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.

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.
- All components are hot-swappable and are dual redundant.
- The Output Signal modules are hot-swappable from the front and minimize the need to disconnect cables.

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 (both 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.

The MMC supports multiple reference oscillator choices, including Rubidium (2U chassis only), Chip Scale Atomic Clock (CSAC) and Ovenized Oscillator (OCXO)

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, 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.
## 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)
- **Sensitivity**
  - Tracking: -159 dBm
  - Acquisition: -147 dBm
- **Accuracy**: 15ns (1σ) (@ -130 dBm)
- **Connector Type**: BNC
- **TTFF**
  - Hot Start: <5 sec (@ -130 dBm)
  - Warm Start: 70 sec (@ -130 dBm)
  - Cold Start: 70 sec (@ -130 dBm)

#### SAASM GPS Receiver (optional)
- **Receiver Type**: GB-GRAM Type II
- **Keyfill cable**: DAGR compatible DB15

### External 1PPS Input
- **Signal Format**: Per ICD-GPS-060B
- **Rate**: 1 pulse per second
- **Impedance**: 50 ohm

### External GPS Have Quick T/C Input
- **Signal Format**: Per ICD-GPS-060A, STANAG 4246 HQ2A
- **Rate**: 1 frame per second
- **Impedance**: 1k ohm
- **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 Vp-p to 5Vp-p
- **Impedance**: >600 ohm
- **Connector Type**: DB15M

### External 10MHz Reference Input
- **Frequency**: 10MHz +/- 5E-11
- **Amplitude**: 8-15dBm
- **Impedance**: 50 ohm
- **Connector Type**: BNC

### Environmental Power
- **2 power supply slots are available on both 1U and 2U chassis. 2U chassis can be either AC input, DC input or a combination. 1U is single or dual AC supply only.**
- **AC Supply**
  - **Voltage**: 90-265 VAC 50/60 Hz.
  - **100W Maximum**
- **Connector**
  - IEC 320 C14 (standard)
  - MS3102A-10SL-3P (optional MS shown)
- **DC Supply**
  - **Voltage**: 18-36VDC
  - **Connector**: Barrier Terminal Block

### Physical
- **Length (depth)**: 20.00"
- **Width**: 19.00" (Front Panel Width)
- **Height**: 3.47" 2U chassis
  - 1.72 1U chassis
- **Weight**: 25 lbs nominal (slides not included)

### Temperature
- **Air Temperature**: -15 to 55degC
- **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
- **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
- **FCC Part 15, Class A**
- **IEC CISPR 22**
- **CE**
Modular Master Clock

Master Clock Module (MCM)

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

<table>
<thead>
<tr>
<th>Oscillator</th>
<th>Rubidium</th>
<th>CSAC</th>
<th>OCXO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time Locked</td>
<td>&lt;5ns 2o</td>
<td>&lt;5ns 2o</td>
<td>&lt;10ns 2o</td>
</tr>
<tr>
<td>Frequency Locked</td>
<td>&lt;1x10^-7</td>
<td>&lt;2x10^-7</td>
<td>&lt;2x10^-7</td>
</tr>
<tr>
<td>Temperature -0 to 50°C</td>
<td>&lt;2x10^-4</td>
<td>&lt;5x10^-4</td>
<td>&lt;1x10^-3</td>
</tr>
</tbody>
</table>

MCM Inputs

<table>
<thead>
<tr>
<th>Available Reference selection</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPS (optional)</td>
</tr>
<tr>
<td>IRIG B</td>
</tr>
<tr>
<td>IRIG B + 1PPS</td>
</tr>
<tr>
<td>Have Quick +1PPS</td>
</tr>
<tr>
<td>1PPS</td>
</tr>
<tr>
<td>10MHz</td>
</tr>
<tr>
<td>Crosslink A</td>
</tr>
<tr>
<td>Crosslink B</td>
</tr>
</tbody>
</table>

MCM Outputs

1PPS (2ea)
IRIG B + IEEE1344 CF
Have Quick
50 bit BCD
5 MHz
10 MHz

Time and Frequency Outputs
1PPS (2ea)
IRIG B + IEEE1344 CF
Have Quick
50 bit BCD
5 MHz
10 MHz

Status and Control
100BaseT Ethernet
SNMP v3 RFC 3411, 3418
NTP v4 RFC 5905
IP v4, IP v6

Touch panel display
4.1 inch WVGA (800 X 480) LED 350 NIT
Digital Landscape TFT LCD w/ Touch Screen

Alarm Relay
Dry Contact Closure 100mA
Audible Buzzer Alarm

1 2U chassis only

2 Averaged over 24 hours

3 Not available if GPS option is fitted
**Modular Master Clock**

**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

### Specifications:

#### Pulse-per-second/minute

<table>
<thead>
<tr>
<th>Signal Format</th>
<th>Per ICD-GPS-060B</th>
</tr>
</thead>
<tbody>
<tr>
<td>1PPS Rate</td>
<td>1 pulse per second</td>
</tr>
<tr>
<td>1PPM Rate</td>
<td>1 pulse per minute</td>
</tr>
<tr>
<td>Rising Edge</td>
<td>On Time</td>
</tr>
<tr>
<td>Rise Time</td>
<td>&lt;20ns</td>
</tr>
<tr>
<td>Fall time</td>
<td>&lt;100ns</td>
</tr>
<tr>
<td>Pulse Width</td>
<td>20 μs ±5% default.</td>
</tr>
<tr>
<td>Amplitude</td>
<td>10V ±10% into 50Ω</td>
</tr>
<tr>
<td>Output condition</td>
<td>when TFOM&lt;7 only</td>
</tr>
</tbody>
</table>

#### Have Quick Time of Day Output

<table>
<thead>
<tr>
<th>Signal Format</th>
<th>Per ICD-GPS-060A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rising Edge</td>
<td>On Time</td>
</tr>
<tr>
<td>Rise Time</td>
<td>&lt;100ns</td>
</tr>
<tr>
<td>Fall time</td>
<td>&lt;100ns</td>
</tr>
<tr>
<td>1PPS coherence</td>
<td>&lt; 100ns of rising edge</td>
</tr>
<tr>
<td>Amplitude</td>
<td>5V ±5%</td>
</tr>
<tr>
<td>Output condition</td>
<td>when TFOM&lt;7 only</td>
</tr>
</tbody>
</table>

#### BCD Time Code Output

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

#### IRIG B Time code Output

<table>
<thead>
<tr>
<th>Signal Format</th>
<th>B002, B122, B124</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control Functions</td>
<td>B124 per IEEE1344</td>
</tr>
<tr>
<td>Rate</td>
<td>1kHz modulated</td>
</tr>
<tr>
<td>Modulation ratio</td>
<td>10:3 ±10%</td>
</tr>
<tr>
<td>Amplitude</td>
<td>5Vpp±20%</td>
</tr>
<tr>
<td>Output condition</td>
<td>when TFOM&lt;7 only</td>
</tr>
</tbody>
</table>

#### 2137 Time code Output

<table>
<thead>
<tr>
<th>Signal Format</th>
<th>2137</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carrier</td>
<td>1kHz modulated</td>
</tr>
<tr>
<td>Modulation ratio</td>
<td>10:3 ±10%</td>
</tr>
<tr>
<td>Amplitude</td>
<td>5Vpp±20%</td>
</tr>
<tr>
<td>Output condition</td>
<td>when TFOM&lt;7 only</td>
</tr>
</tbody>
</table>

#### XR3 Time code Output

<table>
<thead>
<tr>
<th>Signal Format</th>
<th>XR3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rising Edge</td>
<td>On Time</td>
</tr>
<tr>
<td>Rise Time</td>
<td>&lt;100ns</td>
</tr>
<tr>
<td>1PPS coherence</td>
<td>&lt; 100ns of rising edge</td>
</tr>
<tr>
<td>Amplitude</td>
<td>5V ±5%</td>
</tr>
<tr>
<td>Output condition</td>
<td>when TFOM&lt;7 only</td>
</tr>
</tbody>
</table>
Modular Master Clock

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

<table>
<thead>
<tr>
<th>Phase Noise dBc/Hz</th>
<th>10MHz</th>
<th>5MHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>1Hz</td>
<td>-90dBc</td>
<td>-90dBc</td>
</tr>
<tr>
<td>10Hz</td>
<td>-120dBc</td>
<td>-120dBc</td>
</tr>
<tr>
<td>100Hz</td>
<td>-145dBc</td>
<td>-145dBc</td>
</tr>
<tr>
<td>1KHz</td>
<td>-155dBc</td>
<td>-155dBc</td>
</tr>
<tr>
<td>10KHz</td>
<td>-158dBc</td>
<td>-158dBc</td>
</tr>
</tbody>
</table>

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., BNC 0-5Vpk 1ea., BNC per RS-422 2ea., 3Pin circular 1ea.
- Connector: 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 100BaseT
- Protocols supported: NTPv3 RFC1305, NTPv4 RFC 5905
- Authentication: MD5, SHA-1
- Connector Type: RJ45
- No of Outputs: 2

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 form Master to Slave over a single fiber.

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

* Consult Factory for longer range or multimode

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