Advanced Instrument Cluster V2

Hardware Design Document

Introduction

This Hardware Design Document serves as a technical blueprint for the Advanced Instrument Cluster board. This document is intended to describe the hardware system architecture and the design details.

Target Device

RH850/D1M1A

ISL78206AVEZ

ISL78310ARAJZ

IDTQS3VH16233PAG8

ISL12022MAIBZ

ISL76683

RAA279972

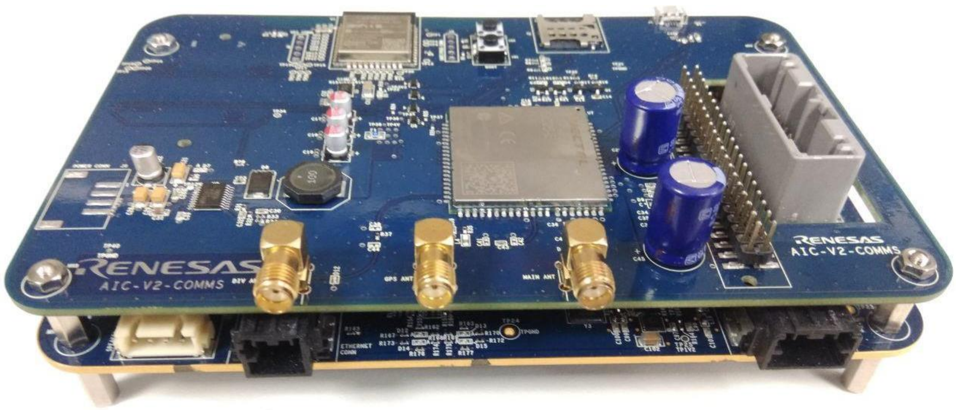

Figure 1-1 Renesas AICV2 Board

Figure 1-2 Renesas AICV2 Main Board

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1. Architecture

Advanced Instrument Cluster is a digital cluster which displays the cluster elements on a TFT display and exchanges the data over cloud using Wifi/LTE. It also interfaces to AHL camera reference design RTKA279971ZB0000BU and displays the captured video over display.

The AIC-V2 board design is based on high end automotive microcontroller RH850/D1M1A MCU suitable for instrument cluster supporting higher end 2D and 2.5D drawing. This board is designed as a single board approach with one expansion connector for future addition of various connectivity options via communication card.

AIC-V2 board includes the RH850/D1M1A Microcontroller (R7F701461 QFP), which is equipped with an RH850 Family G3M CPU core operating at a frequency of 240MHz. The MCU includes 4MB program flash, 512KB RAM and 32x1.2MB Video RAM. This MCU belongs to RH850D1x series which is dedicated for instrument cluster-based application It has dedicated 2D GPU Engine, Sprite Engine, HUD Warping Engine, JPEG unit and RAM wrapper. It has stepper motor control unit, Timers, ADC and external memory interfaces too.

The Cluster board has ISL78206 Buck and ISL78310 LDO in power section. It also has ISL76683 Light sensor and ISL12022 RTC. It interfaces rear camera using RAA279972. It has an expansion connector to connect with communication board which has all wireless communication modules (Wifi/BLE/GPS/GSM) to exchange data over cloud.

Protection for Over-Current, Over-Voltage, Under-Voltage precautions are implemented. Interfaces such as CAN-FD, LIN, UART such as are also integrated in the design.

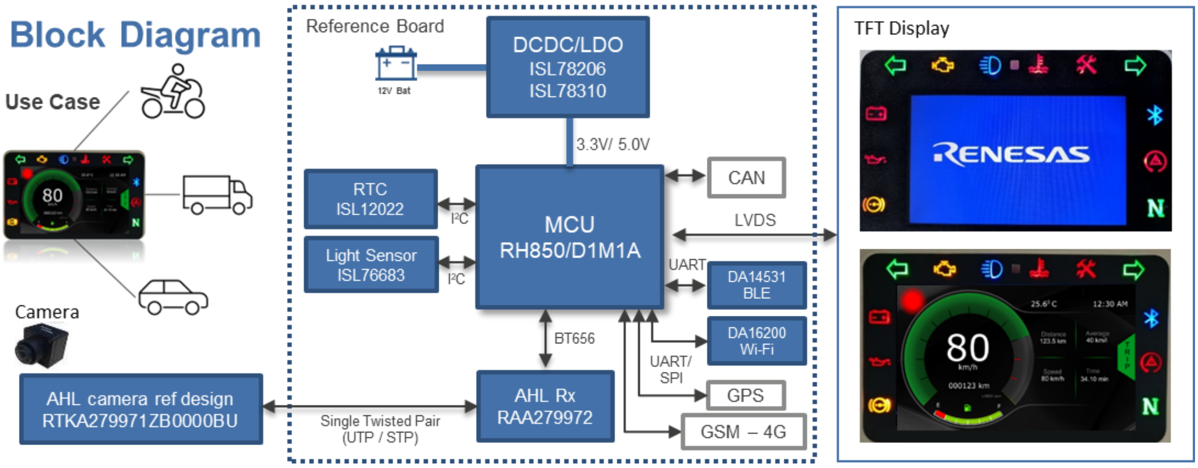


Figure 1-1 - AICV2 Block Diagram

2. Hardware Design

The Hardware is categorized based on the function:

1. **Power Supply section**
2. **Oscillator**
3. **Microcontroller Function Mapping**
4. **TFT LVDS Display**
5. **Memories**
6. **Communication interfaces**
7. **Sensors, Analog, Indicators (Tell-Tale LEDS, Indication LEDs).**
8. **Analog Camera**
9. **Stepper Motor connector**
10. **Audio**
11. **RTC**
12. **Ambient Light Senor**
13. **Accelerometer**
14. **Main Connector**
15. **Communication Connector**

2.1 Power Supply Section

There are four voltage Rails: 5V, 3.3V, 2.5V and 1.2V. Most of the circuits on the board operate at 3.3v.

Following is the diagram of device power tree,

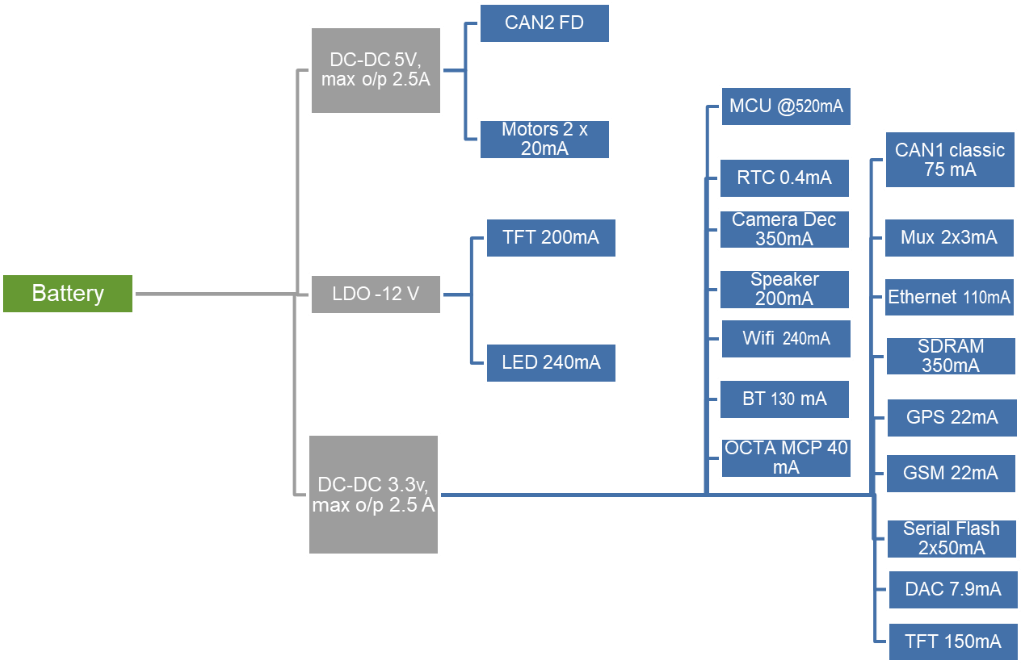


Figure 2-1 System Power Tree

2.1.1 DC-DC 12v to 3.3.v Power Supply

The 3.3v voltage rail is down converted using the DCDC converter “ISL78206AVEZ” from 12V DC input fed in via main connector (J3).

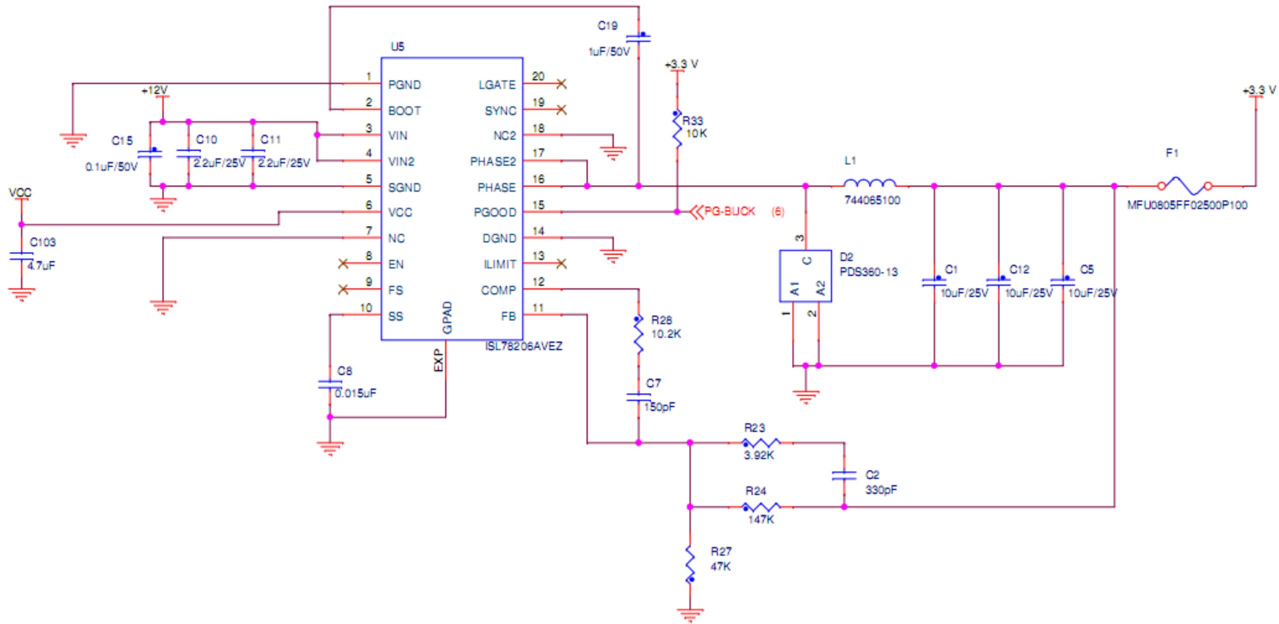


Figure 2-2 3.3V Power Supply Circuit

2.1.2 LDO circuits

5V supply rails are down converted from 12V DC using fixed LDO “**NCV5500DT50RKG**”. The LDO supports enabling the output voltage via external control signal. The enable pin is controlled by an MCU GPIO. The following image depicts the 5V power supply circuit.

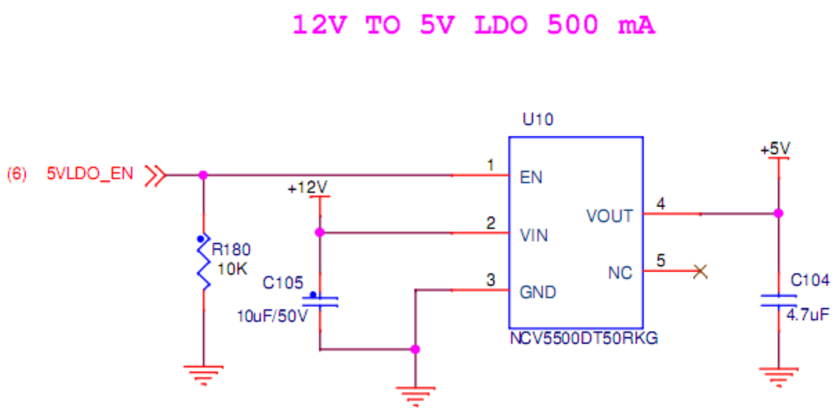


Figure 2-3 5V Power Supply Circuit

2.5V and 1.2V supply rails are down converted from 3.3V DC using adjustable LDO “ISL78310ARAJZ-T7A”. The following image depicts the 2.5V power supply circuit.

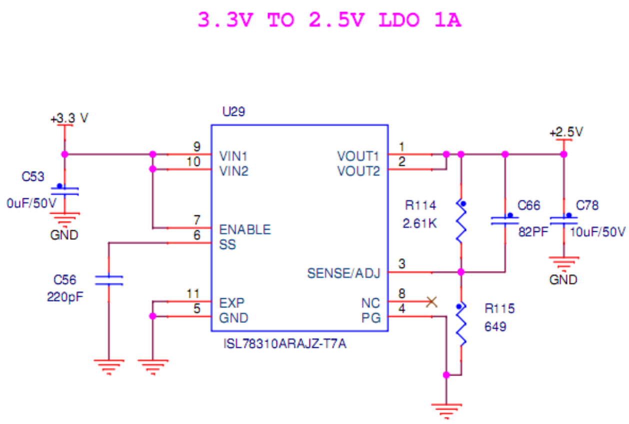


Figure 2-4 2.5V Power Supply circuit

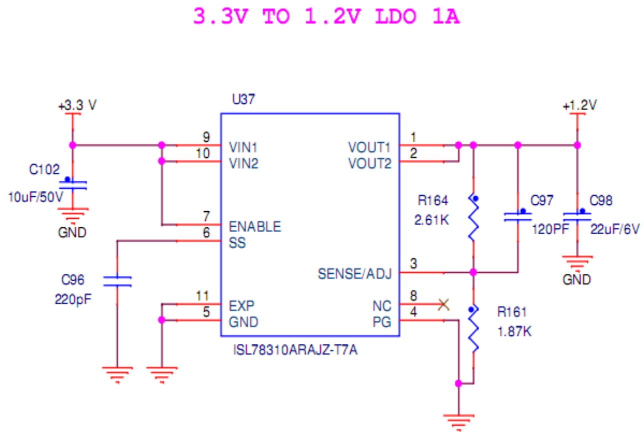


Figure 2-5 1.2V Power Supply Circuit

The following table describes the power profile of the AIC-V2 board,

S.No	2.5V Power Rail	Quantity	Max Current (A)	Total amps
1	Headphone/LM49450SQ	1	0.01	0.01
2.5V POWER CONSUMPTION (AMPS)				**0.01**
			Load on 3.3V power supply	**0.007575758**
			80% EFFICIENCY	**0.009090909**

S.No	1.2V Power Rail	Quantity	Max Current (A)	Total amps
1	Camera/RAA279972A	1	0.5	0.5
1.2V POWER CONSUMPTION (AMPS)				**0.5**
			Load on 3.3V power supply	**0.181818182**
			80% EFFICIENCY	**0.218181818**

S.No	5V Power Rail	Quantity	Max Current (A)	Total amps
1	Stepper motor	2	0.08	0.16
5V POWER CONSUMPTION (AMPS)				**0.16**
			Load on 12V power supply	**0.066666667**
			70% EFFICIENCY	**0.086666667**

S.No	Part	3.3V Power Rail	Quantity	Max Current (A)	Total amps
1	MCU	RH850/D1M1A (R7F701461)	1	0.52	0.52
2	Voltage monitor	BD45271G-TR	1	0.00001	0.00001
3	RTC	ISL12022MAIBZ	1	0.001	0.001
4	Quad Flash	MX25L25735FZ2I-10G	2	0.025	0.05
5	Octa MCP	MX65L12A64AA	1	0.1	0.1
6	Accelerometer	ADXL343BCCZ-RL7	1	0.00014	0.00014
7	SDRAM	MT48LC4M32B2P-6A XITL TR	1	0.32	0.32
8	CAN transceiver	SN65HVD230QDR	1	0.048	0.048
9	Isolated CAN-FD Transceiver	ADM3050EBRIZ	1	0.075	0.075
10	LCD	HSD050JDW2-E00/LCD	1	0.15	0.15
11	Multiplexer	IDTQS3VH16233PAG8	1	0.003	0.003
12	IO expander	TCA9539QPWRQ1	1	0.01	0.01
13	Speaker Output	LM49450SQ/NOPB	1	0.03	0.03
14	Camera Decoder	RAA279972A	1	0.15	0.15
15	ALS	ISL76683	1	0.0004	0.0004
16	Ethernet Transceiver	DP83TC811RWRNDTQ1	1	0.022	0.022
17	2.5V LDO	2.5V POWER CONSUMPTION	1	0.009090909	0.009090909
18	1.2V LDO	1.2V POWER CONSUMPTION	1	0.218181818	0.218181818
3.3V POWER CONSUMPTION (AMPS)					**1.706823**
			Load on 12V power supply		**0.469376**
			85% EFFICIENCY		**0.552207**

S.No	Part	12V Power Rail	Quantity	Max Current (A)	Total amps
1	3.3V DCDC	3.3V Power Rail	1	0.552207	0.552207
2	5V LDO	5V Power Rail	1	0.086666667	0.086666667
3	LED backlight driver	LP8862QPWPRQ1	1	0.015	0.015
4	LCD backlight	HSD050JDW2-E00/Backlight	1	0.38	0.38
5	Tell-Tale LEDS	LED	12	0.03	0.36
12V POWER CONSUMPTION (AMPS)					**1.393874**

Table 1 Current profile

2.2 Oscillator

RH850/D1M1A MCU supports two inbuilt oscillators namely Main oscillator (MainOsc) and Sub oscillator (SubOsc). In this design, main oscillator is selected as the clock source where the sub oscillator is disabled. The main oscillator can generate clock at frequency between 8 to 16MHz. The following image is the block diagram of MCU clock controller.

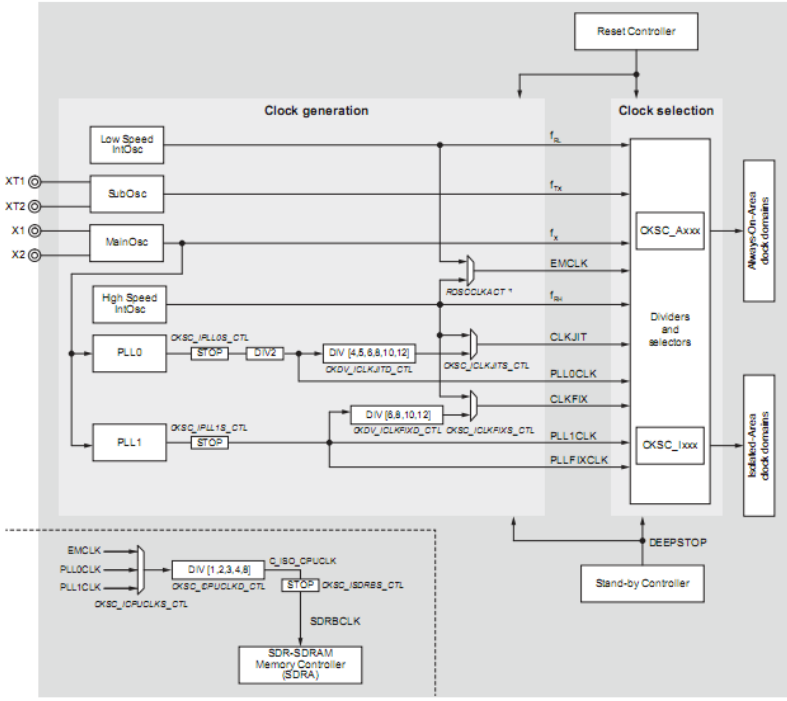


Figure 2-6 MCU clock controller Block diagram

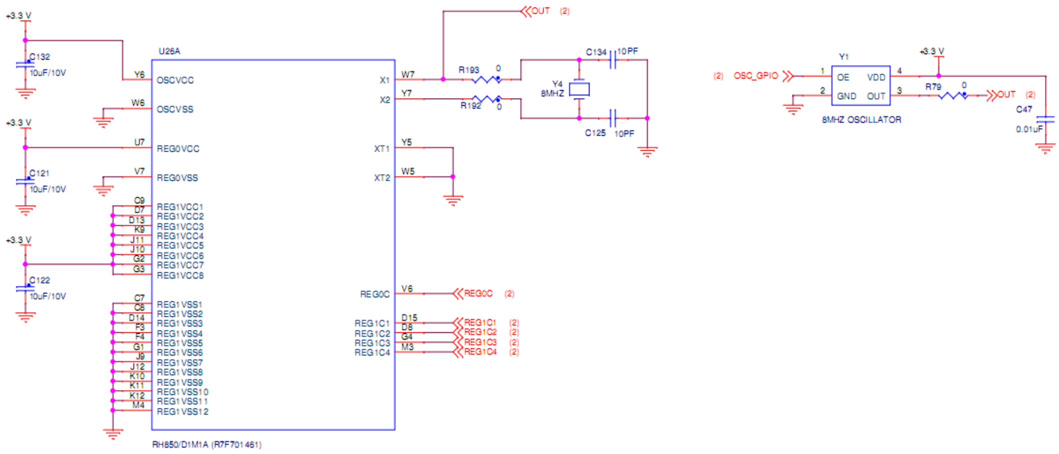


Figure 2-7 Crystal Oscillator Circuit

2.3 TFT LVDS Display

AIC-V2 board supports 5-inch LVDS TFT display. The TFT display is driven by the Video Data Controller (VDCE) of the MCU. Other TFT control pins such as scan direction, reset and standby are controlled by the GPIOs. I2C interface is available for internal TFT register configuration.

The TFT display has a backlight unit of 14 LEDs. The backlight LEDs are controlled using low-EMI two channel automotive LED driver “LP8862QPWPRQ1”. The brightness of the TFT is controlled via PWM signal. The following image depicts PWM based LED backlight control circuit.

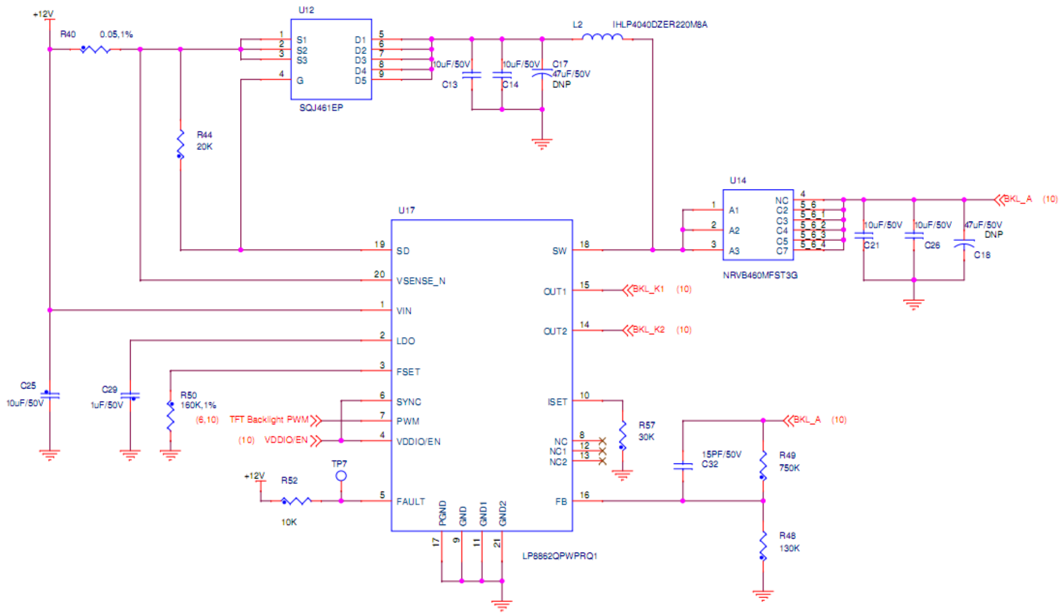


Figure 2-8 Backlight LED controller circuit

External display is interfaced via 50-pin FPS connector "J6". The following table describes the pin details of the FPS connector (J6).

Pin Number	Pin name	Pin description
1	BKL_K1	Backlight cathode
2	BKL_K2	Backlight cathode
3	NC	No connect
4	BKL_A	Backlight anode
5	BKL_A	Backlight anode
6	NC	No connect
7,8,9,12, 15, 18, 21, 24, 27, 30, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43	GND	Ground
10	SDA	I2C SDA
11	SCL	I2C SCL
13	OLDI0_CH4_P	Channel 4 Positive LVDS differential data input
14	OLDI0_CH4_N	Channel 4 Negative LVDS differential data input
16	OLDI0_CH3_P	Channel 3 Positive LVDS differential data input
17	OLDI0_CH3_N	Channel 3 Negative LVDS differential data input
19	OLDI0_CH2_P	Channel 2 Positive LVDS differential data input
20	OLDI0_CH2_N	Channel 2 Negative LVDS differential data input
22	OLDI0_CH1_P	Channel 1 Positive LVDS differential data input
23	OLDI0_CH1_N	Channel 1 Negative LVDS differential data input
25	OLDI0_CH0_CLKP	Positive LVDS differential clock input
26	OLDI0_CH0_CLKN	Negative LVDS differential clock input
28	TFT_RESET	TFT Reset output
29	TFT_STANDBY	TFT standby mode enable output
31	TFT_Direction Left/Right	Left to right scan direction enable
32	TFT_ Direction Up/Down	Up to down scan direction enable
44	NC	No connect
45	+3.3V	3.3V power supply output
46	+3.3V	3.3V power supply output
47	+3.3V	3.3V power supply output
48	NC	No connect
49, 50	GND	Ground

Table 2 TFT LED connector Pin details

2.4 Memories

AIC-V2 board include below memories interfaced with RH850D1M1A:

1. SDRAM
2. Serial Flash

2.4.1 SDRAM

AIC-V2 board includes 128Mb SDRAM. The SDRAM is connected to the MCU via SDRA interface supporting 32 data bits and 12 address bits.

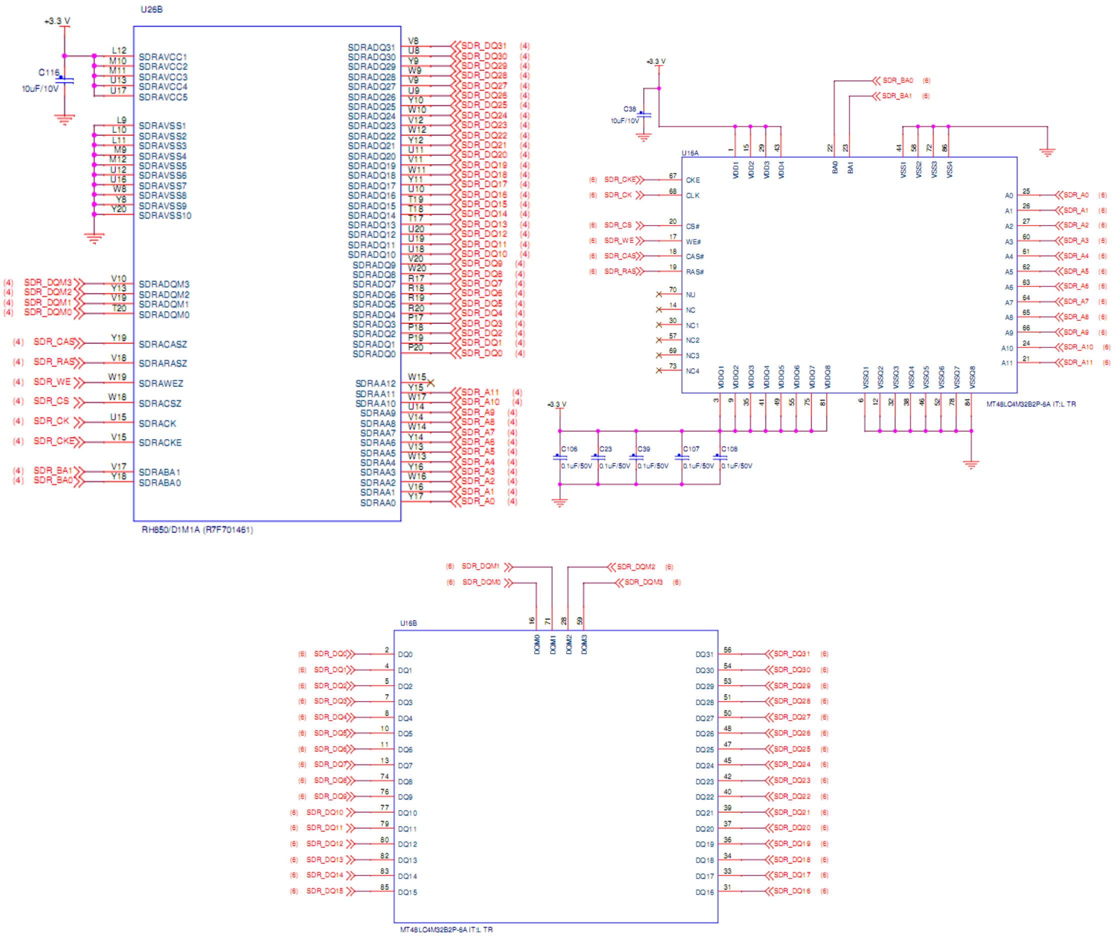


Figure 2-9 SDRAM circuit

2.4.2 Flash Memory

AIC V2 board supports two Quad IO flash memories multiplexed with Octa IO MCP. The flash memory is connected to the MCU via SFMA0IOx0 and SFMA0IOx1 interface. SFMA interface supports both QUAD IO mode and Octa IO mode.

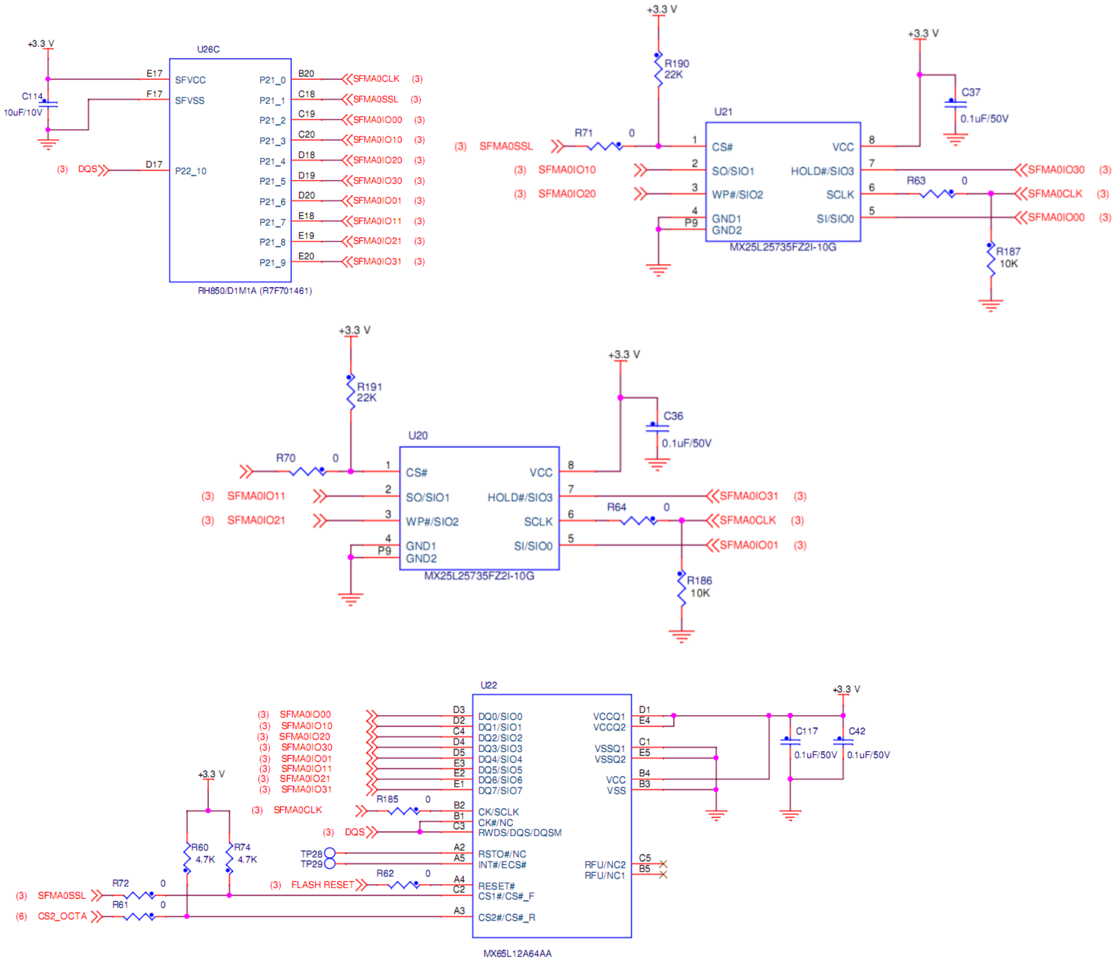


Figure 2-10 Flash memory & MCP circuit

MX65L12A64AA is a multi-chip package which includes 512Mb OctaFlash and 64Mb OctaRAM. It supports single I/O and Octa I/O protocol with DTR mode. It can operate at 133MHz frequency in both single and Octa I/O mode. It has equal sectors with 4K byte each or equal blocks with 64K byte each where any block can be erased individually.

Either two quad IO flash memories “MX25L25735FZ2I-10G” or Octa IO MCP “MX65L12A64AA” can be used at a time. Resister based configuration is provided on the board for selecting memories. The following are the two different resistor configurations.

1. To select two Quad IO flash memory
a. Place resistors “R71”, “R190”, “R63” and “R187” to select flash memory IC “U21”
b. Place resistors “R70”, “R191”, “R64” and “R186” to select flash memory IC “U20”
c. Remove “R185”, “R72”, “R61”, “R60” and “R74” to deselect MCP IC “U22”
2. To select Octa MCP
a. Remove resistors “R71”, “R190”, “R63” and “R187” to select flash memory IC “U21”
b. Remove resistors “R70”, “R191”, “R64” and “R186” to select flash memory IC “U20”
c. Place “R185”, “R72”, “R61”, “R60” and “R74” to deselect MCP IC “U22”

2.5 Communication Interfaces

The Communication interfaces included in AIC-V2 boards as below:

1. Controller Area Network (CAN)
2. Ethernet

2.6 CAN interface

AIC V2 board supports one classic CAN interface and one isolated CAN-FD interface. Classic CAN circuit includes CAN transceiver “SN65HVD230QDR” connected to the MCU via CAN 0 port and CAN-FD circuit includes isolated CAN-FD transceiver “ADM3050EBRIZ” connected to the MCU via CAN 1 port. Output CAN bus signals are routed to the main connector via CMC choke and ESD protection diode. Classic CAN bus include a 120ohm terminator resistor and CAN-FD supports split termination. A 5V power supply should be provided externally to CAN-FD via main connector (J3).

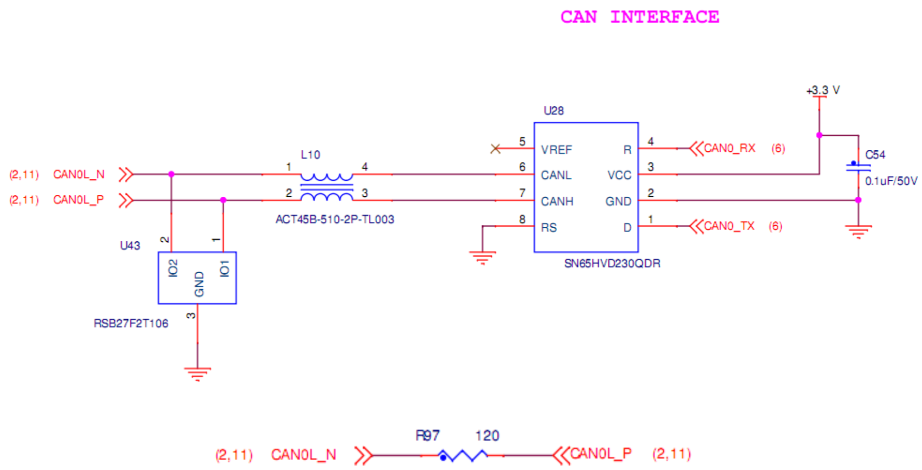


Figure 2-11 CAN Circuit

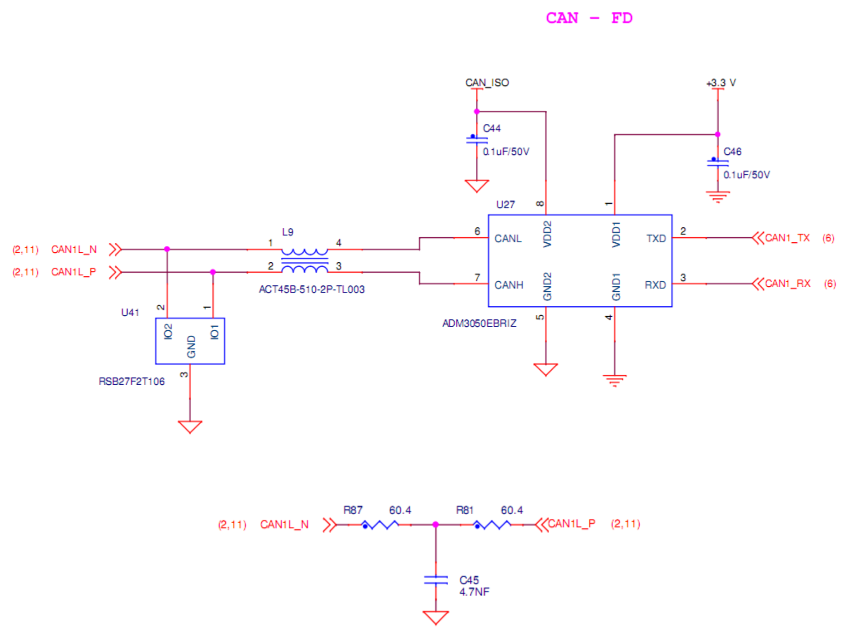


Figure 2-12 CAN-FD Circuit

2.7 Ethernet

RH850/D1M1A MCU supports one Ethernet AVB MAC supporting standard MII interface. An external low power automotive PHY transceiver “DP83TC811RWRNDTQ1” is provided which connects to the MCU via MII interface. The transceiver provides all physical layer functions needed to transmit and receive data over unshielded single twisted-pair cables. It is AEC-Q100 qualified for automotive application that supports BroadR-Reach feature.

IMPORTANT: *The Ethernet MII signals are multiplexed with Camera signals and the selection pin of the multiplexer should be set low for routing the Ethernet signals. Also, proper interface (ENTB) must be configured in the MCU. The following image explains the multiplexer circuit.*

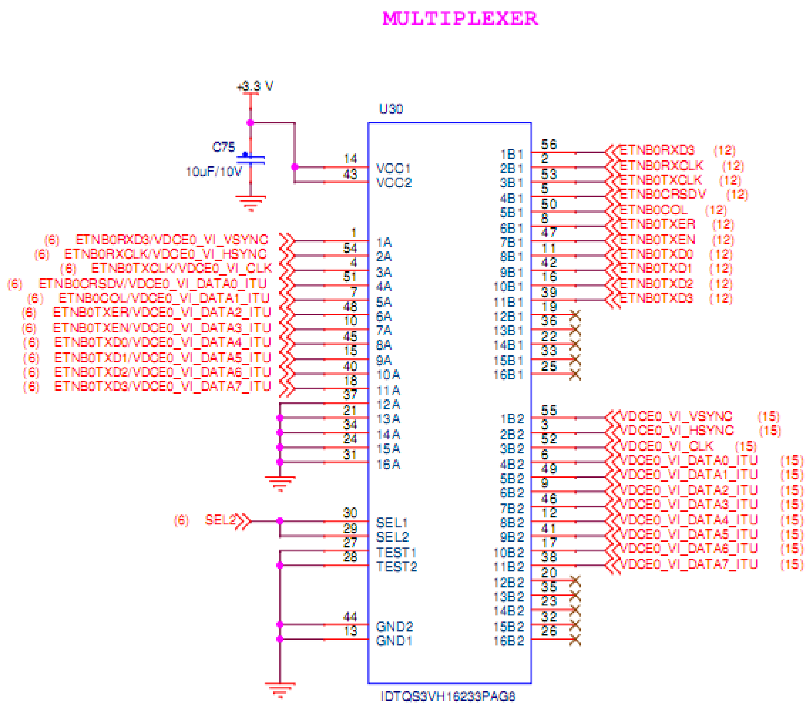


Figure 2-13 Multiplexer circuit

100BASE-T1 automotive Ethernet interface is available via right angled Mini50 series automotive connector “U38”. The part number of this mating connector is "0347910020”. An unshielded single twisted pair cable will be required for external interface, and it should be crimped to the mating connector using the crimp “5600230421”.

The following table describes the pin details of the Ethernet connector.

Pin Number	Pin name	Pin description
1	TRD_PF	Bidirectional differential transmits and receive positive signal
2	TRD_NF	Bidirectional differential transmits and receive negative signal

Table 3 Ethernet Connector Pin details

The following table illustrates the bootstrap configurations.

<table>
<tr><th>PIN NAME</th><th>PIN NO.</th><th>DEFAULT MODE</th><th colspan="3">STRAP FUNCTION</th><th>DESCRIPTION</th></tr>
<tr><td rowspan="5">RX_DV</td><td rowspan="5">15</td><td rowspan="5">1</td><td>MODE</td><td>PHY_AD[0]</td><td>PHY_AD[2]</td><td rowspan="5">PHY_AD: PHY Address ID</td></tr>
<tr><td>1</td><td>0</td><td>0</td></tr>
<tr><td>2</td><td>0</td><td>1</td></tr>
<tr><td>3</td><td>1</td><td>1</td></tr>
<tr><td>4</td><td>1</td><td>0</td></tr>
<tr><td rowspan="5">RX_ER</td><td rowspan="5">14</td><td rowspan="5">1</td><td>MODE</td><td>PHY_AD[1]</td><td>PHY_AD[3]</td><td rowspan="5">PHY_AD: PHY Address ID</td></tr>
<tr><td>1</td><td>0</td><td>0</td></tr>
<tr><td>2</td><td>0</td><td>1</td></tr>
<tr><td>3</td><td>1</td><td>1</td></tr>
<tr><td>4</td><td>1</td><td>0</td></tr>
<tr><td rowspan="5">RX_D0</td><td rowspan="5">26</td><td rowspan="5">1</td><td>MODE</td><td>MAC[0]</td><td>TEST[0]</td><td rowspan="5">MAC: MAC Interface Selection
TEST: Test Mode Selection</td></tr>
<tr><td>1</td><td>0</td><td>0</td></tr>
<tr><td>2</td><td>0</td><td>1</td></tr>
<tr><td>3</td><td>1</td><td>1</td></tr>
<tr><td>4</td><td>1</td><td>0</td></tr>
<tr><td rowspan="5">RX_D1</td><td rowspan="5">25</td><td rowspan="5">1</td><td>MODE</td><td>MAC[1]</td><td>TEST[1]</td><td rowspan="5">MAC: MAC Interface Selection
TEST: Test Mode Selection</td></tr>
<tr><td>1</td><td>0</td><td>0</td></tr>
<tr><td>2</td><td>0</td><td>1</td></tr>
<tr><td>3</td><td>1</td><td>1</td></tr>
<tr><td>4</td><td>1</td><td>0</td></tr>
<tr><td rowspan="5">RX_D2</td><td rowspan="5">24</td><td rowspan="5">1</td><td>MODE</td><td>MAC[2]</td><td>TEST[2]</td><td rowspan="5">MAC: MAC Interface Selection
TEST: Test Mode Selection</td></tr>
<tr><td>1</td><td>0</td><td>0</td></tr>
<tr><td>2</td><td>0</td><td>1</td></tr>
<tr><td>3</td><td>1</td><td>1</td></tr>
<tr><td>4</td><td>1</td><td>0</td></tr>
<tr><td rowspan="5">RX_D3</td><td rowspan="5">23</td><td rowspan="5">1</td><td>MODE</td><td>RESERVED</td><td>RESERVED</td><td rowspan="5">RX_D3 must be strapped to MODE 1</td></tr>
<tr><td>1</td><td>0</td><td>0</td></tr>
<tr><td>Reserved</td><td></td><td></td></tr>
<tr><td>Reserved</td><td></td><td></td></tr>
<tr><td>Reserved</td><td></td><td></td></tr>
<tr><td rowspan="5">LED_0</td><td rowspan="5">35</td><td rowspan="5">1</td><td>MODE</td><td>MS</td><td>RESERVED</td><td rowspan="5">MS: 100BASE-T1 Master & 100BASE-T1 Slave Selection
Note: LED_0 must only be set for bootstrap MODE 1 or MODE 4.</td></tr>
<tr><td>1</td><td>0</td><td></td></tr>
<tr><td>Reserved</td><td></td><td></td></tr>
<tr><td>Reserved</td><td></td><td></td></tr>
<tr><td>4</td><td>1</td><td></td></tr>
<tr><td rowspan="5">LED_1</td><td rowspan="5">6</td><td rowspan="5">1</td><td>MODE</td><td>$\overline{AUTO}$</td><td>RESERVED</td><td rowspan="5">$\overline{AUTO}$: Autonomous Disable
Note 1: LED_1 must only be set for bootstrap MODE 1 or MODE 4.
Note 2: Autonomous bootstrap is only active for 100BASE-T1 Master mode PHYs. This bootstrap is ignored when the PHY is bootstrapped for 100BASE-T1 Slave mode operation.</td></tr>
<tr><td>1</td><td>0</td><td></td></tr>
<tr><td>Reserved</td><td></td><td></td></tr>
<tr><td>Reserved</td><td></td><td></td></tr>
<tr><td>4</td><td>1</td><td></td></tr>
</table>

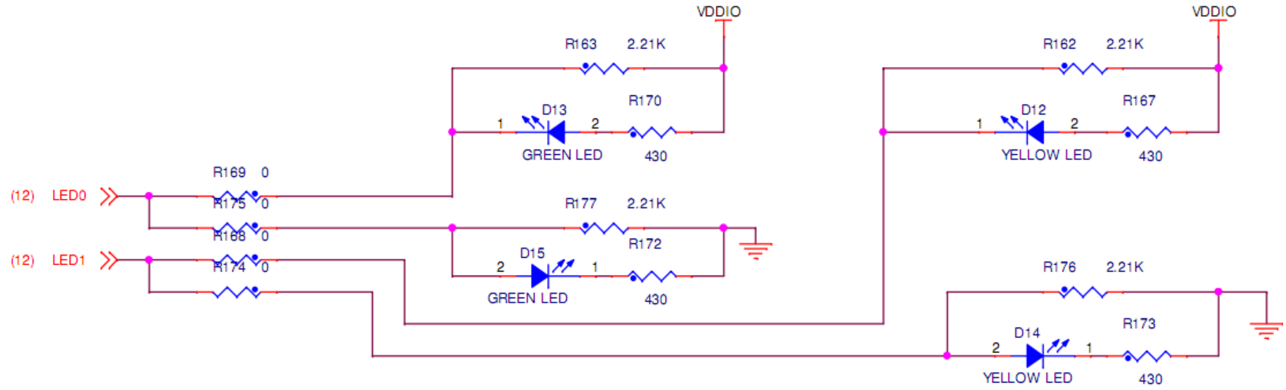
Table 4 Ethernet Bootstrap Configuration

There are few resistors based bootstrap configurations required for Ethernet communication and the following table describes the bootstrap resistor designations and suggested resistor values.

Pin Name	Pin number	Strap Mode	PU Resistor (Kohm)	PU Resister Designation	PD Resistor (Kohm)	PD resistor Designation
RX_D0	26	1	OPEN	R159	OPEN (default)	R160
		2	10.20		2.21	
		3	5.76		2.21	
		4	2.21 (default)		OPEN	
RX_D1	25	1	OPEN (default)	R158	OPEN (default)	R157
		2	10.20		2.21	
		3	5.76		2.21	
		4	2.21		OPEN	
RX_D2(RX_P)	24	1	OPEN (default)	R155	OPEN (default)	R156
		2	10.20		2.21	
		3	5.76		2.21	
		4	2.21		OPEN	
RX_ER	14	1	OPEN (default)	R151	OPEN (default)	R152
		2	10.20		2.21	
		3	5.76		2.21	
		4	2.21		OPEN	
RX_DV	15	1	OPEN (default)	R154	OPEN (default)	R153
		2	10.20		2.21	
		3	5.76		2.21	
		4	2.21		OPEN	
LED_0	35	1	OPEN	R163	2.21	R177
		4	2.21		OPEN	
LED_1	6	1	OPEN	R162	2.21	R176
		4	2.21		OPEN	

Table 5 Bootstrap Register Designation and Suggested Bootstrap Register values

Circuit for Ethernet Bootstrap configurations.



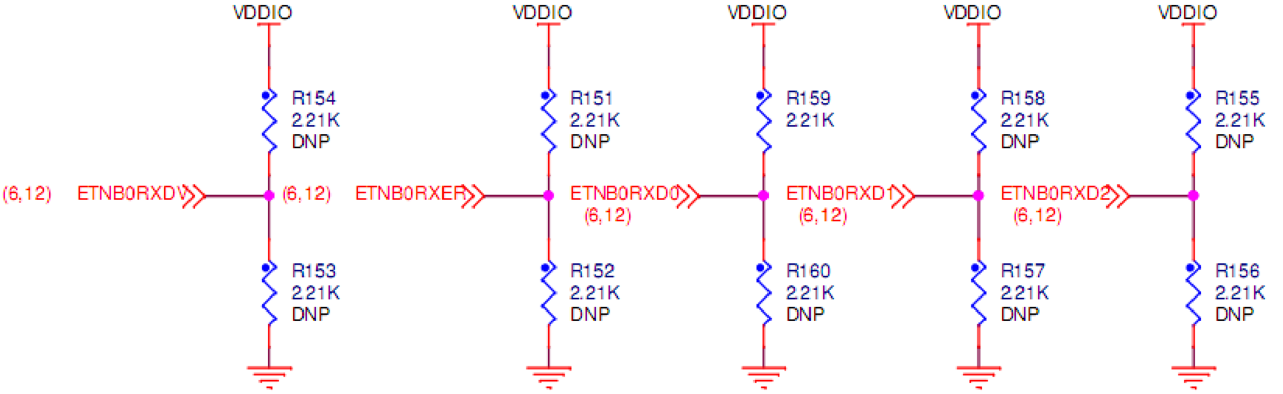


Figure 2-14 Ethernet Bootstrap Configuration

2.8 Sensors, Analog, Indicators (Tell-Tale LEDS, Indication LEDs)

2.8.1 Sensor Interface

AIC V2 board includes multiple sensor interfaces for reading various parameters such as Fuel level, oil level and engine temperature. The following circuits are provided for these sensor interfaces. Input of the circuit is connected to the external sensors via main connector and output of the circuit is connected to the MCU ADC input.

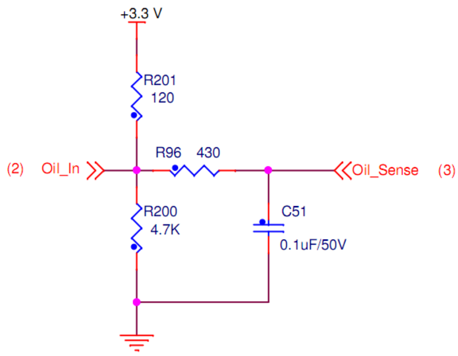


Figure 2-15 Sensor Interface

2.8.2 Signal Conditioning Circuit

AIC V2 board supports signal conditioning of following inputs,

1. High lamp – Active Low Level Input
2. Neutral – Active Low Level Input
3. Speed – Active Low Level Input
4. RPM – Active Low Level Input
5. Turn left – Active High Level Input
6. Turn right – Active High Level Input
7. Ignition switch – Active High Level Input
8. SB – Active High Level Input

The following image depicts the signal conditioning circuits for signals 1 to 4.

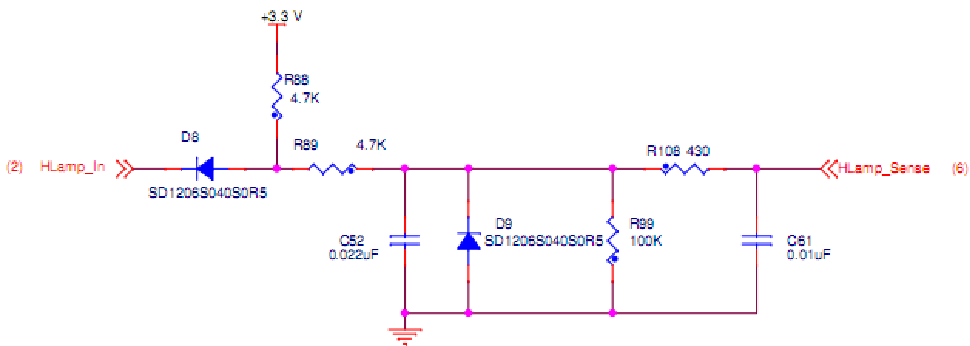


Figure 2-16 Signal Conditioning Circuit

The output of the signal conditioning circuit is connected to MCU GPIO. GPIOs are configured as digital inputs. The following image depicts the signal conditioning circuits for signals 5 to 8.

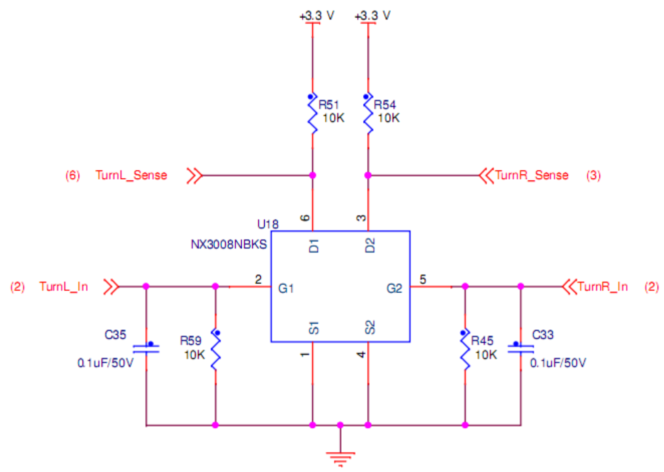


Figure 2-17 Signal Conditioning Circuit for signals 5 to 8

2.8.3 Tell-Tale LEDs

There are 12 Tell-Tale LEDs in the board. Each tell-tale LED is driven by MOSFET based driving circuit. The input for the LED driver circuit is MCU GPIO. The following image depicts the Tell-Tale LED driver circuit.

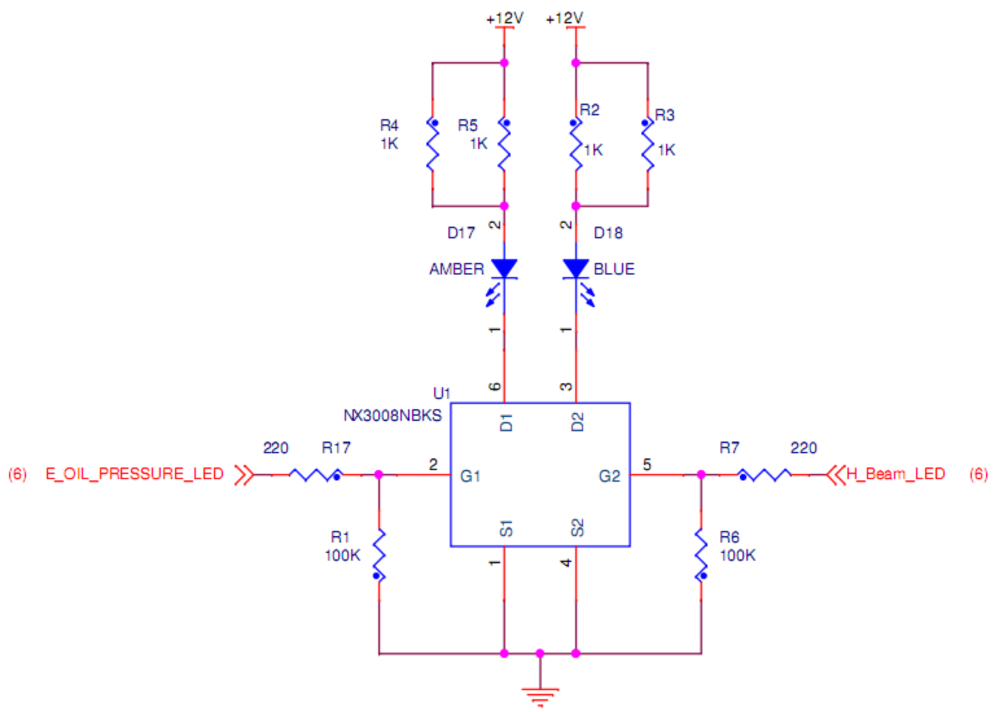


Figure 2-18 Example Tell-Tale LED Driver circuit

The following table describes the indication of each LEDS.

LED Reference	**Indication**
D22	On – Low Battery OFF – Battery level is good
D16	Blink – Turn Left
D17	ON – Engine Oil Pressure low
D18	ON – High Beam ON OFF – High Beam Off
D23	BLE communication status
D21	Blink – Turn Right
D30	ON – ABS off OFF – ABS off
D26	ON – Engine oil temperature high Off – Engine oil temperature normal
D31	ON – In Neutral OFF – In Gear
D27	ON – Engine Malfunction
D19	On – Engine coolant temperature high OFF – Engine coolant temperature normal
D20	ON – Service needed

Table 6 Tell Tale LEDs Indications

2.9 Analog Camera

One camera interface is supported in AIC V2 board. The MCU includes Video Data Controller (VDCE) with which an AHL decoder “RAA279972A” is interfaced for converting the analog video into digital. The decoder includes 10bit ADC and analog clamping circuit with up to 150MHz sampling frequency. The decoder is connected to the MCU via 8bit parallel interface with I2C for register configurations. The output from decoder is BT656 (ITU format) 8-bit interface which is connected to video input of the MCU. Internal registers of the decoder are configured using I2C interface.

IMPORTANT: The camera signals are multiplexed with Ethernet signals and the selection pin of the multiplexer (U30) should be set high for routing the camera signals. Also, proper interface (VDCE0) must be configured in the MCU. The following image explains the multiplexer circuit.

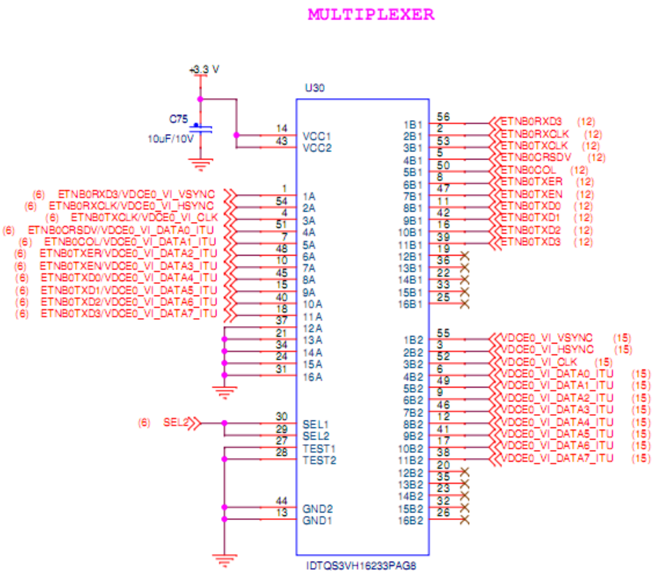


Figure 2-19 Multiplexer Circuit

Camera interface is available via standard 4 pin right angled Mini 50 series automotive connector “U39”. The mating connector part number is “**0347910040**” and four crimps are required to connect the cable with the mating connector. The crimp part number is “**5600230421**”.

Pin Number (U39)	Pin name (U39)	Pin description
1	AHLRx0-	Differential Analog video input negative
2	AHLRx0+	Differential Analog video input positive
3	GND	Optional Ground via jumper resistor “R134”
4	GND	Ground

Table 7 Camera Connector pin details

2.10 Stepper motor

Two Stepper motor driver output is available via right angled 100mils male berg stick connector “J4”. The signals are directly routed from the intelligent stepper motor driver output of MCU. The following image depicts the stepper motor connector.

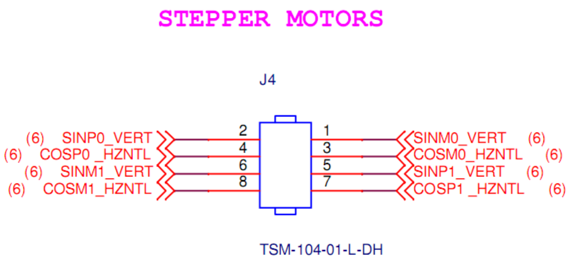


Figure 2-20: Stepper motor connector

The following table describes the pin description of the stepper motor connector (J4).

Pin Number	Pin name	Pin description
1	SINM0_VERT	Minus side of vertical coil
2	SINP0_VERT	Plus side of vertical coil
3	COSM0_HZNTL	Minus side of horizontal coil
4	COSP0 _HZNTL	Plus side of horizontal coil
5	SINP1_VERT	Plus side of vertical coil
6	SINM1_VERT	Minus side of vertical coil
7	COSP1 _HZNTL	Plus side of horizontal coil
8	COSM1_HZNTL	Minus side of horizontal coil

Table 8: Stepper Motor Connector pin details

2.11 Audio

Two speaker outputs are available on AIC V2 board. The speaker circuit includes a dual channel, Stereo, Class-D 24-bit audio DAC with power output of 2.5W per channel. The DAC is connected to the MCU via I2S interface and I2C is used for register configurations. The DAC is configured via I2C interface. The audio data from MCU is sent on I2S interface to DAC.

2.5W speaker outputs are available via 4-pin 100mils RMC connector “J5”. The mating connector part number is “XHP-4” and crimp is required to connect the cable to the mating connector. The part number of the crimp is “ASXHSXH22K305”.

The following image and table describe the pin details of the speaker connector “J5”.

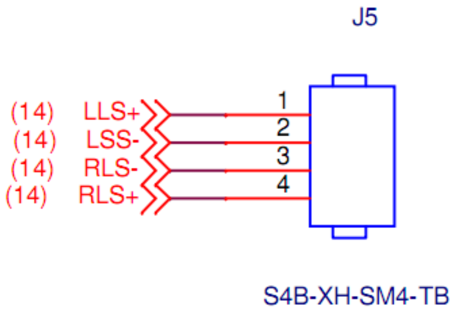


Figure 2-21 Speaker Connector

Pin Number	Pin name	Pin description
1	LLS+	Left Channel Non-Inverting Speaker Output
2	LSS-	Left Channel Inverting Speaker Output
3	RLS-	Right Channel Inverting Speaker Output
4	RLS+	Right Channel Non-Inverting Speaker Output

Table 9: Speaker Connector pin details

2.12 RTC

AIC V2 board includes an Inbuilt RTC chip “ISL12022MAIBZ” backed up with a coin cell holder. The RTC chip includes embedded 32.768KHz quartz crystal in the package with an on-chip temperature compensated oscillator. It supports interrupts for alarm and 15 selectable frequency outputs. The RTC chip is interfaced to the MCU via I2C, and an interrupt output is routed to MCU GPIO for detecting any alarm notification.

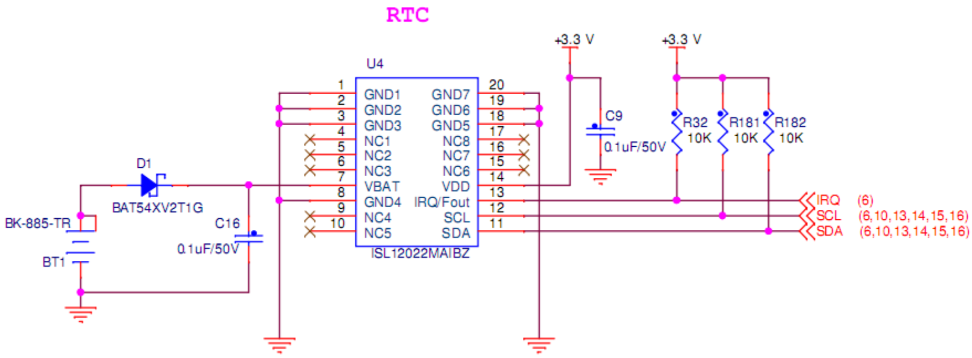


Figure 2-22 RTC circuit

The holder “BT1” supports 3V coin cell of 12.5m dia with part number “CR1220”. It is a surface mount type connector and battery should be pushed in to insert and pulled out for removing.

2.13 Ambient Light Sensor

AIC V2 board includes an ambient light sensor (ALS) “ISL76683” which supports auto brightness feature for the LCD. The ISL76683 is an integrated light sensor with an internal integrating ADC intended for automotive applications. The ADC provides 16-bit resolution and is capable of rejecting 50Hz and 60Hz flicker caused by artificial light sources. The I2C interface provides four user programmable lux sensitivity ranges for optimized counts/lux in a variety of lighting conditions. The I2C interface also provides multi-function control of the sensor and remote monitoring capabilities.

The ALS is interfaced to the MCU via I2C interface, and an interrupt pin is connected to the MCUGPIO for detecting upper and lower thresholds.

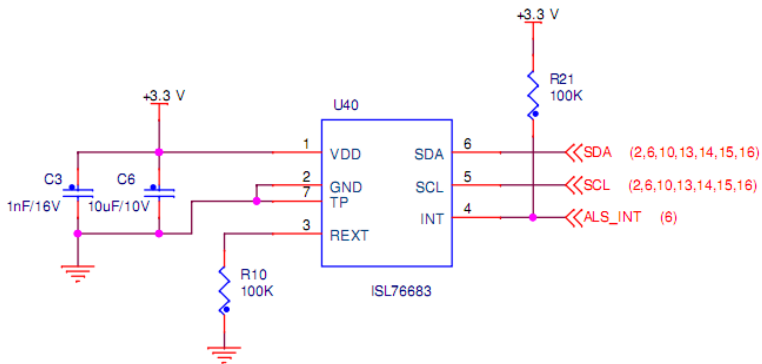


Figure 2-23 ALS Circuit

2.14 Accelerometer

AIC V2 board includes a 3 axis digital MEMS accelerometer with 10 to 13-bit resolution for a wide variety of applications. The accelerometer is interfaced to the MCU via I2C interface and two interrupt pins are connected to the MCU GPIO for various activity detection. The following image depicts the accelerometer circuit.

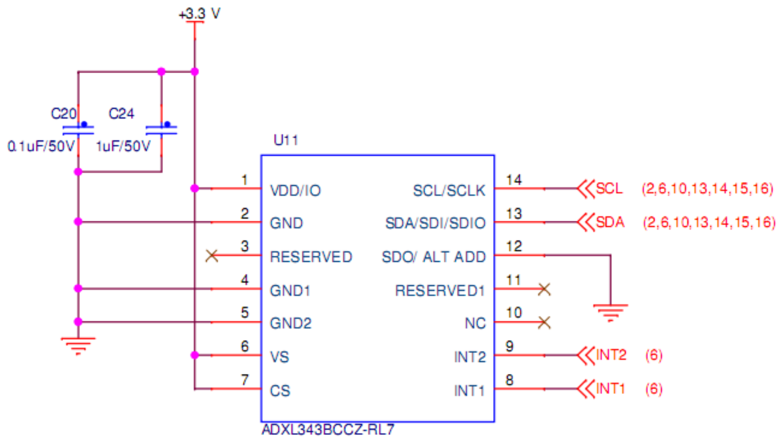


Figure 2-24 Accelerometer circuit

2.15 Main Connector

The main connector “J3” is a 28 pin compact automotive connector with the part number “MX34028UF2”. The part number of the mating connector and crimp is “MX34028SF1” and “M34S75C4F1”. The following table describes the pin details of the connector J3”,

Pin No	Pin name	Signal Type	Pin description
1	Neutral_In	Digital input	Neutral sensor input
2	HLamp_In	Digital input	High Lamp sensor input
3	LPDO	4 pin LPD data output	Low pin debug data output
4	FLDM0	Mode control signal input	FLDM0 signal
5	RESET	Digital input	MCU Reset input
6	SP_SIG	Digital input	Speed Sensor input
7	RPM_SIG	Digital input	RPM Sensor input
8	Fuel_In	Analog input	Fuel sensor input
9	Oil_In	Analog input	Oil sensor inputs
10	IGN_SW	Digital input	Ignition switch input
11	TurnL_In	Digital input	Turn Left switch input
12	TurnR_In	Digital input	Turn right switch input
13	+12V	Power input	Device 12V power input
14	+12V	Power input	Device 12V power input
15	CAN0L_N	CAN bus	Classic CAN_L interface
16	CAN0L_P	CAN bus	Classic CAN_H interface
17	LPDCLKOUT	4 pin LPD clock output	Low pin debug clock output
18	LPDCLKIN	4 pin LPD clock input	Low pin debug clock input
19	LPDI	4 pin LPD input	Low pin debug data input
20	CAN1L_N	CAN bus	CAN_L interface of Isolated CAN-FD
21	CAN1L_P	CAN bus	CAN_H interface of isolated CAN-FD
22	CAN_GND	Isolated Ground	External Isolated CAN-FD ground
23	CAN_ISO	Isolated 5V input	External Isolated CAN-FD 5V power input
24	En_Temp_In	Analog input	Engine temperature sensor input
25	SB1_In	Digital input	Generic digital input
26	+3.3V	Power output	Device +3.3V output
27	GND	12V supply ground	Device ground
28	GND	12V Supply ground	Device ground

Table 10 : Main connector pin details

IMPORTANT: NOTE DEBUG CONNECTOR SIGNALS ARE MAPPED TO MAIN CONNECTOR

2.16 LED Indications

There are various SMD LEDs available on AIC V2 board for indicating different device status. The following table describes various LEDs and their indications.

LED Reference	Indication
D6	Device Reset
D3	Device 3.3V
D13/D15	Link status
D12 / D14	Link Status and blink for TX/RX activity

Table 11 Device Indications

2.17 Communication Connector

30-pin 100 mils berg stick connector “J1” is available for connecting external communication card. Multiple interfaces are available from the expansion connector such as UARTs, SPI, I2C and GPIOs. Following table describes the pin details of the communication connector “J1”,

Pin Number	Pin name	Pin description
1	GND	Ground
2	GND	Ground
3	BL_GPIO2_RES	GPIO for Bluetooth module
4	GPS_GPIO_RES	GPIO for GPS module
5	CSIH1_GPIO1_RES	GPIO1 for SPI based module
6	CSIG2_GPIO1_RES	GPIO1 for SPI based module
7	CSIG2_GPIO2_RES	GPIO2 for SPI based module
8	GPS_PPS_RES	GPIO for GPS module PPS signal
9	CSIH1_GPIO2_RES	GPIO2 for SPI based module
10	LTE_UART_RX_RES	MCU UART RX for LTE module communication
11	LTE_UART_TX_RES	MCU UART TX for LTE module communication
12	CSIG2SSI_RES	MCU GPIO for SPI module1chip select interface
13	CSIG2SC_RES	MCU SPI SC for SPI module1clock interface
14	CSIG2SI_RES	MCU SPI SI for SPI module1MISOinterface
15	BL_UART_TX_RES	MCU UART TX for Bluetooth module communication
16	CSIG2SO_RES	MCU SPI SO for SPI module1 MOSI interface
17	BL_UART_RX_RES	MCU UART RX for Bluetooth module communication
18	GPS_UART_TX_RES	MCU UART TX for GPS module communication
19	GPS_UART_RX_RES	MCU UART RX for GPS module communication
20	CSIH1SO_RES	MCU SPI SO for SPI module2 MOSI interface
21	CSIH1SSI_RES	MCU GPIO for SPI module2chip select interface
22	CSIH1SI_RES	MCU SPI SI for SPI module2 MISO interface
23	LTE_RI_RES	MCU GPIO for LTE module interface
24	CSIH1SC_RES	MCU SPI SC for SPI module2 clock interface
25	LTE_WAKEUP_RES	MCU GPIO for LTE module interface
26	LTE_DTR_RES	MCU GPIO for LTE module interface
27	LTE_RESET_RES	MCU GPIO for LTE module interface
28	BL_GPIO1_RES	MCU GPIO for Bluetooth module interface
29	LTE_PWRK_RES	MCU GPIO for LTE module interface
30	PG-BUCK_4V_RES	MCU GPIO for DCDC converter PG input

Table 12 Communication Connector Pin Details

3. Software Ecosystem

3.1 Software Tools

Supported Compiler tool chains are as below:

1. Green Hills Multi
2. CS+

Below are the software libraries provided:

1. RGL (Renesas Graphics Library)
2. Code Flash Libraries
3. Data Flash Libraries

3.2 Hardware Tools

The hardware tools comprise of the fast emulator/debugger for debugging and a GUI tool for programming. Below are the details of the tools:

E2 Emulator : On-chip debugging emulator for RH850 family and RL78 family. Also available as a flash memory programmer.

Renesas Flash Programmer(Programming GUI): The Renesas Flash Programmer provides usable and functional support for programming the on-chip flash memory of Renesas microcontrollers in each phase of development and mass production.

3.3 Third-Party Support

For creating graphics user can directly use the APIs from RGL libraries or can use some of the below third-party tools:

1. Altia HMI development solutions
2. Qt

For more details on software Ecosystem please refer RH850/D1x Design Support Resources.

4. Electrical Specifications

The AIC-V2 board operates with the 12V DC power supply from the main connector and the following table describes the electrical specification of the board.

Parameter	Description	Min	Max
Supply Voltage	12V DC input	9V	13.5V
Supply Current		-	1.32A
Digital input	High threshold	9V	12V

Digital input	Low Threshold	0V	2.5V
Analog input range		0V	3.3V
Supply voltage output	3.3V DC output	-	3.3V
3.3V DC output current		-	500mA

Table 13 Electrical Specifications

5. Board Dimensions

The following image describes the board dimensions of AIC V2 board. The mechanical holes are at diameter of 4mm. The board edges are curved at a radius of 10mm.

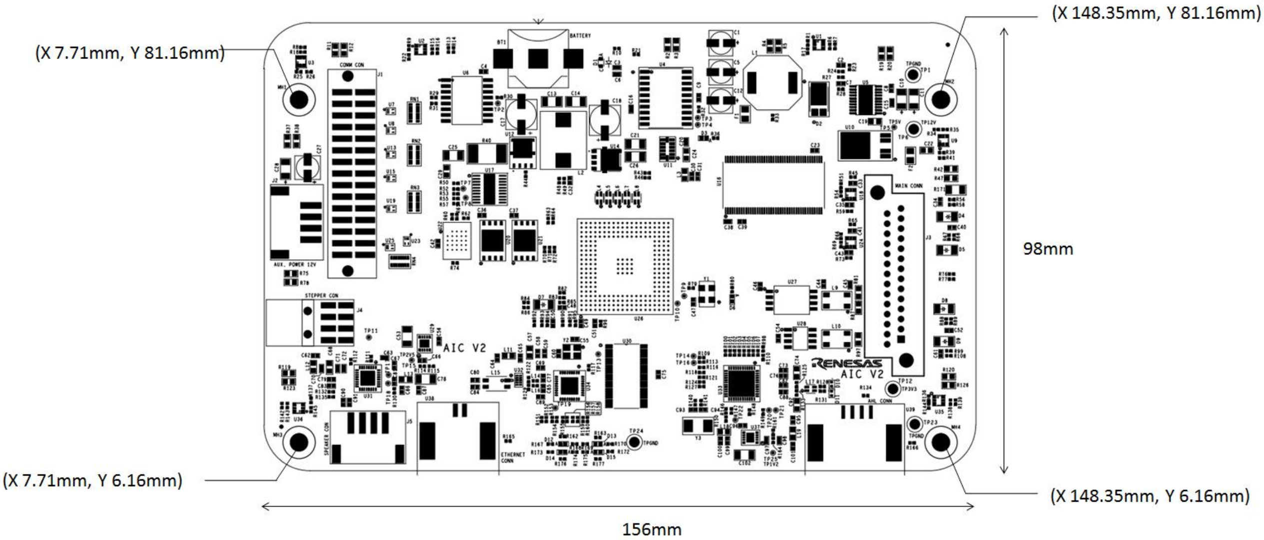


Figure 5-1 Board dimension details

6. PCB Stack-up

The AIC V2 board is a six-layer PCB with the following features,

1. PCB thickness – 1.6mm
2. Soldermask – Blue
3. Silkscreen – White
4. Edge plating
5. Copper thickness - 35 microns (0.035mm)
6. Impedance controlled
7. Finish – ENiG
8. Dielectric material – FR4 (ISOLA Tg 180 Material)

Layer stackup details:

Top Silkscreen
Top Soldermask
Layer1 - Top
Layer2 - MID1
Layer3 - MID2
Layer4 - MID3
Layer5 - MID4
Layer 6 - Bottom
Bottom Soldermask
Bottom Silkscreen

The differential (100 OHM) impedance controlled lines are routed in top and bottom (i.e. Layer1 and Layer6). The reference of the impedance controlled line is MID1 and MID4 (i.e. Layer2 and Layer5).

The following image is the reference PCB stack up with which the PCB is designed.

			Unit mm	Impedance, unit mil			
Layer	Construction	Dielectric	Final Thick	50 ohms	90 ohms	100 ohms	Ref plane
	Solder mask		0.02				
1	Copper		0.035	8	7 / 5	5 / 5	2
	PREPREG	2116	0.128				
2	Copper		0.035				
	ISOLA 185 HR	CCL	0.125				
3	Copper		0.035	7	5 / 6	5 / 10	2
	PREPREG		0.850				
4	Copper		0.035	7	5 / 6	5 / 10	5
	ISOLA 185 HR	CCL	0.125				
5	Copper		0.035				
	PREPREG	2116	0.128				
6	Copper		0.035	8	7 / 5	5 / 5	5
	Solder mask		0.02				

Total Thickness : 1.606 +/- 10%

Figure 6-1 PCB Stackup Details

General Precautions in the Handling of Microprocessing Unit and Microcontroller Unit Products

The following usage notes are applicable to all Microprocessing unit and Microcontroller unit products from Renesas. For detailed usage notes on the products covered by this document, refer to the relevant sections of the document as well as any technical updates that have been issued for the products.

1. Precaution against Electrostatic Discharge (ESD)

   A strong electrical field, when exposed to a CMOS device, can cause destruction of the gate oxide and ultimately degrade the device operation. Steps must be taken to stop the generation of static electricity as much as possible, and quickly dissipate it when it occurs. Environmental control must be adequate. When it is dry, a humidifier should be used. This is recommended to avoid using insulators that can easily build up static electricity. Semiconductor devices must be stored and transported in an anti-static container, static shielding bag or conductive material. All test and measurement tools including work benches and floors must be grounded. The operator must also be grounded using a wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions must be taken for printed circuit boards with mounted semiconductor devices.
2. Processing at power-on

   The state of the product is undefined at the time when power is supplied. The states of internal circuits in the LSI are indeterminate and the states of register settings and pins are undefined at the time when power is supplied. In a finished product where the reset signal is applied to the external reset pin, the states of pins are not guaranteed from the time when power is supplied until the reset process is completed. In a similar way, the states of pins in a product that is reset by an on-chip power-on reset function are not guaranteed from the time when power is supplied until the power reaches the level at which resetting is specified.
3. Input of signal during power-off state

   Do not input signals or an I/O pull-up power supply while the device is powered off. The current injection that results from input of such a signal or I/O pull-up power supply may cause malfunction and the abnormal current that passes in the device at this time may cause degradation of internal elements. Follow the guideline for input signal during power-off state as described in your product documentation.
4. Handling of unused pins

   Handle unused pins in accordance with the directions given under handling of unused pins in the manual. The input pins of CMOS products are generally in the high-impedance state. In operation with an unused pin in the open-circuit state, extra electromagnetic noise is induced in the vicinity of the LSI, an associated shoot-through current flows internally, and malfunctions occur due to the false recognition of the pin state as an input signal become possible.
5. Clock signals

   After applying a reset, only release the reset line after the operating clock signal becomes stable. When switching the clock signal during program execution, wait until the target clock signal is stabilized. When the clock signal is generated with an external resonator or from an external oscillator during a reset, ensure that the reset line is only released after full stabilization of the clock signal. Additionally, when switching to a clock signal produced with an external resonator or by an external oscillator while program execution is in progress, wait until the target clock signal is stable.
6. Voltage application waveform at input pin

   Waveform distortion due to input noise or a reflected wave may cause malfunction. If the input of the CMOS device stays in the area between V_{IL} (Max.) and V_{IH} (Min.) due to noise, for example, the device may malfunction. Take care to prevent chattering noise from entering the device when the input level is fixed, and also in the transition period when the input level passes through the area between V_{IL} (Max.) and V_{IH} (Min.).
7. Prohibition of access to reserved addresses

   Access to reserved addresses is prohibited. The reserved addresses are provided for possible future expansion of functions. Do not access these addresses as the correct operation of the LSI is not guaranteed.
8. Differences between products

   Before changing from one product to another, for example to a product with a different part number, confirm that the change will not lead to problems. The characteristics of a microprocessing unit or microcontroller unit products in the same group but having a different part number might differ in terms of internal memory capacity, layout pattern, and other factors, which can affect the ranges of electrical characteristics, such as characteristic values, operating margins, immunity to noise, and amount of radiated noise. When changing to a product with a different part number, implement a system-evaluation test for the given product.

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Contact information

For further information on a product, technology, the most up-to-date version of a document, or your nearest sales office, please visit: www.renesas.com/contact/.