SATURN

**PCIe/104 Expandable Single Board Computer
with Intel "Apollo Lake" E3940 Processor**
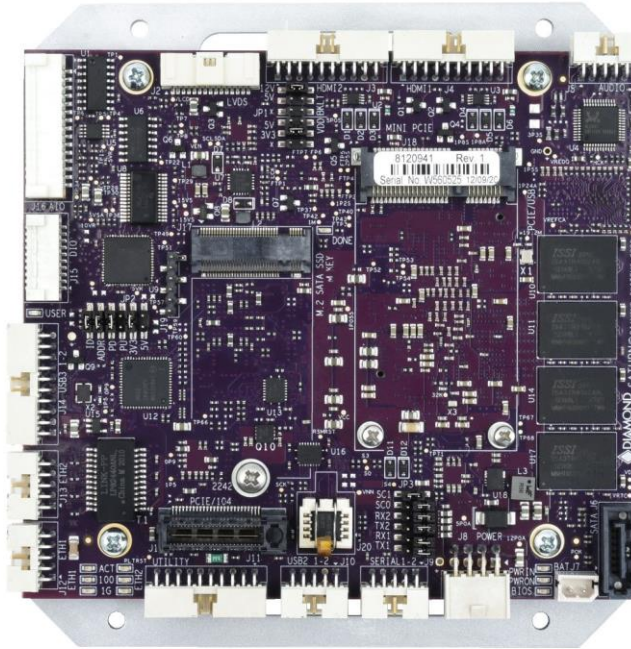
Revision	Date	Comment
1.01	09/13/2021	Initial Release

*FOR TECHNICAL SUPPORT
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CONTENTS

1 IMPORTANT SAFE HANDLING INFORMATION

WARNING!

ESD-Sensitive Electronic Equipment

Observe ESD-safe handling procedures when working with this product.

Always use this product in a properly grounded work area and wear appropriate ESD-preventive clothing and/or accessories.

Always store this product in ESD-protective packaging when not in use.

Safe Handling Precautions

The Saturn SBC contains a high number of I/O connectors with connection to sensitive electronic components. This creates many opportunities for accidental damage during handling, installation and connection to other equipment. The list here describes common causes of failure found on boards returned to Diamond Systems for repair. This information is provided as a source of advice to help you prevent damaging your Diamond (or any vendor's) embedded computer boards.

ESD damage – This type of damage is usually almost impossible to detect, because there is no visual sign of failure or damage. The symptom is that the board eventually simply stops working, because some component becomes defective. Usually the failure can be identified and the chip can be replaced.

To prevent ESD damage, always follow proper ESD-prevention practices when handling computer boards.

Damage during handling or storage – On some boards we have noticed physical damage from mishandling. A common observation is that a screwdriver slipped while installing the board, causing a gouge in the PCB surface and cutting signal traces or damaging components.

Another common observation is damaged board corners, indicating the board was dropped. This may or may not cause damage to the circuitry, depending on what is near the corner. Most of our boards are designed with at least 25 mils clearance between the board edge and any component pad, and ground / power planes are at least 20 mils from the edge to avoid possible shorting from this type of damage. However these design rules are not sufficient to prevent damage in all situations.

A third cause of failure is when a metal screwdriver tip slips, or a screw drops onto the board while it is powered on, causing a short between a power pin and a signal pin on a component. This can cause overvoltage / power supply problems described below. To avoid this type of failure, only perform assembly operations when the system is powered off.

Sometimes boards are stored in racks with slots that grip the edge of the board. This is a common practice for board manufacturers. However our boards are generally very dense, and if the board has components very close to the board edge, they can be damaged or even knocked off the board when the board tilts back in the rack. Diamond recommends that all our boards be stored only in individual ESD-safe packaging. If multiple boards are stored together, they should be contained in bins with dividers between boards. Do not pile boards on top of each other or cram too many boards into a small location. This can cause damage to connector pins or fragile components.

Power supply wired backwards – Our power supplies and boards are not designed to withstand a reverse power supply connection. This will destroy each IC that is connected to the power supply (i.e. almost all ICs). In this case the board will most likely will be unrepairable and must be replaced. A chip destroyed by reverse power or by excessive power will often have a visible hole on the top or show some deformation on the top surface due to vaporization inside the package. **Check twice before applying power!**

Board not installed properly in PC/104 stack – A common error is to install a PC/104 board accidentally shifted by 1 row or 1 column. If the board is installed incorrectly, it is possible for power and ground signals on the bus to make contact with the wrong pins on the board, which can damage the board. For example, this can damage components attached to the data bus, because it puts the $\pm12V$ power supply lines directly on data bus lines.

Overvoltage on analog input – If a voltage applied to an analog input exceeds the design specification of the board, the input multiplexor and/or parts behind it can be damaged. Most of our boards will withstand an erroneous connection of up to ±35V on the analog inputs, even when the board is powered off, but not all boards, and not in all conditions.

Overvoltage on analog output – If an analog output is accidentally connected to another output signal or a power supply voltage, the output can be damaged. On most of our boards, a short circuit to ground on an analog output will not cause trouble.

Overvoltage on digital I/O line – If a digital I/O signal is connected to a voltage above the maximum specified voltage, the digital circuitry can be damaged. On most of our boards the acceptable range of voltages connected to digital I/O signals is 0-5V, and they can withstand about 0.5V beyond that (-0.5 to 5.5V) before being damaged. However logic signals at 12V and even 24V are common, and if one of these is connected to a 5V logic chip, the chip will be damaged, and the damage could even extend past that chip to others in the circuit.

Bent connector pins – This type of problem is often only a cosmetic issue and is easily fixed by bending the pins back to their proper shape one at a time with needle-nose pliers. The most common cause of bent connector pins is when a PC/104 board is pulled off the stack by rocking it back and forth left to right, from one end of the connector to the other. As the board is rocked back and forth it pulls out suddenly, and the pins at the end get bent significantly. The same situation can occur when pulling a ribbon cable off of a pin header. If the pins are bent too severely, bending them back can cause them to weaken unacceptably or even break, and the connector must be replaced.

2   INTRODUCTION

SATURN is a 4.5" x 4.0" PCIe/104-expandable SBC based on Intel Apollo lake x5-E3940 processor with a PassMark rating of approximately 1900. The board provides expansion option over minicard and PCIe/104 OneBank. It features 4GB Non-ECC/ 8GB ECC DDR3L memory soldered on board, conduction cooling, Minicard socket, M.2 socket, two Gigabit Ethernets, multiple displays and -40 to +85C operation. The board is of 4.5x4" form factor.
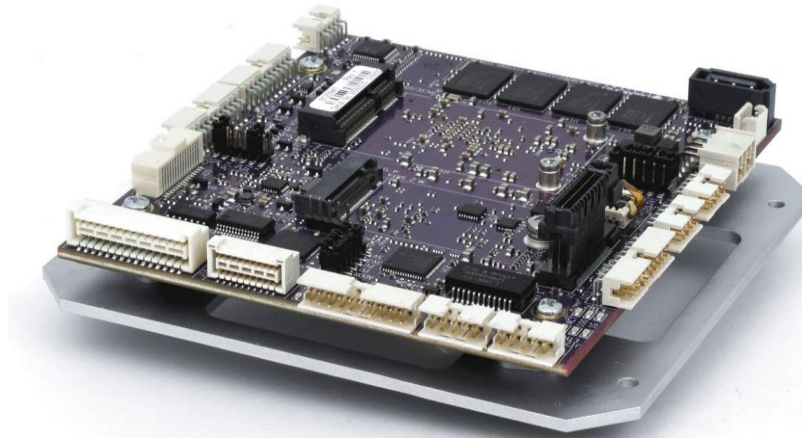
2.1   Models

Model number	Processor / speed	Cores	RAM	Data Acquisition
SAT-E3940-4GA	x5-3940 / 1.80 GHz	4	4GB Non ECC	Analog + Digital I/O
SAT-E3940-4GD	x5-3940 / 1.80 GHz	4	4GB Non ECC	Digital I/O
SAT-E3940-8GEA	x5-3940 / 1.80 GHz	4	8GB ECC	Analog + Digital I/O
SAT-E3940-8GED	x5-3940 / 1.80 GHz	4	8GB ECC	Digital I/O

2.2   Features

- ♦ Processor   Apollo lake,x5-3940, Quad Core, 1.6GHz, 9.5W TDP
                     Apollo lake,x5-3930, Dual Core, 1.3GHz, 6.5W TDP (Optional)
                     Apollo lake,x5-3950, Quad Core, 1.6GHz, 12W TDP (Optional)
- ♦ Memory   On board 8GB DDR3L ECC / 4GB non ECC
- ♦ Ethernet   1 10/100/100 Mbps direct from processor using I210 PHY
                     1 10/100/1000 Mbps from 1:4 PCIe switch using I210 PHY
- ♦ SATA   1 port, direct from processor to standard SATA connector
                     1 port, direct from processor to M.2 2242 connector
- ♦ USB   2 USB 2.0 ports to standard header
                     2 USB 2.0 / USB3.0 ports to standard header
                     1 USB 2.0 port on Mini card socket
                     2 USB 2.0 ports to One Bank PCIe/104
- ♦ LCD   Dual channel LVDS, using eDP to LVDS Bridge
- ♦ HDMI   2 ports direct from processor
- ♦ Audio   HD Audio with Line In, Mic In, Line Out
- ♦ Serial ports   2 ports with RS232/RS422/RS485 capability

1 port with RS232 capability

♦ Data Acquisition

16 16-bit analog inputs with 250KHz maximum sample rate

4 16-bit analog outputs with waveform generator

22 digital I/O lines with programmable direction (16 DIO on N models)

8 32-bit counter/timers

4 24-bit PWMs

♦ Expansion 1 Full MiniCard socket with PCIe x1 and USB2.0

1 M.2 2242 socket with SATA

One Bank PCIe/104 with 4 PCIe x1, 2 USB2.0

2.3 Operating System Support

♦ Windows 10 64bit, Linux 64bit

♦ Driver packages and/or BSPs available for each OS

2.4 Mechanical, Electrical, Environmental

♦ Form factor 4.5"W x 4.0"H / 114 x 102mm

♦ Cooling Conduction cooling, heat spreader

♦ Power +5VDC in

♦ Operating Temp -40°C to +85°C at outer surface of heat spreader

♦ Environmental Designed to meet the following conditions:

♦ Shock: MIL-STD-202G, Method 213-B, Table 213-1 Condition A, 50G / 11ms half sine, non-operational

♦ Vibration: MIL-STD-202G, Method 214A, Table 214-1, Condition D, 11.95G random vibration, 15 minutes per axis, operational

3   FUNCTIONAL OVERVIEW

3.1   Block Diagram

SATURN SBC Block Diagram

DDR3L MD 4GB Non-ECC 8GB ECC Soldered — DDR3L Ch.0 → Apollo Lake x5-E3940 Quad Core 1.6GHz/1.8GHz Processor

LVDS ← NXP PTN3460 — eDP / I2C

Line Out / Line In / MIC In ← Codec ALC662 — HDA

2x RS-232/ 422/485 ← Transceiver SP336 — UART[0:1]

1x RS-232 ← Transceiver SP211 — UART2

SATA 7-Pin — SATA0
M.2 Socket — SATA1
2x USB2.0 — 2x USB 2.0
2x USB3.0 — 2x USB 3.0 / 2x USB2.0
Utility Conn — I2C, RST, PWRBTN
2x HDMI — DDI[0:1]

PCIe x1 → Minicard Socket
1x USB 2.0 → Minicard Socket

2x USB 2.0 → PCIE/104 OneBank Connector
PCIe x1 → PCIE/104 OneBank Connector

PCIe x2 → PCIE Switch 1:4
PCIe x1 / PCIe x1 / PCIe x1 → PCIE/104 OneBank Connector
Optional bypass

PCIe x1 → PHY Intel I210 → Magnetics → Gigabit Ethernet
PCIe x1 → PHY Intel I210 → Magnetics → Gigabit Ethernet

LPC → FPGA
SPI → BIOS
BIOS → TPM 2.0

Data Acquisition → 16 SE / 8 DI Analog In
4 Analog Out
22 Digital I/O
8 Counter/Timers
4 PWM

I2C → PMIC IDT P9180 ← 5V
Voltages to processor and peripherals

Version 6.1

Block Diagram

3.2 Feature Descriptions

This section describes the key subsystems of the Saturn SBC.

3.2.1 Processor and Chipset

The Intel Atom® processor E390x series, formerly Apollo Lake, empowers real-time computing in digital surveillance, new in-vehicle experiences, advancements in industrial and office automation, new solutions for retail and medical, and more. These processors are based on the Goldmont architecture, utilizing Intel's industry-leading 14 nm process technology.

Saturn SBC is based on Intel Atom processor x5-E3940. It is a quad core, 64-bit processor with a maximum frequency of 1.8GHz.

3.2.2 Memory

The design employs DDR3L memory down configuration with ECC. The design supports single channel memory interfaces with each up to 8GB capacity with ECC.

Channel consists of 8nos DDR3L 4Gbit chips with to support 4GB non-ECC memory and 9nos of DDR3L 8Gbit chips with to support 8GB ECC memory configuration.

3.2.3 Ethernet

The board provides two Gigabit Ethernet ports. One port is derived directly from processor's x1 PCIe lane using an external I210 controller. The second port is realized from 1:4 PCIe switch lane using I210 controller. The board also includes the necessary magnetics for both the ports. Ethernet interface is terminated on a latching connector, not an RJ-45 jack.

On-board LEDs are provided for Link, Activity, and Speed. The LEDs are located along the board edge near the Ethernet connector. The GbE ports use dual row,2x5 2mm pitch latching connectors. The connector does not provide access to the LED signals.

3.2.4 SATA

The board offers two SATA ports, both derived from the processor. One port is connected to an industry-standard vertical 7pin SATA connector that accepts cables with latching. The second port is connected to M.2 2242 size, M-key socket. SBC provides onboard M3 2mm spacer and M3 Screw to mount M.2 2242 sata SSD.

3.2.5 Display

The board offers three display output options: two HDMI and one LVDS.

The HDMI ports are directly from the processor and are made available on two separate dual row 2x10 2mm pitch latching connectors. Two HDMI ports support HDMI 1.4b, maximum resolution is up to 3840x2160 @ 30Hz.

LVDS interface is obtained using an eDP to LVDS converter with the NXP PTN3460. The LCD backlight control is provided by a PWM circuit. Both single channel and Dual channel LCDs are supported. VDD voltage can be selected from 5V or 3.3V and Backlight Voltage can be selected from 12V or 5V.

LCD data signals are terminated on a 2x15 1mm pitch latching while LCD Backlight control & enable signals are terminated on a 1x6 1.25mm pitch latching connector. LVDS display supports upto1920x1200 @ 60 Hz resolution in dual LVDS bus mode.

3.2.6 Audio

The board provides HDA compatible audio controller ALC892. Audio I/O signals include stereo line in, stereo line out and mono mic in. The analog audio signals are made available on a dual row 2x5 2mm pitch latching connector.

3.2.7 Minicard Socket

The board provides expansion for one full size (51mm length) Minicard socket. The socket supports mPCIe add on cards. Minicard interface support PCIex1 lane port and one USB2.0 port. Access to sim card signals are not provided. If LTE modem need to be used, please select module with SIM connector.

SBC provides 2nos onboard M2 3.55mm spacer and M2 screws to mount minicard module

3.2.8 USB

The board offers seven USB 2.0 ports and two USB 3.0 ports directly from the processor.

One USB 2.0 port is connected to the Mini card socket, two are made available on dual row 2x5 2mm pitch latching connector, and another two are available on one bank PCIe/104 connector.

USB 3.0 ports are available on 2nos of dual row, 2x5 2mm pitch latching connectors along with USB2.0 ports.The USB3.0 and USB2.0 port mappings are as below:

USB3.0 Ports	
Port Number	Port Termination
Port 0	USB3.0 Connector1
Port 1	USB3.0 Connector2
USB2.0 Ports	
Port Number	Port Termination
Port 0	USB3.0 Connector1
Port 1	USB3.0 Connector2
Port 2	Mini Card Connector
Port 3	PCIe/104 Connector
Port 4	PCIe/104 Connector
Port 5	USB2.0 Connector
Port 6	USB2.0 Connector

3.2.9 Serial Ports

The board provides 3 serial ports from the processor. Two serial ports support RS-232/422/485 protocols using Exar SP336 multiprotocol transceivers. Protocol selection are controlled by FPGA gpio and configurable via application software. TX / RX 121-ohm line termination resistors for RS-422/485 can controlled by Jumper.

One serial port supports RS232 protocol using the RS232 transceiver. In RS-232 mode, only signals TX, RX are provided. Option for TTL level signals is provided. The RS232 port is also used as console redirection for debug/development purposes.

The serial ports are terminated on dual row, 2x5 2mm pitch latching connectors. One such connector provides access to two serial ports.RS232 port is made available as part of the utility connector.

3.2.10 Data Acquisition

The board provides an optional data acquisition subcircuit containing analog input, analog output, and digital I/O features. This circuit is controlled by an FPGA attached to the processor via the LPC bus. A pin header on the board provides access to JTAG signals for reprogramming the FPGA on the board and in the field.

Features of the DAQ subcircuit include: 16 single-ended / 8 differential analog inputs with 16-bit resolution, programmable input ranges, and 250KSPS maximum throughput; 4 analog outputs with 16-bit resolution and programmable output ranges; and 22 digital I/O lines with selectable 3.3V/5V logic levels, selectable pull-up/down resistors, programmable direction, buffered I/O, and capability for use as counter/timer and PWM circuits.

3.2.11 RTC Backup Battery

The RTC current consumption is 6uA with RTC voltage at 3.0V while the system is in a mechanical off (G3) state at room temperature. This data can be used to estimate the battery life. The voltage of the battery can affect the RTC accuracy. In general, when the battery voltage decays, the RTC accuracy also decreases

An onboard 2032 coin cell battery holder and battery are provided on the bottom side of the board, accessible through a cutout in the heat spreader. A 1x2 connector is also provided to enable the use of an external battery for rugged applications.

Batteries are rated by storage capacity in milli-ampere hours (mAh). The battery life can be calculated by dividing the battery's capacity by the average RTC current required and considering external factors that effects the battery life. For example, if the battery storage capacity is 190 mAh (assumed usable) and the average current required is 6 μA, the ideal battery life will be: 190,000 μAh/6 μA = 31,667 h = 3.6 years.

External Battery voltage specification: Typical 3.0V; Max: 3.2V; Min: 2.0V

The board can boot and function properly without a backup battery installed.

3.2.12 Trusted Platform Module (TPM)

The board contains Infineon's SLB 9670XQ2.0 TPM module featuring a fully TCG TPM 1.2/2.0 standard compliant module with an SPI interface. TPM can be used as a root of trust for platform integrity, remote attestation, and cryptographic services.

3.2.13 PCIe link routing

Apollo lake processor supports 4 PCIe 2.0 ports and 6 lanes can be allocated over those 4 ports. Bypass option is provided for I210 Gbe Controller 2 by removing PCIe switch for the configuration where PCIe switch and PCIe/104 connector is not used.

The PCIe port mapping is as below:

PCIe Port No.	Lane Width	Port Termination
Port 1	X2	1:4 PCIe Switch • Three x1 lanes to one bank PCIe/104 connector • One x1 lane to I210 Gbe controller 2
Port 2	x1	I210 Gbe controller 1
Port 3	x1	One bank PCIe/104 connector Port1
Port 4	x1	Minicard socket

3.2.14 PCIe/104 OneBank Expansion

The board offers expansion over one bank PCIe/104 connector with taller 22mm stacking height to ensure clearance over an installed minicard module on the main board.

The OneBank specification supports up to four x1 lane PCIe ports on one bank PCIe/104 connector, and all four lanes are supported on Saturn. The PCIe lane mapping on the one bank PCIe/104 connector is as below:

PCIe Lane No.	PCIe Host
Lane 0	Directly from the processor
Lane 1	Indirectly from the processor via 1:4 PCIe switch
Lane 2	
Lane 3	

5V from input power connector is directly connected PCIe/104 connector so that the board can either powered by input power connector or PCIe/104 one bank connector. Option to disconnect 3.3V to the PCIe/104 connector is provided.

3.2.15 Utility

The board offers two 2x5 utility connectors, one with LPC bus interfaces for external IO expansion and another with Serial Port (RS232), Power Button, Reset button and I2C interface.

Out of the two connectors, one provides 500mA fused 3.3V and 5V and the other connector provide 500mA fused 3.3V.

3.2.16 LED Indicators

The board provides the following LED indicators. All LEDs are located near to a board edge or their respective features. The blue LED is located along the lower edge of the board. All LEDs are labeled in silkscreen with their function.

PWRIN:	Green LED when Input supply 5VDC is applied
PWRON:	Green LED when board is powered on
BIOS:	Green, connected to a GPIO line on the processor; this LED is off during power-up and is turned on in the BIOS to indicate a successful system BIOS startup.
Ethernet:	6 Green LEDs, 1 each for Link, Activity, and Speed per port
DONE:	FPGA is configured successfully.
USER:	Blue, User LED, controlled by processor FPGA

3.2.17 BIOS Features

The BIOS provides the following key features:

♦ Boot from LAN (PXE) as well as USB and SATA ports
♦ Free boot sequence configuration to allow different boot sequences as first, second and third boot devices
♦ Support multi display mode. HDMI and LVDS can be active simultaneously
♦ Console (display and keyboard) redirection to one or more COM ports
♦ DSC-configurable default settings in battery-less configurations; the necessary BIOS customization tool must be provided
♦ Customizable splash screen
♦ Quiet boot option
♦ Enable/disable for individual COM ports.
♦ LPC interface for DAQ FPGA
♦ Wake on LAN for on-board Ethernet, minicard socket
♦ Single BIOS to support various memory configurations and processor variants
♦ Integrated verb table for ALC892 Audio codec
♦ BIOS LED to indicate successful BIOS initialization
♦ Supports standard BIOS hotkey. This includes ESC key to enter BIOS menu etc
♦ Password protection
♦ Field upgradeable via a Shell/Windows utility

3.2.18 Power Supply

The board requires only +5VDC input voltage as per the PCIe/104 Specification. It supports ACPI for pushbutton on/off control. It supports Standby mode with an optional +5VSB input. In standby mode, the board may be powered on via Wake on Lan feature on at least one Ethernet port.

The 5V supply on the PCIe/104 connectors is routed directly to the input power connector, so that the board may obtain its input power from either the input power connector or from the bus connector. Maximum allowable reflected ripple, measured at the voltage input connector is 50mV p-p.

All required supply voltages for the board, are derived from the 5V input. These power supplies are sized to support the highest power E3940 family processor with the highest capacity on-board memory plus have enough reserve capacity to support the below add-on features:

5V	3.3V	Feature
2.0A	0.5A	PCIe add-on modules
	1.3A	PCIe Minicard add-on modules
	1.5A	M.2 Sata SSD
1.4A	0.7A	LCD power
0.9A		LCD backlight
	0.05A	DAQ connector
	0.05A	Utility connector
1.0A		USB 2.0 ports x2
1.8A		USB 3.0 port x2

The PCIe/104 connector obtains 5V power directly from the input connector. The +12V pin on the input power connector is routed to the +12V source for the LCD backlight.

3.3 Rugged Design

Saturn is designed from the ground up with a comprehensive set of features to meet the challenges of rugged environments and applications:

♦ Memory is soldered down to avoid problems that can occur with commercial style SODIMM type memory modules

♦ The 50% thicker PCB increases rigidity and improves reliability of fine pitch and high-ball-count BGA solder joints

♦ All I/O connectors are latching for increased ruggedness

♦ A bottom-side heat spreader provides more efficient cooling than a traditional heat sink. Processor and memory chips are both thermally connected to the heat spreader. In addition, the exterior surface features recessed thermal pads for improved thermal connectivity to the system enclosure.

♦ All components are rated and/or tested to ensure reliable -40 to +85⁰C operation
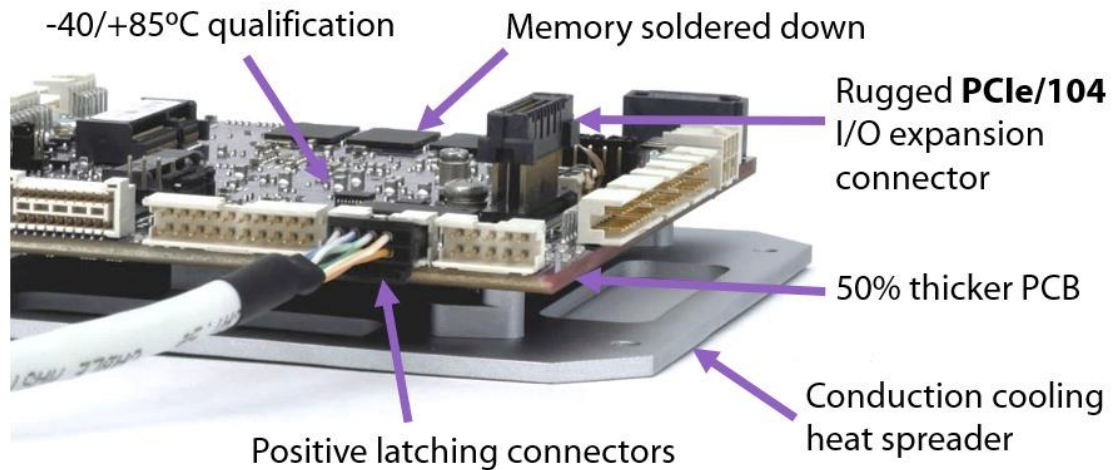
4 BOARD MECHANICAL DRAWING

Dimensions are in inches [mm]. Connector dimensions indicate the center of the pad for pin 1.
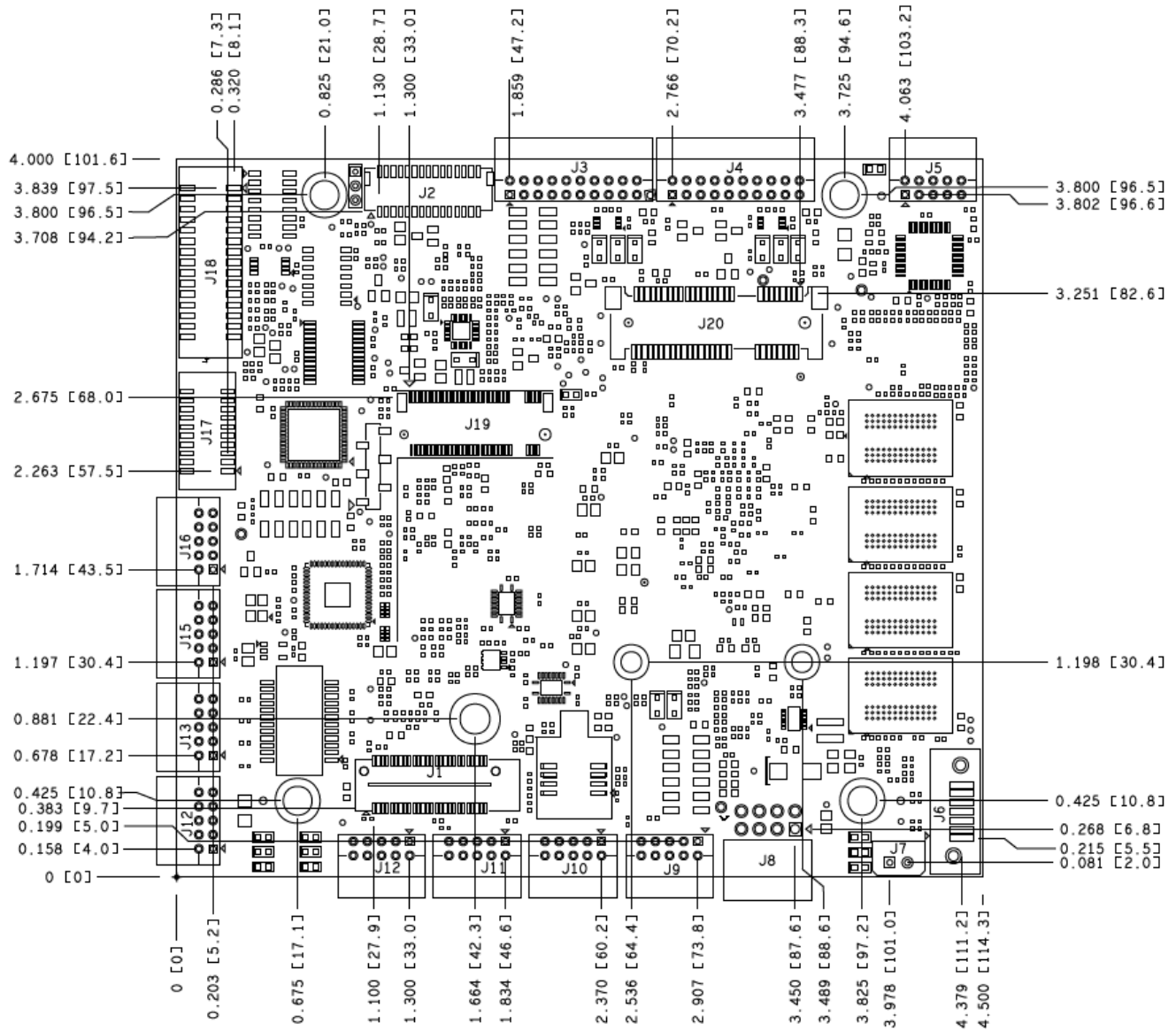
Mechanical Drawing

5 CONNECTOR AND JUMPER LOCATIONS
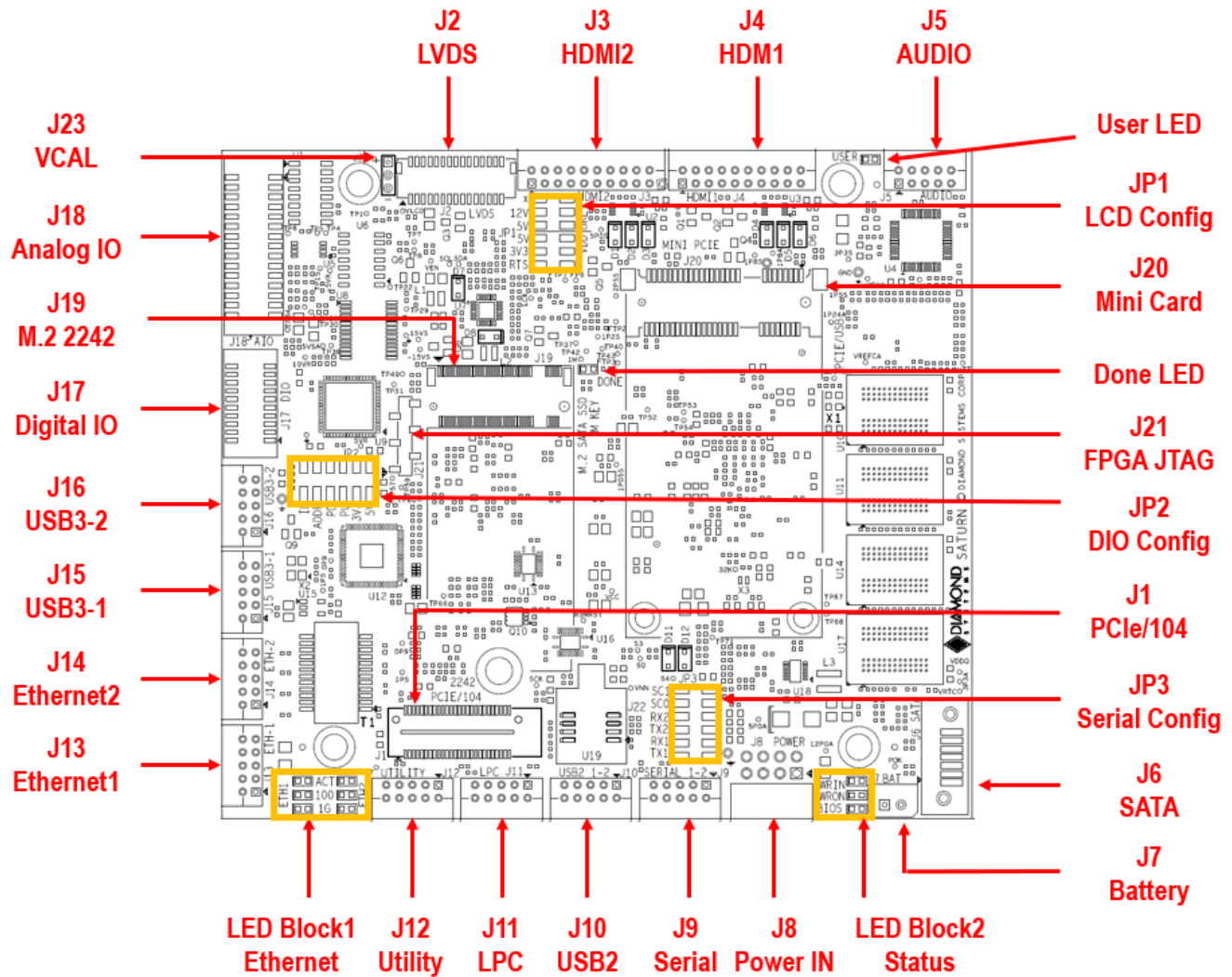
Board layout – Top
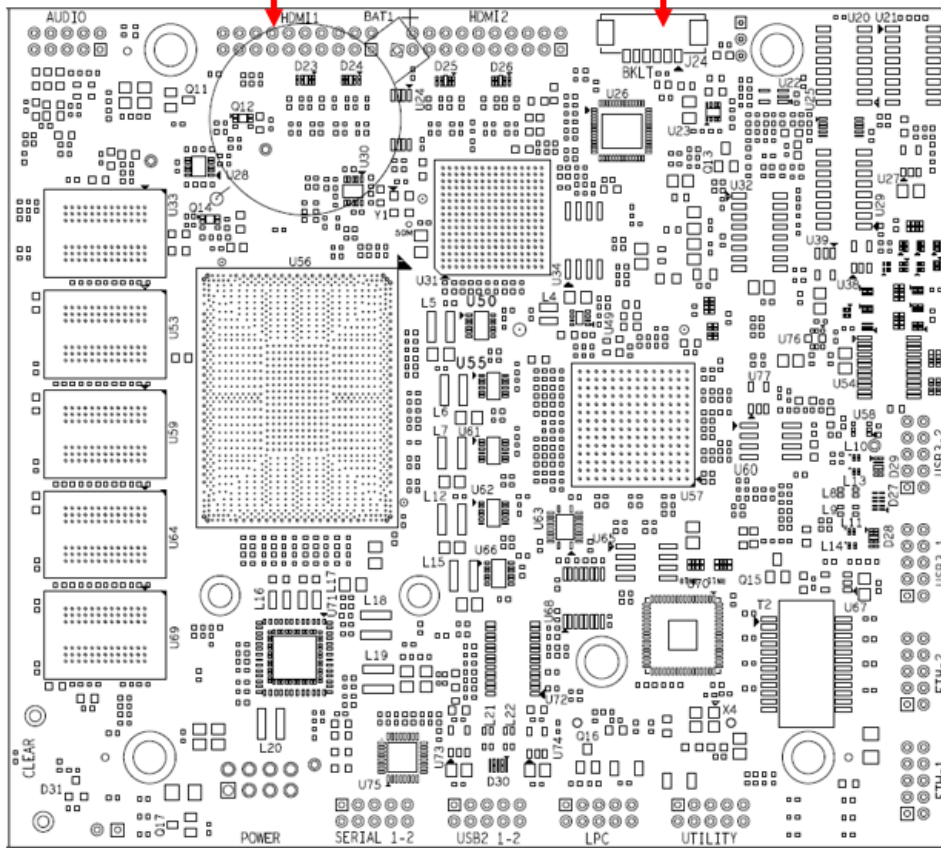
Board layout – Bottom

I/O Connectors, Jumpers and LED Summary

Connector	Function	Jumper	Function
J1	PCIe/104 One bank	JP1	LVDS Vcc & Backlight Voltage Selection
J2	LVDS LCD	JP2	Digital IO voltage and pull resistors, FPGA Address
J3	HDMI2	JP3	Serial Port protocol and Termination selection
J4	HDMI1	*LED Block 1 (ETH1)*	
J5	Audio	Top LED	GBE0 ACT
J6	SATA Standard	Middle LED	GBE0 Link100
J7	External Battery	Bottom LED	GBE0 Link1000
J8	Power In	*LED Block 1 (ETH2)*	
J9	Serial Ports 1-2	Top LED	GBE1 ACT
J10	USB2 Port x2	Middle LED	GBE1 Link100
J11	LPC Bus	Bottom LED	GBE1 Link1000
J12	Utility	*LED Block 2*	
J13	GbE Ethernet1	Top LED	Power In LED
J14	GbE Ethernet2	Middle LED	Power On LED
J15	USB3 Port1	Bottom LED	BIOS LED
J16	USB3 Port2	*LED Block 3*	
J17	Digital IO	User LED	
J18	Analog IO	*LED Block 4*	
J19	M.2 Sata 2242	FPGA Done LED	
J20	Minicard Socket		
J21	FPGA JTAG		
J22	LVDS backlight		
J23	Voltage Calibration		
BAT1	2032 Coin Battery Holder		

6 I/O CONNECTORS

6.1 Connector Pin-out and Signal Description

6.1.1 Power In (J8)

Input power may be supplied through the connector J8. All the required supply voltages for the board are derived from the 5V input. The +12V input is optional and necessary only to drive LCD backlight.

Ground	**1**	**2**	+12V(Optional)
Ground	**3**	**4**	+5V
Ground	**5**	**6**	+5V
Ground	**7**	**8**	+5V

Connector used is a custom version of Samtec IPL1 with longer pins for better PCB soldering.

Mating Cable: DSC no. 6980512

The following diagram depicts the Front View of the Power Connectors. Note that this pinout is different compared to Samtec datasheet.
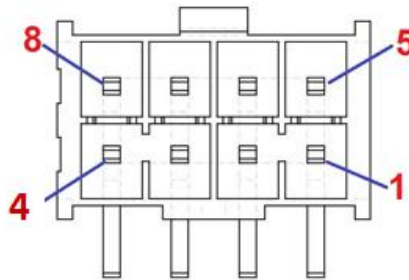
Mating Side View of Power Connector

6.1.2 External Battery (J7)

To maintain the on-board real-time clock (RTC), Saturn has an on-board coin battery holder and by default a BR-2032/BN is installed. It is possible to connect an external battery via connector J7 for longer battery life or long term maintainability.

1	VBAT
2	Ground

VBAT = +3.0V

Connector used is 22-05-7025 right angle type friction lock pin header.

Mating cable: DSC 6980524

External Battery voltage specification: Typical 3.0V; Max: 3.2V; Min: 2.0V

The RTC current consumption is 6uA with RTC voltage at 3.0V while the system is in a mechanical off (G3) state at room temperature. This data can be used to estimate the battery life. The voltage of the battery can affect the RTC accuracy. In general, when the battery voltage decays, the RTC accuracy also decreases

Example batteries are: Duracell* 2032, 2025, or 2016 (or equivalent), which can give many years of operation. Batteries are rated by storage capacity. The battery life can be calculated by dividing the capacity by the average current required and considering external factors that effects the battery life. For example, if the battery storage capacity is 190 mAh (assumed usable) and the average current required is 6 µA, the ideal battery life will be: 190,000 µAh/6 µA = 31,667 h = 3.6 years.

6.1.3 Serial Ports (J9)

Serial ports 1 and 2 are provided on a connector which can be configurable for RS-232, RS-422, or RS-485 Modes. The pinouts of the connector are as below:

RS-232

TX1	A01	B01	RTS1
RX1	A02	B02	CTS1
GND	A03	B03	GND
TX2	A04	B04	RTS2
RX2	A05	B05	CTS2

RS-422

TX1+	A01	B01	TX1-
RX1+	A02	B02	RX1-
GND	A03	B03	GND
TX2+	A04	B04	TX2-
RX2+	A05	B05	RX2-

RS-485

TX1/RX1+	A01	B01	TX1/RX1-
NC	A02	B02	NC
GND	A03	B03	GND
TX2/RX2+	A04	B04	TX2/RX2-
NC	A05	B05	NC

Connector Type: 2x5 2mm pitch latching RA TH header of Amphenol# 98464-G61-10ULF

Mating Cable: DSC no. 6980601

Serial port 3 (RS232 only) is part of utility connector. Please refer utility connector section for pinouts.

6.1.4   USB 2.0 Ports (J10)

The USB2.0 connector provides access to two USB 2.0 ports. The pinouts are as below:

Key	A01	B01	Shield
USB0 Pwr-	A02	B02	USB1 Pwr-
USB0 Data+	A03	B03	USB1 Data+
USB0 Data-	A04	B04	USB1 Data-
USB0 Pwr+	A05	B05	USB1 Pwr+

Connector Type: 2x5 2mm pitch latching RA TH header of Amphenol# 98464-G61-10ULF

Mating Cable: DSC no. 6980602

6.1.5   LPC & Utility (J11, J12)

The utility connector provides access to power button, reset signal, I2C port, Serial Port and LPC signals. It provides fused 3.3V and 5V power that can be used for powering customer auxiliary circuitry.

The pinouts of the Utility and LPC connectors are below:

RS232 TXD	A01	B01	I2C Clock
RS232 RXD	A02	B02	I2C Data
Ground	A03	B03	Power Button
5V Fused 0.5A	A04	B04	Ground
3.3V Fused 0.5A	A05	B05	Reset

3.3V Fused 0.5A	A01	B01	Ground
LPC Frame	A02	B02	LPC AD0
LPC Clock	A03	B03	LPC AD1
LPC SERIRQ	A04	B04	LPC AD2
PLTRST	A05	B05	LPC AD3

Connector Type: 2x5 2mm pitch RA TH header of Amphenol# 98464-G61-10ULF.

Mating cable: DSC no. 6980609

The 3.3V and 5V pin on this connector is connected to the system 3.3V and 5V rail through a polyswitch resettable fuse. The fuse is rated for ~500mA maximum sustained current. If DC current exceeds this value, the polyswitch will heat up and create a high resistance to limit current flow. The current is reduced to the level required to maintain the resistance, maintaining a steady state protection condition. When the overload is removed, the polyswitch will cool down and return to normal low-impedance mode

6.1.6   Ethernet (J13, J14)
The board provides two ethernet ports accessed on two identical connectors. The pinouts of one of these connectors is as below:

Chassis Gnd	A01	B01	Key
DA+	A02	B02	DA-
DB+	A03	B03	DB-
DC+	A04	B04	DC-
DD+	A05	B05	DD-

Connector Type: 2x5 2mm pitch latching RA TH header of Amphenol# 98464-G61-10ULF

Mating Cable: DSC no. 6980604

6.1.7   USB 3.0 Port (J15, J16)
The USB3.0 connector provides access to USB 3.0/USB2.0 ports on two identical connectors. The pinouts of one of these connectors is as below:

USB1 SSRX-	A01	B01	Shield
USB1 SSRX+	A02	B02	USB1 Pwr-
USB1 Pwr-	A03	B03	USB1 Data+
USB1 SSTX-	A04	B04	USB1 Data-
USB1 SSTX+	A05	B05	USB1 Pwr+

Connector Type: 2x5 2mm pitch latching RA TH header of Amphenol# 98464-G61-10ULF

Mating Cable: DSC no. 6980603

6.1.8 SATA (J6)

The board provides access to SATA interface through a standard 7-pin connector. The pinout of this connector is as below:

1	Ground
2	SATA TX+
3	SATA TX-
4	Ground
5	SATA RX-
6	SATA RX+
7	Ground

Connector Type: 7-position vertical through connector, Molex# 0678008025.

Mating Cable: Standard HDMI cable

6.1.9 Audio (J5)

The board provides access to HDA interface on q 10 pin connector. The pinout is shown below:

LineOut-L	**A01**	**B01**	LineOut-R
GND_Audio	**A02**	**B02**	GND_Audio
LineIn-L	**A03**	**B03**	LineIn-R
GND_Audio	**A04**	**B04**	GND_Audio
NC	**A05**	**B05**	MIC_IN

Connector Type: 2x5 2mm pitch latching RA TH header of Amphenol# 98464-G61-10ULF

Mating Cable: DSC no. 6980608

6.1.10 LVDS LCD (J2)

The board provides access to an LVDS LCD display on a 30-pin connector. The LCD panel power is jumper-selectable for 3.3V (default) or 5V

VDD 5V/3.3V	**1**	**2**	VDD 5V/3.3V
VDD 5V/3.3V	**3**	**4**	VDD 5V/3.3V
CLK+ Odd	**5**	**6**	CLK+ Even
CLK- Odd	**7**	**8**	CLK-Even
Ground	**9**	**10**	Ground
D0+ Odd	**11**	**12**	D0+ Even
D0- Odd	**13**	**14**	D0- Even
D1+ Odd	**15**	**16**	D1+ Even
D1- Odd	**17**	**18**	D1- Even
D2+ Odd	**19**	**20**	D2+ Even
D2- Odd	**21**	**22**	D2- Even
D3+ Odd	**23**	**24**	D3+ Even
D3- Odd	**25**	**26**	D3- Even
Ground	**27**	**28**	Ground
DDC CLK	**29**	**30**	DDC DATA

Connector Type: 2x15 1mm pitch RA SMT shrouded header of Molex# 5015713007.

Mating cable: Custom cable depending upon the target display. The LCD end of the cable will be different for each LCD or LCD family. Because of the wide variety of LCDs and the fact that many applications do not require a display, this cable is not included in the Saturn standard cable kit CK-SAT-01. DSC cable no. 6981213 may be used as the starting point for this cable, with the LCD end to be modified by the customer as per the LCD requirements.

If Single channel LCD is used, use the Odd channel signals and leave the Even channel signals unconnected.

6.1.11 LCD Backlight (J24)

The brightness control for the LCD backlight has a weak pull-down resistor to ensure maximum brightness when it is not connected externally. This signal may be controlled by a PWM pin from the processor. A jumper selects the source of the brightness signal to this pin.

Pin	Description
1	Power +5V/+12V, jumper selectable
2	Power (same as pin 1)
3	Ground
4	Ground
5	Enable (GPIO output), 0 = off, open circuit = on
6	Brightness, 0-5VDC variable; 0V = max, 5V = min

Connector Type: 1x6 1.25mm pitch SMD RA header of Molex# 053261-0671.

Mating cable: Custom cable depending upon the target display. Because of the wide variety of LCDs and the fact that many applications do not require a display, this cable is not included in the Saturn standard cable kit CK-SAT-01. DSC cable 6981210 may be used as the starting point for this cable, with the LCD end to be modified by the customer as per the LCD requirements.

6.1.12 HDMI (J3, J4)

The board provides access to two HDMI ports on two identical connectors. The pinout is shown below:

Data 2+	A01	B01	GND
Data 2-	A02	B02	Data 1+
GND	A03	B03	Data 1-
Data 0+	A04	B04	GND
Data 0-	A05	B05	Clock+
Ground	A06	B06	Clock-
CEC (NC)	A07	B07	Reserved
DDC Clock	A08	B08	DDC Data
GND	A09	B09	+5V
Hot Plug Detect	A10	B10	Chassis ground

Connector Type: 2x10 2mm pitch latching RA TH header of Amphenol# 98464-G61-20ULF.

Mating cable: DSC no. 6980605

6.1.13 Analog I/O (J18)

The VIO pins on the analog and digital I/O connectors are tied together on the board and provide access to jumper-selectable 3.3V / 5V system voltage rail through a polyswitch resettable fuse. The fuse is rated for ~100mA maximum sustained current.

Ain 0	1	2	Ain 8
Ain 1	3	4	Ain 9
Ain 2	5	6	Ain 10
Ain 3	7	8	Ain 11
Ain 4	9	10	Ain 12
Ain 5	11	12	Ain 13
Ain 6	13	14	Ain 14
Ain 7	15	16	Ain 15
Analog Ground	17	18	Analog Ground
Aout 0	19	20	Aout 1
Aout 2	21	22	Aout 3
Analog Ground	23	24	DIO C0
DIO C1	25	26	DIO C2
DIO C3	27	28	DIO C4
VIO (fused)	29	30	Digital Ground

Connector type: 2x15 contact right angle latching connector SM30B-ZPDSS-TF

Mating cable : DSC no. 6981504

6.1.14 Digital I/O (J17)

VIO (fused)	1	2	DIO A0
DIO A1	3	4	DIO A2
DIO A3	5	6	DIO A4
DIO A5	7	8	DIO A6
DIO A7	9	10	DIO B0
DIO B1	11	12	DIO B2
DIO B3	13	14	DIO B4
DIO B5	15	16	DIO B6
DIO B7	17	18	DIO C5
Ground	19	20	Ground

Connector type: 2x10 contact right angle latching connector SM20B-GHDS-GAN-TF.

Mating cable : DSC no. 6980501

6.1.15 MiniCard Socket (J20)

The board provides access to PCIe mini card interface via Mini card socket. For the connector shown below, all TX/RX signals are with respect to the host. TX on the socket drives RX on the installed module, and RX on the socket is driven by TX on the installed module. The two mounting standoffs at the far end of the module installation site are not connected to ground. The pinout of the connector is shown below:

	1	2	+3.3V
	3	4	Gnd
	5	6	+1.5V
Clkreq-	7	8	
Gnd	9	10	
PCIe 1 Clk-	11	12	
PCIe 1 Clk+	13	14	
Gnd	15	16	
	KEY		
	17	18	Gnd
	19	20	Disable-
Gnd	21	22	PCIe Reset-
PCIe 1 RX-	23	24	+3.3V
PCIe 1 RX+	25	26	Gnd
Gnd	27	28	+1.5V
Gnd	29	30	SMB Clk
PCIe 1 TX-	31	32	SMB Data
PCIe 1 TX+	33	34	Gnd
Gnd	35	36	USB2 D-
Gnd	37	38	USB2 D+
+3.3V	39	40	Gnd
+3.3V	41	42	WWAN LED-
Ground	43	44	WLAN LED-
	45	46	WPAN LED-
	47	48	+1.5V
Pull-up to +3.3V	49	50	Gnd
	51	52	+3.3V

Connector Type: SMT 52 position 0f 0.8mm pitch for full size mPCIE modules

Mating Cable: NA

6.1.16 FPGA JTAG (J21)

A 1x6 2mm Pin header is provided for FPGA programming at the factory and is not normally accessed by the customer. Pinouts is shown below.

1	3.3V
2	Ground
3	TCK
4	TDO
5	TDI
6	TMS

Connector used is 1x6 2mm Vertical Header.

Mating cable: Factory test cable

6.1.17 M.2 SATA Socket (J19)

The board provides mass storage support via an M.2 socket that supports SATA modules of size 2242. For the pinouts shown, all TX/RX signals are with respect to the host. TX on the socket drives RX on the installed module, and RX on the socket is driven by TX on the installed module. The mounting standoff at the far end of the module installation site is not connected to ground.

The pinout of the connector is shown below:

Signal	Pin	Pin	Signal
Gnd	1	2	+3.3V
Gnd	3	4	+3.3V
	5	6	
	7	8	
	9	10	
	11	12	
	13	14	
	15	16	
	17	18	
	19	20	
Gnd	21	22	
	23	24	
	25	26	
Gnd	27	28	
	29	30	
	31	32	
Gnd	33	34	
	35	36	
	37	38	DEVSLP
Gnd	39	40	
SATA_RX+	41	42	
SATA_RX-	43	44	
Gnd	45	46	
SATA_TX-	47	48	
SATA_TX+	49	50	
Gnd	51	52	
	53	54	
	55	56	
Gnd	57	58	
	KEY		
	67	68	
Gnd	69	70	+3.3V
Gnd	71	72	+3.3V
Gnd	73	74	+3.3V
Gnd	75		

Connector Type: SMT 67 position with 0.5mm pitch for PCIe/104 one bank expansion of Samtec# ASP-129646-22

Mating Cable: NA

6.1.18 Analog Circuit Calibration (J23)

A 1x3 2mm pin header is provided for Analog IO calibration for factory use. In normal conditions the customer should not need to access this connector.

Pin	Signal
1	Voltage for calibration
2	NC
3	Aground

Connector used is 1x3 2mm Vertical Header.

Mating cable: Factory test cable

6.1.19   PCIe/104 (J1)

The board provides expansion to PCIe/104 via a One-Bank connector. The connector provides access to four x1 PCIe lanes, two USB2.0s, ATX power & control signals, +3.3V & +5V power rails and SMBus interfaces. The pinout of the connector is shown below:

Signal	Pin		Pin	Signal
USB-OC#	1		2	PCIe Reset#
+3.3V	3		4	+3.3V
USB_1+	5		6	USB_0+
USB_1-	7		8	USB_0-
Ground	9		10	Ground
PCIe1 Tx+	11		12	PCIe0 Tx+
PCIe1 Tx-	13		14	PCIe0 Tx-
Ground	15		16	Ground
PCIe2 Tx+	17		18	PCIe3 Tx+
PCIe2 Tx-	19		20	PCIe3 Tx-
Ground	21	+5V TAB	22	Ground
PCIe1 Rx+	23		24	PCIe0 Rx+
PCIe1 Rx-	25		26	PCIe0 Rx-
Ground	27		28	Ground
PCIe2 Rx+	29		30	PCIe3 Rx+
PCIe2 Rx-	31		32	PCIe3 Rx-
Ground	33		34	Ground
PCIe1 Clk+	35		36	PCIe0 Clk+
PCIe1 Clk-	37		38	PCIe0 Clk-
+5VSB	39		40	+5VSB
PCIe2 Clk+	41		42	PCIe3 Clk+
PCIe2 Clk-	43		44	PCIe3 Clk-
Ground(Dir)	45		46	PWRGOOD
SMB Data	47		48	NC
SMB Clk	49		50	NC
SMB Alert#	51		52	PSON#

Connector Type: SMT 52 position with 0.64mm pitch for PCIe/104 one bank of Samtec# ASP-129646-22

Mating Cable: Board to board connection only

6.2   List of Connectors

The following table provides a summary of all I/O connectors on the board.

| Function	Manufacturer	Part no.	Description	Mating part	Mating Cable
Power in	Samtec	ASP-194529-01	2x4 box header T/H Right angle .1" pitch	IPD1-04-D-K	6980512
External battery	Molex	22-05-7025	2 pos. 2.54mm pitch Vertical latching	0050375023	6980524
Serial ports	Amphenol	98414-F06-10ULF	10 Pos 2mm Pitch T/H Vertical Angle Latching	10073599-010LF	6980601
USB 2.0	Amphenol	98464-G61-10ULF	10 Pos 2mm Pitch T/H Right Angle Latching	10073599-010LF	6980602
USB 3.0 / 2.0	Amphenol	98464-G61-10ULF	10 Pos 2mm Pitch T/H Right Angle Latching	10073599-010LF	6980603
Ethernet	Amphenol	98414-F06-10ULF	10 Pos 2mm Pitch T/H Vertical Angle Latching	10073599-010LF	6980604
HDMI	Amphenol	98464-G61-20ULF	20 Pos 2mm Pitch Right Angle Latching	10073599-020LF	6980605
SATA	Molex	0678008025	Conn Header 7pos Vert T/H	-	NA
Audio	Amphenol	98464-G61-10ULF	10 Pos 2mm Pitch T/H Right Angle Latching	10073599-010LF	6980608
Utility & LPC	Amphenol	98464-G61-10ULF	10 Pos 2mm Pitch Right Angle Latching	10073599-010LF	6980609
Digital I/O	JST	SM20B-GHDS-GAN-TF	20 Pos 1.25mm Pitch SMT Right Angle Latching	GHDR-20V-S	6980517
Analog I/O	JST	SM30B-ZPDSS-TF	30 Pos 1.5mm Pitch SMT Right Angle Latching	ZPDR-30V-S	6980518
LVDS LCD	Molex	5015713007	Conn Header SMD R/A 30pos 1mm	5011893010	NA
LCD backlight	Molex	053261-0671	6 Pos 1.25mm Pitch Right Angle	0510210600	NA

7   I/O CABLES

Photo No:	Cable Part No	Description	Saturn Connector
1	6980512	Power in	J8
2	6980524	External Battery	J7
J93	6980601	Serial Port	J9
4	6980602	USB2.0	J10
5	6980603	USB3.0	J15, J16
6	6980604	Ethernet	J13, J14
7	6980605	HDMI	J3, J4
8	6980608	Audio	J5
9	6989101	SATA	J6
10	6980517	Digital I/O	J17
11	6980518	Analog I/O	J18
12	6980609	LPC, Utility	J11, J12

I/O Cables

8 JUMPER DESCRIPTION

Following drawing shows only the connectors and jumper blocks on the board. The default jumper positions are shown in blue.
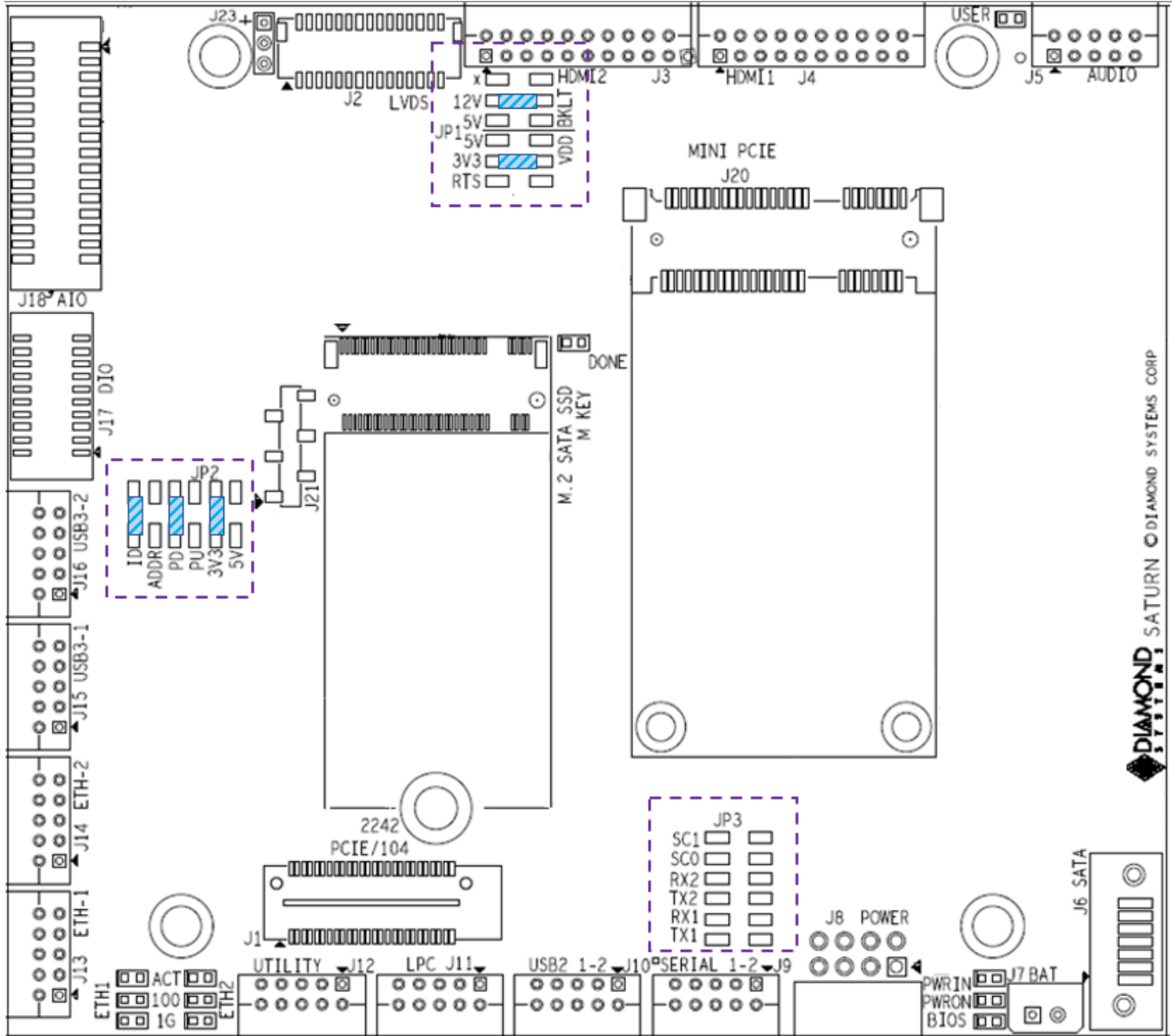
Default Jumper locations

Jumper	Description
JP1	LVDS LCD VCC and Backlight
JP2	DIO PU/PD, Voltage, Address
JP3	Serial Port protocol and termination

8.1 LVDS Backlight and LVDS VDD (JP1)

Jumper block JP1 configures the voltage supply for the LCD backlight and LVDS VDD.

By default, LVDS backlight is provided with +12V and the LVDS VDD is provided with 3.3V.

Position	Function	IN	OUT
12V*	**LCD Backlight Voltage**	**12V**	-
5V	LCD Backlight Voltage	5V	-
x	-	-	-
5V	LCD VDD Voltage	5V	-
3V3*	**LCD VDD Voltage**	**3.3V**	-
Default Mode			

8.2 Digital IO and Address (JP2)

Jumper block JP2 configures the Voltage level for Digital IO and Pull up/down. It also selects the base address for Data acquisition FPGA.

By default, Digital IO is 3.3V and pulled down. FPGA base address is set to 0x280 and USB3.0/2.0 Port 0 is Host by default.

Position	Function	IN	OUT
ID	USB3.0/2.0 Port0 Mode	**Host**	Device
ADDR	FPGA Base Address	*0x240*	**0x280**
PD	DIO Pull Down Enable	**Enabled**	Disabled
PU	DIO Pull Up Enable	Enabled	Disabled
3V3	DIO Voltage Level	**3.3V**	-
5V	DIO Voltage Level	5V	-
Default Mode			

8.3 Serial Port Configuration (JP3)

Jumper block JP3 configures Serial Port1-2 protocol and termination select during RS422/485 mode.
By default, Serial ports are set to Internal loopback mode and terminations are disabled. The protocol selection is superseded by DAQ software setting.

Position	Function	IN	OUT
SC1	Ser Port1-2 Mode select1	Refer Table Below	-
SC0	Ser Port1-2 Mode select0	Refer Table Below	
RX2	Serial Port2 RX Termination	Enabled	**Disabled**
TX2	Serial Port2 TX Termination	Enabled	**Disabled**
RX1	Serial Port1 RX Termination	Enabled	**Disabled**
TX1	Serial Port1 TX Termination	Enabled	**Disabled**
Default Mode			

Serial port Mode selection Jumper (Detailed):

SC1	SC0	Protocol
OUT	OUT	Internal Loopback
OUT	IN	RS485
IN	OUT	RS232
IN	IN	RS422

9   BIOS KEY FEATURES (TBU)

The BIOS on Saturn provides access to many valuable features. These instructions show how to enter the BIOS and set up features.

9.1   Entering the BIOS

The BIOS may be entered during startup by pressing the **DEL** key on an attached keyboard. Press the key repeatedly soon after a power-on or reset until the BIOS screen appears.

After a specific period during startup (generally a few seconds), the BIOS will ignore the DEL key. If the system does not respond expectedly after pressing the DEL key, user can simply reset the board (or power down) and try again.

9.2   Restoring Default BIOS Settings

While making changes to the BIOS settings, the new settings are stored in SPI flash internal in the DX3 processor. If the user wants to restore the BIOS settings to default state, follow the procedure listed below.

1. Connect a keyboard to the USB keyboard port or PS/2 keyboard port and connect a monitor.
2. Reboot the CPU (reset or power-down and power-up).
3. Hold down the F3 key while the CPU is booting.
4. The board will boot up normally. The BIOS settings will be reset to their defaults.

End key functionality also works in BIOS menu. When the BIOS menu is displayed press the end key.

9.3   Upgrading BIOS using SHELL Utility

Please follow the below steps for BIOS programming through SHELL Utility.

5. In BOOT menu, enter launch shell based file systems to boot to shell. Make sure that Shell based USB flash disk is connected to one of the USB ports.
6. Once booted to shell, identify which is the file system for USB flash disk. It can be fs0 or fs1 or fs2. You can check this by pressing page up button.
7. Make sure that afuefix64.efi utility and BIOS file that need to programmed are available in the root folder.
8. Then follow the below commands.
   > fs0:
   > afuefix64.efi <BIOS_filename>.bin /b /p /n
9. While BIOS is getting programmed, the status will be displayed. Wait for 100% completion and switch-off the board.
10. Turn-on the board, confirm the BIOS programming by checking BIOS version in BIOS menu.

9.4   Setting the Date and Time

To set the date and time in the BIOS, select **Main** menu, then enter the date and time at the top of the screen. This screen also displays the CPU speed and memory capacity of the board.

9.5 Boot Priority

To select Boot devices and priority, go to the **Boot** menu and select **Boot Device Priority**. Only devices which are connected to the board will appear in the list of options. Therefore, if the user wants to select a hard drive or USB device as the boot device, CPU should be connected first, then boot up and enter the BIOS, then select it as a boot device. If this menu option does not appear on the screen, it means that the on-board flash drive is not enabled, and either no boot devices are attached or the CPU does not recognize any attached boot devices. The user can change the boot devices priority in this screen.

9.6 LED

A green BIOS LED has been provided to indicate that the board has been booted to BIOS GUI. The location of the BIOS LED is being shown in the Board Layout Section.

9.7 Quiet / Quick Boot / Splash Screen

Quiet boot replaces the system status and configuration screen that appears during startup with a blank screen or custom splash screen (if available). Quick boot turns off memory test during startup to save time. To enable these features, go to the Boot menu, then select Boot Settings Configuration. Diamond can provide custom splash screens upon request from an image file.

9.8 Serial Port Configuration

Saturn SBC supports 4 serial ports. All the 4 ports support RS-232/422/485 functionalities. The functionality can be configured from the BIOS GUI. In BIOS setup go to advanced menu then Serial/Parallel port configuration. Select the appropriate mode for the Serial Ports

10 GETTING STARTED

This section describes the steps needed to get Saturn SBC up and running and assumes that user also has a Saturn Development Kit or Saturn Cable Kit. The Cable Kit includes all cables needed for the I/O, except the LCD and backlight. The Development Kit includes the Cable Kit, an AC adapter to power the board, M.2 SATA and the hard drive programmer board.

10.1 Quick Setup

1. Attach HDMI cable 6980605 and USB cables 6980602 as needed.

2. Attach display, keyboard, and mouse (if needed) to the cables.

3. Connect power (5V) to power input connector J8 using external power supply with power cable 6980512. The input connector and cable keyed to prevent incorrect connection.

    WARNING: Attaching the power connector incorrectly will destroy the Saturn SBC!

4. For a quick verification that the system is set up and working properly, if no boot device is attached, the system will boot to BIOS mode.

10.2 Boot Device Options

Saturn can boot from SATA or any of the available USB ports or PXE (10/100 Ethernet Port only). Either a M.2 SATA DOM or an externally powered SATA HDD can be connected to the SATA port. DSC will provide a M.2 SATA with pre-loaded OS.

WARNING: It is possible to destroy the Saturn SBC by connecting a SATA cable incorrectly (reverse orientation or offset from correct position). Always use keyed cables to avoid connection errors.

The Boot device selection and priority are configured in the BIOS **Boot** menu. Only devices which are connected to the SBC will appear in the list of options. Therefore if user wants to select a hard drive or USB device as the boot device, the SBC should be connected first, then boot up and enter the BIOS, then select it as a boot device.

The following are a few example boot scenarios.

♦ Install an externally powered SATA hard drive directly on the SATA connector (J7).

♦ Attach a M.2 2242 SATA device on the M.2 socket (J19)

♦ Attach a bootable USB device to one of the USB ports (J10,J15,J16).

♦ PXE boot over Ethernet (J13, J14)

10.3 Installing OS and Booting

Ensure that SATA data cable and power cable are connected to SATA HDD. Follow below steps to install Windows 10 operating system in SATA HDD.

♦ Connect a USB pen drive to a USB port of (J15/J16) Saturn board having Windows 10 installation image.

♦ Boot the Saturn board to BIOS. The SATA HDD and USB device should be detected in BIOS under boot devices.

♦ Under boot priorities, set highest priority for USB.

♦ Save BIOS settings and restart.

♦ Windows 10 installer would start running. Follow the instructions in the installer.

♦ Upon successful installation, boot to Windows 10 and install the necessary drivers.

11 VIDEO FEATURES

Saturn SBC offers three video output options: 2 DDI and one eDP.

The DDI ports are configurable for either HDMI 1.4, DP 1.1a, or eDP. All the three outputs can be active at any time.

DDI port 1 is configured as HDMI 1.4 and supports a maximum resolution of 1920 x 1080 x 60Hz x 24bpp.

DDI port 2 is used for VGA and VGA is realized using DP to VGA converter. Maximum resolution of VGA is 1920 x 1200 x 60Hz x 24bpp.

An eDP to LVDS converter provides a dual-channel LVDS LCD output. Maximum LVDS resolution is 1920 x 1080 x 60Hz x 24bpp. The LCD backlight control is provided by a PWM circuit. LCD backlight power and control are on a separate latching connector.

The BIOS supports options for selecting Single channel /Dual Channel, Color Depth, resolution and brightness control.

By default, the BIOS will support 7 EDID configuration Emulation as shown in below table. The orrect resolution needs to be selected based on the LCD used. Please contact DSC for the EDID values OR one can use PTN3460 DPCD utility for changing the configuration.

EDID N0	Resolution	EDID Description
0	1024 x 768 @60Hz	NXP Generic
1	1920 x 1080 @60Hz	NXP Generic
2	1920 x 1080 @60Hz	NXP Generic
3	1600 x 900 @60Hz	Samsung LTM200KT
4	1920 x 1080 @60Hz	Samsung LTM230HT
5	1366 x 768 @60Hz	NXP Generic
6	1600 x 900 @60Hz	ChiMei M215HGE

12 SERIAL PORTS AND SYSTEM CONSOLE

12.1 Configuration

Saturn SBC supports total 4 serial ports. All the 4 ports support RS-232/422/485 modes. The modes can be configured in BIOS. Both TX and RX termination selection option are available under BIOS menu.

12.2 Console redirection

Connect any of the Saturn serial ports to PC. In BIOS menu, go to **Advanced** settings menu, then in Remote Access Configuration enable the Remote access feature. Then select the serial port. User should see the BIOS setup menu in the PC console.
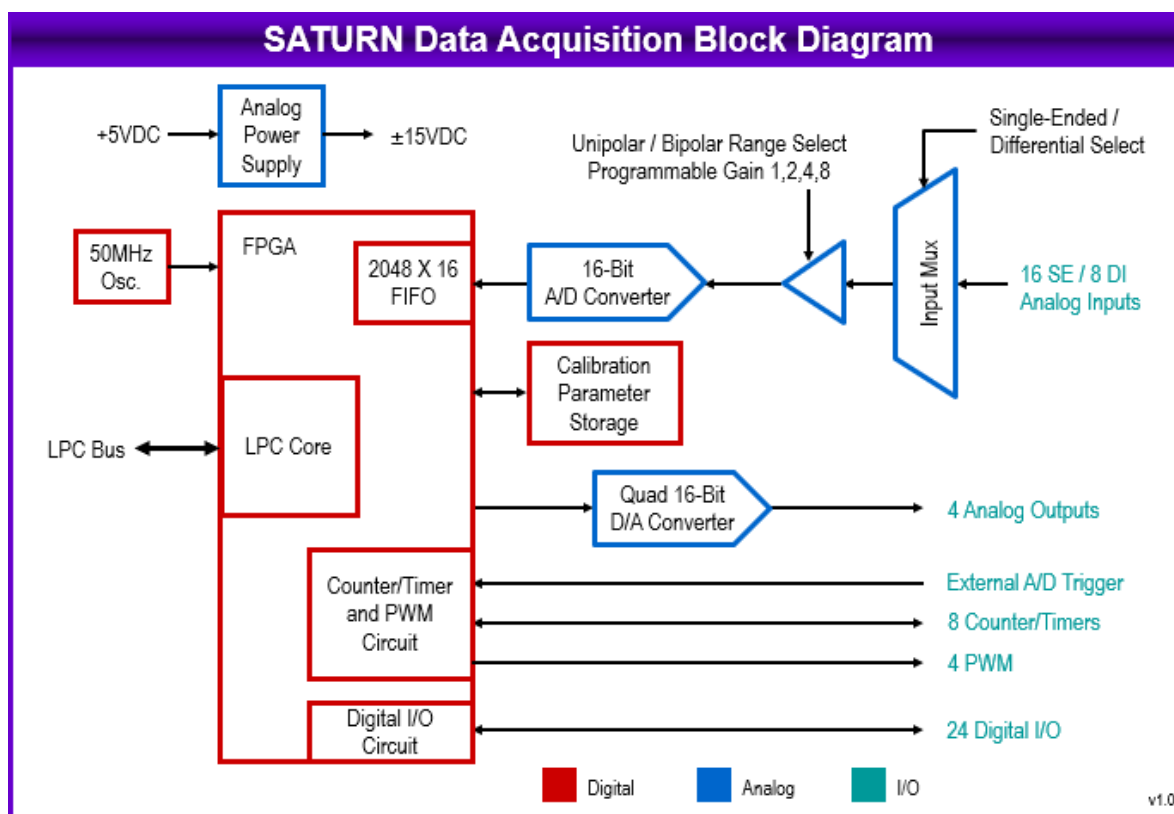
13 DATA ACQUISITION CIRCUIT

13.1 Overview

Saturn contains a data acquisition subsystem consisting of A/D, D/A, digital I/O, and counter/timer features. The circuit is controlled by an FPGA and connected to the SBC via the LPC bus.

The A/D section includes a 16-bit A/D converter, 16 analog input channels and a 2048-sample FIFO. Input ranges are programmable, and the maximum sampling rate is 250 KHz. The D/A section include 4 16-bit D/A channels. The digital I/O section includes up to 22 lines with programmable direction. The counter/timer section includes 32-bit counter/timer to control A/D and a 32-bit counter/timer for user applications.

High-speed A/D sampling is supported with interrupts and a FIFO. The FIFO is used to store up to 2048 A/D samples. An interrupt occurs when the FIFO reaches a user-selected threshold. Once the interrupt occurs, an interrupt routine runs and reads the data out of the FIFO. In this way the interrupt rate is reduced by a factor equal to the size of the FIFO threshold, enabling a faster A/D sampling rate and lower software overhead.

The A/D circuit uses the default settings of I/O address range 0x280-0x28F (base address 0x280). These settings can be changed in the BIOS if needed.

The illustration below shows the architecture of the data acquisition circuit.

Data Acquisition Circuit Block Diagram

All data acquisition features are supported by Diamond's Universal Driver software, available for free download at:
http://www.diamondsystems.com/products/dscud

User documentation for Universal Driver may be found here:
https://diamondsystems.gitbook.io/user-manuals/universal-driver/dscud-sw-user-manual

14 SOFTWARE DRIVER OVERVIEW

Saturn SBC supports Windows 7/8.1/10 and Linux operating systems. Software and Hardware Development kits contain a SATA DOM installed with either Windows 10 or Linux. All the necessary I/O drivers are also available as part of the Development Kit. Please contact Diamond Systems for more details.

Some of the drivers that are required with the Windows 10 operating system are given below. These drivers are available for download from Diamond Systems' website.
1. Audio Driver
2. Chipset Driver
3. Gigabit Ethernet Driver
4. Graphics Driver

15 THERMAL SOLUTION

Saturn integrates a heat spreader mounted on the bottom side of the board. The heat spreader is intended for installation onto a metal enclosure surface to aid in conducting heat away from the processor and dissipating it through the enclosure body. This method provides more efficient and greater capacity cooling than a traditional heat sink which relies on convection cooling by transmitting heat to the much less dense air.

The mechanical drawing of the heat spreader is shown below. The heat spreader supports mounting with either internal or external fasteners. The internal mounting holes will support up to #6 or M3 size screws. External mounting points have separate tapped blind holes for both #6 and M3 screws. Maximum ingress of the screws into the heat spreader is 5mm / .197". The tapped holes are blind to prevent screws from driving into the circuit board and damaging it.
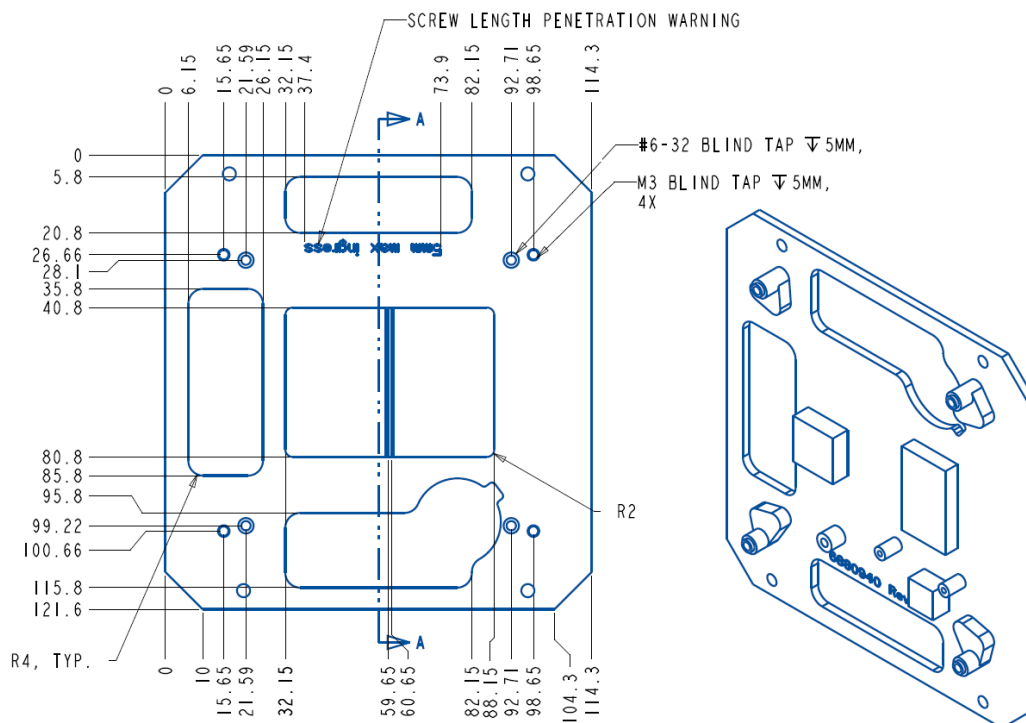
The outer surface of the heat spreader contains thermal pads with protective films. These films must be removed prior to installation in order to maximize thermal contact between the heat spreader and the enclosure.

Heat spreader outer surface; remove films from thermal pads before installation

Heat spreader inner surface

Mechanical Drawing of Heat Spreader

16 SPECIFICATIONS

Item	SAT-E3940-4GA	SAT-E3940-4GD	SAT-E3940-8GEA	SAT-E3940-8GED
Processor	Apollo Lake E3940	Apollo Lake E3940	Apollo Lake E3940	Apollo Lake E3940
Speed	1.6GHz	1.6GHz	1.6GHz	1.6GHz
SDRAM memory	4GB Non ECC	4GB Non ECC	8GB ECC	8GB ECC
DAQ	AIO + DIO	DIO	AIO + DIO	DIO
Cooling	Heat Spreader			
Display type	HDMI x2 Dual Channel LVDS LCD			
USB ports	2x USB2.0 2x USB3.0/USB2.0			
Serial ports	2 RS-232/422/485 ports 1 RS232 port			
Audio	HD Audio ALC892 CODEC with stereo line out, line in and microphone			
Networking	Two 10/100/1000Mbps Ethernet ports			
Mass storage	1 SATA port for external hard drive 1 M.2 2242 SATA			
Expansion bus	PCIe/104 One bank 1 Mini PCIe Full card size			
Mechanical / Environmental				
System input voltage	+5VDC +/- 5%			
Power consumption	10W Typical @5V input			
Dimensions	4.5" x 4.0" (114.3mm x 101.6mm)			
Weight				
Operating temperature	-40°C to +85°C (-40°F to +185°F)			
Shock	MIL-STD-202G compatible			
Vibration	MIL-STD-202G compatible			
RoHS	Compliant			