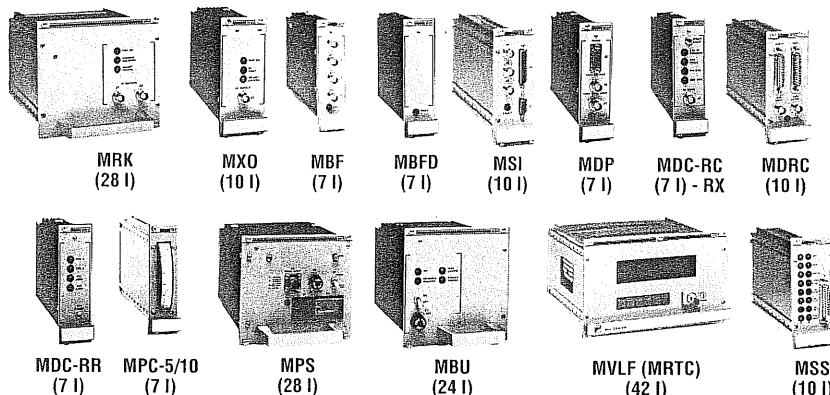
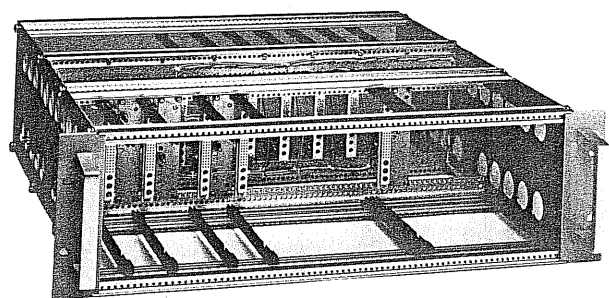


Modular Frequency and Time Systems (MFS)



The Modular Frequency and Time System (MFS) provides the time and frequency industry with an innovative way to use a host of standard modules to form a 19 inch rack system. The main theme is as follows:

- Generate precise frequency and time through use of Rubidium Atomic Oscillators, Crystal Oscillators, and VLF/LF/GPS Receiver signals.
- Buffer and distribute frequency and time with virtually unlimited number of outputs at various frequencies.
- Automatic calibration of Rubidium Oscillators through use of external standards or VLF/LF/GPS receiver modules.
- Redundant systems based on independent or phase-locked oscillators.
- Battery backup to protect against ac power failure.

MFS Concept

The Efratom MFS is conceived as follows: The customer defines system requirements and contacts Efratom. Efratom will assist the customer in providing a custom solution to specific requirements. The custom MFS is based on the standard modules described in this brochure. The modules plug into the front and rear of a standard 19" rack, 5¼" high and 17½" deep. This unique feature doubles the available panel space to 32 inches of modules within the 19 inch rack. Optional chassis slides are available to provide access to the rear modules.

The module size is based on the DIN Euroboard system. The width of each module is specified in increments (I) and space not used is covered by blank panels. Each increment is equal to ¾". A panel of 7(I) would fit into a 1.40" wide space in the rack chassis. The total width of the Efratom chassis is 80(I) front and 80(I) rear for a total usable space of 160(I). An 84(I) wide rack (168 total) is also available, if chassis slides are not used.

All modules interface with the rack using Cannon connector G06M426 series body with 6 rf or HV plug inserts,

except the MSS Module, which uses a 96 pin connector. The connector pins for pin functions are not listed here but are shown in the operating manual for each module. The Cannon G06M426 series connector features 42 pins. The RF connectors used on the dress panels are BNC jacks.

Module	Width	Weight	Basic Function
MRK	28(I)	5.7 lb.	Rubidium Oscillator
MXO	10(I)	1.5 lb.	Quartz Crystal Oscillator
MBF	7(I)	1.2 lb.	Frequency Distribution
MBFD	7(I)	1.2 lb.	Frequency Distribution
MBF-T	7(I)	1.2 lb.	Frequency Distribution
MBF-R	7(I)	1.2 lb.	Frequency Distribution
MSI	10(I)	1.5 lb.	Synthesizer & Interface
MDP	7(I)	1.5 lb.	1 PPS Generation
MDC-RC	7(I)	1.2 lb.	Rubidium Oscillator Calibrator
MGPS	49(I)+14(I)	4.4 lbs.	GPS Receiver Controller
MDRC	10(I)	1.5 lb.	Disciplined Rb Controller for GPS
MDC-RR	7(I)	1.5 lb.	Frequency Synchronizer RF switch
MDC-RX	7(I)	1.5 lb.	Frequency Synchronizer RF switch
MPC	7(I)+7(I)*	1.1 lb.	Phase Comparator
MPS	28(I)	9 lb.	Power Supply
MBU	24(I)	8 lb.	Battery
MVLF	42(I)+14(I)*	4.4 lb.	VLF/LF Frequency Receiver
MRTC	42(I)+7(I)*	4.4 lb.	Real Time Clock and IRIG Code Generator
MSS	10(I)	1.5 lb.	System Status

*Connector Panel

The MFS is designed, fabricated, and tested to standard commercial practices.

The environments for the MFS rack are as follows:

- Operating Temperature: -25°C to 50°C ambient (0 to 50°C for those modules noted)
- Storage Temperature: -40°C to 75°C ambient, (with MBU Battery Module installed: -40°C to 65°C)
- Humidity: 95% Relative Humidity

The Standard Modules

Frequency Generators

- **MRK - Rubidium Oscillator (Basic Model FRK family)**
This module represents the basic ultra-stable frequency generator for the modular line of products at 5 or 10 MHz.
- **MXO - Quartz Crystal Oscillator**
The MXO is primarily intended as a temporary backup oscillator to an MRK.

Frequency Distributors

- **MB* - Frequency Distribution**
 - (MBF) 4 each 0.1, 1.0, 5.0, or 10 MHz outputs, individually adjustable for 0.5 to 1.5 Vrms.
 - (MBFD) 5 outputs for internal distribution within the rack
 - (MBF-T) 4 each TTL compatible 0.001, 0.01, 0.1, 1.0, or 5 MHz outputs
 - (MBF-R) 4 each RS-422 compatible 0.001, 0.01, 0.1, 1.0, or 5 MHz outputs
- **MSI - Synthesizer and Interface** – Designed to serve as an interface between the MFS and the Trimble TANS receiver in a Rb/GPS disciplined system. The MSI accepts a 10 MHz reference frequency and generates octave multiples of 1.023 or 1.024 MHz, with a maximum multiplication factor of 16. Three outputs are available in either sine or TTL format.
- **MDP - 1 PPS Generation** – 1 output 1 PPS, 10 volts and 1 output RS-422 CMOS/TTL Compatible.

Frequency Calibrators

- **MDC-RC - Rubidium Oscillator Calibrator** – Automatically calibrates an MRK Rubidium Oscillator to a temporarily connected external high-performance cesium oscillator. With the proper external reference, a calibration of 5E-12 can be achieved.
- **MGPS- GPS Receiver Controller** – Automatically calibrates a Rb Oscillator to the GPS L1 C/A coded signal. Features *built-in GPS receiver*; provides precision time (± 100 nsec) and frequency (1E-12 rms) via independent control loops. User friendly LCD display.

- **MDRC - Disciplined Rb Controller for GPS** – Calibrates an MRK Rubidium Oscillator via an *externally supplied GPS receiver* to GPS satellite signals.

Frequency Synchronizers/RF Switches

- **MDC-RR and MDC-RX** - Rb to Rb and Rb to Crystal – Synchronization and/or RF switching of two oscillators to form a redundant, uninterruptible frequency source/time-base in the event of an oscillator failure. In such a case, the MDC switches-in the backup oscillator to drive the MFS.

Frequency/Phase Comparison

- **MPC - Phase Comparator** – The MPC measures phase difference between a unit under test and the 5 MHz or 10 MHz reference signal generated by the internal MRK or MXO. The unit under test can have an output frequency of 1, 2, 3, 4, 5, 6, 7, 8, 9, or 10 MHz.

Power Supplies

- **MPS - Power Supply** – Using externally supplied ac or dc, the MPS supplies the required voltages to the MFS modules. The MPS is capable of supplying up to ~100W of dc power. This is sufficient power for 2 MRK, 2 MDC, and 5 MBF modules (example only).
- **MBU - Battery** – Supports the MFS modules in the event of a power failure (2.5 Ah).

Frequency Receiver and Clock Display

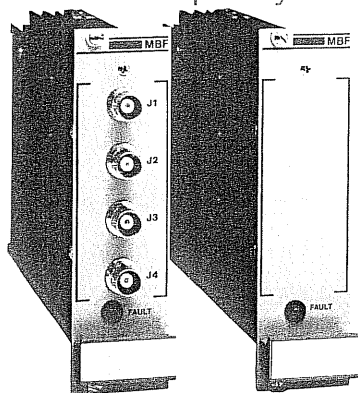
- **MVLF - VLF/LF Frequency and Time Receiver** – Contains a synchronization processor to discipline the MRK Rubidium Oscillator to an accuracy of 1E-11. This eliminates the long-term drift of the Rb oscillator. Time can be maintained to <1 μ sec for VLF and <0.2 μ sec for LF.
- **MRTC - Real Time Clock and IRIG Code Generator** – Although the MVLF includes the clock functions, the MRTC clock module/display is available without the VLF/LF receiver.

System Status

- **MSS - System Status** – Monitors status of individual modules within the rack.

Frequency Distributors

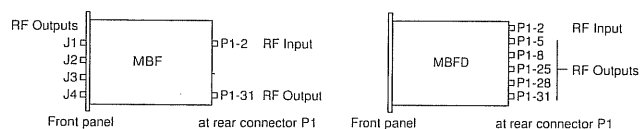
MBF and MBFD Frequency Distribution



The Modular Frequency Distribution unit, Model MBF, provides (4) outputs of 0.1, 1.0, 5.0, or 10 MHz derived from the primary RF Oscillator (MRK or MXO) within the MFS chassis. The MBFD has (5) outputs used to distribute rf within the 19" rack (consult factory for MBFD usage). Both the MBF and MBFD contain fault monitor circuits which will alert the user if one or more of its outputs fail or if the input signal drops below minimum drive levels.

MBF Model	Input/Output	MBFD Model
MBF-OA1C1 MBF-8A1C1	10 MHz / 10 MHz	MBFD-OA1C1
MBF-OA1C2	10 MHz / 5 MHz	
MBF-OA1C3	10 MHz / 1 MHz	
MBF-OA1C4	10 MHz / 0.1 MHz	
MBF-OA2C1	5 MHz / 10 MHz	
MBF-OA2C2 MBF-8A2C1	5 MHz / 5 MHz	MBFD-OA2C1
MBF-OA2C3	5 MHz / 1 MHz	
MBF-OA2C4	15 MHz / 0.1 MHz	

RF Signal Diagram



Electrical Specifications

RF Input	5 or 10 MHz
MBF-0XXXX	0.4 to 0.6 Vrms, 50 ohm input impedance
MBF-8XXXX	0.4 to 0.6 Vrms, > 1k ohm input impedance
MBFD-0XXXX	0.15 to 0.6 Vrms, 50 ohm input impedance
RF Output	(4) each 0.1, 1.0, 5.0, or 10.0 MHz
MBF	1 Vrms into 50 ohms, each adjustable from 0.5 to 1.5 Vrms
MBFD	0.5 ± 0.1 Vrms into 50 ohms
Isolation	-55 dBc between outputs, -90 dBc between modules -80 dBc between outputs - available
Harmonic	-34 dBc

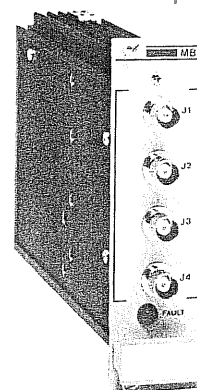
Phase Noise	MBF/MBFD	(-dBc / √Hz) at 100 Hz	(-dBc / √Hz) at 1000 Hz
	MBX-XA1C1	-147 (LN MRK)	-147 (LN MRK)
	MBX-XA2C1	-120 (STD MRK)	-145 (STD MRK)
	MBX-XA2C2	+9 dBc above input	+9 dBc above input
		-155	-155

When an MDC-RX or MDC-RR is used in the system, contact the factory for potential effects on the phase noise floor.

Short Circuit Proof Outputs

Power Input	20.5 Vdc, 3 W
LED Indicators on Dress Panel	Rf Fault (R)

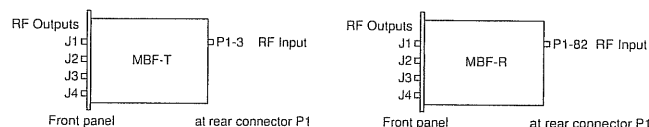
MBF-T and MBF-R Frequency Distribution



The Modular Frequency Distribution units, Model MBF-T and Model MBF-R provide up to four (4) TTL (MBF-T) or EIA RS-422 (MBF-R) compatible outputs derived from a 10 MHz primary rf oscillator (MRK or MXO) within the MFS chassis. Standard output frequencies are 0.001, 0.01, 0.1, 1.0, or 5.0 MHz; however, combinations of these frequencies are available upon request. Each buffer module contains fault indicator circuitry which will alert the user if one or more of its outputs fail or if the input signal drops below minimum drive levels.

MBF-T Model	RF Input/Output	MBF-R Model
MBF-T-OA1C2	10 MHz in / 5 MHz out	MBF-R-OA1C2
MBF-T-OA1C3	10 MHz in / 1 MHz out	MBF-R-OA1C3
MBF-T-OA1C4	10 MHz in / .1 MHz out	MBF-R-OA1C4
MBF-T-OA1C5	10 MHz in / .01 MHz out	MBF-R-OA1C5
MBF-T-OA1C6	10 MHz in / .001 MHz out	MBF-R-OA1C6

RF Signal Diagram



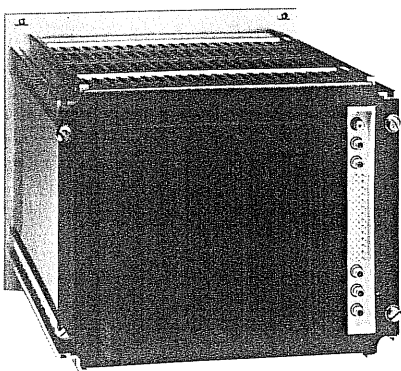
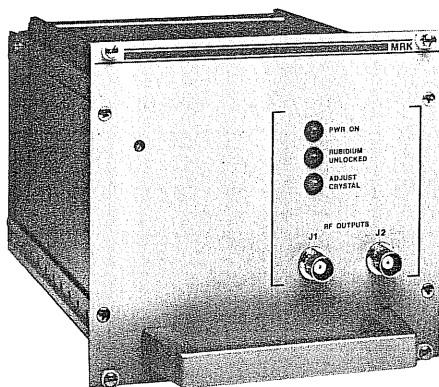
Electrical Specifications

RF Input	10 MHz
	0.4 to 0.6 Vrms; 50 ohm input impedance
RF Output	(4) each 0.001, 0.01, 0.1, 1.0, or 5.0 MHz
MBT	TTL compatible into 50 ohm load; 50% Duty Cycle; 20 nsec Max Rise Time and Fall Time.
MBR	RS-422 compatible into 100 ohm load; 50% Duty Cycle; 20 nsec Max Rise Time and Fall Time.

Short Circuit Proof Outputs

Power Input	20.5 Vdc, 5.0 W
LED Indicators on Dress Panel	Rf Fault (R)

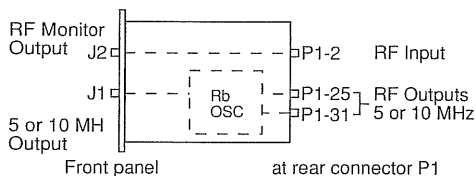
Frequency Generators — MRK, Rubidium Oscillator



The Modular Rubidium Oscillator, Model MRK, is the primary frequency generating source of the Efratom MFS. It provides a 5 or 10 MHz sinusoidal output frequency of excellent short- and long-term stability over a wide range of environmental conditions. This superior stability is achieved by locking an internal crystal oscillator to the ground state hyperfine transition of ⁸⁷Rb. The module is designed to interface to all other MFS modules through the rear connector. The MRK contains the well proven, field tested Model FRK Rubidium Frequency Standard.

Model #	Output Characteristics
MRK-1AOC1	L, 10 MHz
MRK-2AOC1	H, 10 MHz Low Aging
MRK-3AOC2	LLN, 5 MHz Low Noise
MRK-4AOC2	HLN, 5 MHz Low Noise, Low Aging
MRK-3AOC1	LLN, 10 MHz Low Noise
MRK-4AOC1	HLN, 10 MHz Low Noise, Low Aging

RF Signal Diagram



The "Monitor" output is brought through the module from another rf source which is injected at P1-2. This rf signal may originate from an MBF module.

The MRK has 2 rf outputs at the rear connector and one rf output at the front dress panel which are 5 or 10 MHz depending upon model selected.

Electrical Specifications

RF Output 5 or 10 MHz sinewave
0.5 ± 0.1 Vrms into 50 ohms
Frequency set to within ± 5E-11 at shipment

Aging	L	4E-11/month
	H	1E-11/month
Short-Term Stability	L	3E-11 (τ ^{-1/2}) for 1 sec < τ < 100 sec
	H	1E-11 (τ ^{-1/2}) for 1 sec < τ < 100 sec
Temperature Coefficient	L	3E-10 over MFS temp range
	H	1E-10 over MFS temp range

Phase Noise, SSB (1 Hz BW), See Figure 1			
	Output	Hz from carrier	-dBc / √Hz
L	10 MHz	100	120
H		1000	145
LLN	5 MHz	100	155
HLN		1000	155
LLN	10 MHz	100	147
HLN		1000	147

Warm-Up 10 minutes to reach 2E-10 at 25°C ambient

Harmonic / Non-Harmonic -40 dBc down / -80 dBc down

Trim Range 2E-9

Retrace 2E-11 (after 1 hr pwr on @ 25°C and up to 48 hrs pwr off)

Magnetic Field 4E-13 / Am⁻¹, or 3E-11 / 0.1 militesla

Altitude 1E-13 / mbar from sea level to 40,000 ft.

Power Input Electronics 20.5 Vdc, 9 W
Heater 18.5 Vdc minimum, 30 W warm-up
5 W at 25°C
10 W at -25°C

LED Indicators on Front Panel

Pwr On (Gm) Normally ON
Rubidium Unlocked (Red) Normally OFF
ON if Rubidium out of lock
Adjust Crystal (Yel) Normally OFF
ON when calibration required

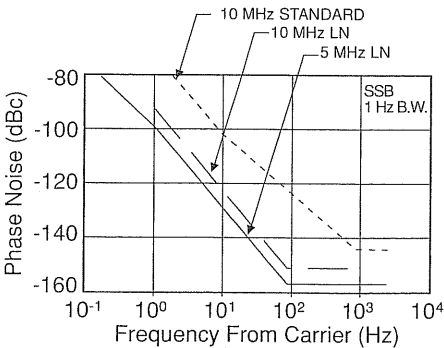


Figure 1

1.0 SPECIFICATIONS

ELECTRICAL:

Front Panel Output (RF):	J1: 10 MHz sinewave 0.4 Vrms minimum, +30%,-10% into 50 ohms													
Low Noise Option:	5 or 10 MHz sinewave, 1 Vrms, ±10%													
Isolation:	40 dB between buffer stages													
Accessory Output:	J2: (Available for ext. monitoring of a system signal.)													
External Outputs (to system):	5 on rear panel: 10 MHz sinewave Frequency set to ±5E-11 at shipment 0.4 Vrms into 50 ohms													
LED Indicators: (on front panel)	PWR on (GRN) Rubidium Unlocked (RED) Adjust Crystal (AMBER)													
BITE Outputs: (at P1)	RF Monitor Resonance Lock Lock Crystal Fault Adjust Crystal Crystal Volts (analog) Lock Volts (analog) Lamp Volts (analog)													
Inputs:	External C-Field Control External Control Enable													
(for electronics)	20.5 Vdc, 9 W													
(for heater)	18.5 to 32 Vdc, 30 W (warmup), 5 W (25° C), 10 W (-25° C)													
Warm-up:	≤10 minutes to ≤2E-10 at 25° C ambient													
Frequency Drift:														
-L Option:	≤4E-11/month													
-H Option:	≤1E-11/month													
Short-Term Stability:														
-L Option	≤3E-11(τ ^{-1/2}) for 1 sec <τ<100 sec													
-H Option	≤1E-11(τ ^{-1/2}) for 1 sec <τ<100 sec													
Phase Noise SSB (1 Hz BW):	≤ -120 dBc / √Hz @ 100 Hz from carrier ≤ -145 dBc / √Hz @ 1000 Hz from carrier.													
Low Noise (LN) Option:	<table><tr><th>Output Freq.</th><th>Hz from Carrier</th><th>dBc/ √Hz</th></tr><tr><td rowspan="2">5 MHz</td><td>100</td><td>≤-125</td></tr><tr><td>1000</td><td>≤-155</td></tr><tr><td rowspan="2">10 MHz</td><td>100</td><td>≤-120</td></tr><tr><td>1000</td><td>≤-147</td></tr></table>	Output Freq.	Hz from Carrier	dBc/ √Hz	5 MHz	100	≤-125	1000	≤-155	10 MHz	100	≤-120	1000	≤-147
Output Freq.	Hz from Carrier	dBc/ √Hz												
5 MHz	100	≤-125												
	1000	≤-155												
10 MHz	100	≤-120												
	1000	≤-147												
Harmonic/Non-Harmonic:	-30 dbc/-80 dBc													
Trim Range:	2E-9													
Retrace:	2E-11 after 1 hour													
Magnetic Field:	4E-13/AM ⁻¹													

MPS

MODULAR POWER SUPPLY

1.0 SPECIFICATIONS

ELECTRICAL

Input Power:

AC: 110 Vac, 120 Vac, 220 Vac, or 240 Vac +10%/-15%,
47-400 Hz/150 watts max.

Outputs:

DC: 22.5 to 32 Vdc (external battery backup)
20.5 Vdc regulated 40 W. 3.5 mV rms ripple

Heater Power A and B:

18.5 to 31.0 Vdc/max 30 W for 10 min., 20 W
steady state ripple 1 Vrms max (during warm-up)
ripple 5 mV rms max when in regulated mode (after warm-up)

-12 Vdc:

.5 W/50V max peak to peak. Output to MBU

BITE Outputs:

dc power available at rack connector

Indicators:

AC Power

ELECTRICAL PROTECTION:

Outputs:

Short circuit protected

DC Input:

Internal diode and fuse protects against reversed polarity

AC Input:

Fused

Low Voltage Sensor:

Control circuit senses voltage level of MBU batteries. Shuts
MFS down to prevent complete discharge of batteries.

ENVIRONMENTAL:

Operating Temp.

-25°C to 50°C ambient

Storage Temp:

-40°C to 75°C

Humidity:

95% Relative Humidity

PHYSICAL:

Size:

28 I (Rack Increments)

Weight:

9.0 lbs (4.1 kg)

MBU

Batterieversorgung

1.0 SPECIFICATIONS

ELECTRICAL:

Outputs:	24 Vdc Nominal, 45 W hours nominal
Battery Composition:	Twelve 2V batteries wired in series (Sealed lead acid construction)
Input Power:	35 Vac, .7 A (From MPS)
Electrical Protection:	ac input and dc output fused

LED INDICATORS:

ON	(GREEN)	Indicates MBU is discharging
RECHARGE REQ'D	(RED)	ON if MBU requires charging
HIGH CHARGE	(AMBER)	ON if MBU is receiving full charge
TRICKLE CHARGE	(GREEN)	ON if MBU is receiving trickle-charge
Recharge Times:	(90% capacity) - 10 hours	
	(95% capacity) - 15 hours	

ENVIRONMENTAL:

Operating Temp:	-25 degreesC to 50 degreesC ambient
Storage Temp.:	-40 degreesC to 65 degreesC
Humidity:	95% RH

PHYSICAL:

Size:	24 I (Rack Increments)
Weight:	8 lbs. (3.6 kg)
Connectors:	Internal: DIN M42 (Cannon Connector G06M426P4BEBL)