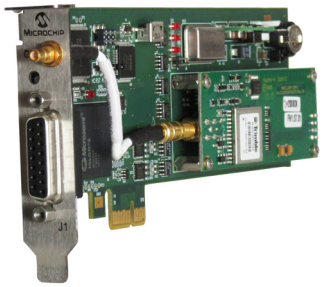
bc637PCIe

GPS Synchronized, PCI Express Time and Frequency Processor



Summary

The Microchip GPS-referenced bc637PCIe timing module provides unparalleled precise time and frequency functions to the host computer and peripheral systems. Precise time is acquired from the GPS satellite system or from time code signals. GPS synchronization provides 170 ns RMS accurate time to UTC (USNO) enabling the bc637PCIe to precisely synchronize multiple computers to UTC. Integration into a custom application is easy and very efficient through the use of the full-featured Windows® and Linux® SDKs/drivers included standard with the module.

Extensive time code generation and translation are both supported. The translator reads and disciplines the internal oscillator to either the amplitude modulated (AM) and DC Level Shift (DCLS) formats of IRIG A, B, G, E, IEEE 1344, NASA 36, XR3, or 2137 time codes. The generator outputs either IRIG A, B, G, E, IEEE 1344, NASA 36, XR3 or 2137 in both AM and/or DCLS formats.

Central to the operation of the module is a disciplined TCXO 10 MHz oscillator that provides the timing module's 100 ns clock. Current time (days to 100 ns) can be accessed across the PCIe bus with no PCIe bus wait states, which allows for very high-speed, low-latency time requests. The 10 MHz oscillator drives the module's frequency and time code generator circuitry. If the input reference is lost, the module will maintain time (flywheel) based on the 10 MHz oscillator's drift rate. If power is lost, a battery backed Real-Time Clock (RTC) maintains the time.

The module has a state of the art Direct Digital Synthesizer (DDS) rate synthesizer with a range from 0.0000001 PPS to 100 MPPS. The module may also be programmed to generate an interrupt at a precise predetermined time based on a time compare (strobe). Three Event Time Capture inputs provide a means of latching time of different external events.

A key feature of the bc637PCIe is the ability to generate interrupts on the PCIe bus at programmable rates. These interrupts can be used to synchronize applications on the host computer as well as signal specific timing events over the bus.

The unique external frequency input allows the time and frequency of the bc637PCIe to be derived from an external oscillator that may also be disciplined (DAC voltage controlled) based on the selected input reference. The module may be operated in generator (undisciplined) mode where an external 10 MHz from a Cesium or Rubidium standard is used as the frequency reference. This creates an extremely stable PCIe®-based clock for all bc637PCIe timing functions.

Integration of the module is easily facilitated with the included SDKs/drivers for 32/64-bit Windows and 64-bit Linux.

Features

- GPS synchronized with 170 ns RMS accuracy to UTC
- IRIG A, B, G, E, IEEE 1344, NASA 36, XR3 and 2137 time code inputs and outputs
- Simultaneous AM and DCLS time code inputs and outputs
- 100 ns clock resolution for time requests
- Programmable <<1 PPS to 100 MPPS DDS rate synthesizer output/interrupt
- 1, 5 or 10 MPPS rate generator output
- 1 PPS and 10 MHz inputs
- Three external event time capture/interrupts
- Programmable time compare output/interrupt
- Zero latency time reads
- Battery backed RTC
- Low-profile PCIe form factor
- Linux and Windows software drivers/SDKs included
- Superior user interface and documentation

Benefits

- Precise sub-microsecond time available to host computer applications
- Easy integration facilitated by included Windows and Linux SDKs and drivers
- Extremely fast time reads
- Programmable time and frequency functions to quickly customize for specific applications
- Wide variety of time codes facilitate easy integration with existing systems
- Dedicated and responsive technical support to assist in PCIe card integration
- Well-documented for easy and fast system integration

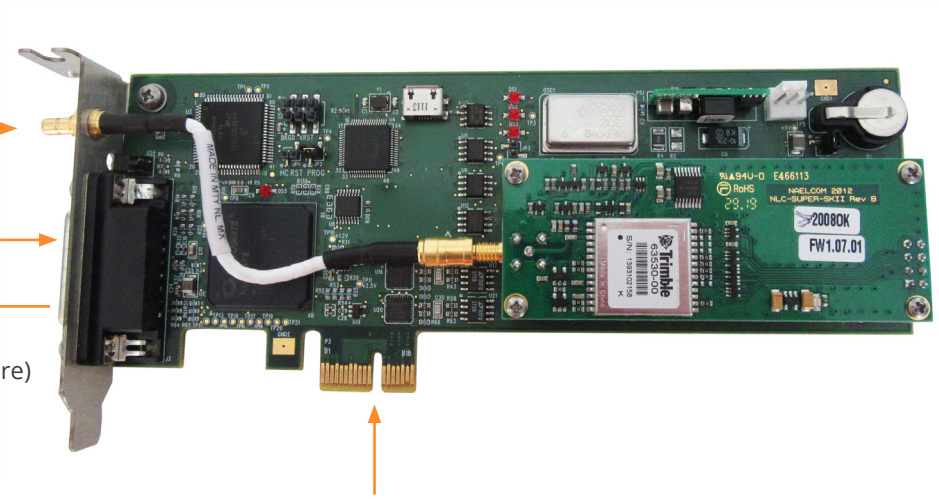
Precision Time and Frequency in the PCIe Form Factor (100-Nanosecond Precision, TCXO Oscillator)

Inputs

- GPS
- AM time codes
- DCLS time codes
- External events (3x)
- 10 MHz
- 1 PPS

Outputs

- AM time codes
- DCLS time codes
- Programmable alarm (strobe/time compare)
- <<1 PPS to 100 MPPS rates
- 1 PPS
- 1, 5 or 10 MPPS
- Oscillator control voltage



Over the PCIe Bus

- Precise time
- Event interrupts
- Alarm interrupts (time compare/strobe)
- Programmable interrupt rates
- Configuration and control

Reading the Precise Time

The bc637PCIe provides precise time on request and extremely fast response to host applications. This request for time is made using the included SDK software functions. Time can be provided in binary or decimal form.

A Multitude of Time Codes

The bc637PCIe has the widest time code input and output support available in any bus level timing card. Support is available for 30 different time codes, including IRIG A, B, G, E, IEEE 1344, NASA 36, XR3 and 2137 in AM and DCLS formats.

Measure External or Internal Events

Measure the exact time up to the occurence of three independent external events. Bus interrupts instantly notify the CPU that

the measurements are made and waiting. Similarly, host application-generated interrupts to the bc637PCIe card over the bus can be precisely time stamped for precise host application-based processes.

Flexible Rate Generation

The DDS on the bc637PCIe can be programmed to generate rates up to 100 MPPS or as little as once every 115 days. These rates are available as timing signal outputs or as interrupts on the bus. The rate adjustment resolution is as small as 1/32 Hz.

Frequency Outputs

Precise clocks are excellent sources of frequency outputs. The bc637PCIe offers 1, 5 or 10 MPPS outputs directly from the steered internal oscillator of the clock.

External Frequency Inputs and DAC Control

The external frequency input is an unique feature that allows the time and frequency of the bc637PCIe to be derived from

an external oscillator such as a 10 MHz Cesium or Rubidium standard. This creates an extremely stable PCIe-based clock for all bc637PCIe timing functions. For closed loop control, an external oscillator may be disciplined using DAC voltage control output from the bc637PCIe.

Time Compare/Strobe/Alarm

A useful feature of any precise clock is the ability to notify when a particular time is reached (like an alarm clock). When the preset time precisely matches the actual time, an external signal and an interrupt to the bus are instantly generated, signaling an application that point in time has just occurred.

Over-the-Bus Features

Beside from precise time stamps, the bc637PCIe can provide very precisely timed interrupts on the bus at fixed rates, predetermined times, or to signal an event has occurred

on the card. These interrupts can be integrated into user applications requiring more deterministic behavior or application synchronization with other computers. Similarly, user applications can use interrupts as markers in time and later retrieve exactly when the interrupt occurred.

Configuration and Control

The bc637PCIe includes easy-to-use programs to easily configure the card and validate operations. This software is also included with the SDKs and driver software.

PCIe Card Integration Made Easy with Included SDKs and Drivers

Windows and Linux SDKs Speed PCIe Integration

The PCIe card includes standard full-featured software development kits, speeding the integration of Microchip PCIe cards into any application.

Using an SDK is an easy-to-integrate and highly reliable alternative to writing lower-level code to address a card's memory registers directly with just a driver. The function calls, and device drivers in the SDKs make inter-facing to a Microchip PCIe card straight forward and help keep the software development focused on the end application.

SDKs Save Time and Money

Programmers find the SDK an invaluable resource in accelerating the integration of Microchip PCIe cards into applications, saving both time and money. The SDK functions address each Microchip PCIe timing card feature, and the function names and parameters provide insight into the capability of each function. By using the SDK, one can leverage Microchip's timing expertise and confidently integrate a Microchip PCIe card into your application.

License-Free

Distribution of embedded Microchip software in customer applications is royalty free.

Driver Comparison

Windows SDK and Driver

- Windows XP/Vista/7/10
- Windows Server 2003/2008/2019
- 64-bit support
- Kernel mode driver
- Code examples
- Test application program
- Complete documentation
- Timekeeping utility program

The Windows SDK for bc637PCIe cards include a Windows XP/Vista/Server/7/10 kernel mode device driver for the 32- and 64-bit PCIe interface. The SDK includes .h, .lib, and DLL files to support both 32- and 64-bit application development.

The target programming environment is Microsoft® Visual Studio (Microsoft Visual C++ V6.0 or higher). Both Visual C++ 6.0 and Visual Studio 2008 project files are supplied with the source code.

Also included is Microchip's bc637PCIcfg application program that can be used to ensure proper operation of the PCIe card, and the TrayTime application that allows the user to update the system clock in which the card is installed. Source code for these programs and smaller example programs are included.

Minimum System Requirements

Operating System

- Windows XP/Vista/7/10
- Windows server 2003/2008

Hardware

PC-compatible system with a Pentium or faster processor

Memory

24 MB

Development Environment

Microsoft Visual Studio (Visual C++) 6 or higher

Linux SDK and Driver

- Up to Linux Kernel 4.6
- 32- and 64-bit kernel support
- Code examples
- Test application program
- Complete documentation

The Linux SDK for bc637PCIe cards includes PCIe kernel mode device drivers for 64-bit kernels, an interface library accessing all bc637PCIe features, and example programs with the source code. The target programming environment is the GNU Compiler Collection (GCC) and the C/C++ programming languages.

Also included is Microchip's bc63xPCIcfg application program, which ensures proper operation of the PCIe card in the host computer. The example program includes sample code, exercising the interface library, and conversion examples of the ASCII format data objects passed to and from the device into a binary format suitable for operation and conversion. The example program is developed using discrete functions for each operation, allowing the developer to copy any useful code and use it in their own applications.

Minimum System Requirements

Operating System

Linux Kernels 5.7.1 or lower

Hardware

x86 processor

Memory

32 MB

Development Environment

GNU GCC recommended

Windows and Linux SDK Function Reference

Note: For complete list of functions, see the manual.

Basic Time and Frequency Processor (TFP) Functions

- bcStartPCI/bcStopPCI — Opens/closes underlying device layer.
- bcStartInt/bcStopInt — Starts/stops the interrupt thread to signal interrupts.
- bcSetInt/bcReqInt — Enables/returns enabled interrupt.
- bcShowInt — Interrupt service routine.
- bcReadReg/bcWriteReg. — Returns/sets requested register contents.
- bcReadDPReg/bcWriteDPReg — Returns/sets requested dual port RAM register contents.
- bcCommand — Sends SW reset command to board.
- bcReadBinTime/bcSetBinTime — Reads/sets TFP major time in binary format.
- bcReadDecTime/bcSetDecTime — Reads/sets TFP major time in BCD format.
- bcReqTimeFormat — Returns selected time format.
- bcSetTimeFormat — Sets the major time format to binary or grouped decimal.
- bcReqYear/bcSetYear — Returns/sets year value.
- bcSetYearAutoIncFlag — Included for backward compatibility to the bc635/637PCI-U card.
- bcSetLocalOffsetFlag — Enables or disables local time offset in conjunction with bcSetLocOff.
- bcSetLocOff — Sets board to report time at an offset relative to UTC.
- bcSetLeapEvent — Inserts or deletes leap second data (in non-GPS modes).
- bcSetMode — Sets TFP operating mode.
- bcSetTcIn — Sets time code format for time code decoding mode.
- bcSetTcInEx — Sets time code and subtype for time code decoding mode.
- bcSetTcInMod — Sets time code modulation for time code decoding mode.
- bcReqTimeData — Returns selected time data from the board.
- bcReqTimeCodeData — Returns selected time code data from the board.
- bcReqTimeCodeDataEx — Returns selected time code and subtype data from the board.
- bcReqOtherData — Returns selected data from the board.
- bcReqVerData — Returns firmware version data from the board.
- bcReqSerialNumber — Returns board serial number.
- bcReqHardwareFab — Returns hardware fab part number.
- bcReqAssembly — Returns assembly part number.
- bcReqModel — Returns TFP model identification.
- bcReqTimeFormat — Returns selected time format.
- bcReqRevisionID — Returns board revision.

Event Functions

- bcReadEventTime — Latches and returns TFP time caused by an external event
- bcReadEventTimeEx — Latches and returns TFP time caused by an external event with 100 ns resolution.
- bcSetHbt — Sets a user programmable periodic output.
- bcSetPropDelay — Sets propagation delay compensation.
- bcSetStrobeTime — Sets strobe function time.
- bcSetDDSFrequency — Sets DDS output frequency.
- bcSetPeriodicDDSSelect — Selects periodic or DDS output.
- bcSetPeriodicDDSEnable — Enables or disables periodic or DDS output.
- bcSetDDSDivider
- bcSetDDSDividerSource — Sets DDS divider source.
- bcSetDDSSyncMode — Sets DDS synchronization mode.
- bcSetDDSMultiplier — Sets DDS multiplier value.
- bcSetDDSPeriodValue — Sets DDS period value.
- bcSetDDSTuningWord — Sets DDS turning word value.

Oscillator Functions

- bcSetClkSrc — Enables or disables on-board oscillator.
- bcSetDac — Sets oscillator DAC value.
- bcSetGain — Modifies on-board oscillator frequency control algorithm.
- bcReqOscData — Returns TFP oscillator data.

Generator Mode Functions

- bcSetGenCode — Sets time code generator format.
- bcSetGenCodeEx — Sets time code and subtype generator format.
- bcSetGenOff — Sets an offset to the on-board timecode generation function.

GPS Mode Functions

- bcGPSReq/ bcGPSSnd — Returns/sends a GPS receiver data packet.
- bcGPSMan — Manually send and retrieve GPS receiver data packets.
- bcSetGPSOperMode — Sets the GPS receiver to function in static or dynamic mode.
- bcSetGPSTmFmt — Sets TFP to use GPS or UTC time base.

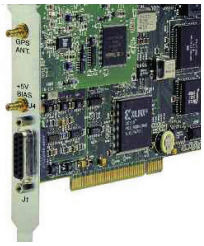
Real-Time Clock (RTC) Functions

- bcSyncRtc — Synchronizes RTC to current TFP time.
- bcDisRtcBatt — Sets RTC circuit and battery to disconnect after power is turned off.

Backward Compatibility Provides Seamless Migration Paths

The PCI-based bc637 cards have long product lifecycles since the first introduction of PCI timing cards in the mid 1990s. To preserve the customer's time and money investments in integrating bc637PCI cards into their systems, Microchip has maintained the bc637PCI cards' existing features and software interface while adding new features and keeping their bus signaling and form factors up to date. This commitment to backward compatibility and current bus architectures assures the bc637PCI cards integrate smoothly into any workstation currently available in the market with little to no impact on customer application software.

PCI Card Developments



bc637PCI

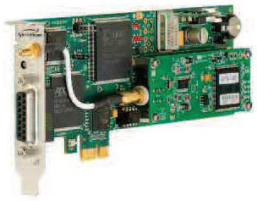
- Mid-1990s
- First PCI timing card introduced

bc637PCI-U

- 2003
- 3.3 V and 5.0 V universal signaling backward compatibility retained

bc637PCI-V2

- 2008
- Electronics updated backward compatibility retained



bc637PCIe

- 2009
- PCIe supported backward compatibility retained

Optional Accessories Speed, Test, and Simplify Integration

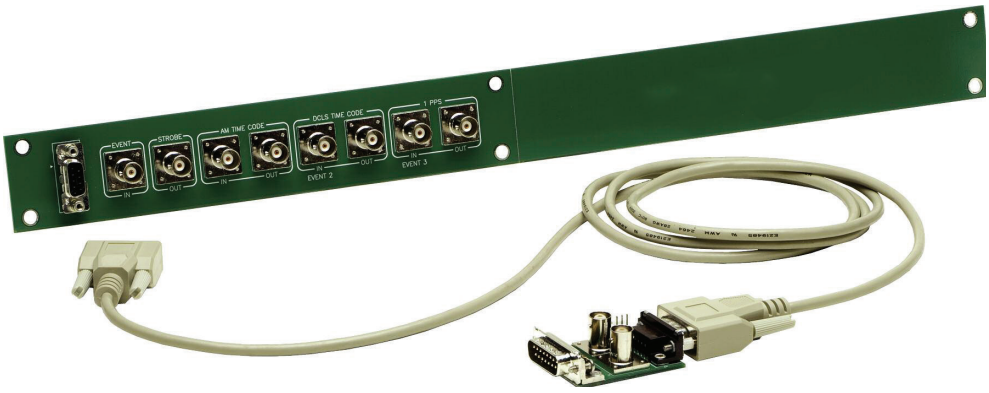
Breakout cables with BNC connectors simplify access to the in and out timing signals of the PCIe card. These labeled cables mitigate the need to create special cables during project development and ensure that the correct timing signals are being accessed.

For more integrated rack mount systems that require easy access to timing signals, the 1U patch panel and high-frequency signal breakout exposes all available signals. The panel provides an organized and professional appearance to the external timing I/O of the PCIe card functions. The 1U panel fits with standard or half rack size chassis. The high-frequency breakout adapter exposes the high-frequency signal as well as the external DC DAC control signal and ground.

Timing Input/ Output Breakout Cable and Patch Panel BNC Map	"D" to 5-BNC (BC11576-1000)	"D" to 5-BNC BC11576-9860115	"D" to 6-BNC	Patch/Breakout
Outputs				
Time code (AM)	✓	✓	✓	✓
Time code (DCLS)			✓	✓
1, 5 or 10 MPPS				✓
Periodic/DDS				✓
Strobe				✓
1PPS	✓	✓	✓	✓
Oscillator control voltage				✓
Inputs				
Time code (AM)	✓	✓	✓	✓
Time code (DCLS); event2				✓
External event1	✓	✓	✓	✓
External 1 PPS; event3		✓	✓	✓
External 10 MHz				✓

Input/Output Signals D to BNC Connector Breakout Cables

1U Patch Panel of Input/Output and High Frequency Signals for Standard Rack Mount Size Chassis



Specifications

Electrical

- GPS receiver/antenna
  - 12 channel parallel receiver
  - GPS time traceable to UTC(USNO)
  - Accuracy — 170 ns RMS, 1 µs peak to peak to UTC (USNO), at stable temperature and ≥4 satellites tracked.
  - Maximum Belden 9104 cable length — 150' (45 m). For longer cable runs see options.
- Real-time C=clock
  - Bus request resolution — 100 ns
  - Latency — Zero
  - Major time format — Binary or BCD
  - Minor time format — Binary
- Synchronization sources — GPS, time code, 1 PPS
- Time code translator (inputs)
  - Time code formats — IRIG A, B, G, E, IEEE 1344, NASA 36, XR3, 2137
  - Time accuracy — <5 µS (AM carrier frequencies 1 kHz or greater) <1 µS (DCLS)
  - AM ratio range — 2:1 to 4:1
  - AM input amplitude — 1 V_{PP} to 8 V_{PP}
  - AM input impedance — > 5 kΩ
  - DCLS input, event2 — 5V HCMOS >2V high, V <0.8 low
- Time code generator (outputs)
  - Time code format — IRIG A, B, G, E, IEEE 1344, NASA 36, XR3, 2137
  - AM ratio — 3:1 ±10%
  - AM amplitude — 3.5 ±0.5 V_{PP} into 50Ω
  - DCLS amplitude — 5V HCMOS, >2V high, <0.8V low into 50Ω
- Timing functions (outputs are rising edge on time)
  - DDS rate synthesizer
  - Frequency range — 0.0000001 PPS to 100 MPPS
  - Output amplitude — 5V HCMOS, >2V high, <0.8V low into 50Ω, square wave
  - Jitter — <2 nS p-p
  - Legacy pulse rate synthesizer (Heartbeat, aka Periodic)
  - Frequency range — <1 Hz to 250 kHz
  - Output amplitude — 5V HCMOS, >2V high, <0.8V low into 50Ω, square wave
  - Time compare (strobe)
  - Compare range — 1 µs through days
  - Output amplitude — 5V HCMOS, >2V high, <0.8V low into 50Ω, 1 µs pulse
  - 1 PPS output — 5V HCMOS, >2V high, <0.8V low into 50Ω, 60 µs pulse
  - 1 PPS input, event3 — 5V HCMOS, >2V high, V <0.8 low
  - External event input — 5V HCMOS, >2V high, <0.8V low, zero latency
  - External 10 MHz oscillator — Digital 40% to 60% or sine wave, V0.5 pp to 8 V_{PP}, > 10k Ω
  - Oscillator control voltage — Jumper selectable 0 VDC–5 VDC or 0 VDC–10 VDC

- On-board disciplined oscillator
  - Frequency — 10 MHz
  - 1, 5, or 10 MPPS output — 5V HCMOS, >2V high, <0.8V low into 50Ω
  - Stability
  - Standard TCXO — 5.0×10^{-8} short term tracking 5.0×10^{-7}/day long term flywheeling
  - Real-time clock (RTC) — Battery-backed time and year information
- PCIe specification — Single-lane PCIe interface, r1.0a compatible
- Size — Standard height low-profile PCIe
- Power — 3.3V at 400 mA 12V at 300 mA (TCXO)
- Connector
  - GPS Antenna — SMB socket
  - Timing I/O — 15-pin 'DS' software

Environmental

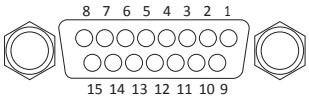
- Operating temperature — Module: –5°C to +65°C GPS antenna: –40°C to +70°C
- Transportation Temperature — –40°C to 85°C
- Storage temperature — Module: –5°C to +55°C GPS antenna: –5°C to +55°C
- Operating humidity — Module: 5% to 95% (non-condensing) GPS antenna: 100% (condensing)
- Certifications
  - FCC — Part 15, Subpart B. Emissions EN 55023
- Immunity — EN 55035
- RoHS compliance
  - EU RoHS 6/6 compliant
  - China RoHS compliant

Complete specifications can be found in the manual located at www.microchip.com.

Pin Description

Pin	Direction	SIgnal
1	Input	External 10 MHz
2		Ground
3	Output	Strobe
4	Output	1 PPS
5	Output	Time code (AM)
6	Input	External event1
7	Input	Time code (AM)
8		Ground
9	Output	Oscillator control voltage
10	Input	Time code (DCLS); event2
11	Output	Time code (DCLS)
12		Ground
13	Output	1, 5 or 10 MPPS
14	Input	External 1 PPS; event3
15	Output	Heartbeat/DDS

Pin Diagram

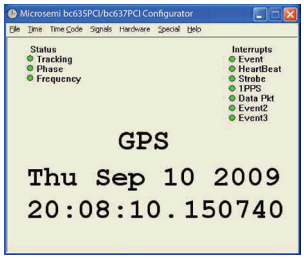


bc637PCIe Low-Profile and Standard Cover Panels

Software

The bc637PCIe software includes the SDKs and drivers for the 32/64-bit versions of Windows and 64-bit Linux. Included are test application programs with source code so that you can review the bc637PCIe card status and adjust board configuration and output parameters. Each SDK includes an extensive list of function calls to quickly and easily integrate the bc637PCIe card into your target environment. For Windows, an additional clock utility program, TrayTime, is provided that can be used to automatically update the host computer's clock. The bc637PCIe firmware is easily field-upgradeable.

Control Panel Interface



Product Includes

This product also includes a bc637PCIe time and frequency processor board, standard height and low-profile cover plates, one-year warranty and an insert sheet that explains how to download the user guide and SDK/driver software.

Ordering Information

Part number: bc637PCIe PCIe time and frequency processor, GPS synchronized.

Connector accessories that can be ordered:

- D connector to x5-BNCs adapter (provides TC in, TC out, 1PPS out, event in, periodic out) p/n: BC11576-1000
- D connector to x5-BNCs adapter with 1PPS in (provides TC in, TC out, 1PPS in, 1PPS out, event in) p/n: BC11576-9860115
- D connector to x6-BNCs adapter (provides TC in, TC out, 1PPS in, 1PPS out, event in, DCLS out) p/n: PCI-BNC-CCS
- GPS Inline Lightning Arrestor with 25 ft. (7.5 m) p/n: 150-709
- GPS Inline Lightning Arrestor with 50 ft. (15 m) p/n: 150-710
- GPS L1 Inline Antenna Amplifier p/n: 150-200

Contact Microchip for pricing and availability.