IoT-Engine Hardware White Paper

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IoT-Engine Hardware White Paper（Ver.1.00.00.B0）

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REVISION HISTORY

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01.00.00.B0	2016/05/26	-	Initial release	

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1. Overview of IoT-Engine

IoT-Engine is the standard development platform that can let products (things) to collaborate in the Internet and make appliances ready for the IoT (the Internet of Things). This is a development platform, but is reasonably small as shown in figure 1-1, and can be embedded into real devices. Standardization is done by the IoT Working Group of TRON Forum. The standardized portion will be made open to the public.
IoT-Engine is MPU-agnostic and semiconductor companies can create IoT-Engine with their own unique MPUs. IoT device makers, in turn, can use IoT-Engines that uses MPU suited for particular applications and develop products in a short time-to-market.

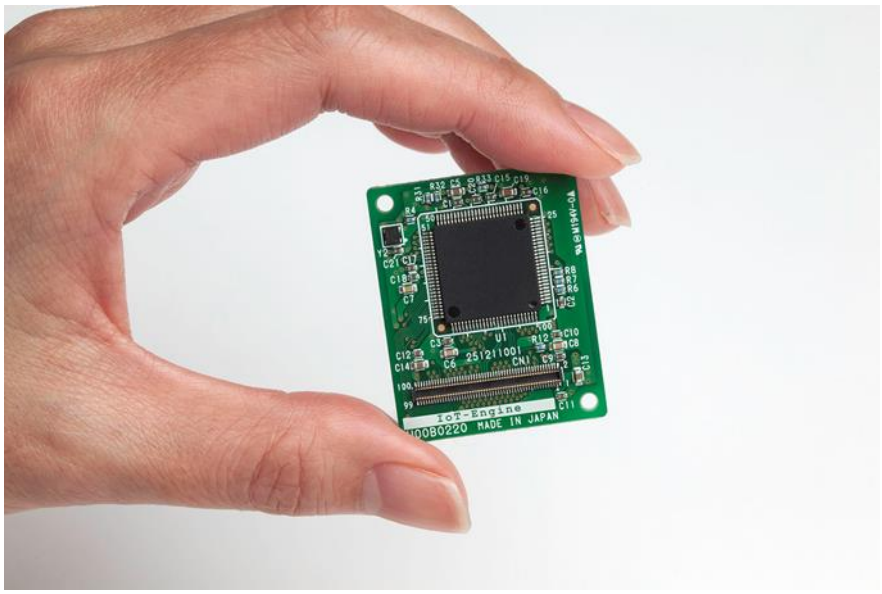

Figure 1-1 An example of IoT-Engine

IoT-Engine comes with wireless module to connect to the Internet. IoT-Engine uses energy-efficient IEEE 802.15.4 for wireless communication. IoT-Engine has adopted IPv6-compatible protocol over UHF-band with the communication speed of 100 - 400 kbps that complies with WPAN (Wireless Personal Area Network), a standard for short-distance wireless communication. Devices that use IoT-Engine connect to the Internet via a so-called 6LoWPAN border router which is reached by low-power short distance wireless communication as shown in figure 1-2. This border route plays the role of access point in the case of Wi-Fi.

Note: In figure 1-2, the 6LoWPAN boarder router connects to a Wi-Fi router via Wi-Fi, but there are 6LoWPAN border routers that connect to wirefull LAN.

IoT-Engine specifies that IEEE802.15.4 wireless function module as part of standard, and this module can be joined to the MPU module. Wireless function can be implemented as part of the MPU module, or MPU can implement the wireless function on its own. IEEE802.15.4 uses

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different frequencies in each country/region in the world, so replaceable wireless module can make the adoption of modules customized for each country's wireless regulations easy, and is convenient for development. Figure 1-3 shows an example of wireless module that is joined to MPU module.

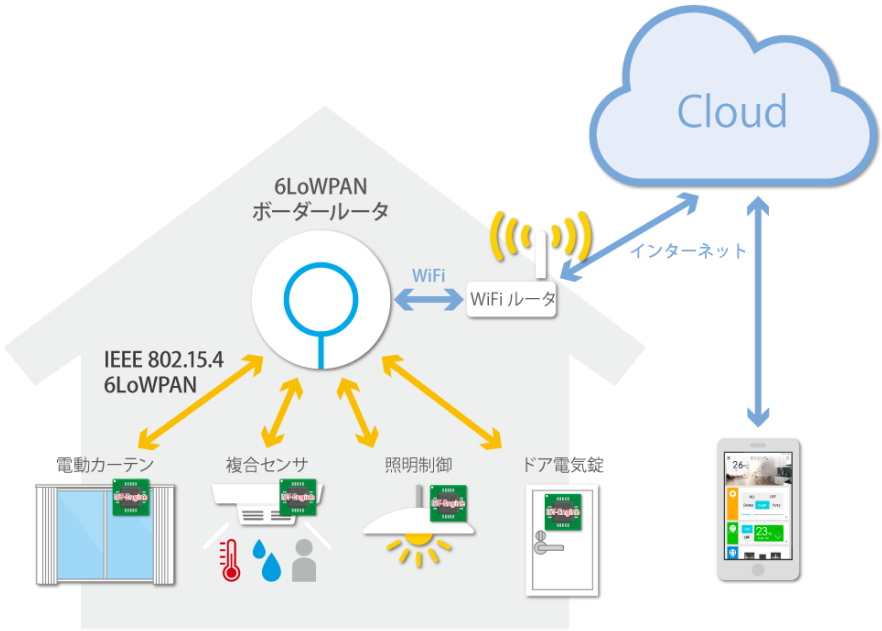

Figure 1-2 The overview of the connection between IoT-Engine and a 6LoWPAN border router

Figure 1-3 An example of wireless module that is joined to MPU module

IoT-Engine specifications include standards for hardware, wireless communication, and operating system, but they are not limited to them only. Rather, it includes the protocol between the Open IoT Platform, i.e., the IoT Aggregator and IoT-Engine compliant devices can collaborate with each other and can use various cloud services. As shown in figure 1-4, IoT-Engine compliant devices from different manufacturers can collaborate with each other. Between IoT-Engine and the cloud, the WPAN and the Internet are used. Since secure communication channel is established between IoT-Engine and the cloud, we can view the connection between the IoT-Engine and the cloud as direct. Access control to allow what users should do what on which devices is managed on the cloud.

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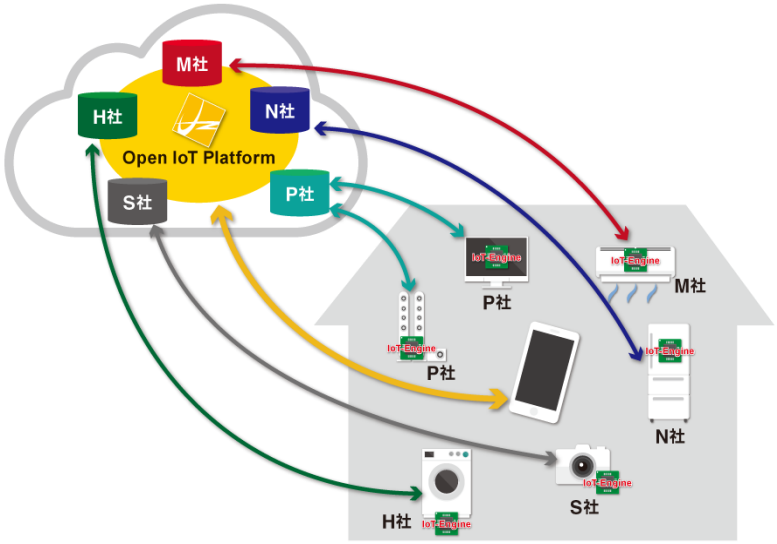

Figure 1-4 Device coordination by Open IoT Platform

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2. Hardware Specifications of IoT-Engine

2.1 Physical Form Factor of IoT-Engine Hardware

IoT-Engine standardizes the size and positions of board connectors and screw holes as in figure 2-1.

The board dimensions are not standardized. In figure 2-1, the sizes in () are for information purposes only and non-normative.

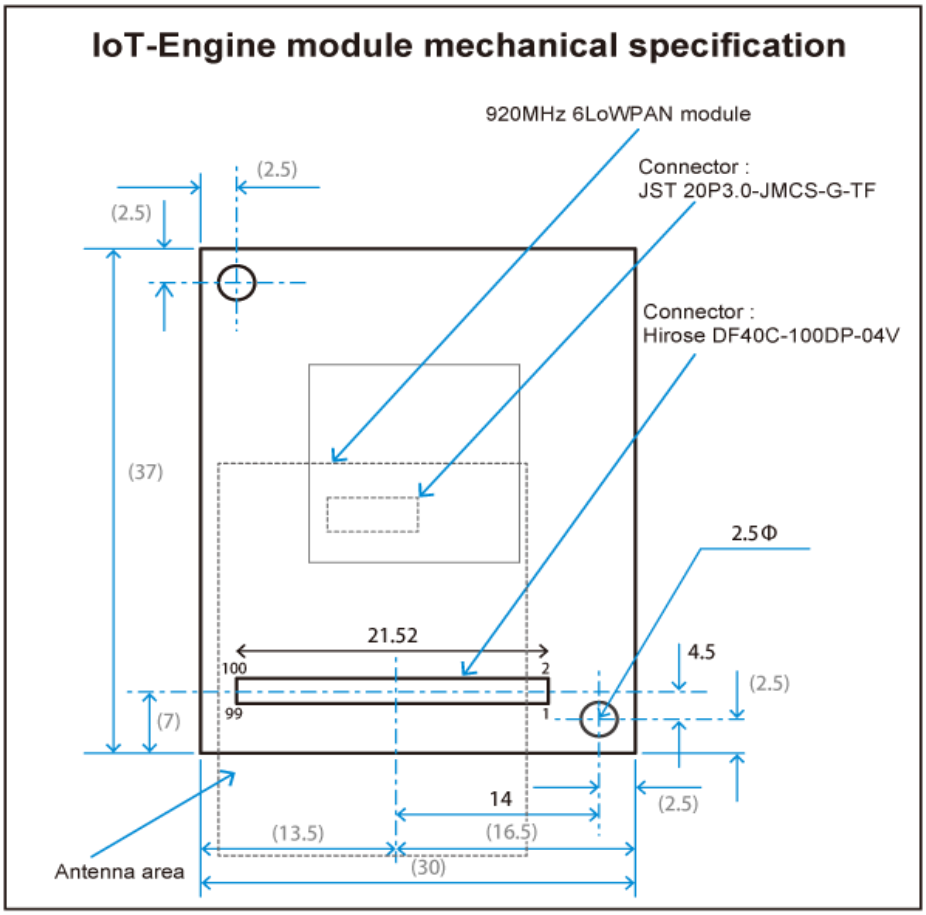

Figure 2-1 IoT-Engine module mechanical specification

A Wireless module can be connected to MPU board via small board, integrated in MPU-chip, or can be placed on MPU board. IoT-Engine uses IEEE 802.15.4 wireless communication channels of sub-GHz UHF or 2.4 GHz band. Sub-GHz UHF band uses different frequencies in each country/region in the world. IoT-Engine complies with 920 MHz ARIB T-108 in Japan.

The position of 920 MHz 6LoWPAN module in the case of separate wireless module is shown in dotted lines for information purpose only and non-normative. It is possible to implement the antennae that goes outside the IoT-Engine MUP board so that the antennae are not easily

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affected by the components on the board and printed wiring.

IoT-Engine uses Hirose DC40C-100DP-04V, a 0.4mm-pitch 100-pin connector that is mounted on MPU side of the board. The distance between vertical center line and the screw hole above the connecter in the figure is 4.5 mm. The distance between the horizontal center line and screw hole is 14 mm. The screw hole is 2.5φ. The connector signal near the fixed screw position in the standard is designated as signal pin No. 1. The odd-numbered pins are on the side of the edge connector of the board.

In the case of separate wireless module, a designer is advised to place the wireless module on the other side of the connector. If the antennae is placed on the board, it is possible to implement the antennae that goes outside the IoT-Engine MPU board.
As an example of wireless module which can be used in Japan, IoT-Engine equipped with UC Technology U02X0014 (RohmBP35A1that uses IoT-Engine connector firmware) uses JST 20P 3.0-JMCS-G-TF as its connector.

2.2 Signal Assignment

The signal assignment of IoT-Engine 100pin connector is shown in Table 2-1. The left side of the table is the edge side of the board. The hatched SIGNAL ASSIGNMENT names are Arduino-compatible I/O signals . These signals are sent to the IoT-Engine development board as Arduino-compatible I/O connector, so many commercially available sensors, interface boards, and extension boards that can connect to the I/O connector of Arduino, etc. can be utilized.

Note: The field of T-Car in figure 2-1 shows the usage of the signal for T-Car , a model car which uses IoT-Engine development board and the interface signal that can connect to sensors. These signals need to be assigned when T-Car is used.

Signal assignments are classified according to types as shown in the TYPE field of the connector signal table: P for digital port, S for multifunction serial port, A for analog port, etc. The latest MPU can overlay different functions on the same I/O pins by programming, and different members of an MPU family often has different number of pins and different I/O functions. So it is impossible to perform common signal assignment for all the MPUs. However, we can follow the guideline in table 2-2, and use the preferred pin (with smaller pin number) in the same type first when we assign signals to reach a very general rough compatibility.

Type U stands for user's custom signal assignment, and you do not pay attention to the compatibility issue for those pins. Type KEY for system use can specify the mode of the system power supply in three mode: open, pull-up, and pull-down. Type R is used when RF module has a controller CPU, and is used for assigning the mode signal and debug signal to it.

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			EDGE-SIDE		OUT-SIDE
T-Car	TYPE		SIGNAL ASIGNMENT		PIN#
	VBATT			VBATT	1
MicroSD-CD	GPIO/INT	[S3]	-WKUP	1	3
Photo-sensor(speed)			SCK	2	5
USB Vbus			TXD	3	7
I2C Enable			RXD	4	9
DIP-SW			GPIO	5	11
	UART	[P0]	GPIO, IO7(IO)	6	13
			RXD, IO0(RX)	7	15
			TXD, IO1(TX)	8	17
	GND			GND	19
	PWM	[P1]	-INT, IO2(**INT**)	1	21
			GPIO, IO4(IO)	2	23
			PWM, IO3(PWM/INT)	3	25
			PWM, IO5(PWM)	4	27
			PWM, IO6(PWM)	5	29
motor PWM		[P4]	PWM	6	31
motor PWM			PWM	7	33
Analog Speaker			PWM	8	35
	GND			GND	37
	SPI	[S0]	MISO, IO12	1	39
			MOSI, IO11	2	41
			CLK, IO13	3	43
			SS, IO10	4	45
	GND			GND	47
		[P2]	PWM, IO9(PWM)	2	49
			GPIO, IO8(IO)	1	51
	GND			GND	53
Pin Header	RTC	[RS]	32kHz-IN	14	55
Jumper Pin			32kHz-OUT	13	57
Front LED				12	59
Front LED				11	61
LED			-RESET_OUT	10	63
LED			-WKUP	9	65
	I2C	[P3]	SDA	8	67
			SCL	7	69
	ANALOG	[A1]	AIN, A3	6	71
			AIN, A4	5	73
			AIN, A5	4	75
		[A0]	AIN, A0	3	77
			AIN, A1	2	79
			AIN, A2	1	81
	GND			AGND	83
-	RF CONTROL /DEBUG	[R1]	RF_SWCLK	6	85
-			RF_SWDIO	5	87
-			RF_SWO	4	89
-		[R2]	RF_NMI	3	91
-			RF_RESET	2	93
-			RF_MODE	1	95
	KEY	[KEY]		KEY2	97
				KEY1	99

Arduino I/O connector compatible signals

Connector : HIROSE DF40C-100DP-0.4V

Table 2-1 IoT-Engine 100pin connector signal assignment (Part 1)

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IN-SIDE

PIN#	SIGNAL ASIGNMENT		TYPE		T-Car
2	D3.3V		D3.3V		
4	D3.3V				
6	1	USER-OPT1	[U0]	USER OPTION	ACC-sensor INT
8	2	USER-OPT2			ACC-sensor SDA (I2C)
10	3	USER-OPT3			ACC-sensor SCL (I2C)
12	4	USER-OPT4	[U1]		-
14	5	USER-OPT5			Jumper Pin
16	6	USER-OPT6			Jumper Pin
18	GND		GND		
20	1	SWCLK	[JS]	DEBUG	SWCLK (JTAG)
22	2	SWDIO			SWDIO (JTAG)
24	3	SWO			-
26	4	Vref			Vref
28	5	-NMI	[Q0]	NMI/INT	Push-SW
30	6	-INT			Push-SW
32	7	-INT			Push-SW
34	8	-INT	[Q1]		USB-D+(UP)
36	9	-INT			Jumper Pin
38	10	-INT			Digital Speaker
40	11	SS	[S1]	SD	SD_CS
42	12	MISO			SD_MISO
44	13	MOSI			SD_MOSI
46	14	CLK			SD_CLK
48	GND		GND		
50	1	D+	[USB]	USB	D+ (USB)
52	2	D-			D- (USB)
54	GND		GND		
56	4	GPIO	[S4]	GPIO	Photo-sensor(Line1)
58	3	GPIO			Pin Header
60	2	GPIO			Photo-sensor(Line2)
62	1	GPIO			USB Status
64	GND		GND		
66	8	-RESET	[MS]	SYSTEM	RESET
68	7	MODE0			MD0
70	6	MODE1			MD1
72	5	CTS	[S2] or [A5]	UART	USB-UART-RTS
74	4	RXD			USB-UART-TXD
76	3	TXD			USB-UART-RXD
78	2	SCK			Pin Header
80	1	RTS			USB-UART-CTS
82	AGND		GND		
84	8	AI	[A2]	ANALOG	Analog-SW
86	7	AI			Analog-SW
88	6	AI	[A3]		Temp-sensor
90	5	AI			Pin Header
92	4	AI			Pin Header
94	3	AI	[A4]		Mic
96	2	AI			Range-sensor
98	1	AI			Light-sensor
100	AVCC		AVCC		

Connector HIROSE DF40C-100DP-0.4V

Table 2-1 IoT-Engine 100pin connector signal assignment (Part 2)

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2.3 Guidelines for connector signal assignment

Utilizing the features of the on-board MPU, the priority of signal assignment is specified to ensure the minimum-level of compatibility. Table2-2 shows the categorized signals to be assigned to each group. Regarding the compatibility, the items with ★ are basically compatible with the signals in the table. JS and MS depend on MPU.

Table 2-2 Guidelines for connector signal assignment

Digital Port

TYPE	
[P0] ★	Arduino I/O-compatible UART
[P1] ★	Arduino I/O-compatible -INT/IO/PWM
[P2]	Arduino I/O-compatible -INT/IO
[P3] ★	Arduino I/O-compatible I^2C
[P4]	General-purpose I/O, PWM

Analog Port

TYPE	
[A0] ★	Arduino I/O-compatible AI (analog input)
[A1]	Arduino I/O-compatible AI (analog input)
[A2]	AI (analog input)
[A3]	AI (analog input) or I^2C
[A4]	AI (analog input) or AO (analog output)
[A5]	AI (analog input) [S2] shared area

Multifunction/Serial Port (USART: Can be used as SPI/UART/I^2C.)

TYPE	
[S0] ★	Arduino I/O-compatible SPI
[S1]	SPI for SD card
[S2] ★	UART (for debug) [A5] shared area
[S3]	UART
[S4]	General-purpose I/O

User I/O (user custom signal)

TYPE	
[U0]	User I/O (UART is added)
[U1]	User I/O

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For System Use

TYPE	
[JS]	For debugger connection
[Q0] ★	- NMI and interrupt for standard systems
[Q1]	Interrupt for USB/SD or GPIO
[MS]	- RESET and mode signal
[RS]	RTC and signal for power management
[KEY] ★	Mode specification of power-supply voltage, etc. (See the appendix for the details)

RF Module Custom Signal

TYPE	
[R0]	Mode signal, etc. for RF
[R1]	Debug signal for RF

Mode specification of power-supply voltage, etc.

KEY1	**KEY2**	**Vcc voltage**	**Other**
OPEN	OPEN	3.3 V	
Pull Down	OPEN	2.5 V	
OPEN	Pull Down	1.8 V	
Pull Down	Pull Down	5 V	
OPEN	Pull Up	3.3 V	The maximum voltage of I/O device is 5 V.
Pull Up	OPEN	3.3 V	w/o AI (analog input) signal
Pull Down	Pull Up	2.5 V	w/o AI (analog input) signal
Pull Up	Pull Down	1.5 V	w/o AI (analog input) signal
Pull Up	Pull Up	reserve	Reserve

“The maximum voltage of I/O device is 5 V.” in Mode specification of power-supply voltage, etc. can identify by using this KEY when the power-supply system of MPU is 3.3 V, but the I/O can connect 5 V system. “w/o AI signal” has A0 in the field with★ to ensure the compatibility. Identification can be performed by using the KEY when some MPU does not have analog input.

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2.4 Variations of signal assignment

The followings are examples of various assignments to meet requirements such as "I^2S, CAN, etc. need to be assigned" and "If the debug signal is different from Table 2-1, where can it be assigned?" according to the type of on-board MPU.

The even-numbered IoT-Engine connector signals are application signals of the devices mainly controlled by IoT-Engine. The odd-numbered signals are the ones of the MPU system of IoT-Engine which are used for debugging and or connecting the programs and data storage. It is **recommended** to assign signals by considering these grouping approach.

SPI signal	I^2C signal	I2S signal	TYPE	PIN	SIGNAL
S3-INT	S3-INT	I2SWS	S3	3	-WKUP
S3-SCLK	S3-SCL	I2SCK	S3	5	SCK
S3-MOSI	S3-SDA	I2SDO	S3	7	TXD
S3-MISO		I2SDI	S3	9	RXD
S3-SS			S3	11	GPIO

DA signal			TYPE	PIN	SIGNAL
DA0			P4	35	PWM /DAC

USART signal	I^2C signal	SIM card signal	TYPE	PIN	SIGNAL
S1-RXD	S1-INT	IC_CLK	S1	39	MISO, IO12
S1-TXD	S1-SDA	IC_VCC	S1	41	MOSI, IO11
S1-SCK	S1-SCL	IC_VPEN	S1	43	CLK, IO13
		IC_RST	S1	45	SS, IO10
			GND	47	GND
		IC_DATA	P2	49	PWM, IO9 (PWM)
		IC_CIN	P2	51	GPIO, IO8 (IO)

USART signal	I^2C signal		TYPE	PIN	SIGNAL
A1-RXD	A1-INT		A1	71	AIN, A3
A1-TXD	A1-SDA		A1	73	AIN, A4
A1-SCK	A1-SCL		A1	75	AIN, A5

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RF SPI signal	RF JTAG signal		TYPE	PIN	SIGNAL
RF_SCLK	RF_TCK		R1	85	RF_SWCLK
RF_SS	RF_TMS		R1	87	RF_SWDIO
RF_MOSI	RF_TDO		R1	89	RF_SWO
RF_MISO	RF_TDI		R2	91	RF_NMI
RF_RESET	RF_TRST		R2	93	RF_RESET
RF_MODE	RF_MODE		R2	95	RF_MODE

EEPROM signal			TYPE	PIN	SIGNAL
KEY-SDA	Pull-Up requirement		KEY	97	KEY2
KEY-SCL	Pull-Up requirement		KEY	99	KEY1

USART signal	I^2C signal		TYPE	PIN	SIGNAL
U0-RXD	U0-INT		U0	6	USER-OPT1
U0-TXD	U0-SDA		U0	8	USER-OPT2
U0-SCK	U0-SCL		U0	10	USER-OPT3

USART signal	I^2C signal	DA signal	TYPE	PIN	SIGNAL
	U1-SCL	DA1	U1	12	USER-OPT4
U1-TXD	U1-SDA		U1	14	USER-OPT5
U1-RXD			U1	16	USER-OPT6

cJTAG signal	JTAG signal		TYPE	PIN	SIGNAL
	(RTCK)		U1	12	USER-OPT4
	TRST		U1	14	USER-OPT5
	TDI/P_MISO		U1	16	USER-OPT6
			GND	18	GND
TCK	TCK/P_SCLK		JS	20	SWCLK
TMS	TMS/P_SS		JS	22	SWDIO
	TDO/P_MOSI		JS	24	SWO
	Vref		JS	26	Vref (Pull-Up)

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CMSIS signal	CMSIS signal		TYPE	PIN	SIGNAL
<GND>			U1	12	USER-OPT4
CMSIS_DAP+			U1	14	USER-OPT5
CMSIS_DAP-			U1	16	USER-OPT6
			GND	18	GND
	(CMSIS_DAP+)		JS	20	SWCLK
	(CMSIS_DAP-)		JS	22	SWDIO
	(<GND>)		JS	24	SWO
	Switching signal	Drive to [L]	JS	26	Vref (Pull-Up)

USART signal	I^2C signal		TYPE	PIN	SIGNAL
S0-RXD	S0-INT		S0	42	MISO
S0-TXD	S0-SDA		S0	44	MOSI
S0-SCK	S0-SCL		S0	46	CLK

UART Signal	CAN Signal	RS485 Signal	TYPE	PIN	SIGNAL
TXD	CAN_H	D+	USB	50	D+
RXD	CAN_L	D-	USB	52	D-

USART signal	I^2C signal	SPI signal	TYPE	PIN	SIGNAL
S4-RXD	S4-INT	S4-MISO	S4	56	GPIO
S4-TXD	S4-SDA	S4-MOSI	S4	58	GPIO
S4-SCK	S4-SCL	S4-SCLK	S4	60	GPIO
		S4-SS	S4	62	GPIO

on board LED signal	I2S signal		TYPE	PIN	SIGNAL
	I2SDI		S4	56	GPIO
LED-A	I2SDO		S4	58	GPIO
LED-B	I2SCK		S4	60	GPIO

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	I2SWS		S4	62	GPIO

BOOT signal			TYPE	PIN	SIGNAL
(BOOT)			MS	68	MODE0

SPI signal	USART signal	SIM card signal	TYPE	PIN	SIGNAL
S2-SS	S2-RTS	IC_CLK	S2	72	CTS
S2-MOSI	S2-TXD	IC_VCC	S2	74	RXD
S2-MISO	S2-RXD	IC_VPEN	S2	76	TXD
S2-SCLK	S2-SCK	IC_RST	S2	78	SCK
S2-INT	S2-CTS	IC_DATA	S2	80	RTS
			GND	82	AGND
		(IC_CIN)	A2	84	AI

USART signal	I^2C signal	UART Signal	TYPE	PIN	SIGNAL
	S2-SDA		S2	76	TXD
	S2-SCL		S2	78	SCK
	S2-INT		S2	80	RTS
			GND	82	AGND
	A2-SDA		A2	84	AI
	A2-SCL		A2	86	AI
S5-RXD	A3-INT		A3	88	AI
S5-TXD	A3-SDA		A3	90	AI
S5-SCK	A3-SCL		A3	92	AI
			A4	94	AI
		S6-RXD	A4 (S6)	96	AI
		S6-TXD	A4 (S6)	98	AI

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