MR-CANHUBK344 Hardware User Manual

Rev. 0.1 — May 30, 2023

Document information

Info	Content
Keywords	MR-CANHUBK344, S32K344, FS26, SE050, TJA1103, TJA1443, TJA1463, TJA1153, CANHUBK3
Abstract	Hardware notes describing package contents, instructions, open issues, fixes, and limitations.

Revision history

Rev	Date	Description
0.1	05/30/2023	Initial version for MR-CANHUBK344

Contact information

For more information, please visit: http://www.nxp.com

1. Introduction

MR-CANHUBK344 board is an evaluation board designed for mobile robotics applications and is based on Arm® Cortex®-M7 core S32K344 general-purpose automotive microcontroller featuring the latest in safety, security, and software support.

While targeted to mobile robotics applications the board can certainly be used for multiple purposes where automotive lockstep cores may be desirable:

- A primary small vehicle controller
- A safety domain controller,
- A high specification "CAN FD node" board,
- Bridging between 100Base-T1 and multiple CAN PHYsical interfaces.
- Potentially as a BLDC motor controller.

Special notes on processor:

While the dual-core lockstep (DCLS) S32K344 is installed on this board, the same board may support an S32K324 where the Cortex-M7 cores operate independently as a dual independent core device. Additionally, the S32K35x (240Mhz/3 core) will also install in the same footprint with minor modifications. Both these ideas would require manual rework to a board to replace the processor.

MR-CANHUBK344 includes one 100Base-T1 Automotive Ethernet and populates all six of the CAN FD ports available on S32K344. The feature set it provides is quite suitable for a wide variety of other applications. One example is experimenting with tunneling CAN over Ethernet using IEEE 1722 protocol. A software example is available for this on the NXP webpage for the device.

The 6 CAN ports are connected to three distinct types of NXP CAN PHYs, and allow for direct comparison between standard CAN FD, CAN FD/SIC (signal improvement CAN) and CAN FD/SCT (Secure CAN Transceivers)

Also on board is the SE050 Secure element with NFC (Near Field Communication) as well as UART, SPI, I²C, PWM and other GPIO accessible on DroneCode standard JST-GH connectors.

In addition to the published S32K design studio example software application as an IEEE 1722 CAN over Ethernet bridge, please also look for opensource NuttX RTOS, NuttX/PX4 and Zephyr RTOS support on this board for general purpose applications in their respective opensource repositories.

- https://github.com/apache/nuttx
- https://github.com/PX4/PX4-Autopilot
- https://github.com/zephyrproject-rtos/zephyr

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NXP HoverGames contest uses these and other boards which are intended to work together. You will find other code examples, additional links, and "Engineering Notebook" style documentation specific to Mobile Robotics team at the following gitbook URLs:

https://nxp.gitbook.io/hovergames/

https://nxp.gitbook.io/mr-canhubk3

1.1 Abbreviations

IEEE 1722	Layer 2 transport protocol working group for time-sensitive streams
100BASE-T1	Full-duplex single twisted pair Ethernet
BEC	Battery Eliminator Circuit (power rail for servos and ESCs)
BLDC	Brushless DC (motor)
CAN	Controller Area Network 1Mbps "classical CAN", although may sometimes be inclusive of CAN FD
CAN FD	CAN Flexible Data rate (up to 8Mbps)
CAN SIC	CAN FD using Signal Improvement CAN PHY
CAN SCT	CAN FD using Secure CAN Transceiver
ESC	Electronic Speed Controller
FMU/VMU	Flight/Vehicle Management Unit
IMU	Inertial Measurement Unit (Combination of accelerometer, Gyro, Magnetometer)
JTAG	Joint Test Action Group, interface commonly used for software debugging
KB	1024 bytes
MAC	Media Access Control, a MAC address is a so-called PHYsical address.
Mbps	Million bits per second (10^6 bits/s)
NFC	Near Field Communication
PCB	Printed Circuit Board
RTK GPS	Real Time Kinematic Global Positioning System (Precision GPS Module)
SDK	Software Development Kit

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2. Contents

The MR-CANHUBK344 comes as a kit that includes the items specified on the packing slip documents. Note a reduced kit is also expected to be made available. In the full version the following hardware components are included:

- Hardware
    - MR-CANHUBK344 board
    - DCD-LZ Programming Adapter board.
        - This is an adapter board that gives access to a console UART at the same time as a SWD debug connector.
    - USB-UART adapter cable (attaches to DCD-LZ)
    - Power adapter cables
        - Including JST-GH to commonly use red JST-SY connector, barrel connector, XT-60 LiPo battery connector.
    - 6x CAN cables
    - 6x CAN Termination boards
    - 1x 100Base-T1 "two wire" Ethernet cable using JST-GH connectors
        - Note automotive applications will specify alternative connector types. You may wish to fabricate an adapter cable.
    - Generic JST-GH cables for UART/SPI/I^{2}C used for customizing to your specific needs.
    - Small 0.91" OLED display
    - NFC antenna connected to Secure Element.

The JST-GH connectors will follow the DroneCode pinout Standard where one exists for that type of interface. Otherwise confirm the pinout using the schematics.

The JST-GH connectors are intended to will work directly with other Mobile Robotics boards such as NavQPlus, UCANS32K1, RDDRONE-BMS772, MR-BMS771, and RDDRONE-FMUK66, RDDRONE-FMURT6, or MR-FMURT1176.

NOTE That the intent with these DroneCode cables and particularly with the Generic UART/SPI/I^{2}C 4/6/7pin cables is that you *may cut or otherwise adapt them to attach to your specific interface requirements*

Figure 1: JST-GH style connectors

Figure 2: JST SY, JST SYP SYR style connectors

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3. Changes

Table 1.   Changes

Item	Description
xxx	xxx
Documentation	

4. Limitations

Table 1 Limitations

Item	Description
xx xx	**Limitation:** xxx.
	Impact: xxx.

5.   Main components

This compact board includes components that are briefly described in this section. More detailed documentation on each of these individual components is available on their respective NXP.com webpages on-line.

5.1.1   S32K344

The S32K344 is an Automotive General Purpose MCU of NXP Semiconductors. Figure 1 gives the block diagram of this chip. The software discussed in this document is running on the Lockstep Arm$^®$ Cortex$^®$-M7embedded in this chip.
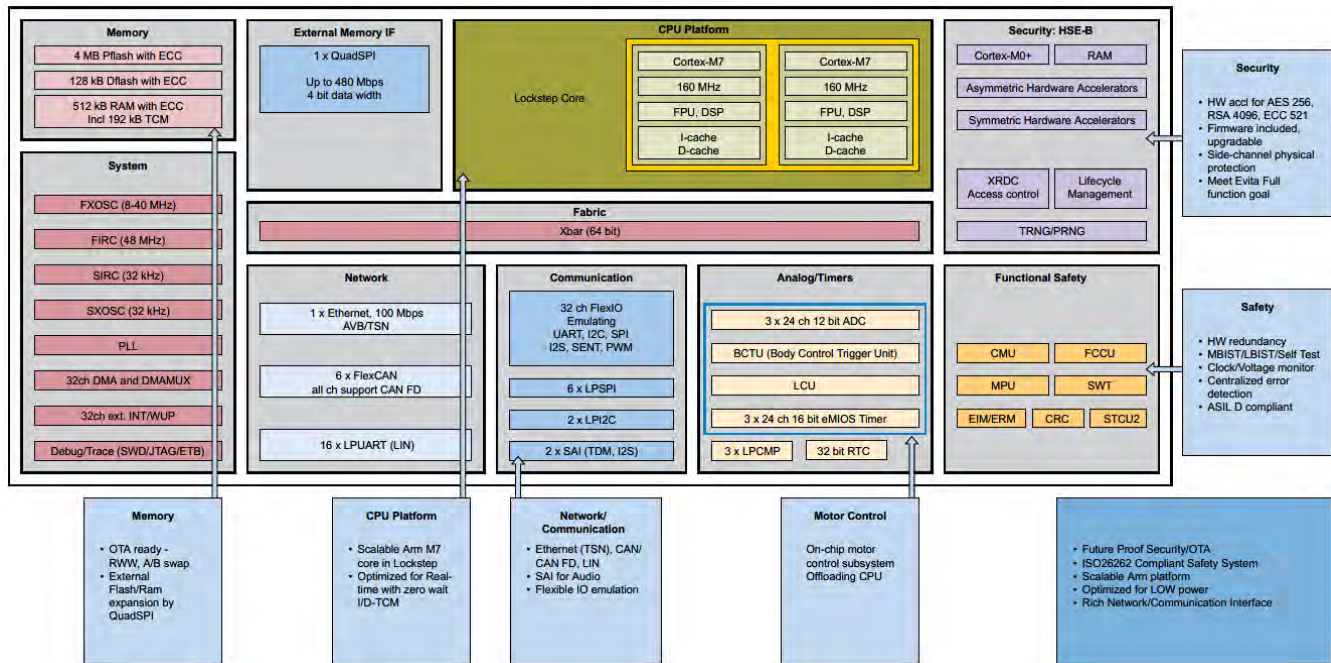

Figure 1: Block Diagram of S32K344 chip

5.1.2   FS26

The FS26 is the '*Safety System Basis Chip with Low Power Fit for ASIL D*' of NXP Semiconductors. Figure 3 gives the block diagram of this power supply chip. This part is sophisticated and is capable of additional complex configurations than implemented here, however in this design it primarily allows for a compact power supply design and high input voltage.

Normally the FS26 is connected through SPI to the S32K344 and implements a challenger window watchdog. Sending challenges to the through SPI S32K344 as the window watchdog when the response is invalid or not during the timing window the FS26 will reset the S32K344 MCU. In included sample code, the challenge watchdog functionality has **not** been implemented. Instead during startup of the S32K344 the sample application sends a request to the FS26 to *disable the watchdog* functionality thus avoiding resetting the S32K344 while running sample applications.
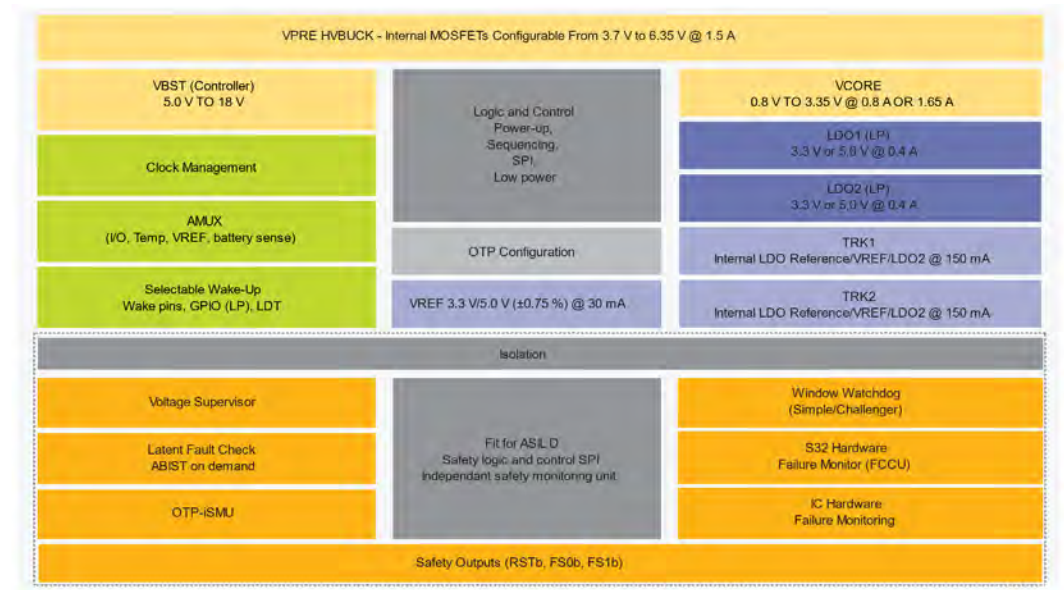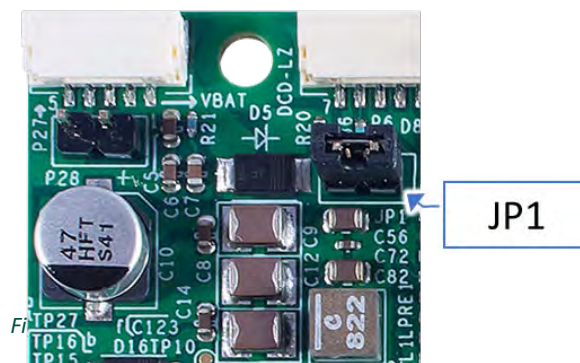

Figure 3: FS26 PMIC Block diagram

5.2 Note on PMIC and board power up sequence

The FS26 onboard PMIC by default implements a challenger window watchdog that will reset the S32K344 MCU continuously if the challenge is not handled in software.

To avoid this, the FS26 must be put into debug mode. This is done by removing the JP1 and then supplying exactly 12.0V on P27 or P28 and then inserting the JP1 jumper.

Now the reset LED D24 should no longer blink and the S32K344 will not be reset continuously by the FS26.

6. Board connections

The MR-CANHUBK344 board includes a variety of connectors to permit access to the on-chip interfaces. The intended application space is mobile robotics, which mostly defined the DroneCode JST GH connectors and pinouts. Where an interface did not have a formal DroneCode standard, a typical derivative pinout was used. To support power input directly from a battery, a wide input voltage range is supported from 5V to 40V. The 100Base-T1 2-wire Automotive Ethernet interface uses the latest TJA1103 Ethernet Phy. Also included is a SE050 secure element for authentication into the system and also NFC interface into the board.
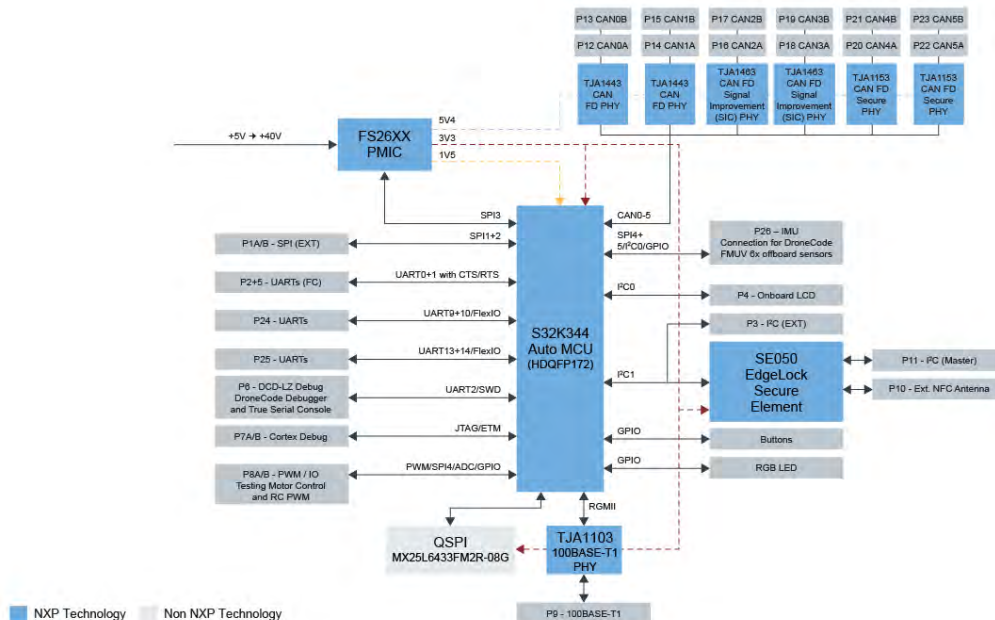
6.1 Evaluation Board Block diagram

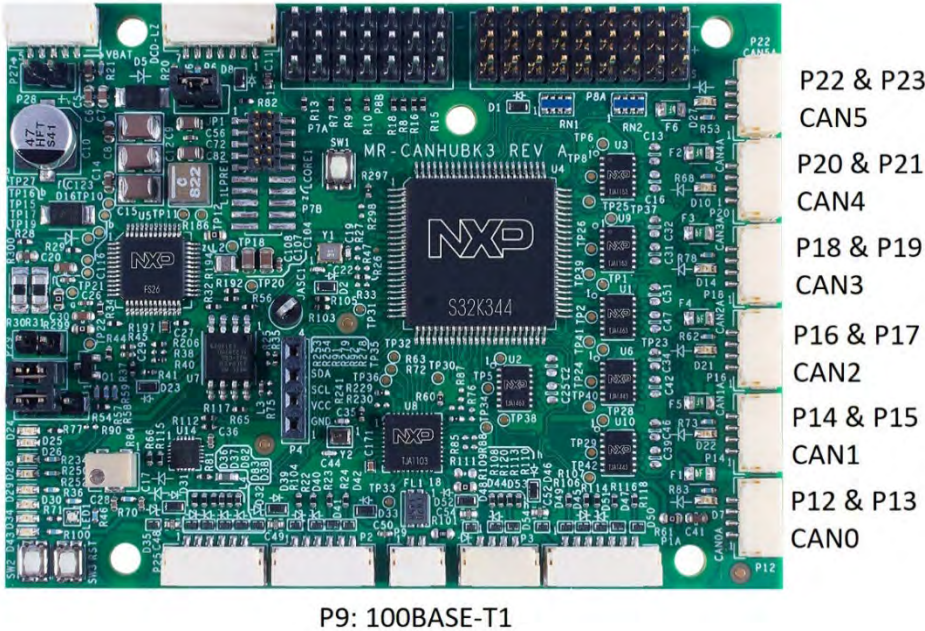*Figure 3: Evaluation board Block Diagram*

P27 & P28 VBAT +5-40V

P22 & P23
CAN5

P20 & P21
CAN4

P18 & P19
CAN3

P16 & P17
CAN2

P14 & P15
CAN1

P12 & P13
CAN0

P9: 100BASE-T1

Figure 4: Connectors used in CAN over Ethernet demo

6.2 Power Input Connectors

P27: Power is normally applied at the 5-pin JST-GH connector P27

pin #	signal	specification
1	Power+	+5 to +40V
2	Power+	+5 to +40V
3	NC	NC
4	Power (GND)	0V
5	Power (GND)	0V

Figure 5: P27 Power input connector

P28: Alternatively, power may be supplied at the two-pin header P28 located directly below P27

pin #	signal	specification
1	Power+	+5 to +40V
2	Power- (GND)	0V (GND)

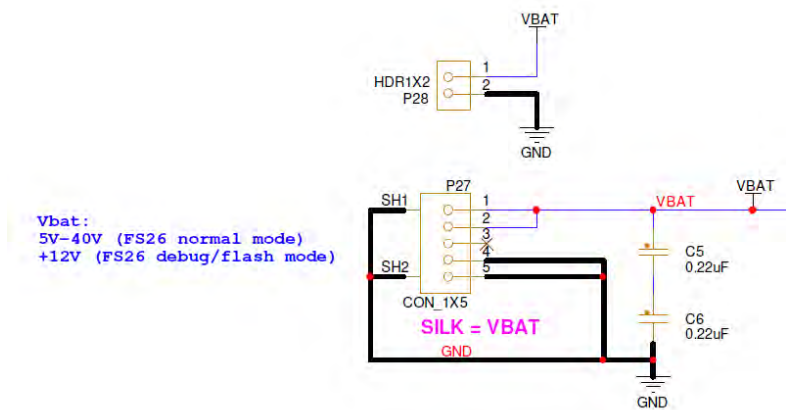*Figure 6: P28 Alt Power input connector*

Figure 7: Power input connectors P27, P28 schematic

6.3 CAN Connectors

There are six independent CAN FD capable CAN busses each with two connectors. The dual connectors are only for convenience in forming a bus and or plugging in a can termination board.

BUS name	CAN PHY	Type
CAN0, CAN1	TJA1443	CAN FD
CAN2, CAN3	TJA1463	CAN SIC (Signal Improvement)
CAN4, CAN5	TJA1153	CAN FD/SCT (Secure CAN Transceiver)

Connectors P12 through P23 are the CAN connectors. For each "CANx" bus connector the pinout is as follows (where x = BUS number 0 to 5):

Figure 8: CAN interface chip assignment

pin #	signal	specification
1	5V4	5.4V *output*
2	CANx_H	5.0V
3	CANx_L	5.0V
4	GND	0V

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Figure 9: CAN Connectors Pinout

Pin 1 of each CAN connector is available to supply 5V to externally connected CAN devices. This optionally may be used to supply limited power to a CAN peripheral. A blocking diode prevents powering the CANHUBK344 from the CAN BUS
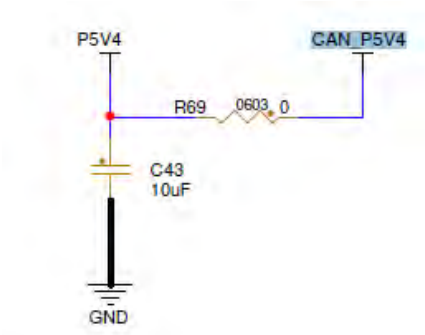

Figure 10: CAN_P5V4 power output R69 disconnect

Termination:

A CAN bus usually requires 60 Ohm termination at both ends of a CAN bus. This may be accomplished using one of the included CAN-TERM boards.

Each can bus connects to TWO identical connectors labelled A and B. This is to allow for daisy chain wiring and multiple drops along a can bus. Should the MR-CANHUB344 be the end of the CAN bus and require termination, then termination may be provided by plugging in a termination board or populating (soldering) the normally unpopulated termination resistors directly on the board.
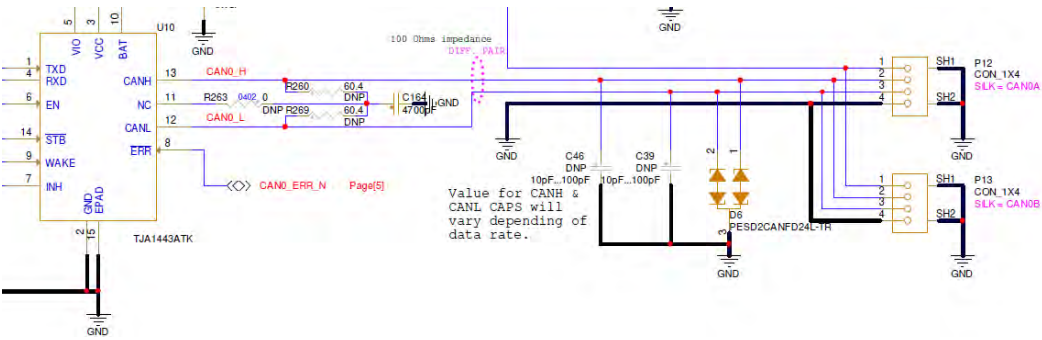

Figure 11: CAN bus representative schematic

6.3.1 CAN SIC Termination

Note that the CAN **SIC** PHYs are able to operate with **stub** connections and potentially a single or **central termination**. The signal integrity should be validated against your

specific system configuration.
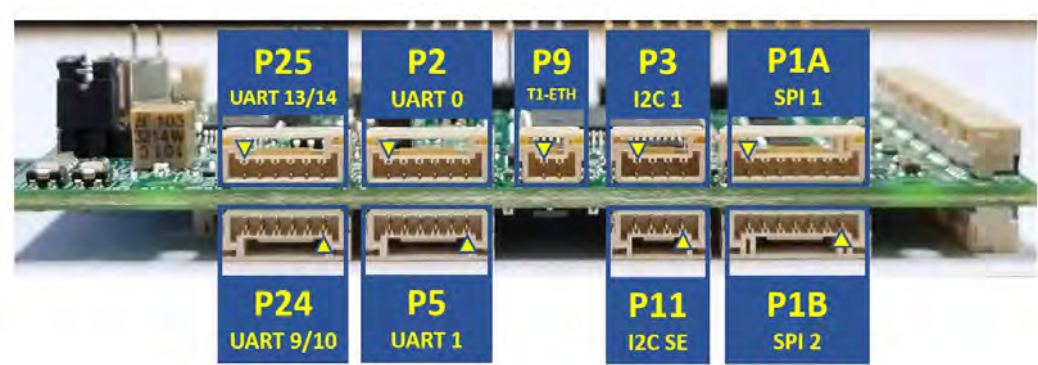
6.4 P9 - 100Base-T1 Ethernet Connector

Figure 12: Bottom Edge connectors

P9 is a two pin JST-GH connector provides the 100Base-T1 "two wire" Ethernet connection. The connection can plug directly into a MR-T1ETH8 network switch or other mobile robotics boards such as NavQPlus or FMURT6.

You may need to create a simple adapter cable to adapt to other systems (such as automotive devices) which have 100Base-T1 Ethernet.

Automotive 100Base-T1 Ethernet uses two wires to provide full duplex 100Mbps Ethernet signaling without the need for large or heavy magnetics like 100Base-TX Ethernet. The signals are capacitively coupled and there is a simple filter network before external signals reach the PHY.

The Yellow LED (D88) on the backside of the PCB indicates the link status. Flashing indicates there is a link.

Connector P9

pin #	signal	specification
1	T1-P(N)	Polarity is automatically negotiated
2	T1-N(P)	Polarity is automatically negotiated

Figure 13: P9 100Base-T1 "two wire" connector

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6.5 UARTS

6.5.1 P2 - UART0, P5 - UART1

These two S32K3 LPUARTs follow the DroneCode 6 pin UART standard. Pin 1 is able to supply limited 5V power to an external device such as a GPS module or sensor.

pin #	signal	specification
1	5V	(Optional) Limited 5V Output
2	TX	3v3
3	RX	3v3
4	CTS	3v3
5	RTS	3v3
6	GND	0v (GND)

Figure 14: P2 UART 0 and P5 UART 1 pinout

6.5.2 P24 - UART9/10, P25 - UART 13/14

Connectors P24 and P25 are also 6 pin JST-GH. However, they are not fully compliant with the DroneCode standard since pins 4 and 5 are repurposed to be a second UART channel instead of the handshaking lines RTS/CTS. The pinouts are shown below.

pin #	signal	specification
1	5V	(Optional) Limited 5V Output
2	TX (UART9)	3v3
3	RX (UART9)	3v3
4	TX (UART10)	3v3
5	RX (UART10)	3v3
6	GND	0v (GND)

Figure 15: P24 UART9/10 pinout

pin #	signal	specification
1	5V	(Optional) Limited 5V Output
2	TX (UART13)	3v3
3	RX (UART13)	3v3
4	TX (UART14)	3v3
5	RX (UART14)	3v3

6	GND	0v (GND)

Figure 16: P25 UART13/14 pinout

6.6 I²C Interfaces

6.6.1 P3 - I²C1

I²C1 interface connects to the outside via a 4 pin JST-GH as well as internally to the SE050 Secure Element. Note that there is also a second I²C bus described in the next chapter that comes from the SE050 itself.

Power output supply on I²C connectors:
The I²C1 and I²CSE interfaces include zero-Ohm resistor jumpers which can be used to select 5V (default) or 3v3 output on pin one. Note that the PWR output is intended for limited current supply and the overall power supply draw for external peripherals must be considered.

Pin	Signal	Specification
1	PWR	5V output default (3v3 optional)
2	SCL	3v3
3	SDA	3v3
4	GND	0v (GND)

Figure 17: I2C1 pinout

6.6.2 P11 - I²CSE

P11 is a I²C bus which is from the SE050 Secure Element device. It can be used for special applications such as encrypted sensor data. Refer to the SE050 datasheet for detailed information on how this may be used.

Pin	Signal	Specification
1	PWR	5V output (optional)
2	SCL	3v3
3	SDA	3v3
4	GND	0v (GND)

Figure 18: I²CSE (Secure Element)

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6.6.3   P4 - I²C0 OLED Interface

This connector is for attaching the included I²C-connected 0.91 OLED display. These OLED displays use an SSD1306 type controller and information about their use is commonly available from online sources. Note that the pinout does not follow a standard, but most of them use the pinout chosen here. Please double check the pinout and orientation should you replace or use an alternative similar display.
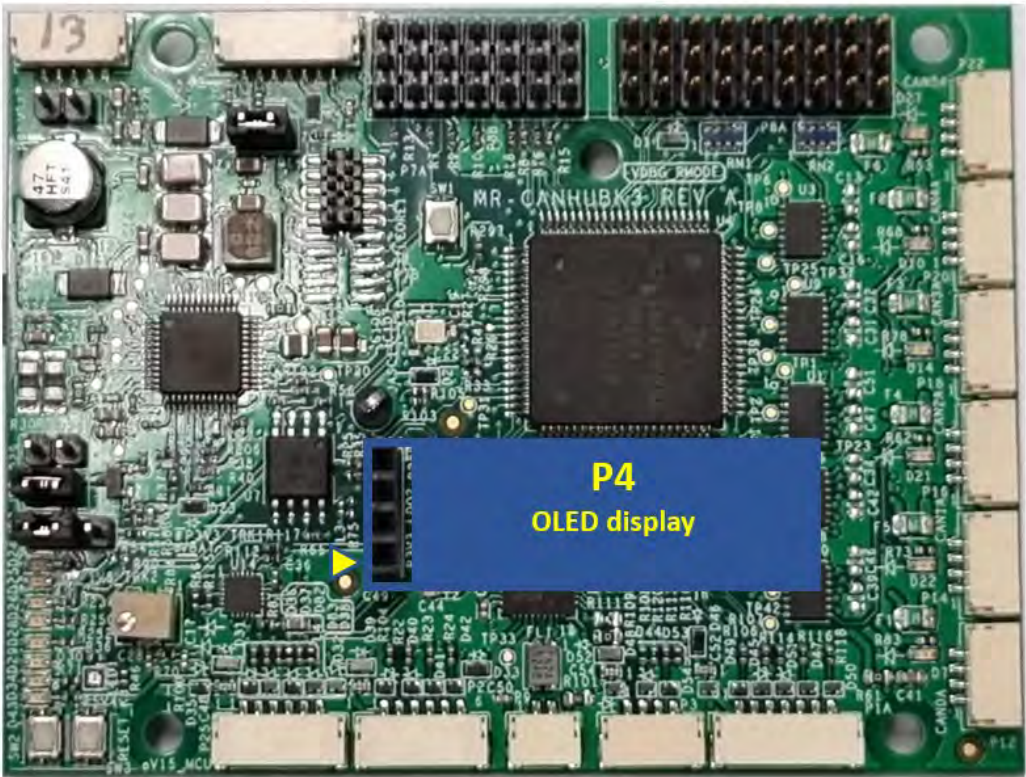

Figure 19: P4 I2C OLED and display placement

Pin #	Signal	Specification
1	GND	0V (GND)
2	VCC	5V default (3v3 optional using R25)
3	I²C0 SCL	3v3 (w/ 4K pullup on signal line)
4	I²C0 SCK	3v3 (w/ 4K pullup on signal line)

Figure 20: I²C0 OLED display Pinout

6.7 SPI Interfaces

6.7.1 P1A - SPI1, P1B - SPI2

Two independent SPI interfaces are available and follow the DroneCode connector standard for a SPI port. Two independent chip selects available on each connector using a JST-GH 7 pin connector.

Pin #	Signal	Specification
1	PWR	5V
2	LPSPIx_SCK	3v3
3	LPSPIx_MISO	3v3
4	LPSPIx_MOSI	3v3
5	LPSPIx_CS0	3v3
6	LPSPIx_CS1	3v3
7	GND	0V

Figure 21: SPI interface(s) pinout

6.8 P26 - Pixhawk V6X IMU

This is a custom connector for attaching an Intertial Measurement Unit (IMU) board from a Pixhawk V6X FMU module. It is included in the design for testing purposes only, this IMU board is not readily available from NXP. The Pixhawk design is opensource and may be obtained from Linux Foundation Dronecode.org.

It may also be possible to buy this module directly from the manufacturer - *Holybro*.

For more general investigation of IMUs please note the NXP Mobile robotics team may have adapter boards (or designs to share) that plug on top of the MR-CANHUBK344 and provide typical IMU components and connector interfaces such as RTK GPS connectors

like those needed for a full FMU/VMU (Flight/Vehicle Manangement Unit)

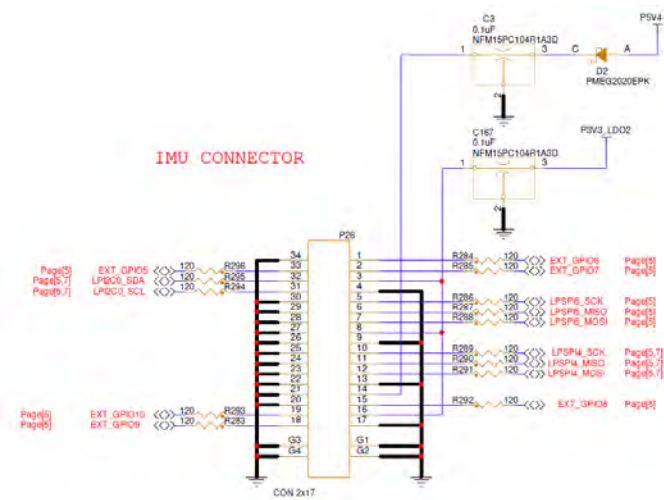*Figure 22: Connection of Holybro IMU module*

Figure 23: IMU pinout and power

6.9 Programming connectors

Two programming connectors are provided. The traditional ARM 10 Pin JTAG/SWD and a "DCD-LZ" Drone code Debug connector. Note also that the 10-Pin JTAG/SWD may be removed and replaced with a larger connector giving full access to the TRACE debug pins.

6.9.1 P6 - DCD-LZ

This is an JST-GH connector from DroneCode Standard which combines the SWD and Console UART into a single connector. The *-LZ* version of the spec also adds an RST pin.

6.9.2 P26 - ARM 10 Pin JTAG/SWD

This is a 10 pin 0.50" space JTAG with the standard pinout used by standard Arm® debuggers.
Ensure pin 1 on the PCB silkscreen is aligned with pin 1 on the debugger.
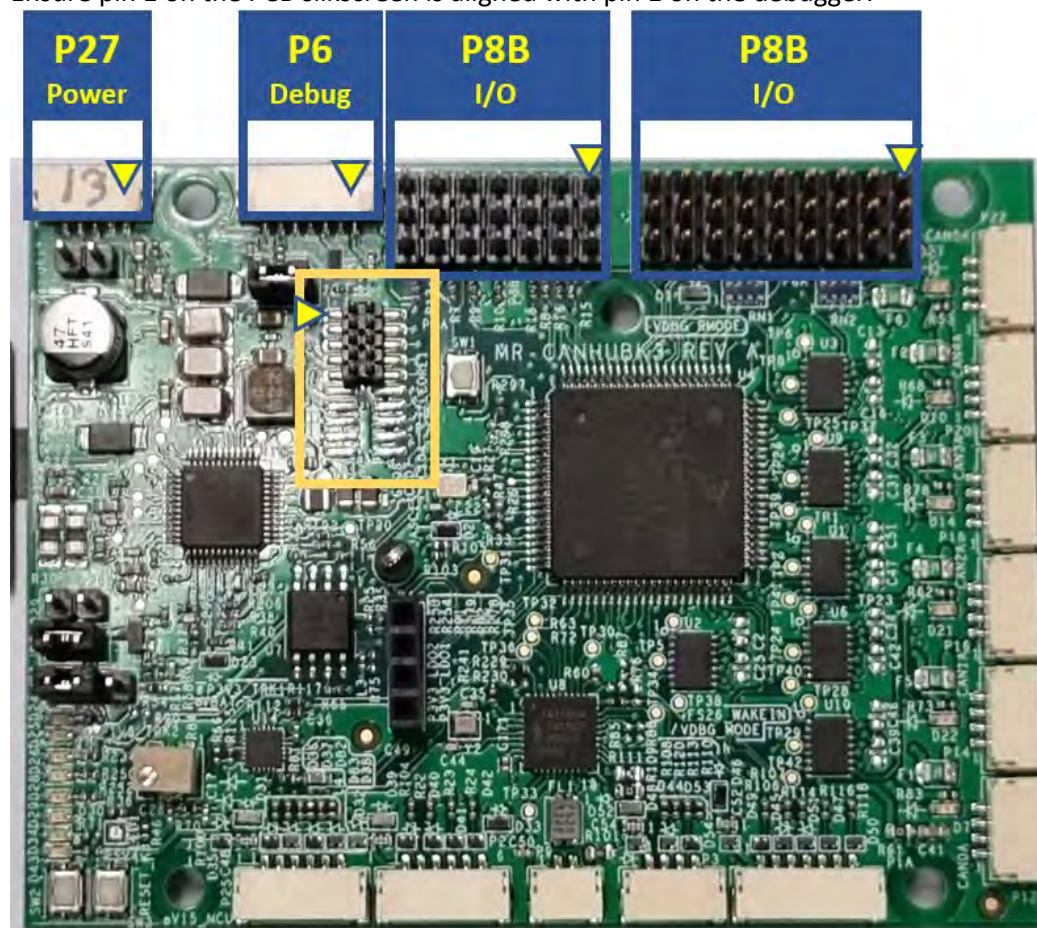

Figure 24: JTAG header, P6"DCD-LZ" w/ SWD+Console

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6.10 SW1, SW2 User buttons

Two user programmable buttons are available for use.
These buttons are configured as pull-downs and are active high when pressed. The buttons are filtered with a pi filter to minimize transient effects.

There are multiple options for which pin functions mapped and are generally assigned to PTx/GPIO but note that SW2 does allow mapping to WKPU37 (wakeup) signal on the MCU and SW1 does allow mapping to CMP0 (comparator) signal on the MCU. These pin mux settings could be configured for interesting software use cases.

Figure 25: SW1, SW2 User buttons

6.11 P10 - NFC Antenna

This two-pin connector is suitable for an ISO-14443 NFC antenna system. One is provided in your kit from AMOTECH

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Figure 26: P10 NFC antenna connector

6.12 PWM and GPIO headers P8A P8B

These 0.100" pin headers are available for experimentation with PWM signals and other GPIO.

6.12.1 RC-PWM

RC-PWM refers to radio control hobby style PWM signals. These are pulses between 1000 and 2000 msec. (The PWM channels that drive these pins are capable of faster and high-resolution timing and could be configured to drive a BLDC motor Gate driver directly.)

6.12.2 P8A, P8B connectors

P8A has intentionally been *physically* configured with the center pin as a common BEC power rail and the left pin as GND to allow RC hobby style RC servos or ESCs to plug in directly. Often one of the RC devices such as an ESC, can actually supply 5V BEC power to the other servos. An actual separate RC BEC may also be plugged in to provide independent power to the RC devices.
Refer to the schematics for further details. Note that there are no actual constraints on the PWM signal timings from the MCU.
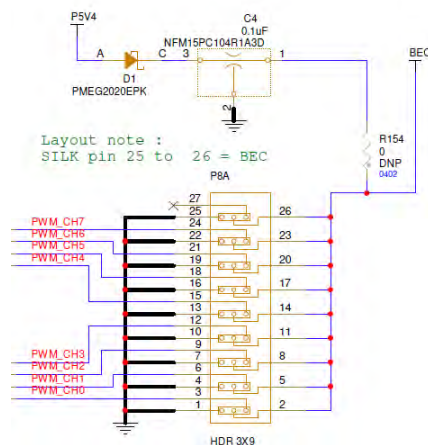

Figure 27: Typical RC servo

Figure 28: P8A pin header PWM (RC-PWM)

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P8B includes access to SPI4 interface, ADC channels and eight GPIOs. Reminder that these pins also will have alternative pin map assignments available. The ADC channels may be considered for use in motor control applications.
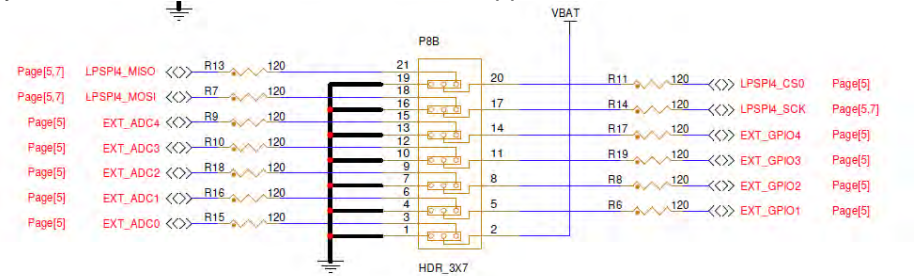

Figure 29: P8B pin header w/ SPI4, ADC and GPIO

6.13 R84 - Analog Potentiometer

R84 is a 10K potentiometer between 3V3 and GND and is connects to the net named ADC_POT0. This net then connects to pin 11 – PTE13/ADC1_S19. The potentiometer
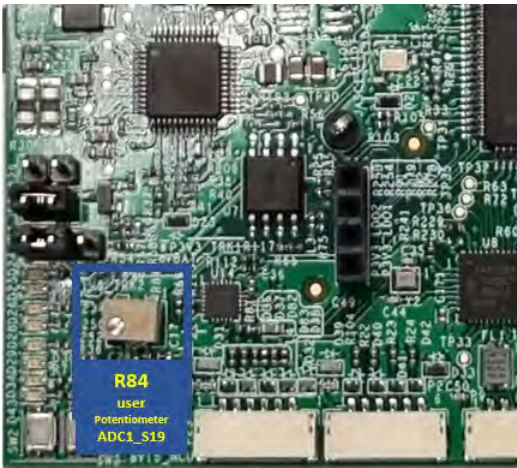

Figure 30: R84 User Potentiometer

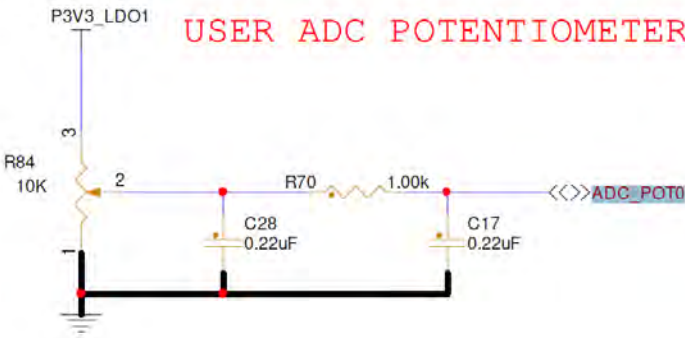was included for board test validation and can be repurposed for any user intent.

Figure 31: User Potentiometer Schematic

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7. Board status LEDs

The MR-CANHUBK344 has various LEDs to indicate status as shown in Figure 6. Under normal circumstances, the state of the LEDs should as indicate in the table below.

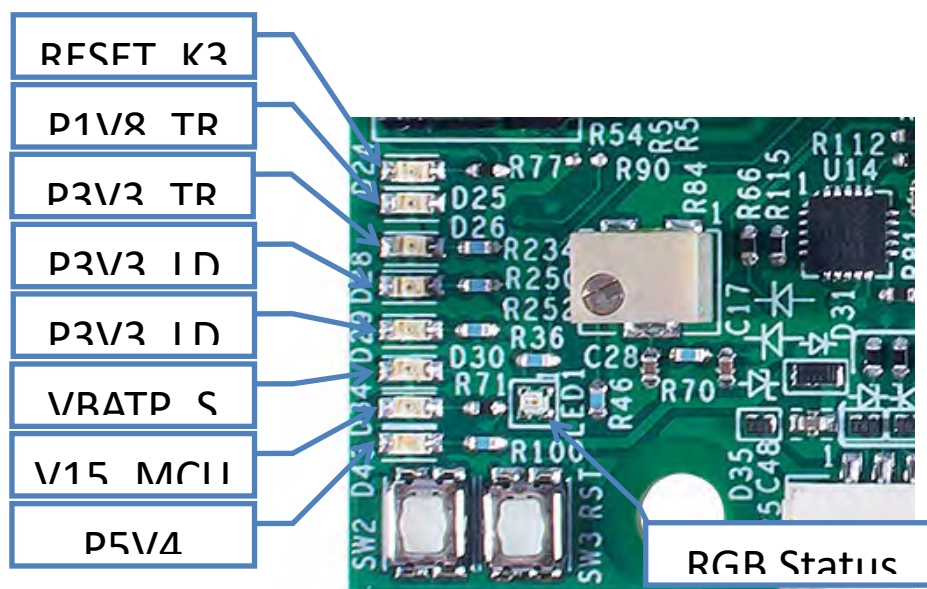| Dxx	LED Name	Normal State	Description
D24	RESET_K3	Off	Indicates if the S32K344 is in reset
D25	P1V8_TRK2	On	Indicates FS26 SBC 1V8_TRK2 status
D26	P3V3_TRK1	On	Indicates FS26 SBC 3V3_TRK1 status
D28	P3V3_LDO2	On	Indicates FS26 SBC 3V3_LDO2 status
D29	P3V3_LDO1	On	Indicates FS26 SBC 3V3_LDO1 status
D30	VBATP_SW	On	Indicates VBAT status
D34	V15_MCU	On	Indicates FS26 SBC V15 status
D43	P5V4	On	Indicates FS26 SBC P5V4 status
LED1	RGB Status led	Green	Controlled by the software, green indicates normal operation, blue indicates initialization, red indicates that an error has occurred.

Figure 32: Onboard LEDs description

Figure 33: Onboard LEDs

8. Legal information

8.1 Definitions

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