INTELLIGENT REFERENCE/TM-4D™

TIME & FREQUENCY SYSTEM

ADDENDUM TO TM-4 USER MANUAL

MANUAL PART NUMBER: 40013-002

SPECTRUM INSTRUMENTS, INC.
570 E. ARROW HIGHWAY
SUITE D
SAN DIMAS, CA 91773

WARNINGS AND NOTICES

FCC NOTIFICATION

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the Federal Communications Commission Rules & Regulations. These limits are assigned to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with this user manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area may cause harmful interference, in which case the user will be required to correct at his own expense.

DC POWER CONNECTION

Exercise caution when connecting a power source to the Intelligent Reference/TM-4D™. The standard model is supplied with the correct AC power adaptor. If you choose to power the unit in some alternative fashion, be sure to observe correct voltage and polarity. The unit requires 12-35 volts DC, with the tip of the power connector positive. While the TM-4D is reasonably protected against reverse polarity, no protection scheme is foolproof. Damage due to incorrect powering of the Intelligent Reference/ TM-4D™ is not covered by the warranty.

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SECTION 1 - INTRODUCTION

INTRODUCTION TO THE INTELLIEGNT REFERENCE/TM-4D™

The Intelligent Reference/TM-4D™ is an enhanced version of the Intelligent Reference/TM-4™. It incorporates all of the features of the TM-4 and adds user-configurable distributed digital and analog outputs, visible signal indicators and external user-configurable inputs.

If you are not familiar with the setup and operation of the standard TM-4, you are encouraged to read its manual first in order to become familiar with basic TM-4 operation and characteristics before attempting to operate or configure the TM-4D.

The additional features (some are optional) offered by the Intelligent Reference TM-4D™ are:

- Up to 16 rear-panel and 8 front-panel fully isolated digital outputs, with TTL/CMOS drive capability into 50 ohms.
- Up to 8 rear-panel and 4 front-panel buffered analog outputs with 2 volt $_{PTP}$ signal level into 50 ohms.
- Output signals may consist of signals generated by the internal TM-4 or those supplied by the user externally.
- Two independent very wide-range frequency synthesizers, allowing the generation and distribution of custom signals.
- Two independent square-to-sine wave convertors.
- Standard DB-9 RS-232 control port for connection to a personal computer without the need for a special cable.
- Mirroring of all TM-4 functions, signals and inputs at the DB-15HD connector. Cables designed for the standard TM-4 may be used at this connector.
- Rear analog and digital inputs for distributing externally supplied signals.
- Front analog and digital inputs for distributing externally supplied signals.
- Indicators for analog and digital signal presence.
- Standard 19" 1U rack mount, or benchtop with included rubber bumpons.
- GPS timing antenna and AC power supply included.

SECTION 2 – SIGNAL FLOW AND ARCHITECTURE

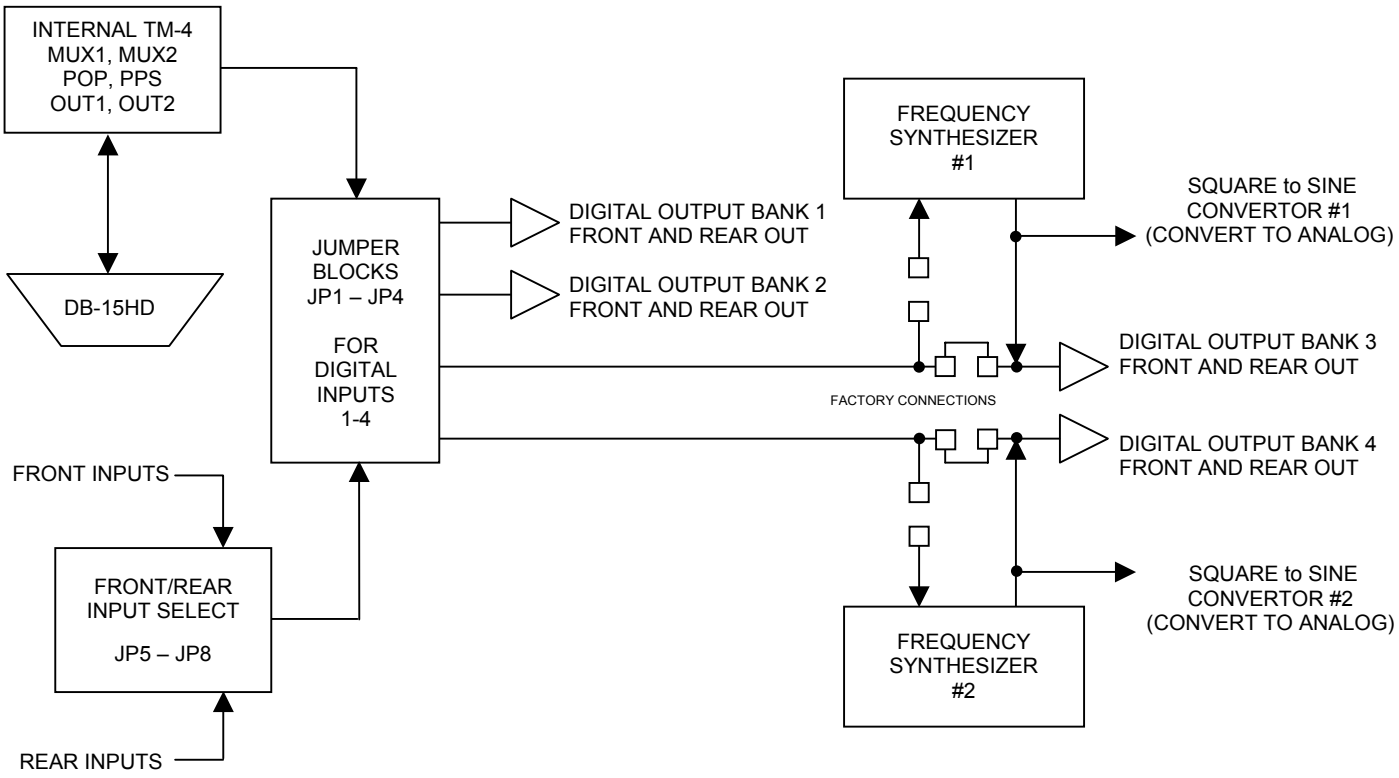
OVERVIEW

In order to take maximum advantage of the capabilities of the Intelligent Reference/TM-4D™, it is important to gain an understanding of the methods of signal generation and their path through the unit. The TM-4D contains four digital sections (1-4), consisting of input selectors and up to 24 outputs, and two analog sections (A-B), consisting of input selectors and offering up to 12 outputs. Some sections are custom in nature (such as the frequency synthesizers) and are factory set, and others are user-configurable. The user may set all the digital sections to the same signal, or may choose any combination of up to four different signals, depending upon the application. The analog portion is similar, except that there are two sections, not four. Normally, the internal TM-4 generates the signals distributed and the TM-4D will come configured by the factory to standard defaults, unless otherwise specified.

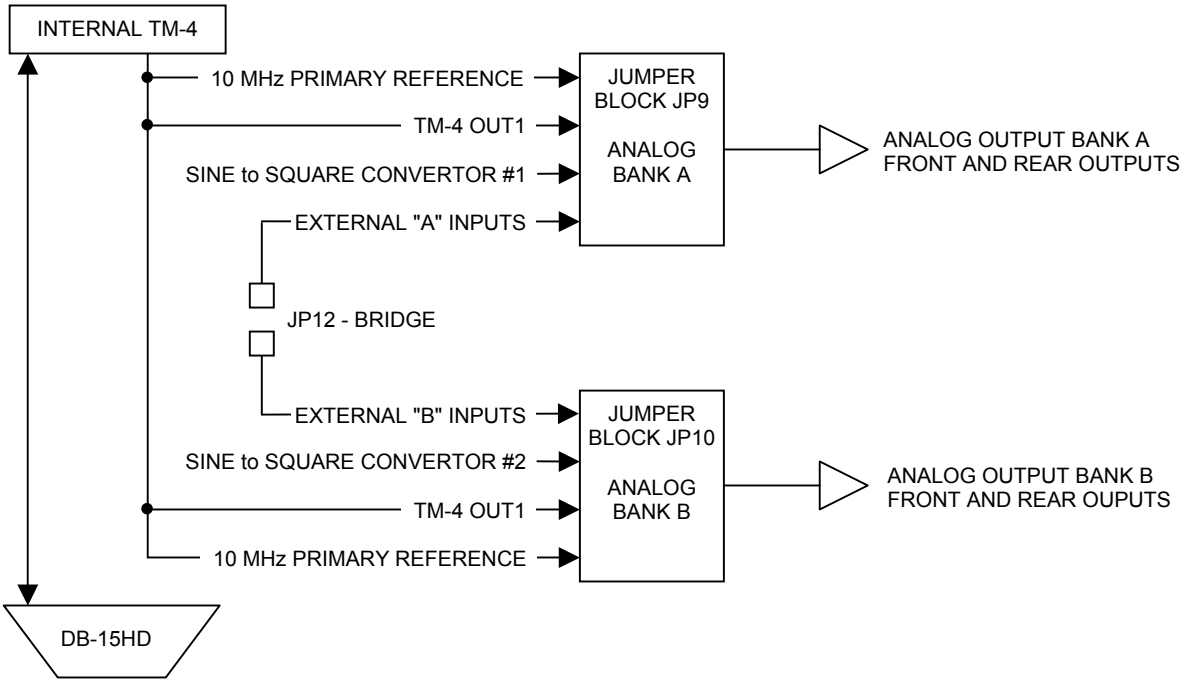
The user may choose standard input signals from the internal TM-4 or from optional external input BNC jacks in any desired combination. This is accomplished by simple jumper changes inside the unit. Standard digital signals available from the TM-4 are PPS, MUX 1, MUX2, and POP. In addition, OUT1 and OUT2 are custom signals that may originate from the internal TM-4 if they are factory-enabled. The remaining four inputs (TTL/DIGITAL 1-4) correspond to the optional BNC external digital inputs.

Note that in the standard TM-4D, the front input and output jacks are optional. The front input/output selection jumpers JP5 – JP8 are factory-wired to select the rear inputs only.

SIGNAL FLOW – DIGITAL SECTION



SIGNAL FLOW – ANALOG SECTION



The analog section is similarly configured. It can accept analog signals from the internal TM-4 (such as the 10 MHz sine wave, optional modulated IRIG or custom signals), signals from optional external input jacks, or the output of the optional square to sine convertor. The square to sine convertor is a factory-configured feature that allows a generated or supplied digital signal to be converted into a sine wave and distributed as desired.

Each bank may operate independently or may share one input signal. Each bank is terminated via a jumper at 50 ohms. IMPORTANT: If both banks are set to the same signal or the external input jacks are bridged, be sure to remove *both* of the terminating jumpers for a 50-ohm termination.

FACTORY DEFAULT SETTINGS

The standard factory configuration of the TM-4D assigns signals from the internal TM-4 to the distribution amplifier outputs in the following manner:

PPS – Digital output banks 1 and 2
MUX1 – Digital output bank 3
MUX2 – Digital output bank 4
10 MHz – Analog output banks A and B

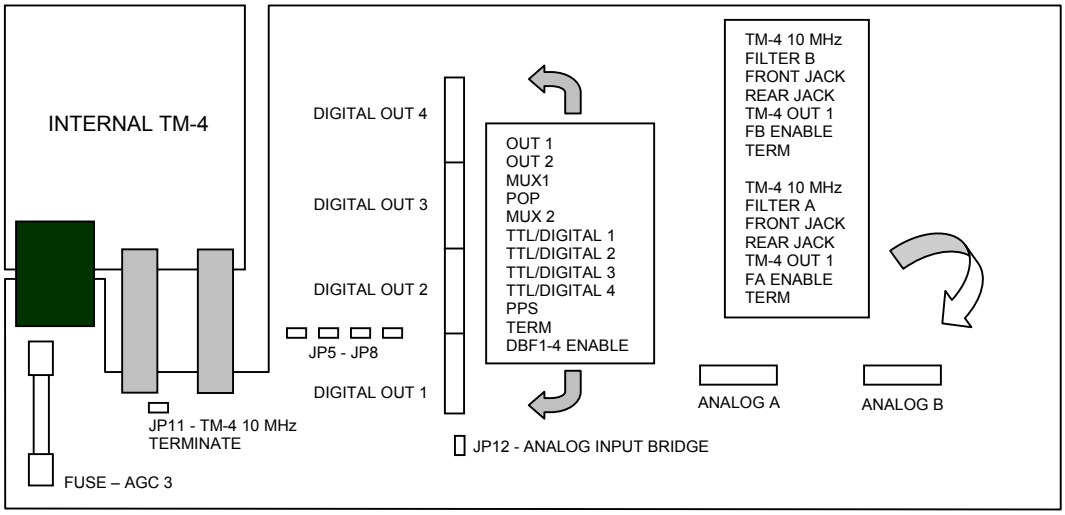
SECTION 3 – QUICK START AND SETUP

This section is provided as an overview and simplification of the steps needed to configure and operate a standard Intelligent Reference/TM-4D™ with no options installed. For comprehensive setup instructions and details on optional and advanced features, see sections 4, 5 and 6.

SETUP

Setting up the TM-4D is a simple and straightforward process. If no changes are desired from the default configuration, setup can be as simple as connecting the power supply, GPS antenna cable and desired output connections, and then turning the unit on.

To configure the TM-4D for different output choices, you will need to remove the top cover and change jumper settings. Refer to the diagram for jumper block locations for the analog and digital output banks.



TM-4D BOARD LAYOUT and JUMPER LOCATIONS

Select the output signal that you desire for each particular output bank by moving the jumper to the corresponding choice. If you desire an internal signal termination of 50-ohms for a particular digital or analog section, install the jumper on the TERM location. Note that if you send identical signals to more than one output bank, you should only use one terminator jumper for the combined group (since they are now in parallel with each other).

Run the Control/Display software to configure the internal TM-4 to set options such as MUX frequency, POP time, etc. You will need the 9-pin cable to communicate with the unit. If this is the first time the unit has run, or if its position is substantially different from the last time it was operated, then use the software to enter an approximate position. This will help to speed up satellite acquisition time.

LED INDICATORS

LEDs on the front panel of the unit are used to indicate various operating parameters.

POWER: Illuminated when power is supplied to the unit.

ANALOG A –B: Illuminated when signal is present at the output of the corresponding analog signal jumper block.

DIGITAL 1 – 2: Illuminated when signal is present at the output of the corresponding digital signal jumper block. Blinks with signals below about 10 Hz at the signal rate.

ALARM: Illuminates and flashes to indicate tuning mode and Coast Alarm condition (See chart on page 11)

READY: Illuminates or flashes in combination with the STATUS indicator to indicate tuning status.

STATUS: Illuminates in combination with the READY indicator to indicate tuning status. Flashes to indicate antenna failure or absence of the primary output frequency from the internal TM-4.

See section 6 for more detailed information about how these indicators function during various phases of operation.

After initial setup, the TM-4D requires no further user intervention. Depending upon your required level of accuracy you may start using the available signals immediately, or you may wait for the READY LED to illuminate to indicate that the unit has reached a minimum level of accuracy. See section 6 for a detailed discussion of various signals, when they are available and their precision at various points in the startup phase.

SECTION 4 – DETAILED SETUP INSTRUCTIONS

INTELLIGENT REFERENCE/TM-4D™ INSTALLATION

There are no special requirements for the location of the unit itself other than the obvious considerations of access for cable connections and visibility of the front panel LEDs.

Avoid electromagnetic interference (EMI); keep the unit and its cabling away from sources of strong radio frequency (RF) energy such as radio transmitter cables and antennas. Also, keep the unit away from sources of heat. Normally, no special cooling provisions are required as long as adequate clearance is provided around the unit so that internally generated heat can dissipate by natural air convection.

The unit may be operated either standalone or in a rack mount configuration. If mounting the unit in a rack, it is best to use the flat spacers provided, though they are not absolutely necessary. If you do not have the spacers, contact Spectrum for replacements.

Normally, the factory configures the front panel according to the mounting requirements specified by the user at order time. If you did not specify rack mounting at order time but later wish to rack mount the unit, the laminate over the mounting holes will have to be cleared out. The easiest way to accomplish this is to carefully carve them with an eXacto knife. Use a brand-new blade. From the front, first cut a cross in each hole. Next, cut out each "pie slice" of every hole along its arc, trying not to nick the aluminum. Use caution, as the laminate is thick and may be somewhat difficult to cut.

CONNECTION TO A PERSONAL COMPUTER

The Intelligent Reference/TM-4™ is connected to a personal computer by means of the DB-9 (or the DB-15HD) connector located on the rear of the unit. If you wish to use the supplied Control/Display software, you must use a 32-bit Windows®-based computer with a free serial port. Since the message output from the Intelligent Reference/TM-4D™ is simple ASCII, you may also easily create your own control software. You can use a longer serial cable (up to 50 feet), but make sure that it is fully shielded in order to prevent unwanted radiation from the cable. Many computer suppliers carry shielded monochrome monitor cables (9-pin) in various lengths that are suitable for this application.

If the serial port on your computer has a DB25 connector instead of a DB9 connector, use a DB9 to DB25 adapter available from most any computer supplier. In the case where a serial port is not available (as is the case with many newer laptop computers), you may use a serial-to-USB adapter.

The software defaults on first use to COM1. If you plan to use a port other than COM1, make a note of the port you choose so that you can set the software to match.

POWER INPUT

Power is supplied to the unit via the coaxial DC input jack. The AC power adaptor supplied with the TM-4D is a universal switching power supply that operates from 100 – 240 VAC at 50 – 60 Hz, and it supplies 24 VDC at 1.5 amperes. The input cord for this supply may be substituted for compatibility with non-US AC sockets. The output cord plugs directly into the TM-4D.

In cases where the Spectrum power supply is not being used, you may supply power to the Intelligent Reference/TM-4D™ from any source that can supply a clean DC voltage in the range of 12 to 35 VDC at 2 amperes. Use caution when supplying power, and be sure to observe correct polarity of the power connections. The center pin of the DC input jack must be positive.

The Intelligent Reference/TM-4D™ contains an internal AGC-3 fuse that is user-replaceable.

Avoid applying power to the unit with the power switch depressed in the ON position. Make the power connection first, then apply power with the switch.

CONNECTIONS AND CONFIGURATION

Unless otherwise specified, the TM-4D comes configured from the factory to supply PPS on digital output banks #1 and #2, POP on digital output bank #3 and MUX1 on digital output bank #4. The analog output banks are configured to supply the primary (usually, 10 MHz) frequency output of the internal TM-4. If you desire different outputs or combinations, you may remove the top cover and change jumper configuration. See the board layout diagram in Section 3.

The digital sections of the TM-4D are configured with four blocks of jumpers, one for each of the four digital output banks. Each bank may be set to the same signal, if desired. The jumpers correspond to either signals generated internally by the TM-4 (OUT1, OUT2, PPS, POP, MUX1, MUX2), or signals the user supplies via the optional external input jacks (TTL/DIGITAL 1-4). There are two other jumper positions on each block. One is the enable for the optional front outputs, marked DBFx ENABLE, where x corresponds to the number of the digital output. When this jumper is installed, the front outputs are slaved to whatever signal choice is selected at the corresponding jumper block. The last position is marked TERM, and terminates the input signal with a 50-ohm load. Depending upon application and characteristics, you may or may not wish signal sources to be internally terminated. Note that if you send identical signals to more than one output bank, you should only use one terminator jumper for the combined group (since they are now in parallel with each other).

Note that the optional external input jacks may be further sub-divided into front and rear inputs via jumpers JP5 –JP8, if the unit is configured for both front and rear external inputs.

DIGITAL OUTPUT CONFIGURATION JUMPER BLOCKS JP1 – JP4

POSITION	SIGNAL	SIGNAL TYPE	FUNCTION
1	OUT1	INTERNAL - TM-4 GENERATED	OPTIONAL TM-4 DIGITAL SIGNAL
2	OUT2	INTERNAL - TM-4 GENERATED	OPTIONAL TM-4 DIGITAL SIGNAL
3	MUX1	INTERNAL - TM-4 GENERATED	MULTIPLEXER 1 OUTPUT
4	POP	INTERNAL - TM-4 GENERATED	PROGRAMMED OUTPUT PULSE
5	MUX2	INTERNAL - TM-4 GENERATED	MULTIPLEXER 2 OUTPUT
6	TTL/DIGITAL 1	EXTERNAL - USER SUPPLIED	OPTIONAL DIGITAL INPUT 1
7	TTL/DIGITAL 2	EXTERNAL - USER SUPPLIED	OPTIONAL DIGITAL INPUT 2
8	TTL/DIGITAL 3	EXTERNAL - USER SUPPLIED	OPTIONAL DIGITAL INPUT 3
9	TTL/DIGITAL 4	EXTERNAL - USER SUPPLIED	OPTIONAL DIGITAL INPUT 4
10	PPS	INTERNAL - TM-4 GENERATED	PULSE PER SECOND
11	TERM	N/A	INTERNAL TERMINATE AT 50 OHMS
12	DBFx ENABLE	OUTPUT	ENABLE FRONT OUTPUT

ANALOG SECTIONS

The output banks in the analog sections are similarly configured. JP9 and JP10 are the corresponding signal configuration jumper blocks. The analog banks are designed to operate independently or may share the same signal, depending upon the jumper settings or presence of a bridging jumper on JP12.

The first position in the jumper block is labeled **TM-4 10 MHZ**. The TM-4D comes equipped from the factory (unless specified otherwise) with both stages of the analog section set to the 10 MHz sine wave output from the internal TM-4, with both termination jumpers removed (see below).

The second position in the jumper block is labeled **FILTER A (or B)**. In a TM-4D optionally equipped with the square to sine convertors, a sine wave signal created from a signal that the internal TM-4 generates will appear at this position. Note that the TERM jumper should be installed when using this signal.

The positions labeled **FRONT JACK** and **REAR JACK** correspond to the external signals from either the rear or optional front input jacks.

The **TM-4 OUT1** position corresponds to the signal from the internal TM-4 (such as an optional modulated IRIG time code) or from the OUT1 pin on the DB-15HD connector.

The **FA ENABLE** and **FB ENABLE** positions allow the optional front outputs to become operational. The signal that is selected on the jumper block will also appear at the optional front outputs.

The **TERM** position terminates the signal line with a 50-ohm load. If a small amount of gain for the analog signal is desired, the user may choose to omit the termination jumpers. Note that this may or may not result in signal degradation (depending upon several factors), and the user is therefore advised to confirm that the distributed signal is acceptable at the anticipated output conditions before proceeding.

JP12 (ANALOG IN BRIDGE) allows the user to supply the identical signal from either input jack to both analog stages. If a jumper is installed in the JP12 position, there must only be one input signal supplied on one or the other (but not both) input jacks. In bridged mode, omit *both* termination jumpers for a 50-ohm termination. JP12 is located near the bottom of the digital input jumpers.

The TM-4D comes configured from the factory set to deliver the internal 10 MHz signal to both sets of analog jacks. If you elect to change the delivered signal. be sure to configure the 10 MHz termination jumper correctly. If 10 MHz is not to be used at all, terminate the signal using JP11 (located near the internal TM-4 module). If 10 MHz is delivered via one set of outputs, use the terminating jumper for that section, and do not use JP11.

ANALOG OUTPUT CONFIGURATION JUMPER BLOCKS JP9 and JP10

POSITION	SIGNAL	SIGNAL TYPE	FUNCTION
1	**TM-4 10 MHZ**	INTERNAL - TM-4 GENERATED	PRIMARY FREQUENCY OUTPUT
2	**FILTER A (B)**	INTERNAL – SYNTH. GENERATED	S/S CONVERTOR OUTPUT
2	**FRONT JACK**	EXTERNAL - USER SUPPLIED	ANALOG INPUTS FROM FRONT
3	**REAR JACK**	EXTERNAL - USER SUPPLIED	ANALOG INPUTS FROM REAR
4	**TM-4 OUT1**	INTERNAL - TM-4 GENERATED	OPTIONAL TM-4 ANALOG SIGNAL
5	**FA (FB) ENABLE**	OUTPUT	ENABLE FRONT OUTPUT A, B
6	**TERM**	N/A	INTERNAL TERMINATE AT 50 OHMS*

*Omit jumpers in bridged mode or when both stages are using the same input signal for a 50-ohm termination.

ANTENNA INPUT

The GPS antenna is connected via a standard TNC connector. Power for the antenna (5 VDC) is supplied from the internal TM-4. For best timing performance, Spectrum supplies an approved antenna with the TM-4D, but you may use any active GPS antenna that operates on 5 volts. Note that some non-Spectrum antennas with very low current consumption may trigger the antenna alarm.

DIGITAL AND ANALOG SIGNAL OUTPUTS

Signals generated by the TM-4D always appear at the rear panel BNC outputs. If your TM-4D includes optional front outputs, you may enable and disable them via the appropriate jumper block settings.

DIGITAL AND ANALOG EXTERNAL SIGNAL INPUTS (OPTIONAL)

Depending upon configuration, your TM-4D may include rear panel and/or front panel BNC input jacks that you may use to distribute external signals you supply.

SECTION 5 - OPERATION OF THE INTELLIGENT REFERENCE/TM-4D™

The Intelligent Reference /TM-4D™ contains an Intelligent Reference TM-4/OEM™ module internally. It is highly recommended that you read the accompanying companion manual for the Intelligent Reference/TM-4™ to become familiar with its operational characteristics and advanced capabilities. Installation and operation of the Control/Display software is also described in that manual.

Operation of the TM-4D is relatively simple. After connecting the power supply, the GPS antenna and the desired input and output connections, apply power to the unit by depressing the power switch. The POWER LED on the left of the unit should light immediately, and you should also see the ALARM, READY and STATUS LEDs flash momentarily as the internal TM-4 initializes. The state of the ANALOG and DIGITAL LEDs will depend upon the nature of the signals that are present.

The unit must complete a process of initialization and self-tuning before it achieves its highest level of accuracy. If you are not familiar with the start-up modes of the TM-4, this would be a good time to look at Section 4 of the TM-4 manual. Note that on the standalone TM-4 and in its manual, the STATUS LED is called the POWER LED.

After the initialization, the TM-4 searches for GPS satellites and acquires the satellite signals. The amount of time this process takes depends upon several factors, the most important being how complete and up-to-date the stored information is that resides in the unit's memory. Other factors include whether the unit has ever achieved a position fix (or has been moved since obtaining it), the view of the sky the antenna has, and what search mode the receiver is using. Refer to the TM-4 user manual for suggestions to improve initialization time.

After the TM-4 has acquired the satellite signals and has made the appropriate calculations, it begins to provide accurate time information and PPS output for synchronization. This is called the "Time Valid" state, and is indicated by the ALARM LED extinguishing. The unit then uses GPS timing information to tune its oscillator in order to provide an accurate frequency output. Tuning is a continuous process that starts with coarse tuning ("Mode 2") and progresses to fine tuning ("Mode 4"). As long as the unit is tracking satellites, it continues to fine tune and improve its accuracy and stability. The PPS output should not be used until the unit achieves the Time Valid state, since it is not locked to GPS until then. If your unit is equipped with a TM-4 optimized for phase coherency, you should not use PPS for anything important until the unit reaches Mode 4. Event Time Tag, Programmed Output Pulse and the MUX outputs are also not made available until the unit reaches this point. For best accuracy of frequency-related functions (MUX out, primary frequency output, optional signals), allow the unit to progress to Mode 4 (indicated by the READY LED illuminating steadily) before using them.

If GPS satellite signals are temporarily blocked or interrupted, the TM-4 continues to provide accurate timing information and output signals by using its internal oscillator as a reference until the signals are reacquired. It may be helpful to place the unit in Static timing mode during difficult GPS reception conditions, since only a single satellite is required to provide accurate timing information in this mode. See the TM-4 manual for important details about how and when to use Static timing mode.

The accuracy of the internal oscillator in hold (no GPS available) is dependent upon several factors, including the tuning state the unit was in when the interruption occurred, the oscillator option installed, and the TM-4's Intelligent Holdover™ technology.

The availability and generation of various signals is different during the initialization and warm-up phases than during normal locked operation. Because of this, the indicator LEDs will behave differently during these phases. In a standard unit with no external inputs, the ANALOG signal indicators will generally appear almost immediately and will be on continuously if signal is present. The DIGITAL indicators will generally not illuminate or flash until the unit has achieved the Time Valid state, since those signals are generally not available until then. If the TM-4D is configured for external inputs, the corresponding LEDs will illuminate immediately after power-up, providing that those signals are present.

SECTION 6 - HARDWARE INFORMATION

This section of the manual provides detailed information on the Intelligent Reference/TM-4D™ hardware, including power specifications, input/output signal definitions and specifications, connector and pin assignments, and other miscellaneous hardware details.

FRONT PANEL

The front panel of the TM-4D includes ten LED indicators that provide operating, system and signal status. These LEDs may be off, steadily illuminated, or they may flash. Important information about the unit is conveyed by various combinations of the states of these indicators. The information on the following pages will also help you to understand the various combinations possible and how they relate to the current status of the unit.

POWER LED

This LED indicates that the unit is on.

ANALOG A&B LEDs

These indicators will illuminate when analog signals are present at the output of the corresponding analog signal jumper blocks.

DIGITAL 1 – 4 LEDs

These indicators will illuminate when digital signals are present at the output of the corresponding digital signal jumper blocks. If the signal frequency is lower than about 10 Hz, these LEDs will flash at the signal rate. For signal rates higher than this, they will illuminate steadily.

ALARM LED

This LED indicates the general status of GPS. Under normal useable operating conditions, it will be off. It will illuminate steadily while the unit acquires GPS satellites and waits for the Time Valid condition. Once time is valid, this LED will turn off. As long as the unit is receiving satellites, it will stay off. If the satellite signal is disrupted, the ALARM LED will flash, warning that the unit is in hold. If the TM-4 has achieved Mode 4 and loses the GPS satellite signal, it will stay in fine tuning hold mode (Mode 5) for 60 minutes, and then the ALARM LED will illuminate steadily to indicate a Coast Alarm condition.

READY LED

This LED indicates confidence in the accuracy of the reference outputs. Under normal useable operating conditions, it will be on to indicate that the TM-4D has reached a minimum acceptable accuracy level of 1 in 10^{-9} parts. After initialization, it will stay off until the unit acquires GPS. When the unit enters coarse tuning mode, this indicator will begin to flash. Once the TM-4D enters the fine tuning mode, the LED will stay on. If the unit subsequently enters the fine tuning hold (mode 5) condition, this indicator will again flash. If the TM-4D enters Coast Alarm, the LED will turn off.

STATUS LED

This LED is used to indicate a hardware fault, detected by the internal TM-4. Under normal operating conditions, it will be on. The internal TM-4 has a current-sensing circuit that monitors the antenna and cable condition for open or short, and a circuit that monitors the primary frequency output. In the case of a detected hardware fault, this LED will change from steady illumination to a flashing state.

ALARM/READY/STATUS LED COMBINATIONS AND THEIR MEANINGS

ALARM	READY	STATUS	INTERNAL TM-4 STATUS
rapid flash	rapid flash	rapid flash	Start-up. The unit is completing initialization tasks.
on	off	on/flash*	Warm-up. GPS is not yet supplying valid time information.
off	off	on/flash*	Warm-up/Time Valid. GPS is supplying valid time information.
off	flash	on/flash*	Oscillator coarse tuning (Mode 2). GPS is normal.
flash	off	on/flash*	Coarse tuning hold (Mode 3). Unit is in coast mode, due to lack of input from GPS.
off	on	on/flash*	Oscillator fine-tuning (Mode 4). Accuracy better than $1x10^{-9.}$ GPS is normal.
flash	flash	on/flash*	Fine tuning hold (Mode 5). Unit is no longer fine-tuning due to lack of input from GPS, but is using Intelligent Holdover™ technology to maintain oscillator accuracy. In hold mode for less than 60 minutes.
on	off	on/flash*	Coast Alarm. Same as above, but unit has been in this condition for more than 60 minutes.

* The STATUS LED will indicate hardware faults in these modes by flashing.

POWER INPUT

Power is supplied to the unit via the coaxial DC input jack, and a standard power supply is included with the TM-4D. In cases where the Spectrum power supply is not being used, you may supply power to the Intelligent Reference/TM-4D™ from any source that can supply a clean DC voltage in the range of 12 to 35 VDC at 2 amperes. Use caution when supplying power, and be sure to observe correct polarity of the power supply. The center pin of the DC input jack must be positive.

The Intelligent Reference/TM-4D™ contains an internal AGC-3 fuse that is user-replaceable.

Avoid applying power to the unit with the power switch depressed in the ON position. Make the power connection first, then apply power with the switch.

There is a one-to-six minute (depending on the type of oscillator installed and its temperature at start up) period during which the unit requires more power than that normally required when operating. Note that the period of higher current consumption can be shorter than the fixed oscillator warm-up period (Mode 1 time) if the oscillator is already warm.

DB-15HD CONNECTOR

The DB-15HD connector on the rear of the unit is connected in parallel to the connector for the internal TM-4, with the exception of the power pin. This makes it possible to use all accessories and cables designed for a standalone TM-4 with the TM-4D. As indicated in the signal flow diagrams, this connector is also in parallel with the digital and analog input selector jumper blocks. All of the outputs supplied by the TM-4 go to both the input jumper blocks and to the DB-15HD, and all of the external inputs from the DB-15HD (such as ETT) also go to both the internal TM-4 and to the input jumper blocks. It is possible to generate a signal with the internal TM-4, supply that signal to the jumper blocks and distribute it, and also to tap it at the DB-15HD and use it somewhere else. Note that since this signal is paralleled and not individually buffered at this point in the signal path, it is possible for some degradation (ringing, level change or noise) to occur if the TM-4D is used in this fashion. The user will have to determine if any degradation that may occur is acceptable in the application.

DB-15HD CONNECTOR PIN FUNCTIONS		
PIN	**SIGNAL NAME**	**FUNCTION**
1	OUT2	10 MHZ TTL OUTPUT OR CUSTOM OUT
2	GND	SIGNAL/POWER GROUND
3	CPTXD232	RS-232 SERIAL DATA TO HOST
4	CPRXD232	RS-232 SERIAL DATA FROM HOST
5	PPS/AUX232	PPS/CUSTOM
6	TPTXD232	TIME PORT RS232 OUTPUT
7	MUXOUT1A	MULTIPLEXER 1, A OUTPUT
8	ALM	ALARM OUTPUT
9	GND	SIGNAL/POWER GROUND
10	EVENT	EVENT INPUT
11	N/C	NO CONNECTION
12	POP	PROGRAMMED OUTPUT PULSE
13	MUXOUT2	MULTIPLEXER 2 OUTPUT
14	IN1	RESERVED
15	OUT1/IRIG/IN2	OUTPUT/TIME CODE/CUSTOM INPUT

DB-9 CONNECTOR

This connector is for RS-232 serial communications with the internal TM-4. Use a 9-pin monochrome monitor extension cable, available at most computer retailers and the supplied Control/Display software to communicate with and control the internal TM-4. The connections at this connector are in parallel with the same connections on the DB-15HD connector. See the user manual for the Intelligent Reference/TM-4™ for details about the Control/Display software and how to communicate with the unit.

EXTERNAL DIGITAL INPUTS 1-4 (OPTIONAL)

Depending upon the configuration of the unit as ordered, there may be as many as eight (four on the rear panel, four on the front) BNC-style input jacks on the TM-4D. There are four independent, user-configurable digital sections designed for TTL/CMOS level signals up to 200 MHz.

EXTERNAL ANALOG INPUTS A AND B (OPTIONAL)

Similar to the digital sections, there are two independent analog sections. Bandwidth for the analog circuits is 300Hz to 150 MHz. There may be as many as four (two on the rear panel, two on the front) BNC-style input jacks on the TM-4D, depending upon how the unit is configured.

DIGITAL OUTPUTS 1-4

A standard TM-4D has 16 buffered digital output jacks on the rear panel. These outputs may all provide the same signal, or they may provide up to four different signals. Optionally, there may be eight additional outputs available on the front of the unit. Signal selection is accomplished via the internal configuration jumpers JP1 – JP4. Each output is designed to drive a 50-ohm load.

ANALOG OUTPUTS A AND B

The standard unit has eight isolated analog output jacks on the rear panel. These outputs may provide the same signal, or they may provide two different signals. Optionally, there may be four additional outputs available on the front of the unit. Signal selection is accomplished via the internal configuration jumpers JP9 and JP10. Each output is designed to drive a 50-ohm load.

INTERNAL TM-4 OUT1 SIGNAL CHARACTERISTICS

The OUT1 terminal on the internal TM-4 is capable of supplying either an analog or digital signal, depending upon how the unit is configured at the factory. For example, it may supply modulated IRIG-B serial time code, in which case the signal would be analog. Conversely, it may supply a custom or additional standard digital signal of some type. It is important to know what type of signal is present and to which section type (analog or digital) it must be routed. Routing the signal to the incorrect section will result in unsatisfactory or no output.

WARM-UP AND OPERATING CURRENTS

If you are planning to operate the Intelligent Reference/TM-4D on a power supply other than that supplied by Spectrum, the chart below depicts typical maximum current requirements for 12 and 24 volt operation, with all outputs enabled and driving a 50-ohm load, including optional front outputs. Various factors may affect these values somewhat. These include installed options, OCXO type, number of outputs enabled and load, ambient temperature and time valid condition. The current requirement for the warm up phase will be initially high, then will settle to a lower value. When the internal TM-4 achieves the time valid condition, current consumption will increase somewhat, because outputs that were initially disabled become active.

INPUT VOLTAGE	WARM-UP CURRENT	OPERATING CURRENT
12	1.50A – 700mA	800mA
24	800mA –350mA	400mA

SECTION 7 - IN CASE OF DIFFICULTY

NOTE: Should you have difficulty with the installation or operation of your TM-4D, please take a few minutes to look through this manual and the companion manual for the internal TM-4. You will find the answers to most of your questions in these documents. If you are still having difficulty after reviewing the manual, please contact us for technical support and assistance.

ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY

The Intelligent Reference/TM-4™ radiates very little electrical noise, and should not create interference problems in most installations. It has been tested and found to comply with FCC Part 15 Class A requirements. In critical situations, consider the following precautions:

1. Always use a fully shielded cable to connect to the host computer or other controlling device.
2. Use shielded and terminated cables to connect signals from the TM-4 to other equipment.
3. Run a ground wire from the TM-4's chassis to an earth ground point in your system, such as an AC safety ground or ground rod. A solder lug placed under one of the connector retention nuts of the DB15 connectors on the rear panel is a good way to connect such a ground line.
4. Apply a ferrite sleeve to the AC adaptor wire at the DC plug.
5. Use a shielded cable to supply external DC power to the unit if you are not using the AC adapter.
6. Locate the unit as far away as possible from any other equipment in your system that may be particularly sensitive to interference, particularly receivers, antenna cables and antennas.

These same precautions will also be helpful in avoiding adverse effects on the operation of the TM-4D from other nearby equipment.

CONTACTING SPECTRUM

If you need to contact Spectrum, please telephone or write to us at:

Spectrum Instruments, Inc.
570 East Arrow Highway
Suite D
San Dimas, California 91773

Phone: (909) 971-9710
E-mail: support@spectruminstruments.com

Before you call, please have the following information available so that we may better assist you in trying to resolve the problem immediately:

1. Model number and serial number of the unit.
2. Purchase date.
3. An accurate description of the problem.

LIMITED WARRANTY

Spectrum Instruments, Inc. (Spectrum) warrants its products to have been manufactured in accordance with its standard manufacturing practices and to be free from defects in material and workmanship for a period of three (3) years from date of shipment. During the warranty period, Spectrum will, at its option, either repair or replace products which prove to be defective. The repaired or replaced product will be warranted for the balance of the original warranty extended by the amount of time the product was at Spectrum's repair facility or for a period of ninety (90) days from the date of return shipment, whichever is longer.

To obtain repair under this warranty, Buyer must obtain a Return Material Authorization Number ("RMA") from Spectrum and return the product to a designated repair location, freight prepaid. All returned products must be accompanied by complete documentation, including the RMA and product discrepancy report. Spectrum shall pay shipping costs to return the product to the Buyer. In the case of products returned from another country, the Buyer shall pay all applicable duties or taxes required and freight charges both ways. Products not qualifying for warranty service will be returned at Buyer's risk and expense. Spectrum may charge at its standard rates for any handling of such products.

EXCLUSIONS

This warranty shall not apply to defects caused by abuse, neglect, accident, improper repair, alteration, unreasonable use of the product by the Buyer or damage in shipment to Spectrum for repair. Spectrum shall make the evaluation of the item and shall be the sole determiner of its eligibility for or exclusion from warranty coverage.

Software included with the product, if any, is intended (but not guaranteed) to run on any Windows95® (or higher)-based computer, and is provided solely for the convenience of the Buyer. It is supplied as-is, and is expressly excluded from any warranty.

LIMITATIONS & DISCLAIMER

The remedies provided by this warranty are the Buyer's sole and exclusive remedies. Spectrum shall not be liable for any direct, indirect, special, incidental, or consequential damages resulting from the Buyer's use of this product or software supplied by Spectrum.

NO OTHER WARRANTIES ARE EXPRESSED OR IMPLIED. SPECTRUM SPECIFICALLY DISCLAIMS ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, TITLE OR NONINFRINGEMENT, OR ANY OTHER OBLIGATION ON THE PART OF SPECTRUM. NO DESCRIPTIONS OR SPECIFICATION SHEETS SHALL BE DEEMED A WARRANTY BY DESCRIPTION OR OTHERWISE HAVE ANY LEGAL EFFECT.

IT IS THE BUYER'S SOLE RESPONSIBILITY TO DETERMINE THE SUITABILITY OF THE PRODUCT FOR THE INTENDED USE PRIOR TO PURCHASE.

Some states and jurisdictions do not allow limitations on warranties, so some or all of the above limitations may not apply to you.

BUYER'S SOLE AND EXCLUSIVE REMEDY, AND SPECTRUM'S SOLE LIABILITY, WITH RESPECT TO ANY BREACH OF WARRANTY, SHALL BE, AT SPECTRUM'S OPTION, (A) REPAIR OR REPLACEMENT OF THE DEFECTIVE OR NONCONFORMING PRODUCT OR (B) REFUND OF BUYER'S PURCHASE PRICE FOR THE DEFECTIVE OR NONCONFORMING PRODUCT. THE REMEDIES SET FORTH HEREIN SHALL CONSTITUTE THE EXCLUSIVE REMEDIES AVAILABLE TO BUYER AND ARE IN LIEU OF ALL OTHER REMEDIES THAT WOULD OTHERWISE BE AVAILABLE TO BUYER.
IN NO EVENT WILL SPECTRUM'S TOTAL LIABILITY FOR ANY AND ALL LOSSES AND DAMAGES ARISING OUT OF ANY CAUSE WHATSOEVER (WHETHER SUCH CAUSE BE BASED ON CONTRACT, NEGLIGENCE, STRICT LIABILITY, OTHER TORT OR OTHERWISE) EXCEED THE PURCHASE COST OF THE PRODUCTS IN RESPECT TO WHICH SUCH CAUSE ARISES OR, AT THE OPTION OF SPECTRUM, THE REPLACEMENT OF SUCH PRODUCTS; IN NO EVENT SHALL SPECTRUM BE LIABLE FOR INCIDENTAL, CONSEQUENTIAL OR PUNITIVE DAMAGES RESULTING FROM ANY SUCH CAUSE.

RETURNING EQUIPMENT FOR REPAIR

Should it become necessary for you to return equipment for repair, please take the following steps:

1. Contact us to obtain a Return Material Authorization (RMA) number. We can only accept repair returns if an RMA has been obtained.
2. Carefully pack the equipment and clearly mark the RMA number on the outside of the package.
3. Ship the package **freight or postage prepaid** (insurance is recommended) to the above address unless you have been given an alternate shipping address at the time the RMA number was assigned. Be sure to include any items or accessories that we have asked to have included and any information that may be helpful in resolving the problem. Also, be sure to include your name and information on how to contact you so that we can get additional information from you if needed and let you know when the equipment has been repaired.

We will make every effort to repair your equipment and have it on its way back to you within five working days from the time it arrives at our repair facility.

APPENDIX A – SPECIFICATIONS

PHYSICAL (TM-4D)

HEIGHT: 1.72 in. (44 mm)
WIDTH: 18.950 in. (481 mm) front panel, 17.7 in. (449 mm) rear panel
DEPTH: 8.375 in. (213 mm), excluding connectors
WEIGHT: 6.75 lbs. (3.07 kg) typical

PHYSICAL (GPS TIMING ANTENNA)

HEIGHT: 5.0 in. (126.6 mm)
DIAMETER: 3.54 in. (90.0 mm)
WEIGHT: 0.66 lbs. (0.30 kg)
MOUNTING: Marine-thread (1.0-14UNS2A) pole mount. Optional flush and 1.25" mast mount. 4 in. stainless steel masts available with flange base or as L-bracket style
CABLE: RG-58 (50 ft.) with TNC connectors standard. Longer cables optional.

ENVIRONMENTAL (TM-4D)

STORAGE TEMPERATURE: -40 to +85^{O}C.
OPERATING TEMPERATURE: -20 to +70^{O}C.
HUMIDITY: Up to 95% RH, non-condensing.

ENVIRONMENTAL (GPS TIMING ANTENNA)

OPERATING TEMPERATURE: -45 to +85^{O}C
HUMIDITY: Water-resistant, all-weather.

PERFORMANCE (FREQUENCY)

GPS-CORRECTED 10 MHz SINE WAVE FREQUENCY OUTPUT:

Conditions: Time Valid, Tuning in Mode 4.
Long-term Stability (while tracking): $1x10^{-12}$ after 24 hours of tracking (Δt=24 hours)
Short-term Stability: $1x10^{-11}$ (Δt=1 second)
Accuracy (while coasting): $<5x10^{-10}$ per day after 3 days of locked operation.
Phase Noise, 1 Hz Bandwidth:
10 Hz: < -124 dBc
100 Hz < -139 dBc
1 kHz: < -149 dBc
10 kHz: < -151 dBc
100 kHz: < -155 dBc
Harmonic Outputs: < -50 dBc
Spurious Outputs: < -70 dBc
Level: +10 dBm nominal into 50 ohms

PERFORMANCE (TIME)

1 PPS OUTPUT (Referenced to UTC):

Conditions: Time Valid.
Accuracy: 25 ns, PTP
Accuracy while coasting: Same as primary frequency output.

PERFORMANCE (GPS)

RECEIVER TYPE: Twelve parallel channel, code and carrier tracking, CA code, L1 carrier.

TIME TO FIRST FIX:
Hot Start: <15 seconds, typical (valid almanac, time, date, position and ephemeris)
Warm Start: <40 seconds, typical (valid almanac, time, date, and position)
Cold Start: <60 seconds, typical (no information)

POSITION UPDATE RATE: Once per second, nominal.
MAXIMUM VELOCITY: 1000 knots (515 m/s)
MAXIMUM ACCELERATION: 2 g
POSITION ACCURACY: Less than 15 M SEP

STANDARD FEATURES

16 buffered digital outputs: Allows distribution of up to four different signals to any combination of four digital output banks.

8 isolated analog outputs: Allows distribution of up to two different signals to either or both analog output banks.

Programmed Output Pulse (POP): User programmable, precisely timed output pulses.
Interval resolution: 100 nanoseconds
Accuracy to UTC: 25 nanoseconds
POP One-Shot mode and POP Repeat mode
User selectable pulse width and polarity.

Event Time Tag (ETT): Snapshot date and time of external signal event.
Tag resolution: 100 nanoseconds
Positive or negative-going transition trigger
Minimum latency between events: 4 ms; maximum rate: 30 events per second.

NMEA and ASCII Time Messages: User selectable message format on separate RS-232 serial channel.
Spectrum-format serial time message
NMEA messages $GPZDA, $GPRMC and $GPGGA

User Time Bias: Compensation for antenna cable length and system delays.
Sets absolute timing accuracy and synchronization to other system components.

AVAILABLE OPTIONS

External signal inputs, front and/or rear
IRIG and/or NASA serial time code output, modulated and baseband
Network Time Protocol, Type 11
GPS-corrected PLL frequency synthesizer output, to 125 MHz (x3)
Auxiliary frequency output, to 125 MHz
Filtered timing pulse output
Coherent CTCSS (PL) tone generator
Secondary sine wave output (x2)
Substitute other frequency for primary frequency output
Higher baud rates for serial time messages
Custom multiplexer and/or other outputs
Custom functions
Customized user software

DISTRIBUTION AMPLIFIER

DIGITAL: Capacity to distribute as many as four separate signals generated with internal TM-4/OEM™.
External input capability optional on front or rear panel.
Distributes to four banks of four outputs each on rear panel. Sixteen outputs standard. BNC jacks.
Configurable 1:4, 1:8, 1:12, 1:16, 2:4, 2:8, 4:4.
Optional four banks of two additional outputs each on front panel available.
(Configurable in combinations from 1:24 to 4:6).

ANALOG: Capacity to distribute as many as two separate signals generated with internal TM-4/OEM™.
External input capability optional on front or rear panel.
Distributes to two banks of four outputs each on rear panel. Eight outputs standard. BNC jacks.
Configurable 1:4, 1:8, 2:4.
Optional two banks of two additional outputs each on front panel available.
(Configurable in combinations from 1:12 to 2:6).

AVAILABLE DISTRIBUTION AMPLIFIER OUTPUTS

DIGITAL

1 PPS OUTPUT:
DRIVE: TTL levels into 50Ω
PULSE WIDTH: Positive pulse, 1 ms nominal, rising edge on-time
RISE TIME: 10 ns maximum

PROGRAMMED OUTPUT PULSE:
Drive: TTL levels into 50Ω
Rise & Fall Time: 10 ns, maximum
Pulse Width: User-selectable, 1 μsec to 250 ms, nominal
Polarity: Selectable

MULTIPLEXER OUTPUT:
Drive: TTL levels into 50Ω
Rise & Fall Time: 10 ns maximum
MUX1: 1 kHz, 10 kHz, 100 kHz, 1 MHz, 5 MHz, 10 MHz, PPS, optional baseband IRIG
MUX2: 10 MHz, MUX1 mirror, PPS, optional baseband IRIG, optional baseband NASA-36, optional outputs 1 – 3

OPTIONAL SERIAL TIME CODE OUTPUT:
Type: TTL levels into 50Ω
Time Code: IRIG B, NASA-36, other codes available

OPTIONAL AUXILARY FREQUENCY OUTPUT:
Frequency: Almost any standard frequency, including T1/E1. VCXO-derived, GPS-locked, up to 125 MHz. Divide down and multiply up possible. Factory set.
Drive: TTL levels into 50Ω
Accuracy: Same as primary frequency output. Meets Stratum-1 MTIE specifications.
Rise & Fall Time: 10 ns maximum
Output: 50% duty cycle

OPTIONAL FILTERED TIMING PULSE OUTPUT:
Frequency: Virtually any frequency up to 100 kHz, such as 1 Hz, 25 Hz, and 216.2/3 Hz. Factory set.
Characteristics: Coherent with 10 MHz output. Leading edge synchronized to average value of PPS from GPS. Extremely low jitter.
Drive: TTL levels into 50Ω
Accuracy: Same as primary frequency output. Meets Stratum-1 MTIE specifications.
Rise & Fall Time: 10 ns maximum
Pulse Width: Positive pulse, 10 μsec nominal. Rising edge on-time.

OPTIONALWIDE-RANGE PLL FREQUENCY SYNTHESIZER OUTPUT:
Frequency: Almost any desired frequency up to 125 MHz. Factory set.
Drive: TTL levels into 50Ω
Accuracy: Same as for 10 MHz sine wave output. Meets Stratum-1 MTIE specifications.
Rise & Fall Time: 2 ns maximum
Output: 50% duty cycle

ANALOG

PRIMARY FREQUENCY (10 MHz standard) OUTPUT:
DRIVE: High spectral purity sine wave, +10 dBm into 50Ω, ±2dB

OPTIONAL IRIG SERIAL TIME CODE OUTPUT:
Type: Modulated
Output Level: 2.7 V_{ptp} into 600Ω
Modulation Level: 3:3.1

OPTIONAL SECONDARY SINE-WAVE OUTPUT:
Frequency: Identical to or independent of primary output frequency.
Drive: High spectral purity sine wave, +10 dBm into 50Ω, ±2dB

OPTIONALWIDE-RANGE FREQUENCY SYNTHESIZER OUTPUT:
Frequency: Almost any desired frequency up to 125 MHz. Factory set.
Drive: High spectral purity sine wave, +10 dBm into 50Ω, ±2dB

OPTIONAL CTCSS (PL) TONES (x2):
Frequency: Selectable from table of predetermined standard tone frequencies 67.0 Hz to 250.3 Hz.

ADDITIONAL INPUTS AND OUTPUTS

SERIAL CONTROL I/O:
CONNECTOR: DB-9 (female)
SERIAL CONTROL I/O: RS-232C, 9600 bps, 8-N-1
MESSAGE FORMAT: ASCII, Spectrum format
MODE: Continuous broadcast or individual message polling

AUXILIARY I/O:
CONNECTOR: DB-15HD (female)
ALARM OUTPUT: Open collector, 25 mA current capability. RS-232 notification of hardware fault.
SERIAL TIME MESSAGE: RS-232C,1200-38400 bps, 8-N-1
NETWORK TIME PROTOCOL: Optional. Compatible with Type 11 public-domain drivers.
NMEA MESSAGES: $GPZDA, $GPRMC, $GPGGA
EXTERNAL EVENT INPUT: Event Time Tag feature, TTL/CMOS level, edge-triggered. Active edge is software-selectable.

ANTENNA INPUT:
CONNECTOR: TNC
POWER: +5 VDC on center conductor, short circuit protected

OPTIONAL EXTERNAL INPUTS

REAR PANEL:
CONNECTOR: BNC
DIGITAL INPUTS: 1 – 4
ANALOG INPUTS: A & B

FRONT PANEL:
CONNECTOR: BNC
DIGITAL INPUTS: 1 – 4
ANALOG INPUTS: A & B

OPTIONAL OUTPUTS

FRONT PANEL:
CONNECTOR: BNC
DIGITAL OUTPUTS: 1 – 4
ANALOG INPUTS: A & B

POWER

INPUT SUPPLY VOLTAGE: 12 to 35 VDC
WARM-UP CURRENT: 800 mA – 350 mA @ 24 VDC
OPERATING CURRENT: 400 mA @ 24 VDC
AC POWER ADAPTER (Included)**:** 90 – 264 VAC / 47 – 63 Hz to 24 VDC / 3 A
CONNECTOR: 2.5 mm coaxial jack, center pin positive

CAUTION: NEVER APPLY INPUT POWER TO ANY PINS ON THE DB-15HD CONNECTOR!