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PCI Express Time and Frequency Processor
bc635PCIe

The Microsemi bc635PCIe timing module provides unparalleled precise time and frequency functions to the host computer and peripheral data acquisition systems. Integration into a custom application is easy and efficient through the use of the full-featured standard Windows, Linux, and Solaris software development kits (SDKs)/drivers included with the module.

Time is typically acquired from time code signals such as IRIG B. 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 are 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 10 MHz oscillator that is either a TCXO or optional OCXO that provides the timing module a 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 high speed, low latency time requests. The 10 MHz oscillator drives the module frequency and time code generator circuitry. If the input reference is lost, the module continues to maintain time (flywheel) based on the 10 MHz oscillator's drift rate. The optional OCXO oscillator improves flywheel drift performance over the standard TCXO. 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 0.0000001PPS to 100MPPS. 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 bc635PCIe 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 external frequency input is a unique feature allowing the time and frequency of the bc635PCIe 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 bc635PCIe timing functions.

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

KEY FEATURES

- 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 <<1PPS to 100MPPS DDS rate synthesizer output/interrupt
- 1, 5, or 10MPPS rate generator output
- 1PPS and 10 MHz inputs
- Three external event time capture/interrupts
- Programmable time compare output/interrupt
- Zero latency time reads
- Battery backed real-time clock (RTC)
- Low-profile PCIe form factor
- Linux, Solaris, and Windows software drivers/SDKs included
- Superior user interface and documentation
- Optional OCXO upgrade

KEY BENEFITS

- Precise sub-microsecond time available to host computer applications
- Easy integration facilitated by included Windows, Linux, and Solaris 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 or OCXO Oscillators

Inputs

- AM time codes
- DCLS time codes
- External events (3x)
- 10 MHz
- 1PPS
- GPS (bc637PCIe model)

Outputs

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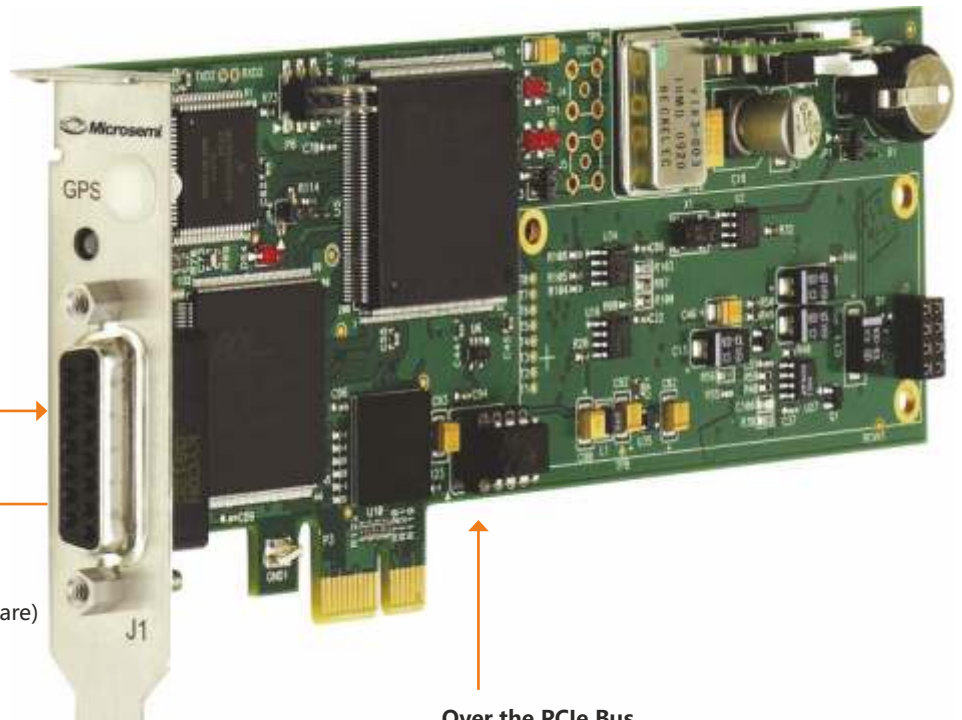
Over the PCIe Bus

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

Reading the Precise Time

The bc635PCIe 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 bc635PCIe 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 bc635PCIe card over the bus can be precisely time stamped for precise host application-based processes.

Flexible Rate Generation

The DDS on the bc635PCIe can be programmed to generate rates up to 100MPPS 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 bc635PCIe offers 1, 5, or 10MPPS 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 bc635PCIe 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 bc635PCIe timing functions. For closed loop control, an external oscillator may be disciplined using DAC voltage control output from the bc635PCIe.

Time Compare/Strobe/Alarm

A useful feature of any precise clock is the ability to notifiy 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 bc635PCIe 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 bc635PCIe 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, Linux, and Solaris SDKs Speed PCIe Integration

The PCIe card includes standard full-featured software development kits, speeding the integration of Microsemi 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 interfacing to a Microsemi PCIe card straightforward 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 Microsemi PCIe cards into applications, saving both time and money. The SDK functions address each Microsemi 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 Microsemi's timing expertise and confidently integrate a Microsemi PCIe card into your application.

License-Free

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

Driver Comparison

Windows SDK and Driver	Linux SDK and Driver	Solaris SDK and Driver
• Windows XP/Vista/7/10 • Windows Server 2003/2008 • 32- and 64-bit support • Kernel mode driver • Code examples • Test application program • Complete documentation • Timekeeping utility program The Windows SDK for bc635PCIe 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 Microsemi'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	• Up to Linux Kernel 4.6 • 32- and 64-bit kernel support • Code examples • Test application program • Complete documentation The Linux SDK for bc635PCIe cards includes PCIe kernel mode device drivers for both 32-bit and 64-bit kernels, an interface library accessing all bc635PCIe 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 Microsemi'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 3.10 **Hardware** x86 processor **Memory** 32 MB **Development Environment** GNU GCC recommended	• Solaris kernel mode driver • 64-bit Solaris 8–10 • Code examples • Test application program • Complete documentation Microsemi's Solaris SDK includes bc63xPCIcfg, an application program to ensure proper operation of the PCIe card in the host computer. The example program includes sample code 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 target programming environment is the Solaris application development tool chain and the C/C++ programming languages. The Solaris SDK includes the Solaris device driver source code. Applications access the features of the hardware through the standard 'ioctl' Solaris system function. The ioctl codes are defined for all the features of the card. The bc63xPCIcfg program shows how to use most ioctl codes. Developers can copy any useful code from the bc63xPCIcfg source code and use it in their own applications. **Minimum System Requirements** **Operating System** Solaris versions 8, 9, and 10 **Hardware** SPARC and x86_64 **Memory** 32 MB **Development Environment** Solaris compilers

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	Sets DDS divider value.
• 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.

Solaris SDK Function Reference

The Solaris SDK uses custom ioctl commands to facilitate easy communication and control of the bc635PCIe card. The commands cover basic operational functions, event management, oscillator controls, and mode-related functions.

The following list is an overview of the Solaris SDK's ioctl functions.

- Interrupt management
- Read/write dual port RAM. Send command to timing engine for processing
- Read and write time
- Timing mode and time format
- Read and write the card control register
- Input time code format and modulation selection
- Set local time
- Leap seconds control
- Read various version information and miscellaneous data
- Reset the board
- Clock source and JamSync management
- DAC control
- On-board oscillator frequency control
- Advance or retard the internal clock

- Read event time latched by external event
- Read event time latched by software event
- Event source/sense control
- Set propagation delay
- Periodic output and output frequency control
- Strobe control
- DDS frequency output control
- Set output time code format
- Set offset for output time code generation
- GPS control
- Sync real time clock
- Disconnect between RTC and battery after power off

Backward Compatibility Provides Seamless Migration Paths

The PCI-based bc635 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 bc635PCI cards into their systems, Microsemi has maintained the bc635PCI 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 bc635PCI cards integrate smoothly into any workstation currently available in the market with little to no impact on customer application software.

bc635PCI
Mid-1990s
- First PCI timing card introduced

bc635PCI-U
- 2003
- 3.3 V and 5.0 V universal signaling backward compatibility retained

bc635PCI-V2
- 2008
- Electronics updated backward compatibility retained

- 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.

Input/Output Signals D to BNC Connector Breakout Cables

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	atch/Breakout
Outputs				
Time code (AM)	•	•	•	•
Time code (DCLS)			•	•
1, 5, or 10MPPS				•
Periodic/DDS				•
Strobe				•
1PPS	•	•	•	•
Oscillator control voltage				•
Inputs				•
Time code (AM)	•	•	•	•
Time code (DCLS); event2				•
External event1	•	•	•	•
External 1PPS; event3		•	•	•
External 10 MHz				•

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

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Specifications

Electrical	
Real-time clock	
Bus request resolution	100 ns
Latency	Zero
Major time format	Binary or BCD
Minor time format	Binary
Synchronization sources	Time code, 1PPS
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	5 V HCMOS >2 V high, <0.8 V 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 V_{pp} ±0.5 V_{pp} into 50 Ω
DCLS amplitude	5 V HCMOS, >2 V high, <0.8 V low into 50 Ω
Timing functions (outputs are rising edge on time)	
DDS rate synthesizer	
Frequency range	0.0000001PPS to 100MPPS
Output amplitude	5 V HCMOS, >2 V high, <0.8 V low into 50 Ω, square wave
Jitter	<2 nS p-p
Legacy pulse rate synthesizer (heartbeat, aka periodic)	
Frequency range	<1 Hz to 250 kHz
Output amplitude	5 V HCMOS, >2 V high, <0.8 V low into 50 Ω, square wave
Time compare (strobe)	
Compare range	1 µs through days
Output amplitude	5 V HCMOS, >2 V high, <0.8 V low into 50 Ω, 1 µs pulse
1PPS output	5 V HCMOS, >2 V high, <0.8 V low into 50 Ω, 60 µs pulse
1PPS input, event3	5 V HCMOS, >2 V high, <0.8 V low
External event input	5 V HCMOS, >2 V high, <0.8 V low, zero latency
External 10 MHz oscillator	Digital 40% to 60% or sine wave, 0.5 Vpp to 8 Vpp, >10 kΩ

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 MHz output	5 V HCMOS, >2 V high, <0.8 V low into 50 Ω
Stability	
Standard TCXO	5.0×10^{-8} short term "tracking" 5.0×10^{-7}/day long term "flywheeling"
Optional OCXO	2.0×10^{-9} short term "tracking" 5.0×10^{-8}/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	3.3 V at 400 mA 12 V at 250 mA (TCXO), 350 mA (OCXO)
Connector	
Timing I/O	15-pin DS software
Environmental	
Temperature	
Operating	0 ºC to 70 ºC
Storage	−30 ºC to 85 ºC
Humidity	
Operating	5% to 95% non-condensing
Operating altitude	Up to 18,000 m MSL
Certifications	
FCC	Part 15, Subpart B.
CE	Emissions EN 55022
Immunity	EN 55024
RoHS compliance	
EU RoHS 6/6 China RoHS	

Pin Description

Pin	Direction	Signal
1	Input	External 10 MHZ
2		Ground
3	Output	Strobe
4	Output	1PPS
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 10MPPS
14	Input	External 1PPS; event3
15	Output	Heartbeat/DDS

Pin Diagram

bc635PCIe Low-Profile and Standard Cover Panels

Software

the 32/64-bit versions of Windows and Linux, and 64-bit Solaris. Included are test application programs with source code so that you can review the bc635PCIe card status and adjust board configuration and output parameters. Each SDK includes an extensive list of function calls to quickly and easily integrate the bc635PCIe 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 bc635PCIe firmware is easily field-upgradeable.

Control Panel Interface

Time Code
Thu Sep 10 2009
20:08:10.150740

Product Includes

This product also includes a bc635PCIe time and frequency processor board, standard height and low-profile cover plates, one-year warranty, a PCIe user guide CD, and a Windows, Linux, and Solaris SDK/driver software CD.

Ordering Information

bc635PCIe PCIe time and frequency processor

bc635PCIe-OCXO PCIe time and frequency processor with oven controlled crystal oscillator for extended holdover connector accessories that can be ordered.

- D connector to x5-BNCs adapter (provides TC in, TC out, 1PPS out, event in, periodic out) BC11576-1000

- D connector to x5-BNCs adapter with 1PPS in (provides TC in, TC out, 1PPS in, 1PPS out, event in) BC11576-9860115

- D connector to x6-BNCs adapter (provides TC in, TC out, 1PPS in, 1PPS out, event in, DCLS out) PCI-BNC-CCS

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