MMC 2U

Modular Master Clock

Brandywine's Modular Master Clock System represents the next generation of modular timing systems. Built on the highly successful High Performance Timing System, the Modular Master Clock System is a leap forward in design.

At the center of the MMC system are Brandywine's powerful dual-redundant Master Clock Modules (MCM). Each MCM may be synchronized by a variety of reference sources and uses the selected reference to steer an embedded oscillator to provide stable and accurate time and frequency for the MMC. Multiple references can be prioritized with automatic failover. Uniquely, the MCM will also validate the GPS reference based upon the inherent stability of the MCM oscillator, providing hardening against possible GPS spoofing.

Available input reference selections include GPS (C/A code and SAASM receivers are supported), IRIG-B, Have Quick/1PPS and external 10 MHz. In additional an MCM may be synchronized to up to 2 other MMC chassis using a fiber optic crosslink, this provides additional resiliency for the MMC time and frequency references. Additional input references are available with the use of an input signal module.

FEATURES

- **Redundant design with multiple signal paths built in for high-availability.**
- **12 expansion slots in the 2U version and 5 expansion slots in the 1U variant.**
- **Industry-first GPS integrity checking**
- **Unique optical crosslink architecture for either Master-Slave hierarchical setups or Master-Master crosschecking and failover**
- **2U version is operated by an intuitive touch-screen interface, a first for any master clock system.**
- **Redundant Master Clock Modules and Power Supplies (AC only)**
- **The Output Signal modules are hot-swappable from the front and minimize the need to disconnect cables.**

The MMC supports multiple reference oscillator choices, including Rubidium (2U chassis only) and Ovenized Oscillator (OCXO, available on both the 1U and 2U models)

The output signals for the Modular Master Clock System are generated by up to 12 hot-swappable Output Signal Modules (OSM), and are ideal for custom solutions or future expansion. Available modules include NTP, PTP, low-phase-noise frequency, time code modules such as IRIG A, B, G, H, and NASA 36, BCD, PPS, PPM, Have Quick as well as optical crosslink.

The MMC status and control is via a full color touch screen that allows control of the local chassis, as well as remote chassis that are connected via crosslink. Other control options are via a Windows application, and via SNMPv3. User controls for the MMC are protected via password with encrypted storage. Network protocols also fully support privacy and authentication.

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System Specifications

Signal Reference Inputs

C/A Code GPS Receiver (Optional)

Receiver Type	GPS L1 C/A, SBAS L1 C/A
GPS Reception	14 channels (GPS, SBAS)

SAASM P(Y) Code GPS Receiver (Optional)

Receiver Type	GB-GRAM Type II
Keyfill cable	DAGR compatible DB15

External 1PPS Input

Signal Format	2.5V to 10V
Rate	1 pulse per second
Impedance	50 Ω

External GPS Have Quick Time Code Input

Signal Format	Per ICD-GPS-060A, STANAG 4246 HQ2A
Rate	1 frame per second
Impedance	1k Ω
Connector Type	DB15M

External IRIG B Input

Signal Format	IRIG B Per IRIG 200-04
Control Functions	Per IEEE1344
Modulation ratio	2.5:1 to 3.3:1
Amplitude	1 V_{p-p} to 5V_{p-p}
Impedance	>600 Ω
Connector Type	DB15M

External 10 MHz Reference Input

Frequency	10MHz
Source	Rubidium or Cesium
Amplitude	8-15dBm
Impedance	50 Ω
Connector Type	BNC

External 5 MHz Reference Input (2U Only)

Frequency	5MHz
Source	Rubidium or Cesium
Amplitude	8-15dBm
Impedance	50 Ω
Connector Type	BNC
Factory Configured Option	

Power

Two power supply slots are available.

AC Supply	
Redundancy	Dual Redundant
Voltage	90-265 VAC 50/60 Hz.
Consumption (typical)	Varies by configuration
Consumption (peak)	500W
Connector	IEC 320 C14 (standard) MS3102A-10SL-3P (optional MS shown)
DC Supply	
Redundancy	Not available
Voltage	36-72 VDC
Consumption (typical)	Varies by configuration
Consumption (peak)	500W
Connector	Barrier Terminal Block

Physical

Length (depth)	21”
Width	17” Chassis Width – 19” (Front Panel Width)
Height	2U
Weight	42 lbs nominal (slides not included)

Environmental

Temperature

Air Temperature	-15 to 55°C
Altitude Conditions	-1500 ft to +11,000 ft
Airflow	30 cfm front to side/rear. Side airflow is not obstructed by rack slides

Shock and Vibration

Designed to meet the following standards:

Operating Shock	MIL-STD 810F 20g/11ms
Bench Handling Shock	MIL-STD 810F
Vibration	MIL-STD-167-1
Structure-borne Noise	MIL-STD-740-2

EMC

Designed to meet the following standards:
FCC Part 15, Class A
IEC CISPR 22
CE

Future Support Planned

- M-Code GPS Receiver
- CSAC Oscillator

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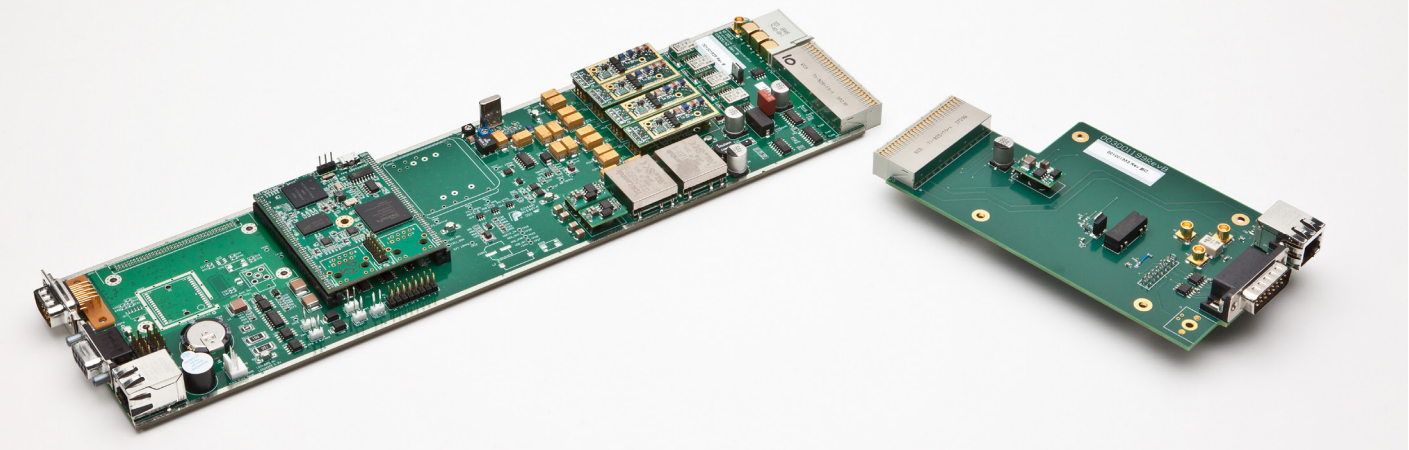
Master Clock Module

The Master Clock Module is the oscillator at the heart of the MMC. The MMC may use either one (standard) or two (optional) hot-swappable Master Clock Modules for redundancy and high-availability operation. The MCM may configured with one of three types of oscillator, depending upon price/performance desired. The MCM is accessed either via the front touch screen display, an external Ethernet port, or a front panel maintenance Ethernet port. All aspects of the MMC operation are available through the front panel display. For MMC configurations where multiple chassis are connected via an optical fiber link, the status and configuration of a remote chassis can be accessed across this link.

MCM's installed in a 2U chassis provide a number of signal outputs without the need to install any Output Signal Modules.

Each MCM includes provision for Information Assurance. The front panel display is password protected, and the password is stored in encrypted form. Password requirements and updates are implemented by means of warning screens. All Network connections use both authentication and privacy corresponding to the protocol in use. Only required ports and protocols are enabled.



Oscillator Options

	Rubidium[1]	**CSAC[2]**	**OCXO**
Time Locked	<5ns 2σ	<5ns 2σ	<10ns 2σ
Accuracy Holdover 10 days	<50µs	1ms	<10ms
Frequency Locked[3]	$<1 \times 10^{-12}$	$<2 \times 10^{-12}$	$<5 \times 10^{-11}$
Temperature -0 to 50°C	$<1 \times 10^{-10}$	$<5 \times 10^{-10}$	$<2 \times 10^{-9}$

MCM Inputs

Available Reference Selection

GPS (optional)
IRIG B
IRIG B + 1PPS
Have Quick + 1PPS
1PPS
10MHz
5 MHz
Crosslink A
Crosslink B

Additional inputs avaialble through Input Signal Module

External NMEA through RS-422
1PPS

MCM Outputs[1]

Time and Frequency Outputs

1PPS (2ea) - 10V into 50 Ω
IRIG B + IEEE1344 CF
Have Quick (STANAG TBA)
40 bit BCD
5 MHz[4]
10 MHz[2]

Propagation delay compensation
Input ±0-500ms in 5ns steps all inputs
Outputs ±0-500ms in 5ns steps

Status and Control
10/100BaseT Ethernet
SNMP v3 RFC 3411, 3418
NTP v4 RFC 5905
IP v4, IP v6
Touch panel display
5 inch WVGA LCD w/ Touch Screen

Alarm Relay
Dry Contact Closure 100mA
Audible Buzzer Alarm

1 2U Chassis Only
2 Planned Support for Future
3 Averaged over 24 hours
4 Not availible if GPS option is fitted

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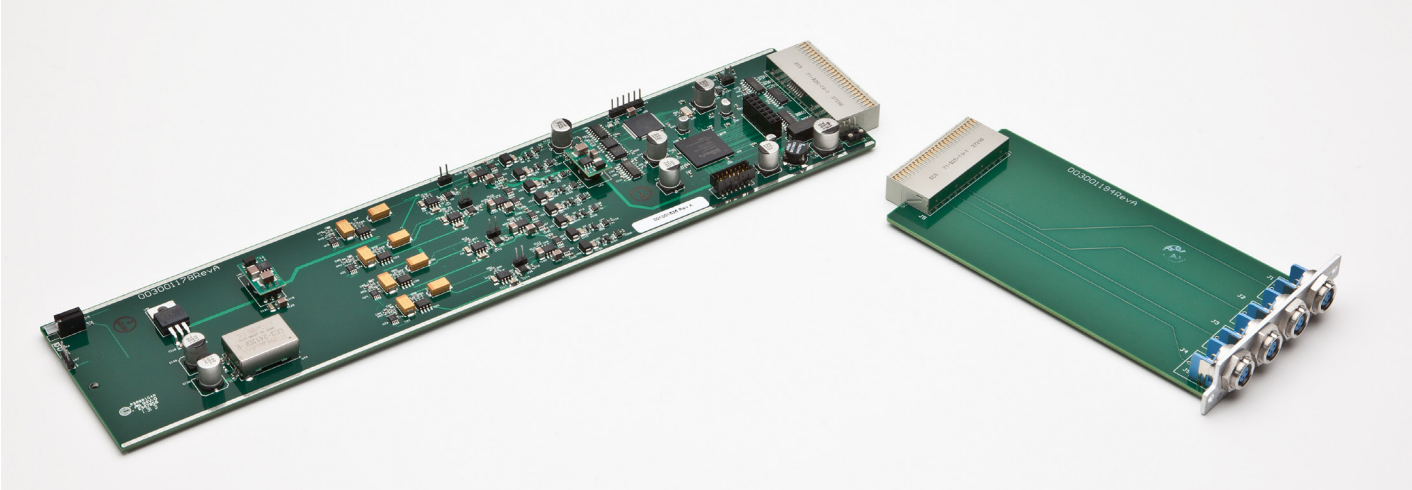
Universal Output Signal Module

The Universal OSM provides the ultimate in flexibility. The Universal OSM has 4 outputs, each of which is user-programmable to a wide variety of time code or pulse outputs. This flexibility ensures that an MMC can be reconfigured as requirements change, and fewer modules are needed in comparison to designs where modules are single function. Time code outputs can be configured independently for local time. Passive rear transition modules are available for single ended BNC, or differential connectors. Each output is individually adjustable for propagation delay, ensuring that for high accuracy synchronization different cable lengths can be accommodated.

Available output formats:

- 1 PPS and 1PPM
- HaveQuick
- IRIG A, B, E, G, H
- XR3
- 2137
- Programmable Pulse Output



Specifications

Pulse per Second/Minute

Signal Format	Per ICD-GPS-060B
1PPS Rate	1 pulse per second
1PPM Rate	1 pulse per minute
Rising Edge	On Time
Rise Time	<20ns
Fall time	<100ns
Pulse Width	20 µs ±5% default.
Amplitude	Selectable 5V/10V ±10% into 50Ω
Output condition	When TFOM<7 only

Have Quick Time of Day Output

Signal Format	Per ICD-GPS-060A
Rising Edge	On Time
Rise Time	<100ns
Fall time	<100ns
1PPS coherence	< 100ns of rising edge
Amplitude	5V ±5%
Output condition	when TFOM<7 only

BCD Time Code Output

Signal Format	Per ICD-GPS-060A
Rate	50 bits/sec
1PPS coherence	< 100ns of rising edge
Mark (logical 1)	+2.5V ±1V
Space (logical 0)	-2.5V ±1V
Output condition	when TFOM<7 only
Connector Type	3 Pin

IRIG B Time code Output

Signal Format	B002, B122, B124
(consult factory for other formats)	
Control Functions	B124 per IEEE1344
Rate	1kHz modulated
Modulation ratio	10:3 ±10%
Amplitude	5Vp-p ±20%
Output condition	when TFOM<7 only

2137 Time code Output

Signal Format	2137
Carrier	1kHz modulated
Modulation ratio	10:3 ±10%
Amplitude	5Vp-p ±20%
Output condition	when TFOM<7 only

XR3 Time code Output

Signal Format	XR3
Rising Edge	On Time
Rise Time	<100ns
1PPS coherence	< 100ns of rising edge
Amplitude	5V ±5%
Output condition	when TFOM<7 only

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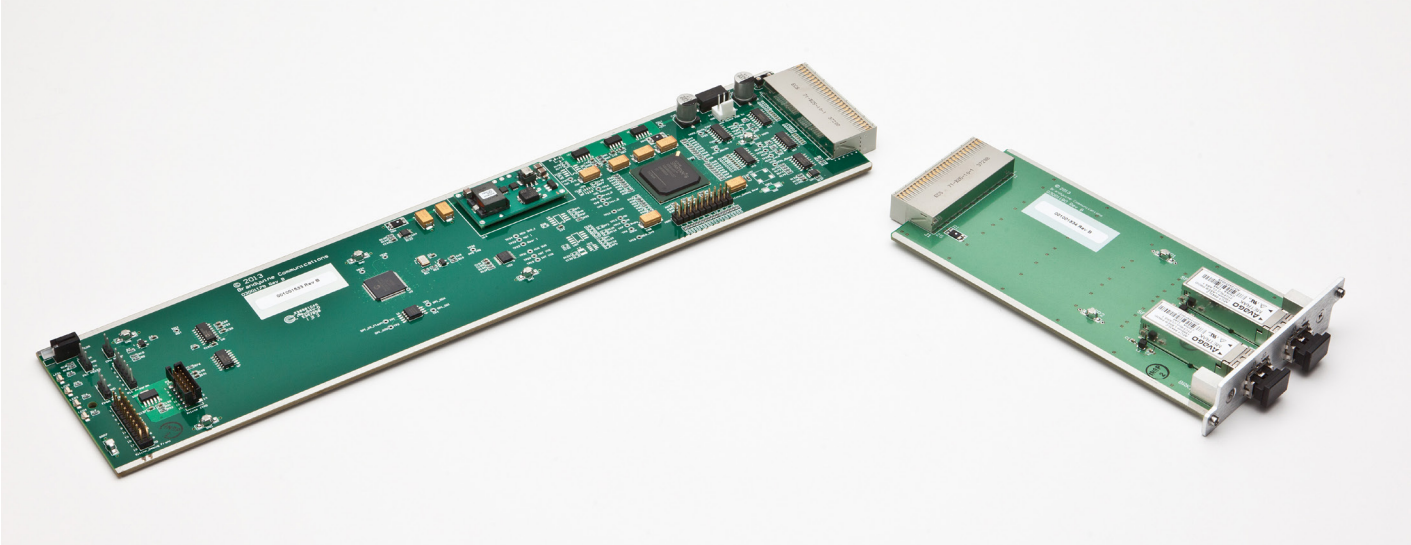
Optical Crosslink Module

The Optical Crosslink Module is a unique feature of the MMC. When installed, it allows a second MMC to be synchronized as a slave chassis. If both chassis have a primary reference installed (e.g. GPS) then the two MCM's operate as peers. Peering provides additional redundancy, as well as providing additional references to detect failures.

When a duplex cable is provided, the optical link provides seamless and automatic propagation delay compensation. A security mode allows the optical link to be operated in a single direction from Master to Slave over a single fiber.



Specifications

Connector Type	LC
No. of Outputs	2 bi-directional per OSM
Synchronization Accuracy	
Phase Measurement Accuracy	1 ns
End to End Accuracy	<5ns synchronization
Optical	
Wavelength	Single Mode 1300 nm
Safety	Class 1 CDRH/IEC 825
Range[1]	2000m 9/125um cable

1 Consult Factory for longer range or multimode

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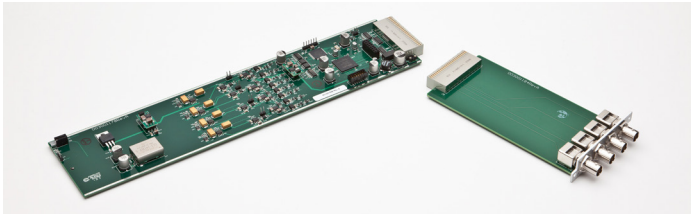
Output Signal Modules

Low Phase Noise Analog



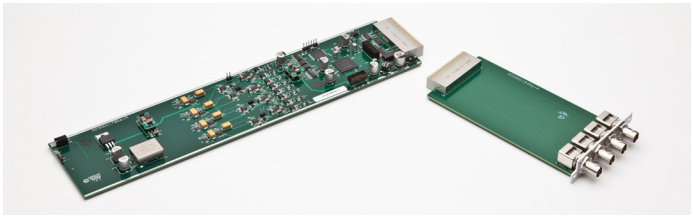
The Analog Low Phase Noise Module provides 4 low phase noise reference frequency outputs at 1, 5, or 10MHz.

Specifications:

Waveform	Sinusoid
Amplitude	13dBm/1Vrms
Harmonic Distortion	-30dBc
Non Harmonic	<-80dBc 10k - 500MHz
Connector Type	Coaxial, BNC
Accuracy	Locked to MCM oscillator
MCM Switching	Hitless switch

Phase Noise dBc/√Hz	10MHz[1]	5MHz[1]
1Hz	-90dBc	-90dBc
10Hz	-120dBc	-120dBc
100Hz	-145dBc	-145dBc
1KHz	-155dBc	-155dBc
10KHz	-158dBc	-158dBc

Telecom Synthesizer Module

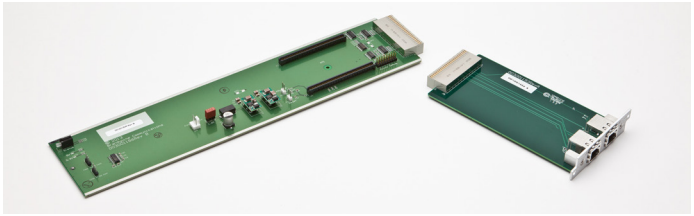


The Synthesizer Module provides 4 programmable output frequencies on the range 250Hz to 33MHz. The frequency scheme ensures that telecom frequencies on multiples of 8kHz are exact.

Specifications:

Waveforms		
Sinusoid	1ea.	10dBm nominal
Connector		BNC
Square	1ea.	0-5Vpk
Connector		BNC
Differential	2ea	per RS-422
Connector		3 Pin circular
Settable Resolution		1Hz
Frequency range		250 Hz to 33MHz
Accuracy		Locked to MCM oscillator
MCM Switching		Hitless switch

NTP Server

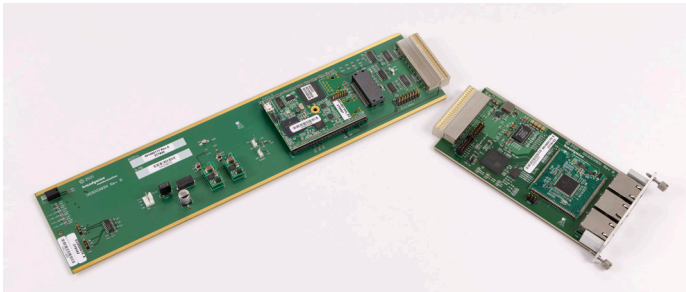


The NTP Server module enables the Modular Master Clock to act as an NTP server over an Ethernet network. Designed with security in mind, the NTP server module uses a custom network stack that enables it to ONLY act as an NTP server, and prevent it from being used as a gateway to compromise the entire system.

Specifications:

Signal Format	Ethernet 10/100BaseT
Protocols supported	NTPv3 RFC1305
	NTPv4 RFC 5905
Authentication	MD5, SHA-1
Connector Type	RJ45
No of Outputs	2

PTP Grandmaster OSM



The PTP Grandmaster Clock Module enables the Modular Master Clock to act as an PTP Grandmaster clock over an Ethernet network. Designed with security in mind, the PTPGM Module features secure hardware timestamping.

Specifications:

Network Interface:
- Interface Option 1:
  - 2 x 100/1000Base-T RJ45 (NTP/PTP)
  - 1 x GBIT SFP – Slot (NTP/PTP).
- Interface Option 2:
  - 3 x 100/1000Base-T RJ45 (NTP/PTP)

Network Protocols:
- IPv4, IPv6, DHCP, DHCPv6, NTPv3, PTPv2 (IEEE1588-2008), SSH, ICMP

PTP:
- Synchronous: Grandmaster
- PTP Modes:
  - Multicast/Unicast Layer 2 (IEEE 802.3)
  - Multicast/Unicast Layer 3 (UDP IPv4/IPv6)
  - E2E / P2P Delay Mechanism
  - Up to 128 messages/second per client
- 1588 Clock Mode: 1-Step/2-Step
- Configurable via profiles

NTP Server:
- NTPv3, SNTP
- MD5, SHA-1 Authentication

1 **Contact factory for better phase noise**

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