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# Datasheet

## Diamond Systems

### Saturn

**SATURN Rugged Apollo Lake x5-E3940 SBC with Data Acquisition and PCIe/104 Expansion**



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**SATURN Rugged Apollo Lake x5-E3940 SBC with Data Acquisition and PCIe/104 Expansion**

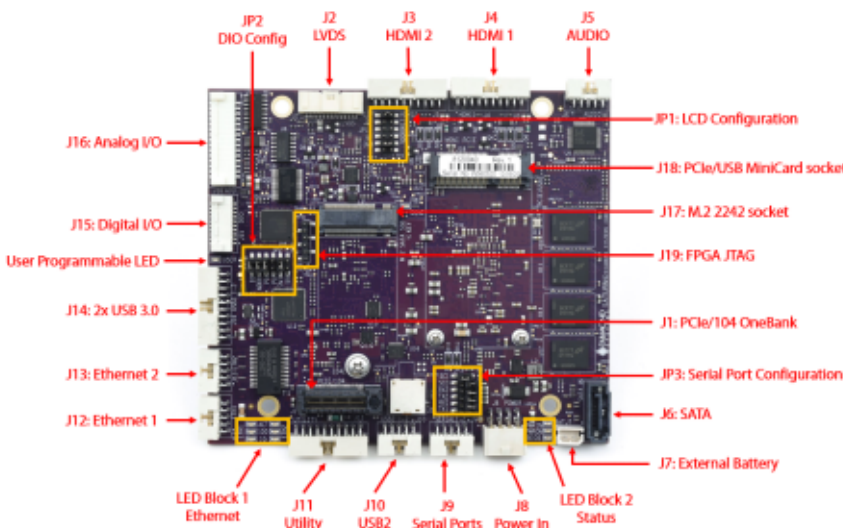


**FEATURES**

**SBC features:**

- Designed for rugged applications with intensive I/O requirements
- Intel "Apollo Lake" x5-E3940 1.6GHz quad-core processor
- 4GB non-ECC / 8GB ECC RAM soldered down
- 2 gigabit Ethernet ports
- 2 HDMI ports
- Dual-channel 24-bit LVDS with backlight power
- 2 USB 3.0 ports with USB 2.0 downward compatibility
- 2 dedicated USB 2.0 ports
- 2 RS-232/422/485 + 1 RS-232 serial ports
- HDA audio (ALC662)
- SATA 7-pin connector
- TPM 2.0 chip on board
- On-board RTC backup battery with external battery connector
- PCIe/104 OneBank I/O expansion connector with 4 PCIe x1 and 2 USB 2.0 connections
- M.2 2242 SATA socket supports up to 1TB flashdisk
- Bottom-mounted heat spreader for efficient cooling and convenient mounting
- 5VDC input voltage
- 4.5 x 4.0" / 114 x 102mm W x H
- 40/+85°C operation fanless
- Windows 10 64-bit and Ubuntu Linux 64-bit OS support

**Saturn rugged SBC with E3940 CPU and data acquisition**



**Saturn features (top side)**

**Data acquisition subsystem features:**

- 16 single-ended / 8 differential analog inputs
- 16-bit A/D resolution
- Unipolar and bipolar analog inputs
- Single-ended and differential input configuration
- Programmable gain 1/2/4/8 providing input ranges +/-10V / 0-10V down to +/- 1.25V / 0-1.25V
- 250KHz maximum A/D sample rate, single-channel and multi-channel mode
- Internal clock / external clock / software A/D triggering
- Single-channel and multi-channel-scan



- A/D operation
- Interrupts with FIFO to support reliable high-speed sampling
- 4 16-bit single-ended analog outputs
- +/-10V, +/-5V, 0-10V and 0-5V output ranges
- Autocalibration with Universal Driver software maintains accuracy over time and temperature
- 24 digital I/O, 3.3V logic / 5V tolerant inputs
- 8 32-bit counter/timers for A/D timing and general counting purposes
- 8 4 24-bit PWM outputs

**Edge view showing heat spreader and latching connectors**

**◆ Overview**

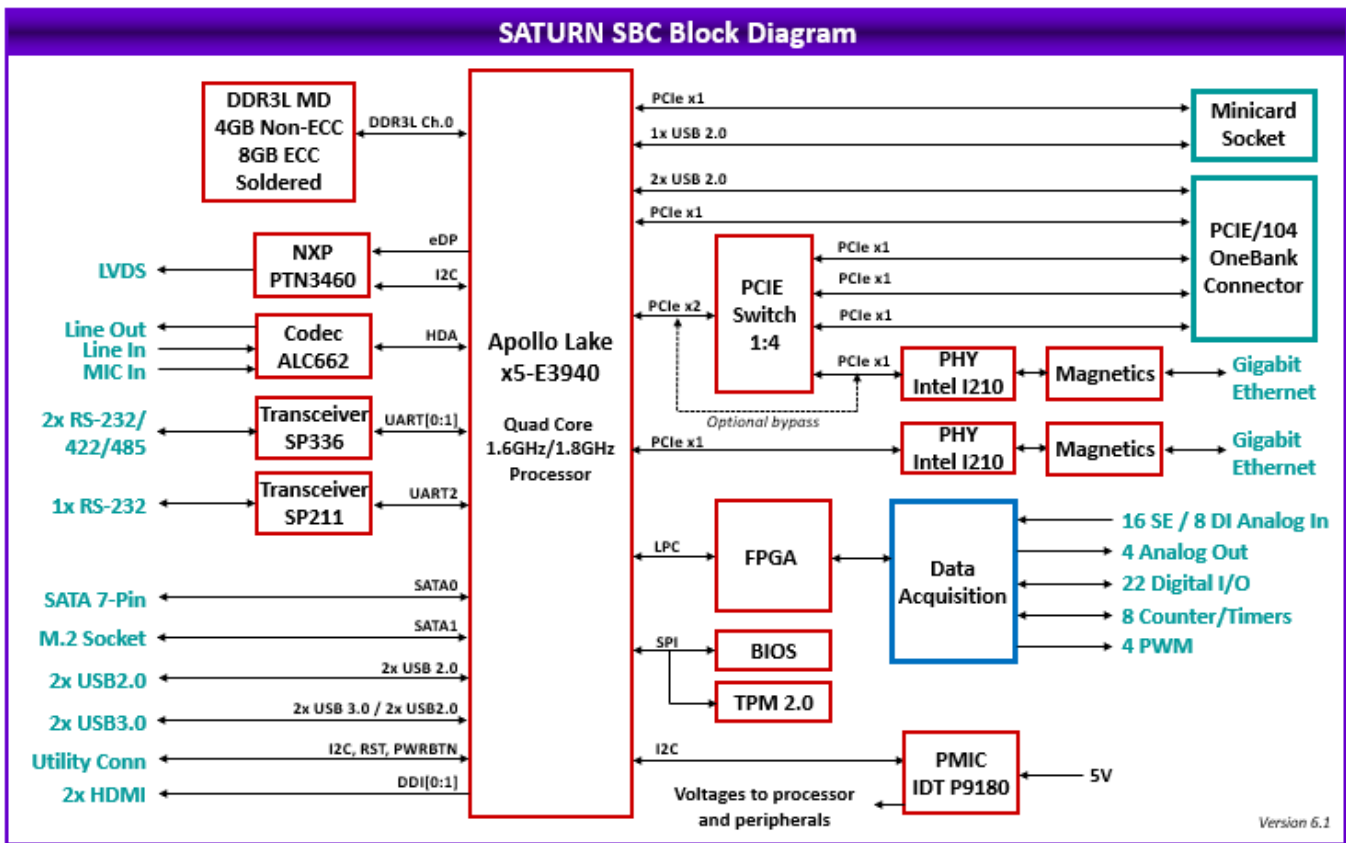
SATURN combines a feature-rich Atom-class processor-based SBC with a professional-quality industrial analog and digital data acquisition subsystem and flexible I/O expansion in a single board designed for rugged applications.

- Intel "Apollo Lake" x5-E3940 1.6GHz (burstable 1.8GHz) quad-core processor with 15-year lifecycle
- 4GB non-ECC or 8GB ECC RAM soldered down
- Integrated professional-quality analog and digital data acquisition subsystem with software support
- Bottom side heat spreader with integrated thermal pad provides efficient cooling and convenient mounting
- Full -40 to +85°C industrial operating temperature range
- Thicker PCB and latching connectors increase resistance to shock and vibration
- PCIe/104 OneBank expansion socket for industry-standard rugged I/O expansion
- Minicard expansion socket for versatile low-cost I/O

Available models:

Model	RAM	Data Acquisition
SAT-E3940-4GA	4GB non-ECC	Analog + digital I/O
SAT-E3940-4GD	4GB non-ECC	Digital I/O
SAT-E3940-8GEA	8GB ECC	Analog + digital I/O
SAT-E3940-8GED	8GB ECC	Digital I/O

**◆ Block Diagram**



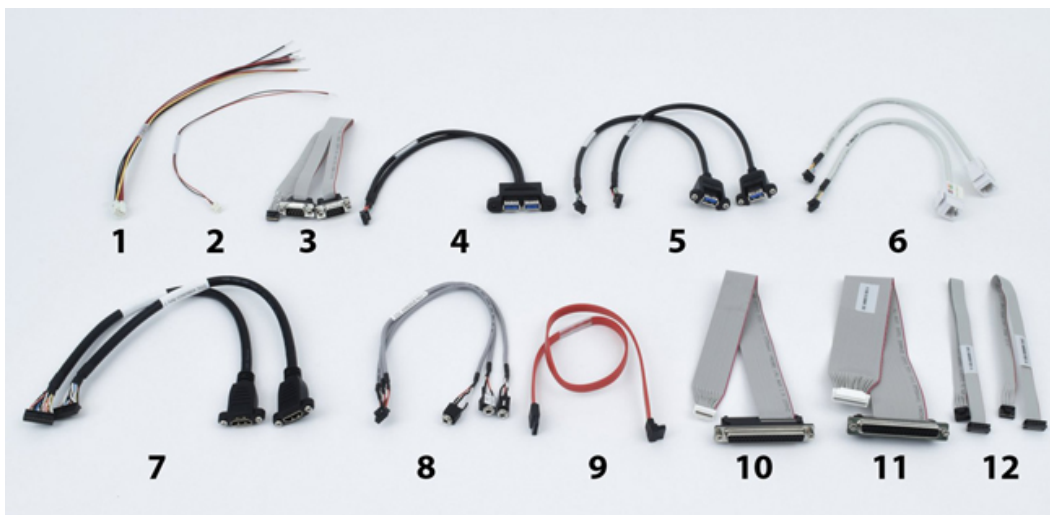
## ◆ Mass storage

Saturn offers two options for mass storage:

- An M.2 2242 size SATA socket is provided for onboard mass storage. Modules up to 1TB are available. This is the most common choice.
- A standard 7-pin SATA connector is available for connecting a standard 2.5" or other form factor hard drive. This connector can be used when higher capacity storage is needed. Diamond offers accessory board ACC-HDDMOUNT which allows a 2.5" drive to be mounted on the PC/104 holes on Saturn.

## ◆ Cable Kit

The Saturn cable kit includes all I/O cables needed for all I/O connectors on Saturn except the LCD data and backlight cables, which are customized for each individual application. Cables are normally sold as complete kits. Individual cables may be available in some cases or may be ordered with minimum order quantities; contact us for availability. Detailed drawings listing all components are provided to enable customers to build their own cables.



CK-SAT-01 includes the following cables:

No.	Qty	Cable	Description	Drawing
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1	1	6980512	Power input cable, discrete wires	<a href="#">Show</a>
2	1	6980524	External battery cable, discrete wires	<a href="#">Show</a>
3	1	6980601	Dual serial port cable, 2x DB9 male	<a href="#">Show</a>
4	1	6980602	Dual USB 2.0 cable, 2x USB 2.0 type A	<a href="#">Show</a>
5	2	6980603	Dual USB 3.0 type A, latching	<a href="#">Show</a>
6	2	6980604	Ethernet cable, RJ-45 socket	<a href="#">Show</a>
7	2	6980605	HDMI Cable	<a href="#">Show</a>
8	1	6980608	Audio cable, 3x 3.5mm jacks	<a href="#">Show</a>
9	1	6989101	SATA Cable, 7-Pin Data, Straight to Right Angle, 500mm	<a href="#">Show</a>
10	1	6980517	Digital I/O cable, DB37F connector	<a href="#">Show</a>
11	1	6980518	Analog I/O cable, DB37F connector	<a href="#">Show</a>
12	2	6980609	FCI latching 2x5 2mm to IC 2x5 2mm, 12"	<a href="#">Show</a>

### ◆ Development kits

Development kits are available to support quick project startup. Each kit includes the Saturn SBC, a cable kit, and a programmed 64GB flashdisk with a read-to-run installation of Windows 10 or Linux operating system, plus a backup USB memory device. Simply install the flashdisk, attach the cables, add your keyboard, mouse, and display, and connect power, and the board will boot into a fully functional OS.

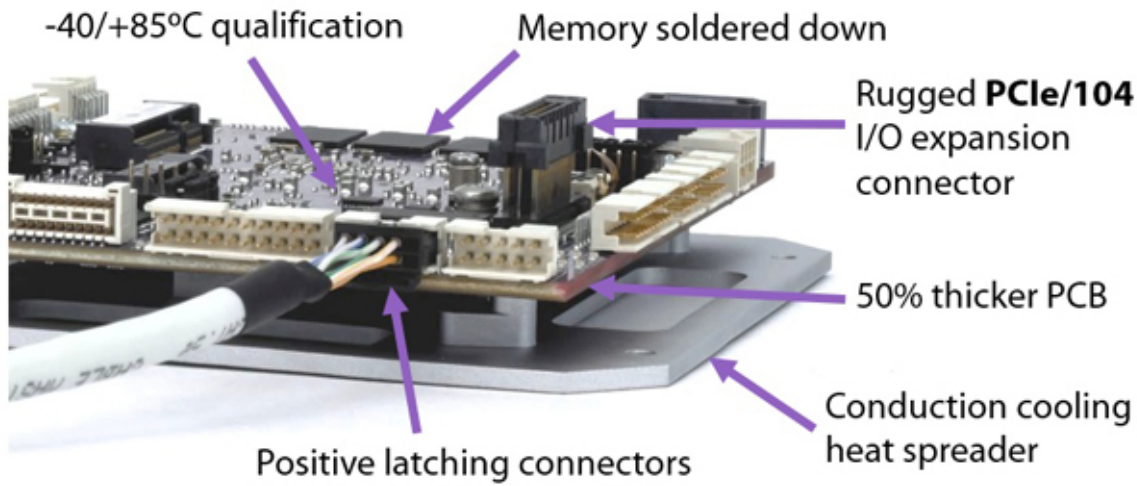
Configuration files and instructions are provided to rebuild the OS with your application. The Linux kit includes all the tools needed to rebuild the OS. The Windows 10 kit includes a runtime license.

A software-only kit is available that consists of just the programmed flashdisk and backup USB memory device. This software kit is intended for customers who already have one or more Saturn SBCs. One software kit can be used on any number of Saturn boards. (Windows licensing requirements still apply.)

### ◆ Rugged Design

Saturn was 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 +85°C operation



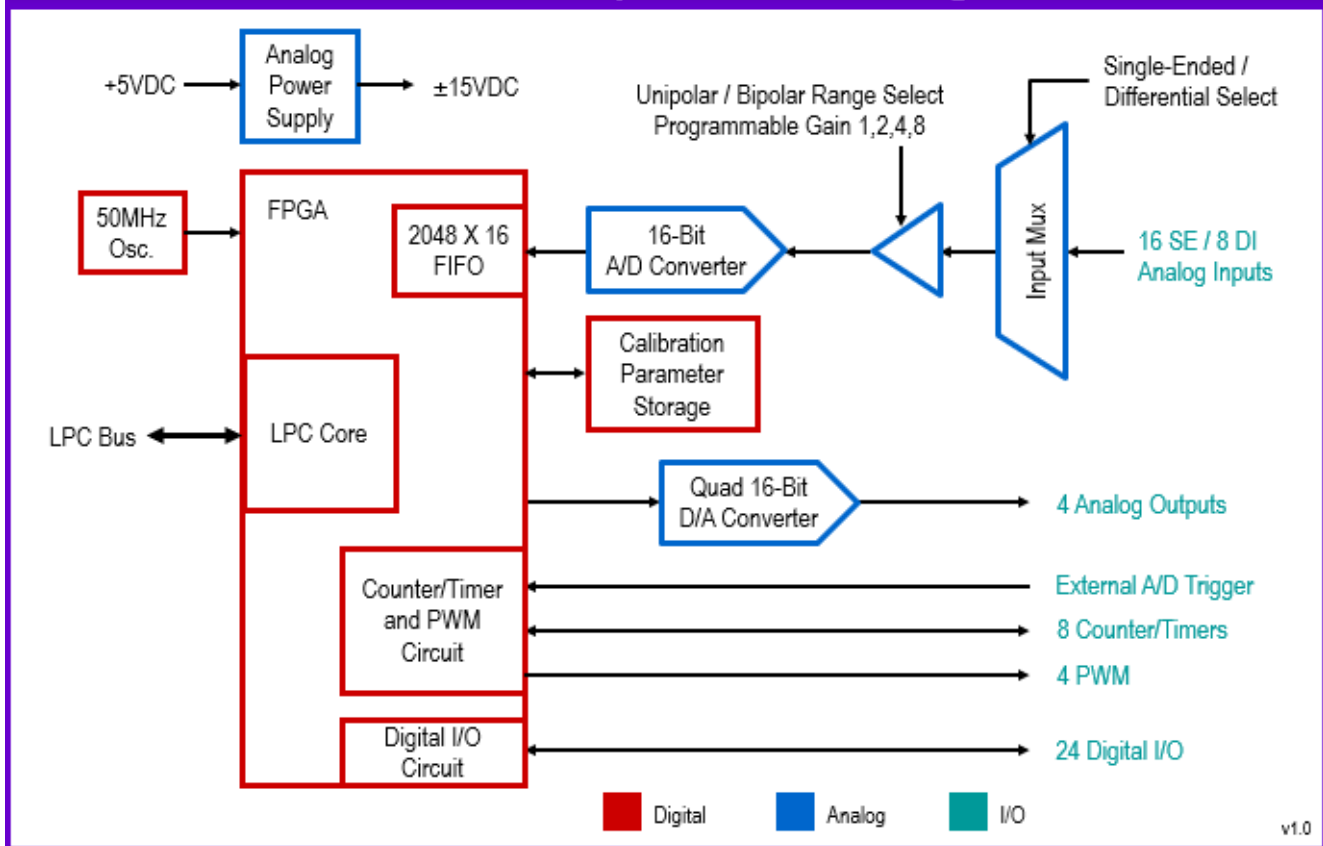
### ◆ Data Acquisition

Saturn is a member of Diamond's 2-in-1 series of SBCs with integrated data acquisition. For applications requiring precision analog I/O, a 2-in-1 SBC is an ideal choice because it reduces the number of boards in the system, resulting in a system that is smaller, lighter, lower cost, and easier to assemble and maintain. The features of the Saturn DAQ circuit surpass those found on most other embedded SBCs in both variety and quality, providing a comprehensive, professional quality subsystem backed with top of the line software support. "A" models include the full DAQ circuit with both analog and digital I/O features, while "D" models include only the digital I/O features.

Saturn's data acquisition circuit features autocalibration, which maintains best accuracy of the A/D and D/A circuits regardless of time and temperature swings. Using the supplied Universal Driver software library, the circuit can be quickly calibrated to within +/-2LSB accuracy at any time, relative to the on-board precision reference voltage circuit.



## SATURN Data Acquisition Block Diagram



The A/D circuit includes 16 single-ended / 8 differential analog input channels with programmable input ranges and a maximum aggregate sampling rate of 250KHz. A built-in programmable counter/timer supports accurate high-speed sampling with precise timing. The 2048-sample FIFO with programmable threshold ensures error-free sampling and enables you to tune the performance of the circuit to minimize interrupt processing overhead.

The D/A circuit consists of 4 16-bit D/A voltage outputs with independently programmable output ranges including 0-10V, +/-10V, 0-5V, and +/-5V. A 2048-sample waveform buffer is included to support arbitrary waveform generator functions on up to 4 channels simultaneously.

The digital I/O circuit consists of GPIO, counter/timers, and pulse-width modulators. The GPIO circuit provides 22 buffered digital I/O lines, consisting of one 8-bit port and 14 1-bit ports. Each port is individually programmable for input or output. The 1-bit direction controllable ports provide better matching of input and output quantities to each application. Jumper configuration enables selection of 5V/3.3V logic levels and pull-up or pull-down resistors on the digital I/O lines.

The 8 32-bit programmable counter/timers feature both up and down counting with clocking selectable from an external digital signal or the on-board 50MHz clock. Counters can be used for generating programmable output frequencies with programmable output pulse widths, counting external events, generating interrupts to the host processor at a programmable rate, and driving A/D sampling at precise frequencies with perfect timing between samples.

The circuit further includes 4 24-bit programmable pulse width modulators also driven by the on-board 50MHz clock. These feature programmable rate, duty cycle, and polarity, with real-time rate and duty cycle update capability.

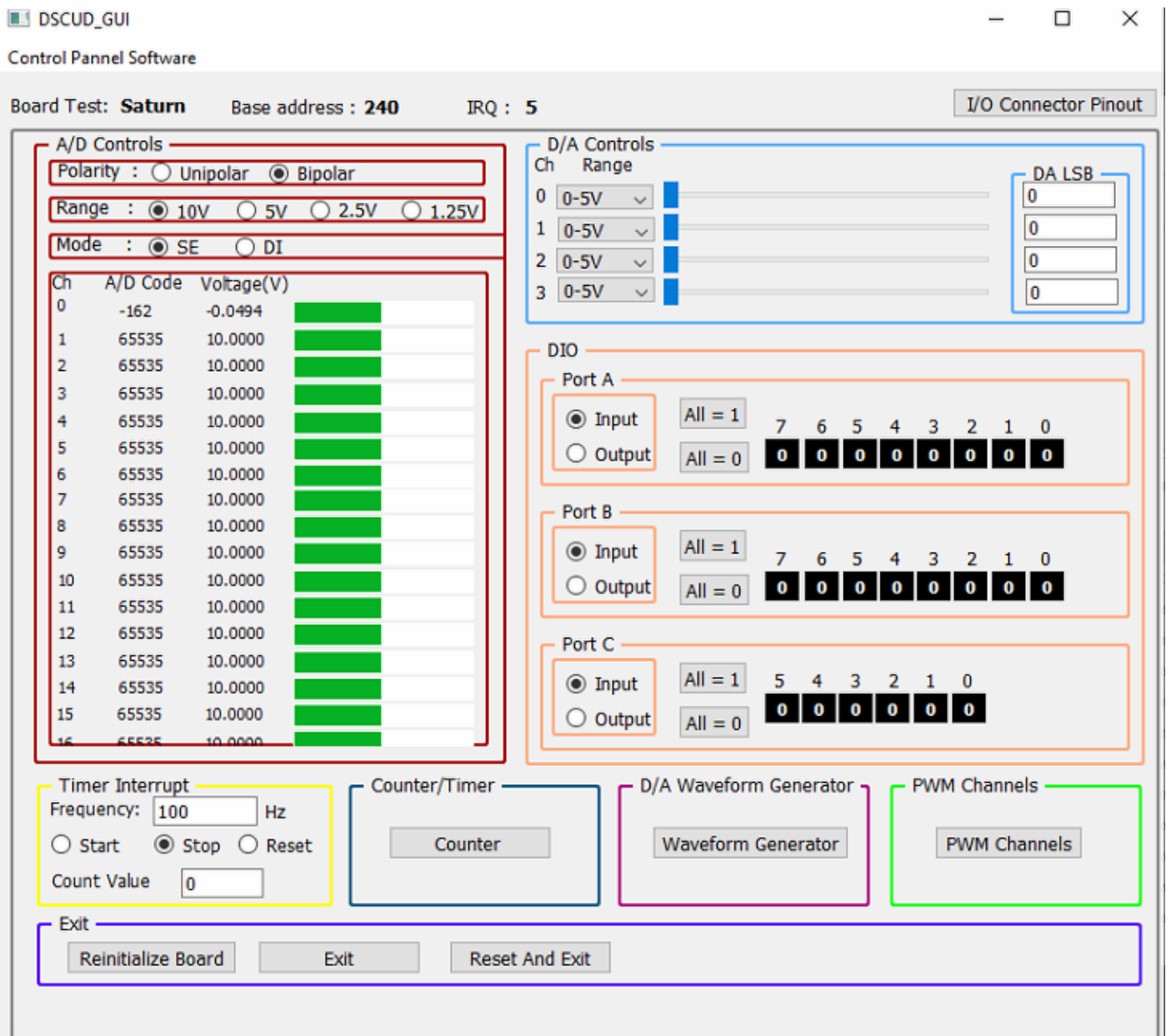
### ◆ Software Support

Diamond Systems' Universal Driver software provides unmatched power and flexibility for embedded data acquisition programming with PC/104 and small form factor I/O boards. It provides flexible C-language programming support for Windows and Linux to control all data acquisition features on Saturn, as well as Diamond's MiniCard data acquisition modules that can be used with Saturn.

A powerful and convenient graphical control panel provides instant, easy access to all data acquisition features on the board. It can be used for proof of concept, testing, and even system debugging.

Visit our "[Universal Driver software](#)" page to learn more.





## ◆ I/O Expansion

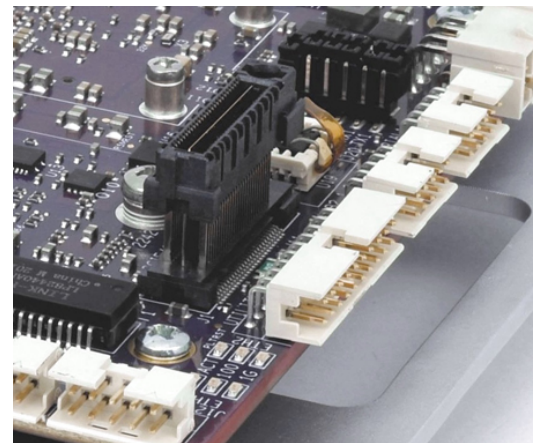
Saturn provides two sockets for the installation of I/O expansion modules:

- A PCIe/104 OneBank I/O expansion socket provides 4 PCIe x1 lanes and 2 USB 2.0 ports to interface with hundreds of PCIe/104 I/O modules from vendors around the world. Only top side expansion is supported, since the bottom side of Saturn is covered by the heat spreader.
- A full-size PCIe MiniCard socket supports both PCIe and USB minicards. Saturn supports Diamond's complete line of **PCIe MiniCards**.

## ◆ What is PCIe/104 OneBank™?

OneBank™ is the name given to the PCIe/104 standard that utilizes a more compact, cost effective connector to support rugged, high-speed I/O expansion. The original PCIe/104 connector features 3 "banks" of contacts. The 2nd and 3rd banks contain PCIe x8 / x16 signals that are not supported on Atom processors nor used by most I/O expansion modules. By eliminating these signals, a smaller and more cost effective connector can be used to provide compatibility with any PCIe/104 I/O module that uses a PCIe x1 or USB host connection, while freeing up precious PCB space for additional I/O or connectors. OneBank is an official expansion connector supported by the PC/104 Consortium (of which Diamond

Systems was a founding member). Click [here](#) to learn more about OneBank. Click [here](#) to learn more about PCIe/104.



## ◆ Models and Accessories

### ◀ Saturn ▶

#### available models:

<b>SAT-E3940-4GA</b>	Saturn SBC, E3940 CPU, 4GB RAM, With Data Acquisition	Available
<b>SAT-E3940-4GD</b>	Saturn SBC, E3940 CPU, 4GB RAM, With Digital I/O	Available
<b>SAT-E3940-8GEA</b>	Saturn SBC, E3940 CPU, 8GB ECC RAM, With Data Acquisition	Min Order Quantity
<b>SAT-E3940-8GED</b>	Saturn SBC, E3940 CPU, 8GB ECC RAM, With Digital I/O	Min Order Quantity
<b>DK-SAT-E3940A-LNX64</b>	Development Kit, Saturn SBC With DAQ, Linux 64-Bit BSP	Available
<b>DK-SAT-E3940A-WE1064</b>	Development Kit, Saturn SBC With DAQ, Windows 10 64-Bit BSP	Available
<b>SDK-SAT-E3940A-LNX64</b>	Software Development Kit for Saturn SBC, Linux 64-bit OS	Available
<b>SDK-SAT-E3940A-WE1064</b>	Software Development Kit for Saturn SBC, Windows 10 64-bit OS	Available

Please [login](#) or [signup](#) for an online quote request.

### ◀ Cables and accessories ▶

#### available models:

**CK-SAT-01** CK-SAT-01 cable kit

Please [login](#) or [signup](#) for an online quote request.

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