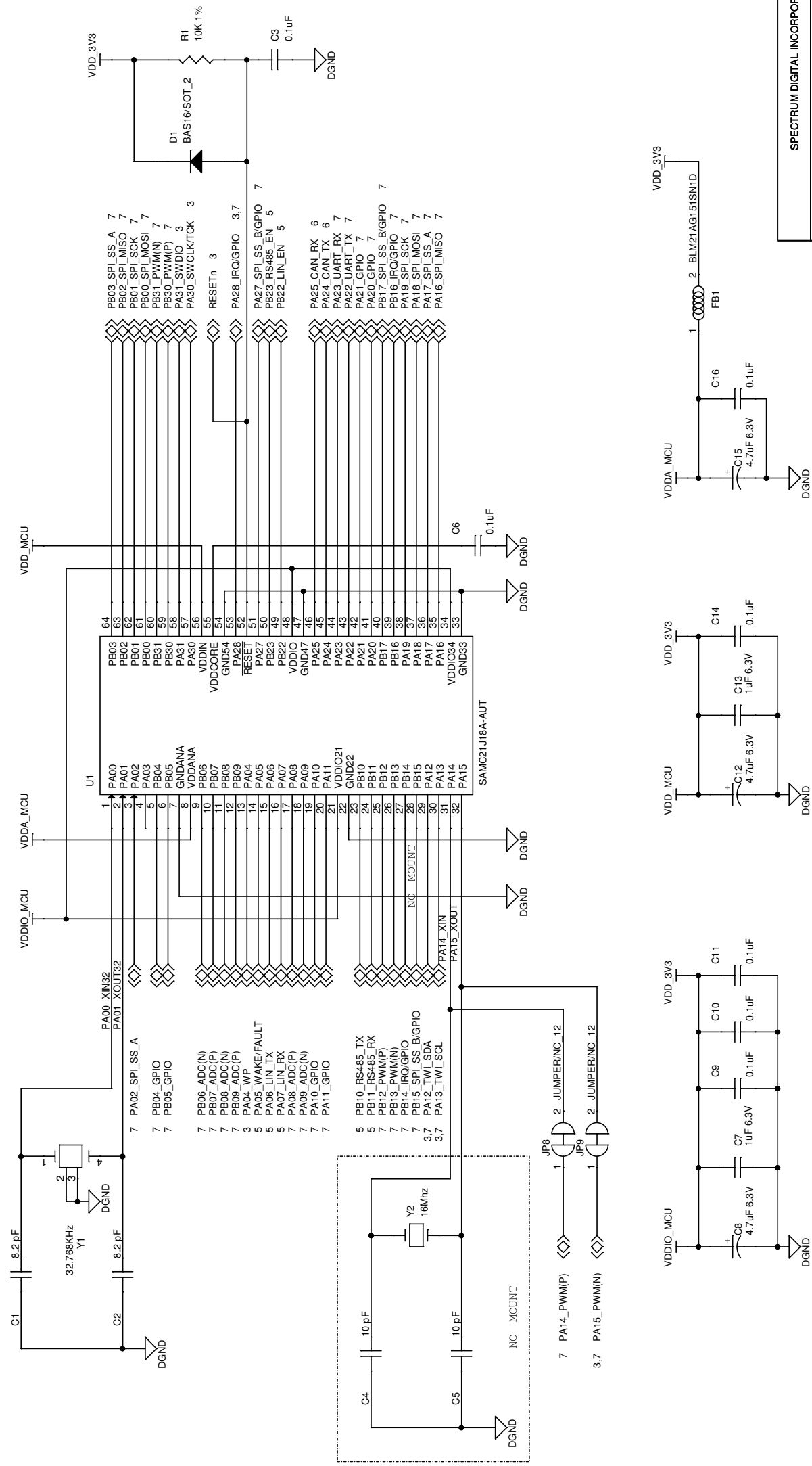
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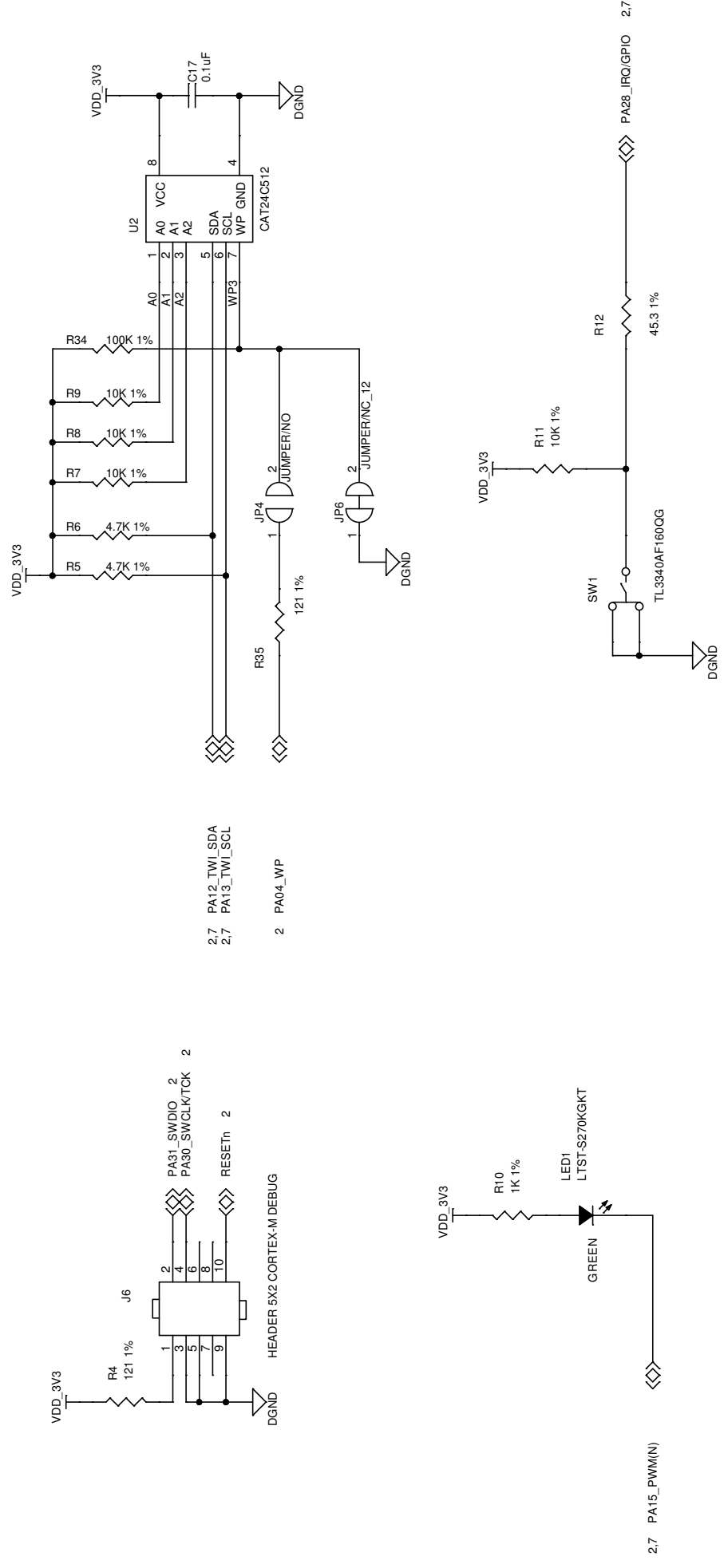
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Size: B DWG NO 519092 Revision: C

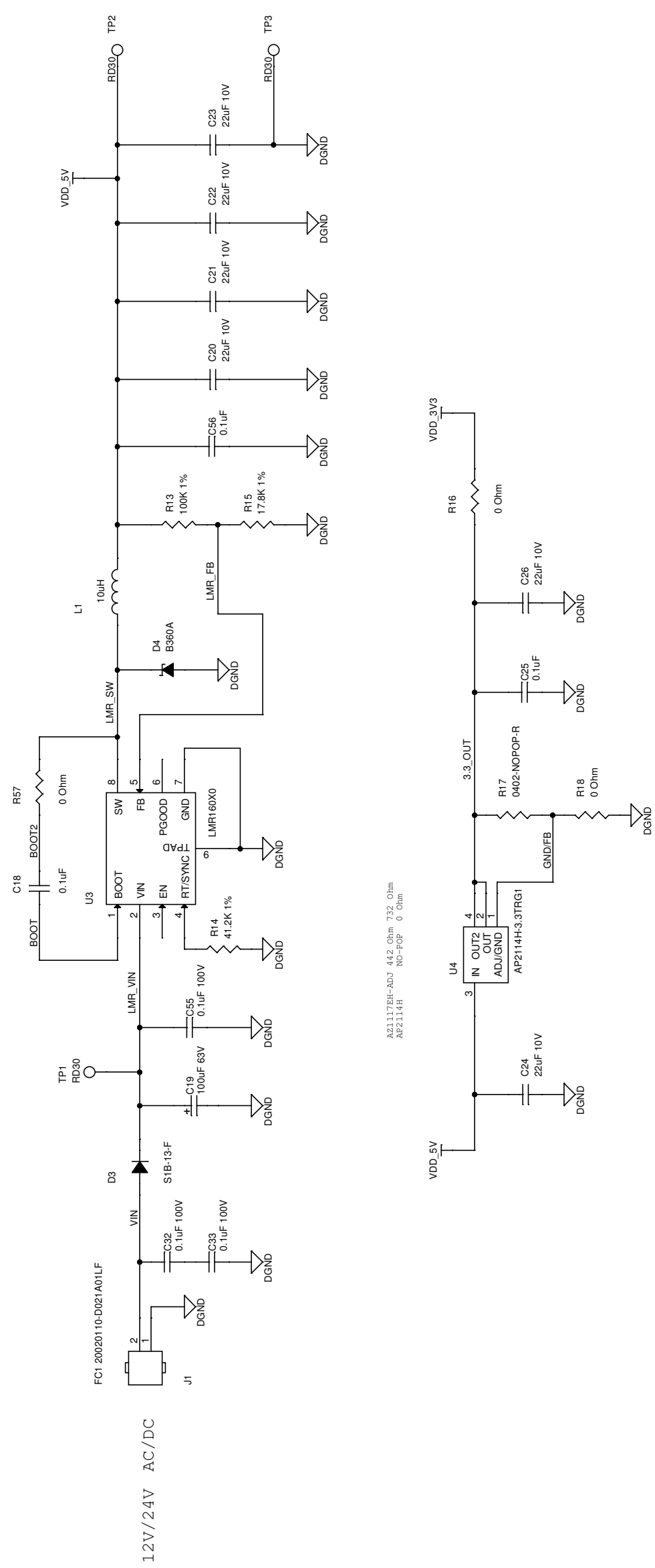
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Title:	C21 APPLICATION BOARD
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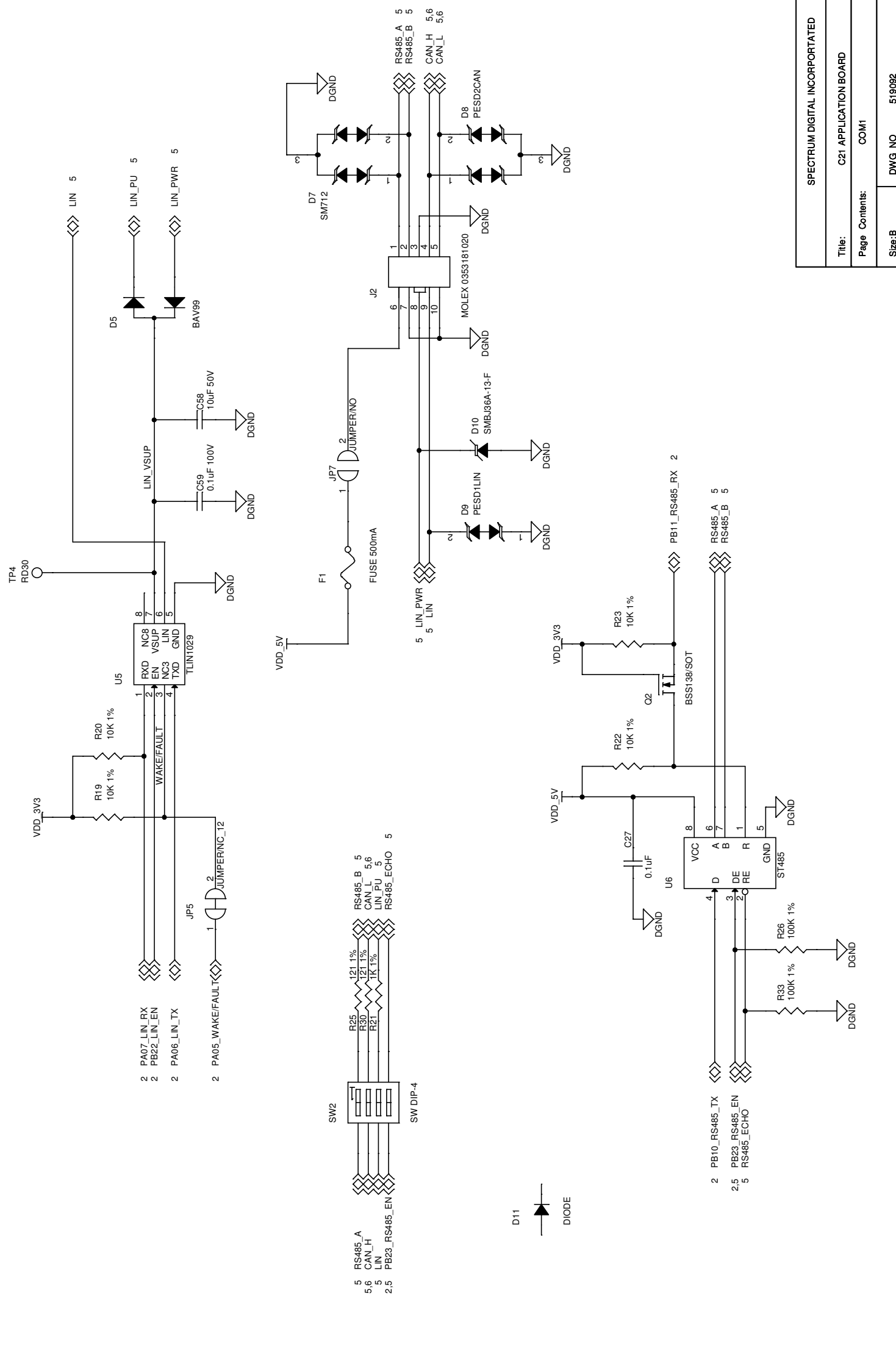
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Page Contents:		MCU2	
Size:B	DWG NO	519092	Revision: C
Date: Friday, March 13, 2020		Sheet 3 of 7	



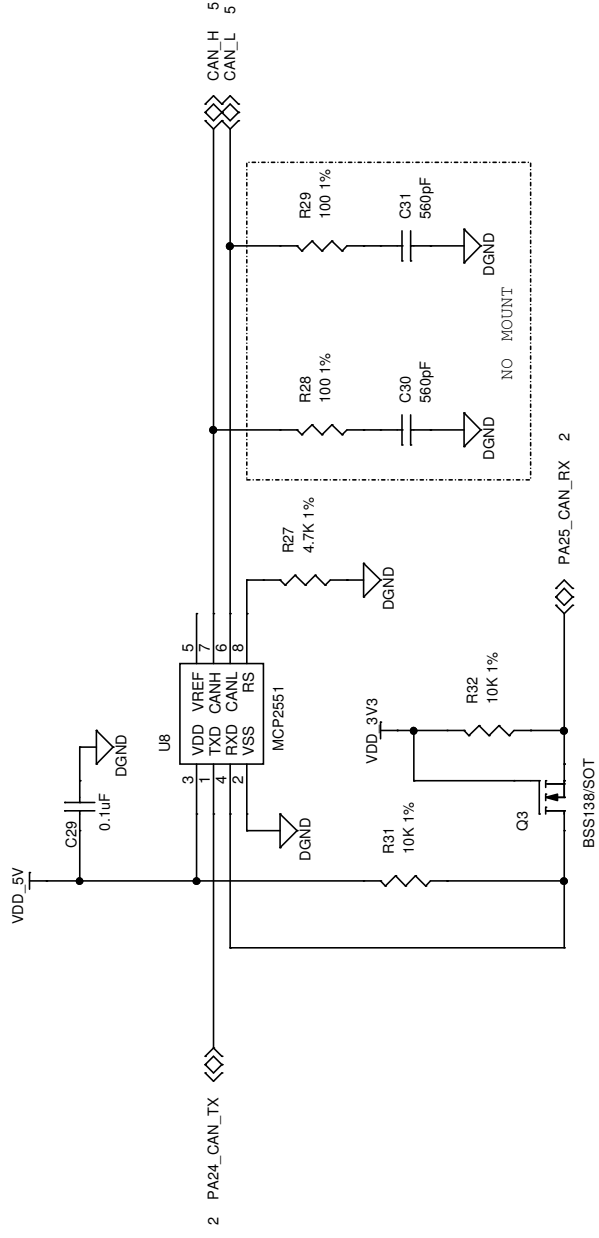
1.2V/24V AC/DC

AZ1117EH-ADJ 442 Ohm 732 Ohm
 AP2114H NO-POP 0 Ohm

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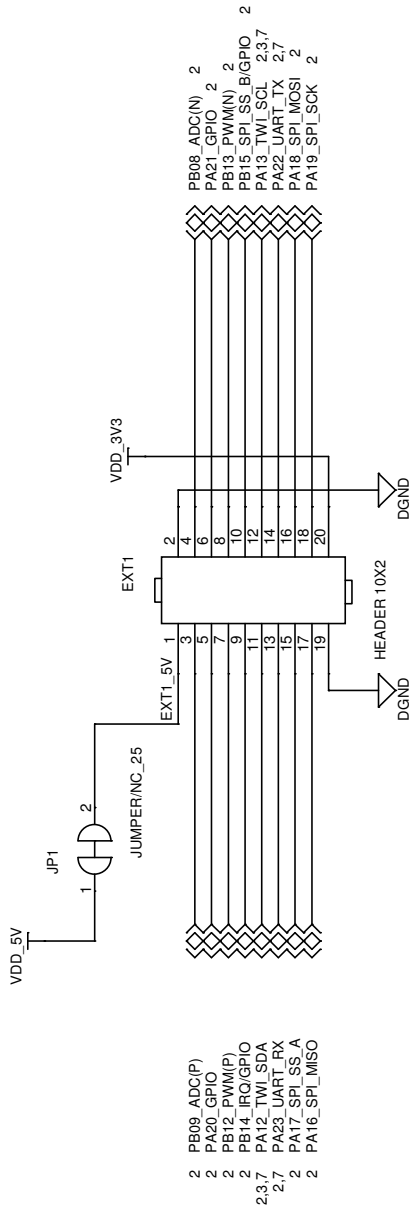
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Title: C21 APPLICATION BOARD

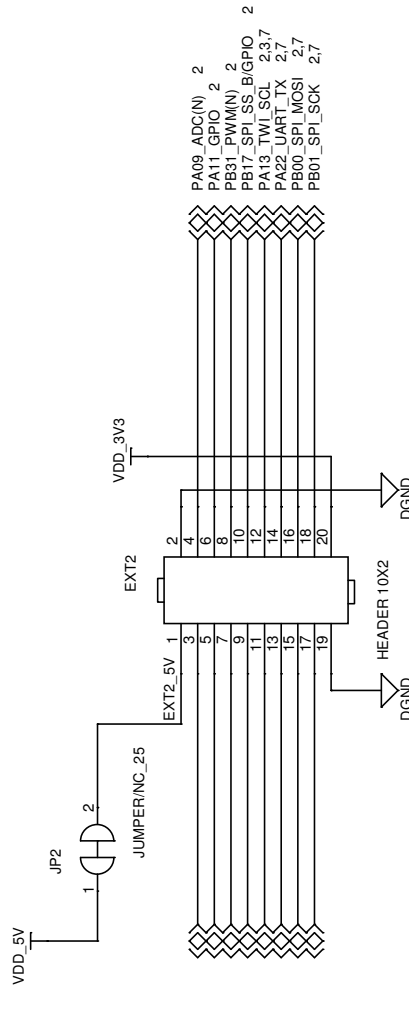
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Size: B DWG NO: 519092 Revision: C

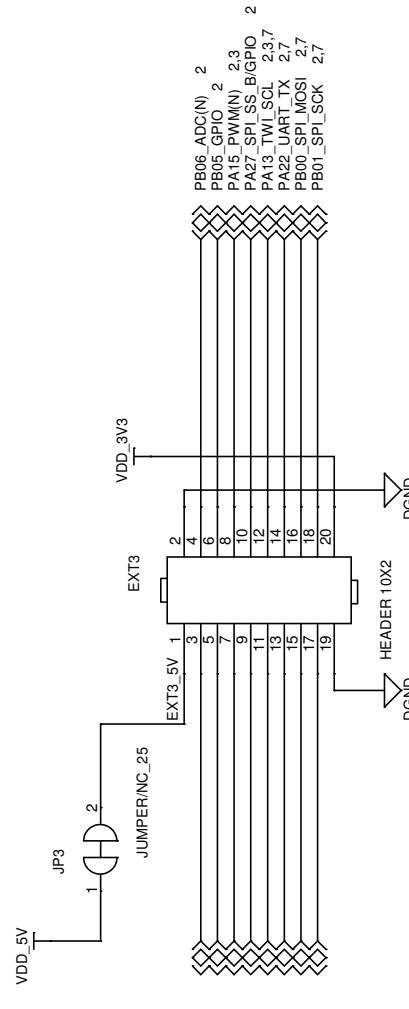
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- 2 PB09_ADC(P)
- 2 PA20_GPIO
- 2 PB12_PWM(P)
- 2 PB14_IRQ(GPIO)
- 2 PA12_TWI_SDA
- 2,3,7 PA23_UART_RX
- 2,7 PA17_SPI_SS_A
- 2 PA16_SPI_MISO



- 2 PA08_ADC(P)
- 2 PA10_GPIO
- 2 PA14_PWM(P)
- 2 PB16_IRQ(GPIO)
- 2,3,7 PA12_TWI_SDA
- 2,7 PA23_UART_RX
- 2 PB03_SPI_SS_A
- 2,7 PB02_SPI_MISO



- 2 PB07_ADC(P)
- 2 PB04_GPIO
- 2 PA14_PWM(P)
- 2,3 PA28_IRQ(GPIO)
- 2,3,7 PA12_TWI_SDA
- 2,7 PA23_UART_RX
- 2 PA02_SPI_SS_A
- 2,7 PB02_SPI_MISO

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