C/O/106031G

X72

PRECISION RUBIDIUM OSCILLATOR

Designer's Reference

datum

Datum — Proprietary

Ordering Information

The ordering number of this document is C/O/106031A. To order this document, call 949 598 7600 and ask for the Datum Irvine Sales Department.

Notice

Every effort was made to ensure that the information in this document was complete and accurate at the time of printing. However, the information presented here is subject to change.

Applicable Patents

This product is protected under the following U.S. patent numbers: 5,457,430, 5,489,821, and patents pending.

Trademarks

X72 is a registered trademark of Datum.
Other trademarked terms may appear in this document as well. They are marked on first usage.

Warranty

Datum provides a 1 year warranty on the electronics and a 20 year warranty on the rubidium lamp and cell of this product.

Table of Contents

Table of Contents (continued)

Section 1 - About This Document

Purpose

This document provides basic recommendations for designing products to use Datum's X72 rubidium oscillator. These guidelines are intended to be generic, as specific product requirements will vary from application to application.

Technical Support and Warranty Coverage

Warranty and non-warranty repair support for the X72 is provided by Datum Irvine's Customer Support group. Designer technical support is provided by application engineering from the Irvine facility's Marketing department during the design process.

Scope

This material consists of a brief description of X72 design supported by block diagrams, description of environmental issues, installation guidelines, required mating connectors, and unit operation. This document is available in both a hardcopy and in Adobe Acrobat Reader (.pdf) electronic format.

Intended Audience

This document is intended for engineers and telecommunications professionals who are designing, installing, operating or maintaining time, frequency, and synchronization systems having a requirement for a low profile and highly precise frequency generator.

Prerequisite Skills and Knowledge

To use this document effectively, the user should have a good understanding of digital telecommunications technologies and analog frequency generation and synthesis techniques.

How to Use This Document

This document consists of Sections 1 through 4, and Appendice A, B and C.

This document is organized as follows:

- **Section 1: About this Document**

  Provides general information about this document, the intended audience, organization and contents.

- **Section 2: X72 Introduction and Overview**

  This section contains a description of the X72 and lists its typical applications. Dimensions, performance and connector pinouts are documented.

- **Section 3: X72 Design Integration Considerations**

  This section contains mechnical issues pertaining to X72 mounting and mating recommendations, including thermal and EMI considerations, external interfaces and grounding, frequency control, susceptibility to noise, and reliability goal.

- **Section 4: X72 Installation and Operation**

  This section contains the information necessary to properly install and operate the X72 unit including a simplified theory of operation, and maintenance and warranty.

- **Appendix A: X72 J1 Connector and Plug**

  This appendix identifies the Molex J1 connector and its mating plug, and provides pinout information for the X72 edge board, and 3.25” cable.

- **Appendix B: Using the Datum Serial Interface Protocol**

  This appendix describes use of the external communications link software.

- **Appendix C: Using the X72 Deverloper’s Kit**

  This appendix describes the X72 developer’s kit hardware.

Section 2 - Introduction

2.0 Description

The X72 rubidium oscillator is the newest and smallest of DATUM's family of precision frequency generator components. This fifth generation Rb oscillator reflects significant advances in physics miniaturization and integration and offers a low height (0.70" / 17.7 mm), a small footprint, and an industrial temperature range of -40˚C to +85˚C.

Drawing on over 30 years of experience, the X72 design has been refined for low cost mass production and can be easily integrated into time, frequency and synchronization systems, requiring only one input supply voltage. It can be mounted directly onto a circuit board as a component of a module used in 0.8" wide card slots. It offers the high reliability and accuracy of a rubidium oscillator, in a new design concept benefiting from the many years of experience Datum has gained in fielding tens of thousands of rubidium oscillators.

Figure 2-1. X72 Rb Oscillator atop an 80's vintage FRK Rb oscillator showing the dramatic reduction in size of Rb oscillator design.

2.1 Typical Applications

The elevated operating temperature range of the X72 sets a new high-point for this type of atomic reference. Compared with traditional quartz oscillators, the stability of the X72 maintains excellent frequency control even when the operating temperature is pushed above 85˚C, so that even if the host system overheats in fault mode, the X72 oscillator will continue to produce a stable and accurate time or frequency reference.

The X72 is easily integrated into time and frequency systems because of its low profile. The height and footprint are designed to accommodate 0.8" (4I) wide card slot application. The unit operates with a low power requirement (+5 Vdc or between +10 to 32 Vdc). The X72 meets all applicable CE and FCC requirements for EMI emissions and susceptibility.

This design is being successfully applied as an OEM component in wireless telecom networks such as digital cellular/PCS basestations, SONET/SDH digital network timing, etc. Linked with a GPS receiver or other external timing reference, the X72 provides the necessary timing requirements for CDMA cellular and PCS systems. The low temperature coefficient and excellent frequency stability extend holdover performance when the GPS signal is not available. Temperature compensated units are available for those special applications requiring even better temperature performance.

The X72's 20 year stability without the need for retuning permits extended operating periods without maintenance (long life Rb lamp, extended crystal control range). The design produces a stable frequency with good short and long term stability, and excellent spur performance.

Datum's commitment to quality and reliability is backed by a 20 year warranty on the physics package (lamp bulb and resonator cell).

The microprocessor-based X72 is a more cost-effective system design that allows serial command selection and enabling of TTL level digital output frequencies. This allows the oscillator output to be divided to a number of different frequencies, as opposed to older oscillators with a single fixed output frequency. The sine output frequency is selected at time of order.

A 1 PPS output is an integral part of the design. An optional 1 PPS input allows the unit to track a GPS or other external reference, and display the difference between the input and the 1 PPS generated by the X72 through the RS232 link.

For simple applications the X72 provides a 5V CMOS-compatible Built-in Self Test (BIST) Service and a LOCK alarm signal derived from the basic physics operation. This lock signal indicates when the output frequency is locked to the atomic resonance of rubidium. When more control over the device is desired, an extensive command - control - status dialog is available.

In addition to controlling the operation of the oscillator, the microprocessor's built-in firmware allows an external host computer to communicate with the embedded controller through a serial port connection. This allows precise frequency control, the dynamic frequency selection mentioned earlier, the ability to enable and disable outputs, to query the system's health, and acquire information about the unit's serial number, operating temperature, fault history, initiate a self test, and other performance indicators. The protocol used is Datum's proprietary Datum Serial Interface Protocol, or DSIP.

The simplified block diagram below shows the importance of the digital control in the unit, how it controls and monitors all aspects of operation, such as the heater circuits of the physics package, as well as the selection of outputs.

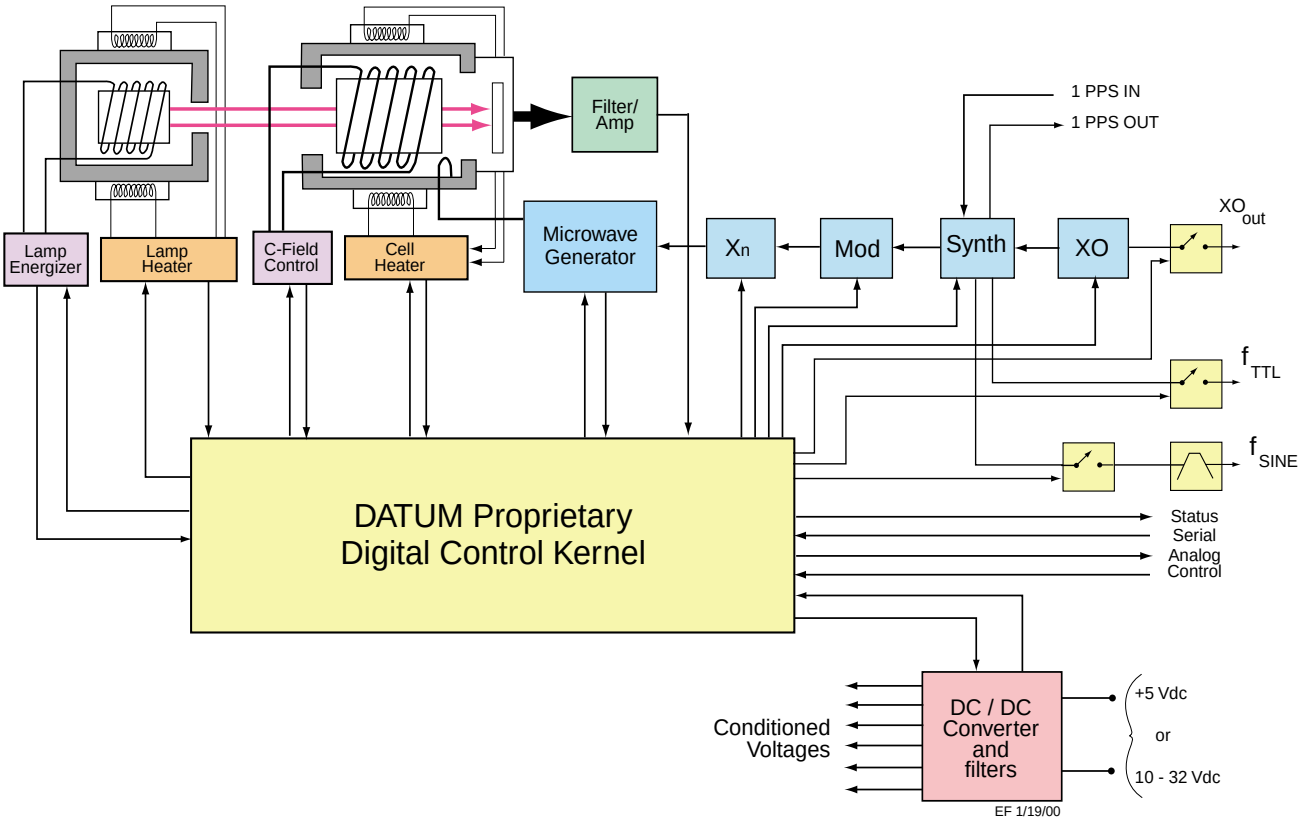


Figure 2-2. X72 Rubidium oscillator simplified block diagram

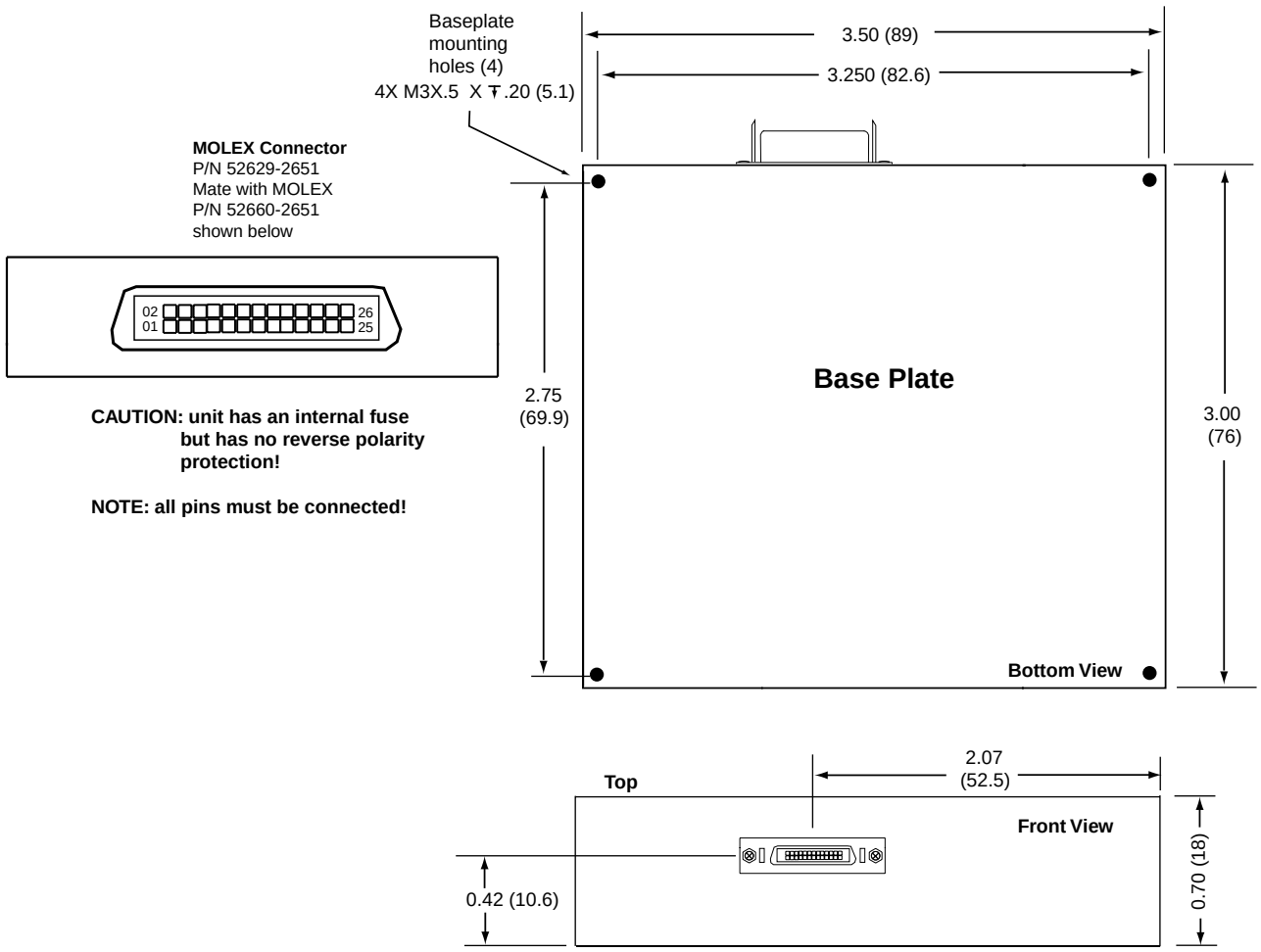


Figure 2-3. Outline Drawing, X72 unit

Table 2-1. J1 Connector Interface

PIN#	SIGNAL NAME	TYPE**	SIGNAL FUNCTION
1 - 7	VDD	PWR	+Power input (+4.5 to 5 Vdc or +10 to +32 Vdc). All power pins must be connected.
8	SERVICE	Output	Indicates unit is nearing limits of frequency control and that Service is required within several months.
9	DOUT	Output	UART data out at ACMOS logic levels.
10	DIN	Input	UART data in at ACMOS logic levels.
11	FREQ CTRL	Analog	Frequency control - analog input between 0 - 5 Vdc.
12 - 18	VSS	GND	-Power & signal return - all grounds must be connected.
19	1 PPS IN	Input	1 PPS input, positive edge triggered.
20	1 PPS OUT	Output	1 PPS output, may be enabled/disabled digitally.
21	LOCK	Output	If low, indicates Rb osc. is locked.
22	FXO	Output*	(FXO) ACMOS output equalling the VCXO frequency.
23	FACMOS RTN	GND	Return for FACMOS & FXO signals.
24	FACMOS OUT	Output	(FACMOS) ACMOS output equalling VCXO frequency.
25	FSINE RTN	GND	Chassis ground - return signal for FSINE signal.
26	FSINE OUT	Output	(FSINE) Sine output option - equals VCXO frequency divided by 2xM (M is set at the factory).

* High impedance ** All inputs and outputs are ESD protected, short circuit protected, and all inputs are compatible with 3.3V ACMOS logic and 5V TTL logic.

NOTE: Refer to Appendix A for the connector manufacturer's drawings and specifications.

TABLE 2-2. X72 Design Absolute Maximum Ratings

Symbol	CHARACTERISTIC (Unit in ambient still air – convection)		-40 Degrees C to 85 C Base-plate	UNITS
V_{CC}	SUPPLY RELATIVE TO GROUND	5 VOLT UNIT	-0.25 to 8	V
		10 TO 32 VOLT UNIT	-0.25 to 40	
V_{IN}	INPUT VOLTAGE RELATIVE TO GND REGARDLESS OF POWER SUPPLY VOLTAGE	DIN & 1PPSIN	-0.5 to 5.5	V
		FREQ CNTL	-0.5 to 5.5	
P_{WU}	**MAX WARM UP POWER**		17	WATTS
P_Q	MAX QUIESCENT POWER	-40˚C BASEPLATE	15	WATTS
		25˚C BASEPLATE	10	
		85˚C BASEPLATE	5.0	
t_{wu}	MAXIMUM WARMUP TIME	-40˚C BASEPLATE Lock to < $1E^{-9}$	<8	MINUTES
		25˚C BASEPLATE Lock to < $1E^{-9}$	<4	
T_{MOBP}	MAXIMUM ABSOLUTE OPERATING BASEPLATE TEMPERATURE	Conditions: Still Air – Convection – No Heat Sink on Unit	-45 to 85	˚C
T_{MTBP}	MAXIMUM ABSOLUTE TURN-ON BASEPLATE TEMPERATURE	Conditions: Still Air – Convection – No Heat Sink on Unit	-40 to 85	˚C
T_{STG}	**MAXIMUM STORAGE TEMPERATURE**		-55 to 85	˚C
	MAXIMUM VIBRATION (Powered but not locked)	Sine – 1 inch DA or 10G	0 to 300	Hz
	MAXIMUM VIBRATION (Powered and maintaining lock)	Sine – 1 inch DA or 10G	0 to 100	Hz
	MAXIMUM ALTITUDE (Powered up unit)	With respect to Sea Level	30,000	Feet
	MAXIMUM ALTITUDE (Unpowered)	With respect to Sea Level	50,000	Feet

NOTE: ALL OUTPUTS ARE SHORT CIRCUIT PROTECTED

TABLE 2-3. X72 Design Operating Characteristics

Symbol	CHARACTERISTIC (Unit in ambient still air - convection)		-40 Degrees C to 85 C Base-plate MIN TYP MAX		UNITS
	DIGITAL INPUTS/OUTPUTS				
V_{CC}	SUPPLY RELATIVE TO GROUND	5 VOLT UNIT	4.5	5.5	V
		10 TO 32 VOLT UNIT	10	32	
V_{IH}	HIGH LEVEL INPUT VOLTAGE	DIN	2.5	5.5	V
		1PPSIN	1.8	5.5	
V_{IL}	LOW LEVEL INPUT VOLTAGE	DIN	0	0.8	V
		1PPSIN	0	0.8	
V_{OH}	HIGH LEVEL OUTPUT VOLTAGE	DOUT, SERVICE, LOCK @IOH = -0.33 mA @ IOH = 0 mA	3.3		V
		FXO, FACMOS, 1PPSOUT @IOH = -3.5mA	3.5		
V_{OL}	LOW LEVEL OUTPUT VOLTAGE	DOUT, SERVICE, LOCK @IOL = 0.1 mA	0.4		V
		FXO, FACMOS, 1PPSOUT @IOL = 1.7 Ma	0.4		
	ANALOG INPUTS/OUTPUTS				
V_{FC}	FREQUENCY CONTROL INPUT VOLTAGE RANGE	RANGE OF ±1.5E-9 WITH RESOLUTION OF 2.0E-12	5		V
P_{SO}	FSINE OUTPUT POWER RANGE	FACTORY SET with 7.0 (Output load of 390pF cap & 50 Ω resistor within 4 inches of FSINE pin).	8.6		dBm
	FREQUENCY CONTROL				
$\Delta F/F_R$	CONTROL RANGE	ANALOG (FREQ CTRL PIN)	-1.5E-9	+1.5	ΔHz/Hz
		DIGITAL INTERFACE	-1.0E-6	+1.0E-6	
$\Delta F/F_{RES}$	**FREQUENCY CONTROL RESOLUTION**			2.04	E^{-12} ΔHz/Hz

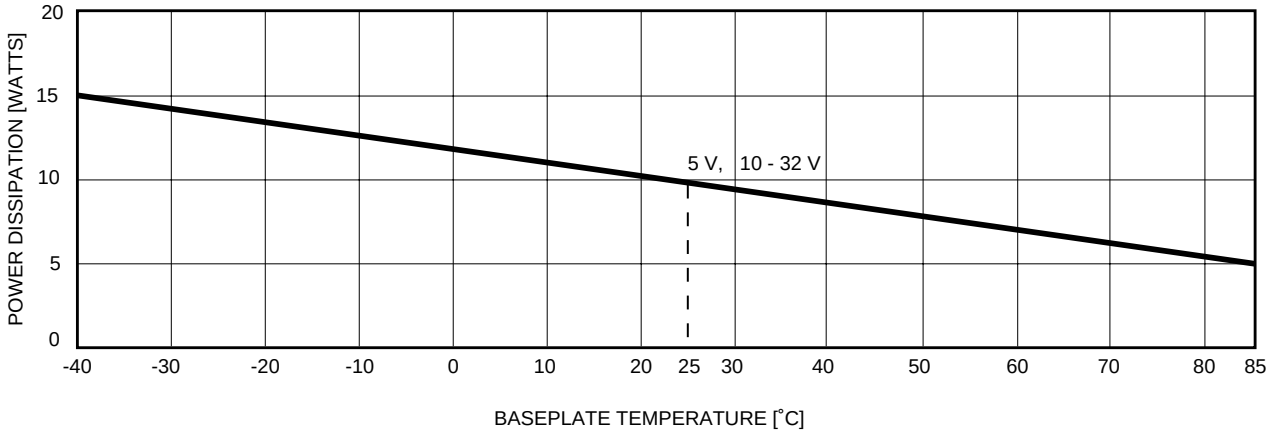


Figure 2-5. Total X72 Quiesent Power Dissipation, Typical (free convection)

To be added when available

Baseplate Temperature (deg C)

Figure 2-6. Representative X.72 Δf/f versus Temperature (uncompensated)

Refer to the X72 Performance Characteristics document for more detailed information.

Section 3 - Design Integration Considerations

3.1 Mechanical Considerations

3.1.1 Mounting Recommendations

The X72 may be mounted to a circuit card or chassis using the four mounting holes located at the corners of its baseplate. An interface cable or adapter card is required to access the X72 outputs and to interface with a host system.

Four M3 stainless steel screws with a minimum penetration depth of .2" and a maximum of .5” can be used to mount the unit.

3.1.2 Recommended Mating Connectors

Shielded cable must be used between the X72 connector and the host system connector in order to meet noise and emissions requirements noted in the engineering specifications of the X72 product. It is recommend that for typical applications this interface cable be no longer than 4 inches (10 cm).

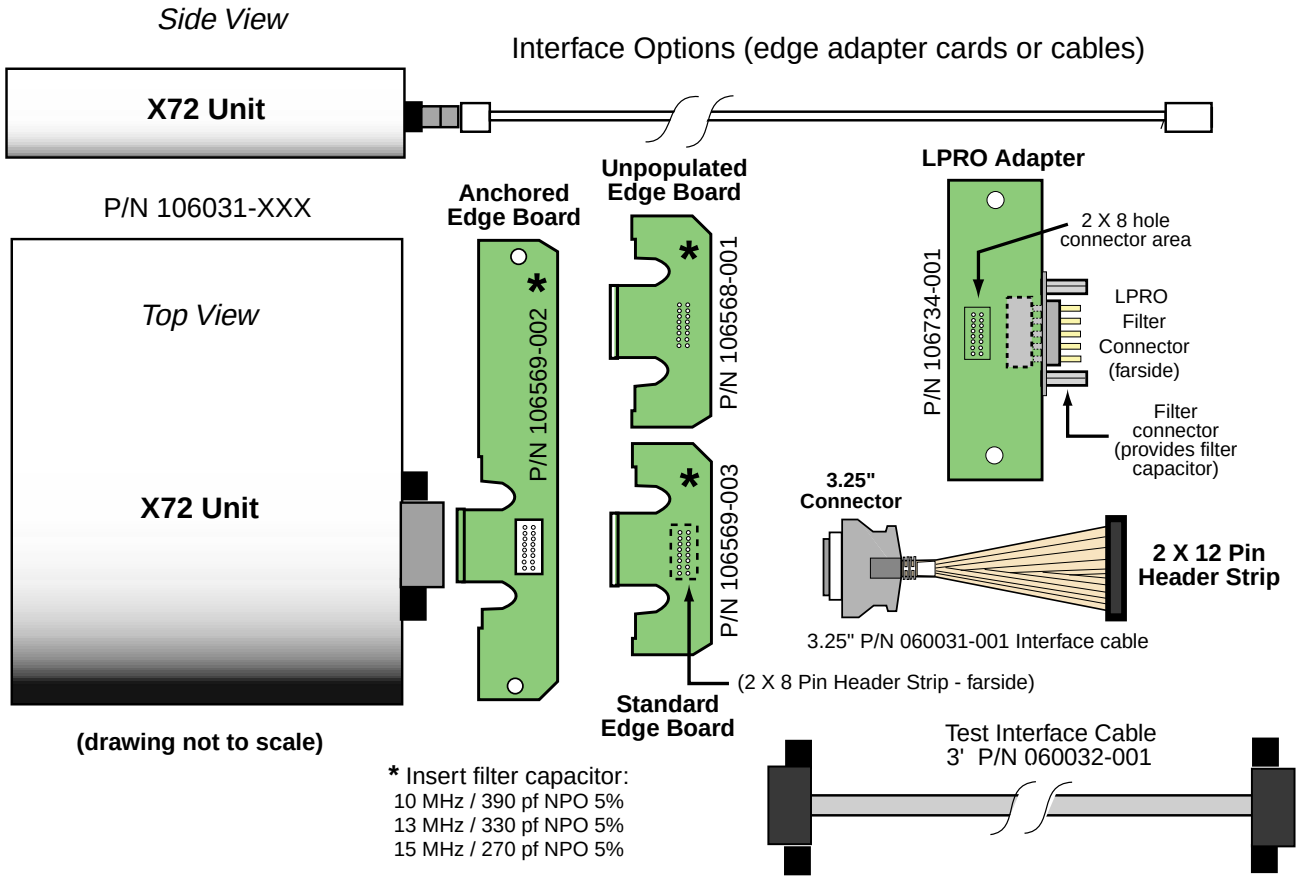


Figure 3-1. Adapter cards, cables and cable options

3.1.3 Integrating the X72 into a System

Datum has developed several integration options to aid the system designer in integrating the X72 into their application. With these options there is almost no limit to the connection schemes possible. Each of these options are described below.

3.1.3.1 Unpopulated Edge Board

The Unpopulated Edge Board is a small printed circuit board (PCB) that plugs directly into the X72's Molex connector.

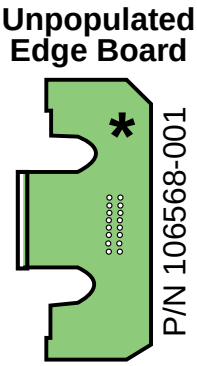
The Unpopulated Edge Board includes ***unpopulated pads*** for the following components

1. 16-pin header (See pin out comparison in Appendix A)
2. Coaxial connector for the Sine Output
3. Resistor and Capacitor pads to allow for improved Sine Output dc filtering (See Capacitor note)

From the various interface points on the Edge Board a system designer can access all inputs and outputs of the X72 and can mount which ever connectors are necessary for their application. This opens the X72 up to nearly any connection scheme. The examples included in this document are just a few of the integration methods possible with these edge boards.

The Edge Board comes in three different versions: Unpopulated (PN 106568-001), Standard (PN 106569-003), and Anchored (PN 106569-002). The three versions are electrically identical. They differ in that the Anchored version is 3.5 inches long (Standard version is 1.74 inches long) and includes two anchor points (refer to Figure 1.6). In addition, the standard edge board includes the header that is mounted directly to the PCB by direct solder connection or by plugging into a socket provided by the user.

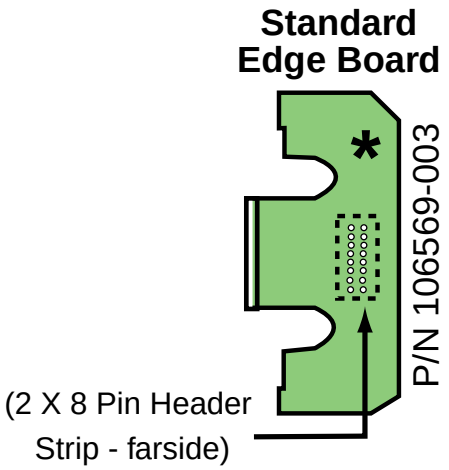
Refer to Figure A-3 in Appendix A for a schematic of the connector pinouts.



* Insert filter capacitor:
10 MHz / 390 pf NPO 5%
13 MHz / 330 pf NPO 5%
15 MHz / 270 pf NPO 5%

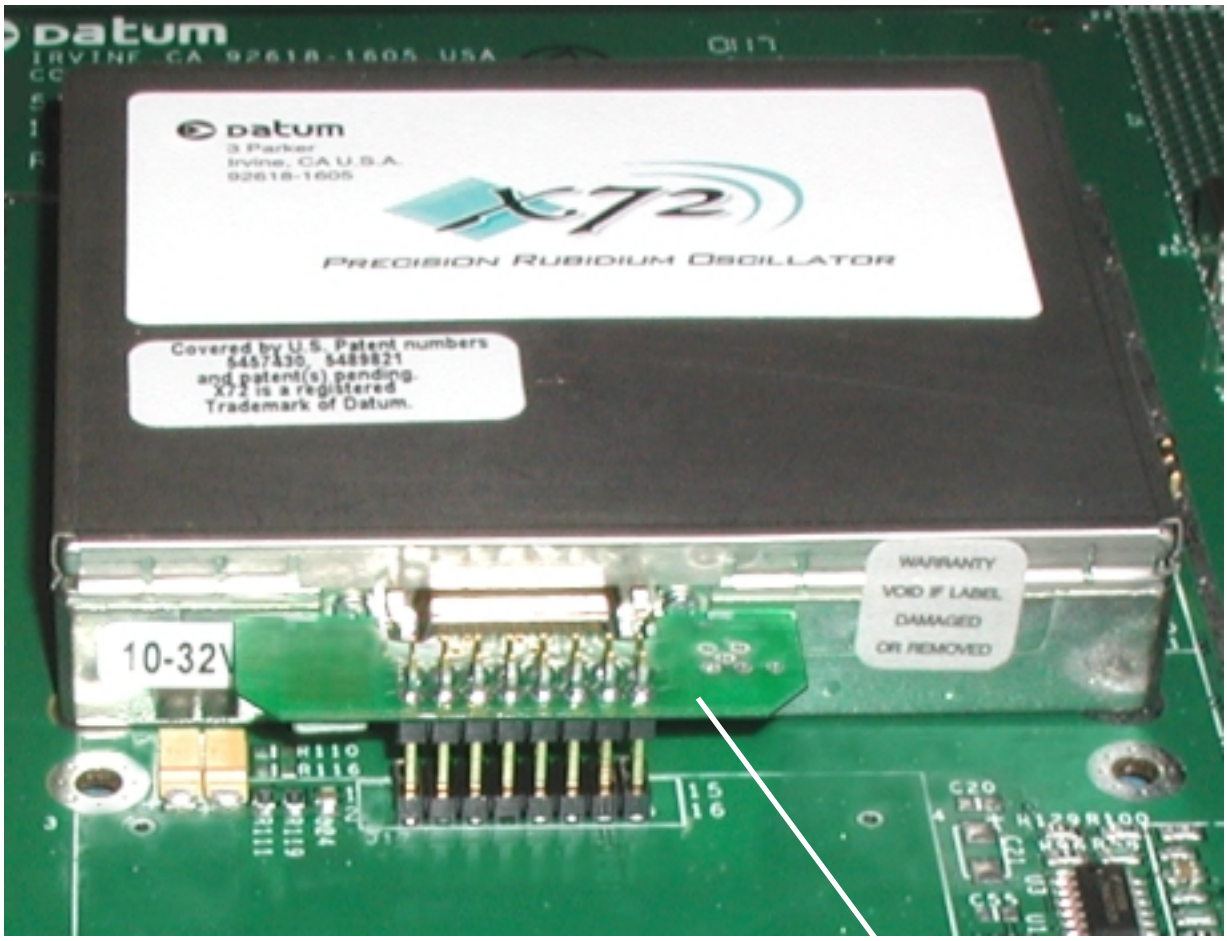
3.1.3.2 Standard Edge Board - PN 106569-003

The Standard version is intended for implementations where the Edge Board is connected directly into the system board by soldering directly to the PCB or plugging into a socket provided by the user (see example below). The Edge Board achieves its mechanical stability from the direct connection.



The Standard Edge Board includes:

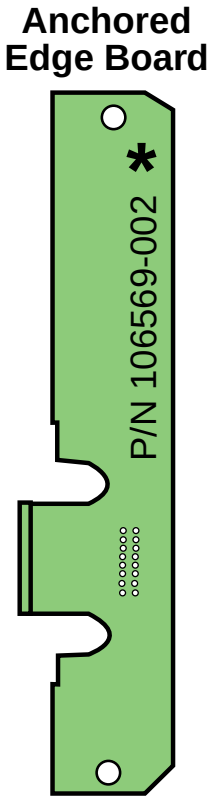
1. 390 pf capacitor
2. 10 Ohm resistor
3. 15 µF capacitor
4. Pad for coaxial connector for sine output
5. Soldered 2 X 8 pin connector adapter for connection to PCB



Example of mounting

3.1.3.3 The Anchored Edge Board - PN 106569-002

The Anchored Edge Board can be used in applications where the Edge Board is not plugged into a PCB and does not have a solid electrica1 connection like a soldered header that can keep the Edge Board in place in harsh vibration environments. To accomodate these applications two anchor points are provided.



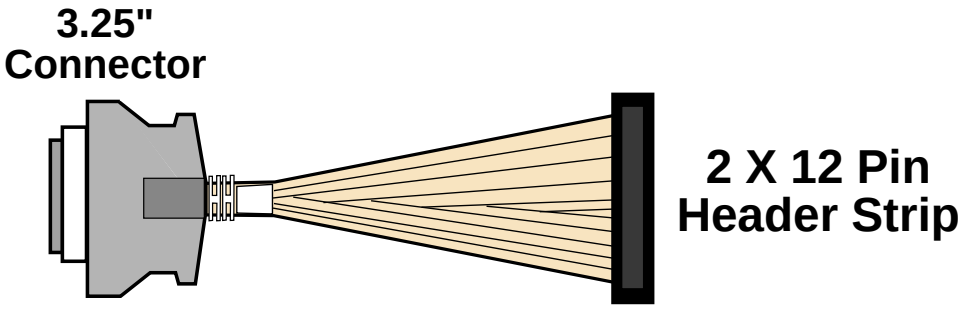
The Anchored Edge Board includes:

1. 390 pf capacitor
2. 10 Ohm resistor
3. 15 µF capacitor
4. Pad for coaxial connector for sine output
5. Unpopulated 16 pin header strip for customer integration.

Example of mounting

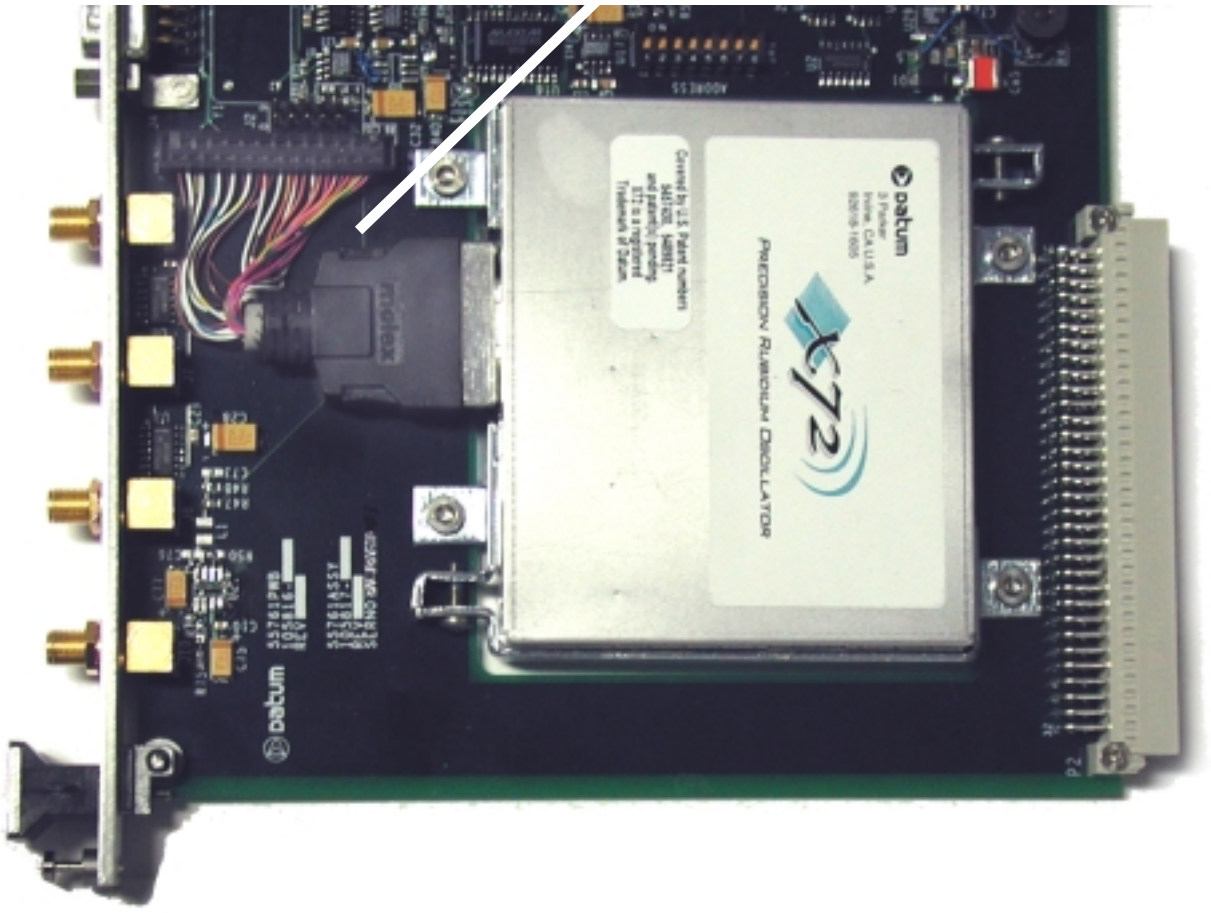
3.1.3.4 3.25 - Connector - PN 060031-001

The 3.25 inch connector is an all in one connection option that includes the mating connector to the X72 and a 24 pin header that can be mounted directly on a system board. The flexible cabling allows the header to be installed in many orientations to the unit.



3.25" P/N 060031-001 Interface cable

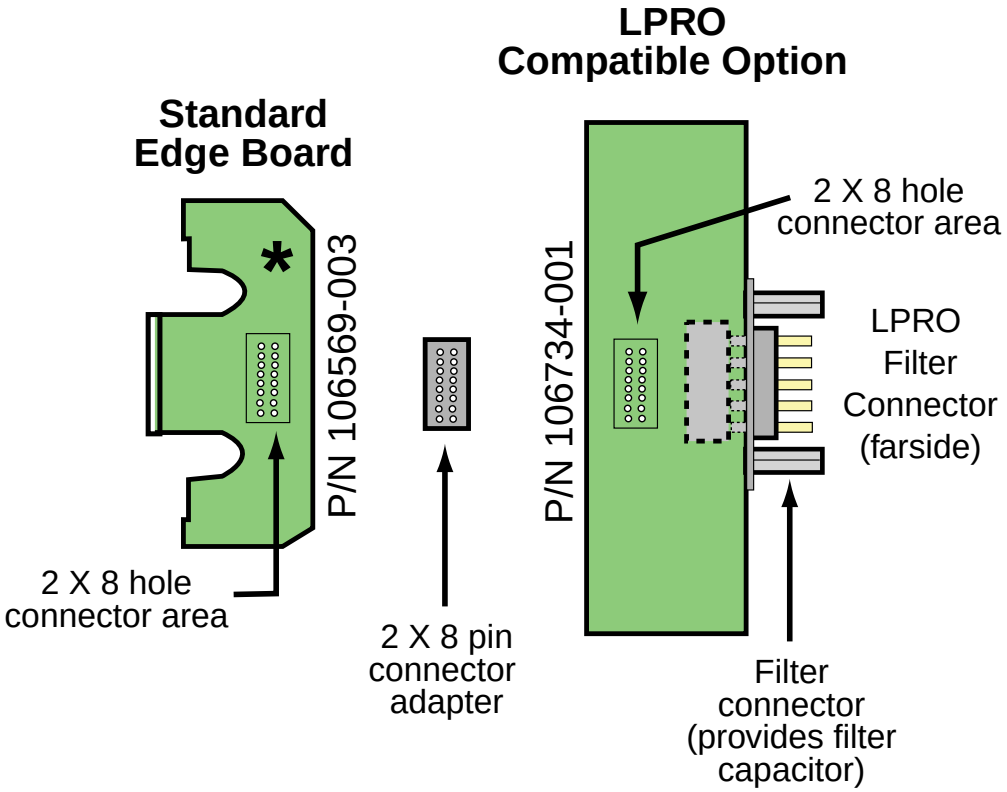
Example of mounting

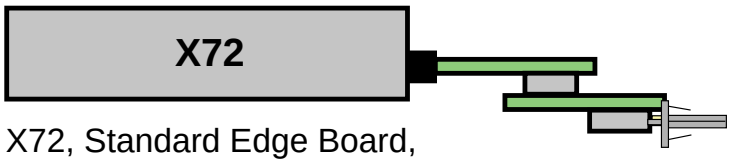


3.1.3.5 X72 - LPRO Adapter - PN 106734-001

The X72-LPRO Adapter was developed for existing Datum LPRO customers. The Datum LPRO Low-Profile Rubidium Oscillator, is the most widely produced rubidium oscillator in the world, and has been designed into hundreds of applications. The X72-LPRO Adapter allow these customers to upgrade to the X72 without changing the physical interface in their unit.

The Standard Edge Board and the LPRO Compatible Option Board both have sockets. The pins of a 2 X 8 pin connector are soldered between these two boards. The LPRO filter connector does not require the installation of a filter capacitor, since it was designed to provide a filtering function.





X72, Standard Edge Board,
and LPRO Connector
(side view)

3.2 Thermal Considerations

3.2.1 Use of Thermal Tape

In order to achieve the highest ambient operating temperature for the X72 operating baseplate temperature it is recommended that the bottom ("baseplate") of the X72 have good thermal contact to the mounting surface. It is also very important to maintain a uniform temperature into the baseplate of the X72 through its mounting points. The X72 unit will operate normally without use of thermal tape, but for some field applications the tape may simplify customer system thermal design requirements.

WARNING: Unless attached to a surface to spread its heat the X72 will be HOT to the touch and may cause handling distress.

The X72 maximum baseplate temperature described in the specifications was based on a model where the unit was covered on five sides with one inch foam to simulate free convection in air as the heat sink/baseplate was exposed to forced air.

If there is air flow over the unit's top cover, the X72's maximum operating baseplate temperature will increase by 1 or 2 degrees C and its power consumption at a given baseplate temperature will also increase by a few tens of milliwatts.

As the baseplate temperature continues to increase the unit will eventually lose lock. Above a baseplate temperature of +85˚C the resonator or lamp heaters shut down as control point temperatures are exceeded and the unit temperaåure coefficients increase to approximately 6E-10/˚C.

3.2.2 Frequency Offset from Water Condensation during Times of Excessive Humidity

Condensation of moisture from the air onto electrical components will produce frequency spikes or instability until the heat of the operating unit drives out the water vapor.

Condensation will not cause a problem for environments meeting the X72 specification if the X72 baseplate thermal ramp rates are controlled so that they rise at less than 2˚C/minute.

3.2.3 Effect of Excessive Dust on the X72

Operating the unit in dusty conditions may cause unexpected thermal effects if it builds up on the top surface. Excessive dust will also contribute to contamination in the shell of the mating connector and could cause intermittent loss of signals.

The X72 is shipped in a dust-protected ESD resistant bag. All connectors on any product must be suitably protected, before mating, in a dust-controlled environment.

3.3 External Interfaces and Grounding

Figure 3-1 shows interface circuitry for J1, the X72 I/O connector. All signals, including power, power return, rf output, signal/chassis ground, and monitor lines are routed through this connector. All voltage supply and ground lines must be connected at the mating connector for the X72 unit to operate properly.

The X72 is constructed with the chassis (unit cover) and signal grounds tied together at multiple points, and with the power supply return isolated from both chassis and signal grounds only by a ferrite bead. This robust grounding approach allows for ESD protection and low spurious emissions. But it can also lead to ground loop issues for the user.

Workarounds commonly used to break dc ground loops at a higher level of integration are to use a rf isolation transformer for the sine rf output, and/or float the transformer secondary winding of the user's power supply.

3.4 ELECTRICAL INTERFACE

3.4.1 X72 rf Outputs

3.4.1.1 RF Output Impedance versus Frequency

The active rf output impedance for X72 is a nominal 50 ohms at 10 MHz, but is a widely varying impedance at other frequencies. This would have to be taken into consideration if the X72 rf output is driving a non-buffered filter. Note that X72 is specified as delivering 0.55V ±10% into a 50 Ohm resistance load. Loads that present complex impedance or resonances will affect signal amplitude. X72 can drive a properly terminated transmission line of 50 Ohms characteristic impedance.

NOTE: a 390 pf capacitor from the 10 MHz sine output to the sine return is required within 4 inches of the output connector. It can be located across the 50 ohm terminator (see Figure 3-1).

If the sine output port is disabled its characteristic impedance remains the same.

3.4.1.2 AC-Coupled rf Load

The X72 is designed to tolerate an ac-coupled rf load without waveform distortion provided the coupling capacitor is low impedance at 10 MHz (for example, a 0.01 uF capacitor has an X_c of 1.6 ohms, which is small compared to the fifty ohm nominal output impedance). The rf output stage of the X72 uses an ac-coupled design.

It is recommended that the coupling capacitor be ceramic, with a X7R or NPO dielectric.

3.4.1.3 Transformer-coupled rf Load

The transformer-coupled rf load is used to break up ground loops. It can also be used to provide some bandpass filtering. However, it also attenuates the rf signal, making it difficult to provide a tight tolerance on the rf output level. It is also difficult to obtain an inexpensive, off-the-shelf wide operating temperature range SMT rf transformer.

3.4.2 X72 1 PPS Input and Output

The 1 PPS output signal of the X72 unit is positive edge triggered and gated with the rising edge of the clock. It's duration for a 10 MHz unit is 400 ns ±10%. Rise/fall time is 4 ns.

The 1 PPS is exactly divided from the XO frequency.

Future implementation will support tracking, synching and smoothing of incoming 1 PPS to produce the output 1 PPS.

3.4.3 Lock Signal

The X72 provides an indication that the internal Voltage Controlled Crystal Oscillator (VCXO) is locked to the atomic transition via the LOCK signal. As long as the LOCK signal is LOW once warm-up is completed, the user can be assured that the output frequency is locked to the Rb atomic clock. The lock signal is also available in the control register when accessed by the DSIP interface.

If the LOCK signal is high, atomic lock has been lost and the X72 will go into sweep mode to reacquire lock. The sweep ranges approximately from -21 ppm to +21 ppm in approximately a 20 second period. During the sweep, outputs are maintained but no reliance should be placed on signal accuracy during sweeping. If the power source to the X72 is OFF, the lock output line is low.

3.4.4 Service Signal

The service signal is valid when the unit is operating and the rubidium oscillator is locked.

The service signal algorithm monitors the health of the Rb physics package, which includes the Rb lamp bulb and resonator cell, and the unit's crystal oscillator that is slaved to the Rb atomic clock.

The control signal is also available through the control register when accessed by the DSIP interface.

The service signal indicates low when any of the internal operating parameters are near the end of their tuning or adjustment range, providing a month's warning of this situation.

3.4.5 X72 Frequency Control Signal

The X72 frequency control signal is an analog input between 0 and 5 Vdc that can be enable or disabled at the factory (making it a default setting) or by the customer at a later date (using the DSIP interface).

When in use, the smallest incremental frequency change is 2E-12 (or f.2). The unit will always power up to the preset freerunning factory set frequency. Adjustments to the frequency are always relative to the free running frequency of the unit (See also Section 3.5).

3.4.6 X72 ACMOS Output Frequency

The ACMOS output frequency is equal to the crystal frequency divided by 2N (N is a number from 1 to 65536). For example, the DSIP command to modify the output of the VCXO for an output of 10 MHz from a 60 MHz XO would be “o3”.

3.5 Frequency Control Analog

3.5.1 Greater Than ±1E-9 Internal or External Control

The external frequency control circuitry is designed so that with no voltage applied at J-11, the voltage will self bias to mid-range, or 2.5V. This input can also be turned off completely eliminating any source of noise via the DSIP. In some versions of the X72, this function can be turned off by customer request on power up. If it is to be used later it would have to be enabled through the DSIP interface (refer to Appendix B).

3.5.2 Time Response of External Frequency Control

The external analog frequency control is a sampled input with a typical response time constant of 154 ms.

3.5.3 Temperature Compensation of Frequency Using External Frequency Control

One of the key specifications for an atomic frequency standard is the temperature coefficient. The X72 is designed for a low temperature coefficient without the need for temperature correction. However, in applications where the user requires a tighter temperature coefficient and a more automated temperature compensated unit was not ordered, a common practice is to monitor the baseplate temperature of the X72 and apply a correction signal via the External frequency control pin, or through the DSIP. A production calibration run is required to set the X72 temperature at several points and determine the correction summary.

This method can be successfully used for moderate correction, for example to bring the maximum frequency change over the full operating temperature range to less than 1E-10.

Compensation using this scheme is generally suitable only for steady state conditions. Inherent mismatches between the thermal time constants of the mechanisms that cause temperature coefficient errors, thermal time constant of the monitoring circuitry, and transients from time constant mismatches will show occur. These transients are minimized if temperature ramp rates are limited. Changing less than +2˚C/minute baseplate temperature should result in negligible transients from mismatches.

In addition, the X72 can be ordered with an internal temperature compensation option which achieves better temperature performance over the entire operating range.

3.6 Modifiable Unit Settings

Some features of the X72 operation are modifiable by the customer. Refer to the X72 Developer's Kit document (DK/106031) for information on how to use the DSIP interface to use these functions.

3.6.1 Hardware Selectable Items (default power up conditions cannot be altered)

FXO Enable - user can turn the XO frequency output on or off with this command.

1PPS Output Enable - user can turn 1PPS output on or off with this command.

ACMOS Output Enable - used to turn the ACMOS output on or off.

Sine Output Enable - used to turn the sine outputs on or off.

3.6.2 Software Selectable items

Analog Frequency Adjust - enables or disables frequency control function

Adjust Frequency - used to adjust output frequency from the factory preset value. Minimum frequency change is 2E-12 (or "f.2"). Values less than this are ignored. Maximum frequency charge, is not constrained. Setting the frequency outside of its operating limits may render the unit non-functional.

HELP command - displays the HELP menu

Change ACMOS output frequency - Defining "N" sets the ACMOS output frequency divider.

View Control Register - displays current settings of the control register

Set Control Register - used to enable or disable outputs.

View Unit Information - displays X72 information stored in firmware

View Health Monitor Data - displays history file of error or fault information

3.7 EMI CONSIDERATIONS

Designed to comply with applicable CE and FCC requirements when used with a shielded cable.

3.8 X72 Susceptibility to Input Noise

When a user has an application where the output spectrum phase noise and spur integrity is crucial, the X72 must be provided with comparatively clean source of dc power (free of spurious current or voltage noise). Connecting fans, heaters, and other switching devices to the dc supply powering the X72 can result in degraded phase noise and spur performance. Best performance is achieved with only one output turned on and the other frequency outputs turned off.

The Rb atomic frequency source uses a modulation/demodulation lock-in amplifier scheme with a modulation frequency of ~156 Hz. Inherent in this approach is sensitivity to noise at multiples of the modulation frequency. This noise is coupled through both the heater and electronic power lines to cause modulation spurs on the output frequency. Care should be taken to avoid the modulation frequency and its lower harmonics (roughly up to the tenth harmonic).

The X72 has an internal dc - dc converter supplying power to the critical electronics, including the crystal oscillator, which is the source for the outputs.

3.8.1 Input Filtering

If filtering is added at the input connector of the X72, it cannot have any resonance points greater than the specified impedance. This would result in peaking the potential for detrimental oscillations. The optimum filtering is as listed below:

- 10V - 32Vdc models: less than 1 ohm from dc to 100 kHz.
- 5Vdc models: less than 0.3 ohms from dc to 100 kHz.

In addition, the input operating voltage range specified for the X72 during turn-on must continue to be met during operation of the unit. For example, using a 0.3 ohm dc source resistance for the input supply line for 5Vdc units would not be appropriate since the voltage drop resulting from this resistance (caused by the turn-on current or quiescent operating current) would cause the input voltage to drop below the allowable value.

3.9 X72 Reliability and Maintenance

3.9.1 X72 Reliability

The X72 is designed with a goal of twenty years of operation without retuning. In order to accomplish this, the major mechanisms impacting the need for maintenance were addressed. Thus, each X72 has been designed to have excess rubidium fill in the lamp to last for the required period, sufficient pulling range for the voltage controlled crystal oscillator, and sufficient dynamic range of the rubidium control loop.

- **User Adjustments**

  There is no mechanical tuning that need be performed by the user. If problems arise in X72 operation, contact DATUM Irvine Customer Support for guidance.

- **User Maintenance**

  The X72 is considered to be factory serviceable only. There are no user service adjustments or maintenance required.

  A monitor signal is provided to allow the user to track indications of pending end-of-life for the unit with sufficient warning to avoid a total and sudden failure of the unit. The key indicator of health is the service indicator that indicates when the Rb physics package or onboard quartz oscillator are near their operating or control limits.

  If the LOCK does not indicate a Rb lock within the specified time or SERVICE indicates that the unit has reached the end of its effective life, the unit should be removed and returned to Datum Irvine for service. The service indicator is valid only when the LOCK signal indicates that the unit is locked.

Section 4 - X72 Operation

4.1 X72 Installation

4.1.1 Site Selection

The X72 may be mounted in any orientation. In environments that approach the operating limits of the X72, the designers should take care to ensure tht the temperature limits are not exceeded.

The X72 should not be installed in locations subjected to strong magnetic fields from transformers or large power supplies. The X72 has some sensitivity to external dc and ac magnetic fields (refer to specification). An external magnetic field under 2 gauss should not result in measureable frequency offsets for X72.

A Rb frequency standard is a very precise component and optimum practices for its use should be employed. Avoid using a power source that is also providing power to fans or equipment that generates high current pulses.

4.1.2 Turn-on Procedure

CAUTION: the X.72 has no reverse voltage protection and damage will occur if power is applied to the unit in reversed direction.

CAUTION: Check the label on the side of the unit BEFORE plugging in the cable. The 5V units and 10-32V units have the same connector and look alike and an inadvertant application of high voltage to the +5V unit will damage it.

- Verify the X.72 voltage requirement (5V or 10 to 32V).
- Verify that the power supply is set to the correct voltage and is turned off.
- Connect J1 of the X.72 to a properly terminated, shielded cable that does not have power applied. Once the unit has been properly terminated, turn on power.

Refer to Figure 4-1 for a block diagram of a suggested hook-up.

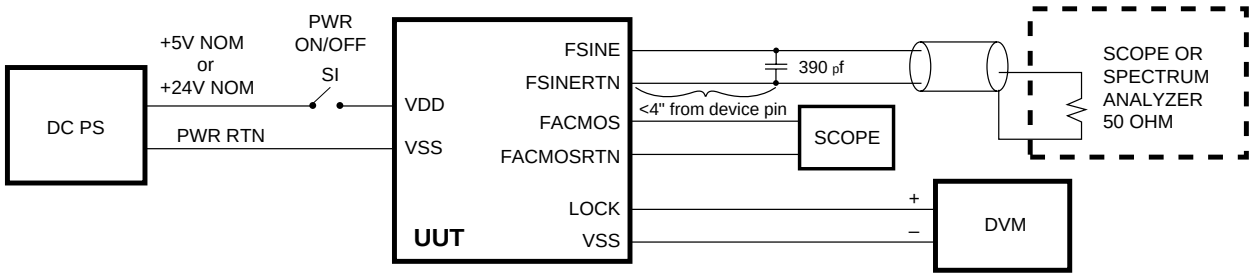


Figure 4-1. Suggested Connections for X72, Initial Turn-on.

Once the X72 is plugged in and is receiving power, wait 3 to 4 minutes while the unit achieves atomic lock. During this period, the monitored LOCK signal should be HIGH. Once the unit achieves atomic lock, the LOCK signal goes LOW.

Depending on baseplate temperature within 4 to 8 minutes the unit should be within 1E-9 of center frequency. Thirty minutes after applying power to the X72 the rf output frequency will be very close to full accuracy (refer to X72 specifications).

> **NOTE:** the output frequency of the X72 is more accurate than most counters. Appropriate measurement equipment can be obtained from DATUM. Inquire with DATUM Irvine Marketing, or your local sales representative, about Datum's line of test and measurement standards, which includes the PRFS and FMS-2001.

4.2 Start-up Sequence

When power is connected to the J1 connector the X72 unit begins its warm-up cycle.

After 4 minutes the rubidium oscillator will reach a locked condition and it's output signals will stabilize. The accuracy at shipment is <±5E-11 at 25˚C, typical..

NOTE: Signals will appear at the outputs immediately after power is applied to the unit, but these output signals will not be stable until after the oscillator has locked.

After 7.5 minutes the acuracy of the X72 oscillator will be at <1E-9.

Performance of the X72 unit will vary according to the application profile specified by the customer at time of order. Refer to the X72 product specification for information on application profiles and unit performance.

Performance of the unit can be monitored and selectively modified through the serial DSIP firmware included in the unit. Simply connect the unit to the COM port of a PC running Windows 98.

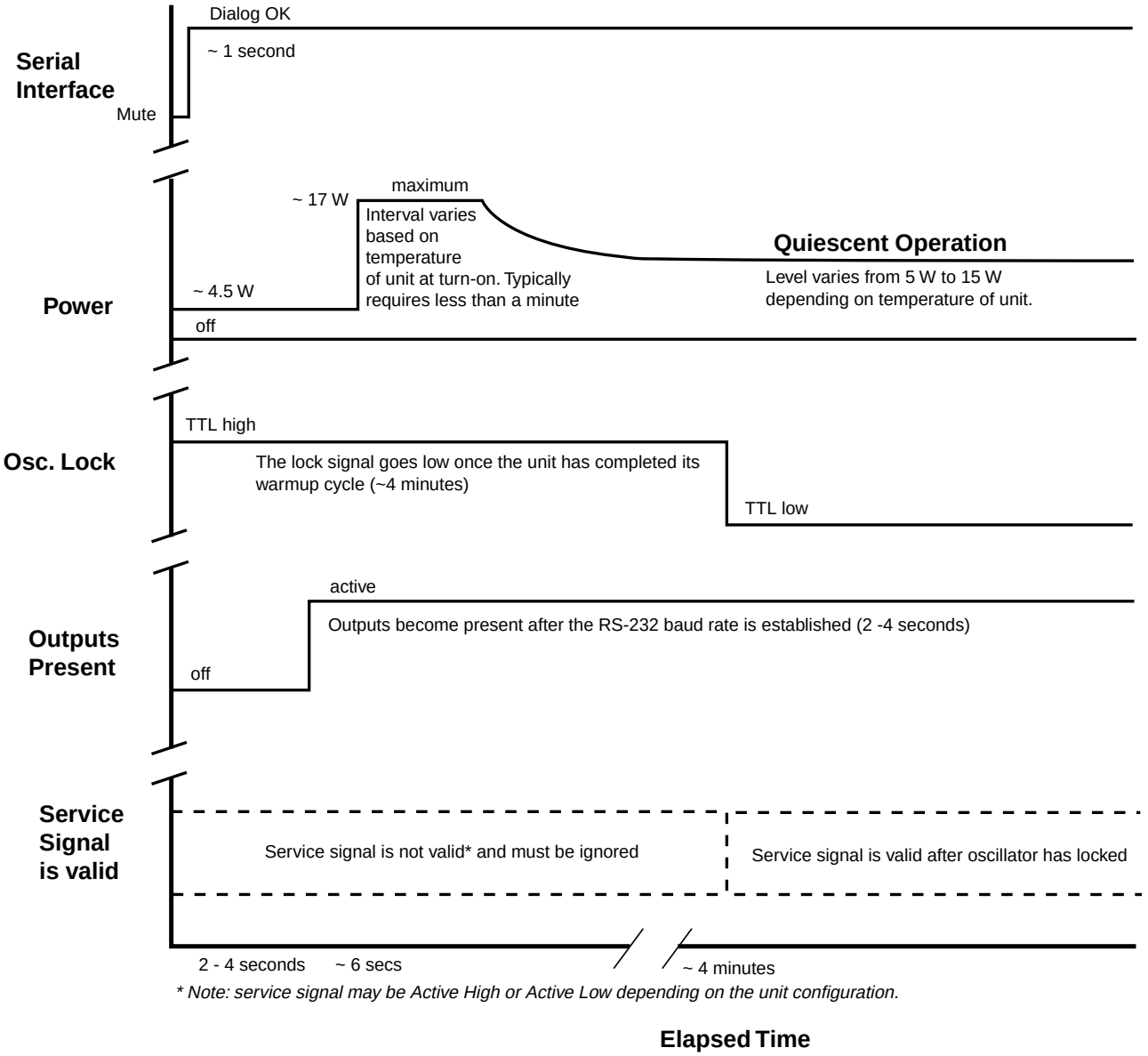


Figure 4-2. Sequence of Start-up Events

4.3 Theory of Operation

The Model X72 makes use of the atomic resonance property of rubidium (^{87}Rb) to control the frequency of a quartz crystal oscillator via a frequency-locked loop (FLL).

The FLL function block is shown in Figure 2-1. A microwave signal is derived from a voltage-controlled crystal oscillator (VCXO)and applied to the ^{87}Rb vapor within a glass cell. The light of a rubidium lamp also passes through this cell and illuminates a photo detector. When the frequency of the applied rf signal corresponds to the frequency of the ground-state hyperfine transition of the ^{87}Rb atom (an ultra-stable high-Q rubidium atomic resonance), light is absorbed, causing a change (decrease) in photo detector current (I_{PH}).

As the change in current is small, modulation techniques are required to be able to extract the desired signal out of the noise background.

The photo detector current is used to generate a control signal with phase and amplitude information, which permits continuous regulation of the VCXO frequency. The servo section converts the photo detector current into a voltage, then amplifies, demodulates, and integrates it for high dc servo loop gain.

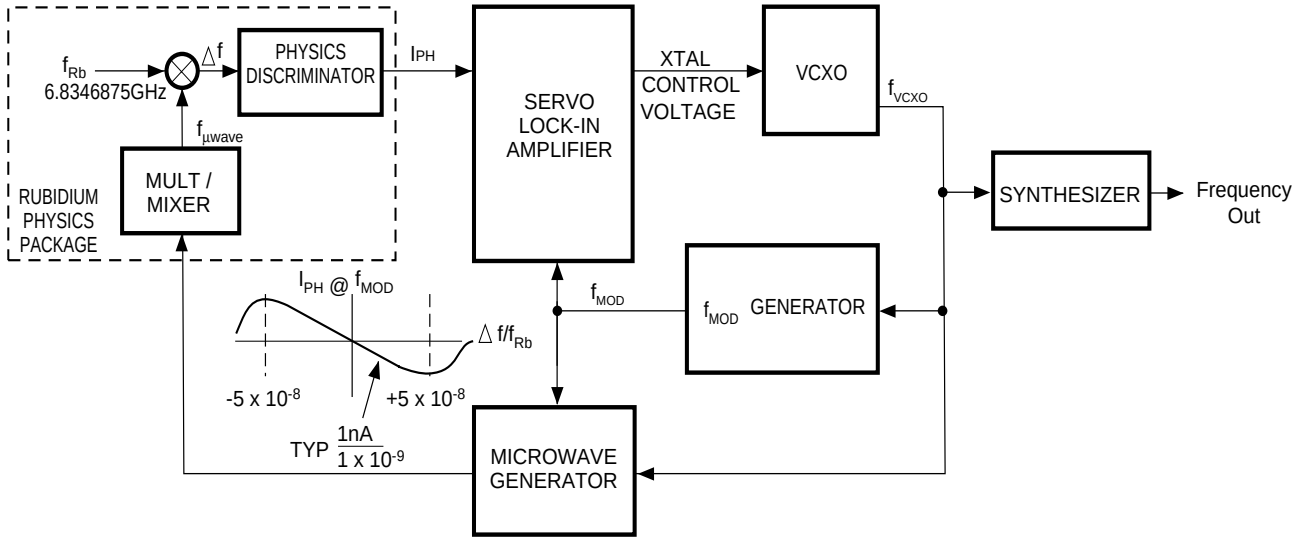


Figure 4-2. X72 Rb Control Loop Block Diagram

4.4 Troubleshooting

If, after installation the X72 unit fails to provide outputs, or the rubidium oscillator fails to achieve lock, check the following:

- •. Is the external power supply providing power?
- Is the external power supply providing the correct power?
- The interface cable may be defective - perform a continuity check.

  NOTE: all pins must have a connection in the cable's Molex connectors. This is especially important in the case of the power and ground pins.
- Is there excess humidity or moisture inside the operating area?
- Is the ambient temperature below -40˚C or above +85˚C? The unit will not startup properly in excessively cold or hot temperatures.

4.5 Maintenance

4.5.1 Repairs

The X72 is not field repairable, but some firmware upgrades can be done in the field, as noted in Section 2.4.. If the unit should fail, do not remove the cover of the unit and attempt to make repairs.

NOTE: Unit warranty is voided if cover is removed or the protective seals covering the two tuning and adjustment holes are torn or removed.

If the unit no longer operates properly, or has reached the end of its' effective life, call DATUM for the return procedure from the Customer Support Group before returning the unit to DATUM.

Send to:

Customer Support
DATUM Irvine
9975 Toledo Way,
Irvine, CA 92718-1819

Telephone (949) 598-7600
Fax: (949) 598-7876 (to obtain return procedures from Customer Support)
Fax: (949) 598-7650 (Marketing)
Fax: (949) 598-7651 (Marketing)
E-mail: custservice@datum.com

Or access the DATUM web site (http://www.datum.com), go to Datum Irvine, Support. Type your question or comment into the comment field and hit SEND.

4.5.2 X72 Warranty

Datum warrants the X72 Electronics for 1 year, and the Rb lamp bulb & resonator cell for 20 years. Datum also warrants that at the time of shipment the X72 will be free from defects in materials furnished and workmanship performed by the Datum. This warranty and Datum's liability are limited to either granting credit or repairing or replacing, at seller's option, with reasonable promptness after return to Datum of any article that is disclosed to Datum's satisfaction to be defective, and only if said article is returned to the Datum promptly after discovery of such defect and in no event later than ***12 months*** (or such other time period as may be specified in writing as a warranty period for a particular article) from the date of delivery thereof. Normal transportation charges in connection with an article returned shall be at the Datum's expense, but only if the Datum is responsible under the terms of this warranty. This warranty does not extend to any article which has been subject to misuse, neglect, or accident, nor does it extend to any article which has been repaired or altered by other than the seller, or operated outside the published maximum temperature ratings.

THIS WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES EXPRESSED OR IMPLIED, INCLUDING ANY WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE AND THE RIGHTS AND REMEDIES PROVIDED HEREIN ARE EXCLUSIVE AND IN LIEU OF ANY OTHER RIGHTS OR REMEDIES. IN NO EVENT SHALL SELLER BE LIABLE FOR CONSEQUENTIAL DAMAGES."

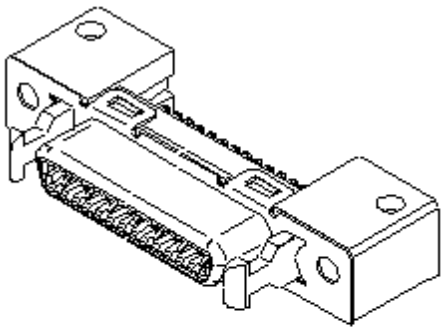
APPENDIX A

X72 J1 Connector and Plug

molex

2D Drawing
Order Numbers

I/O Connector 1.00mm (.039") Pitch Shielded Receptacle Right Angle, SMT 52629



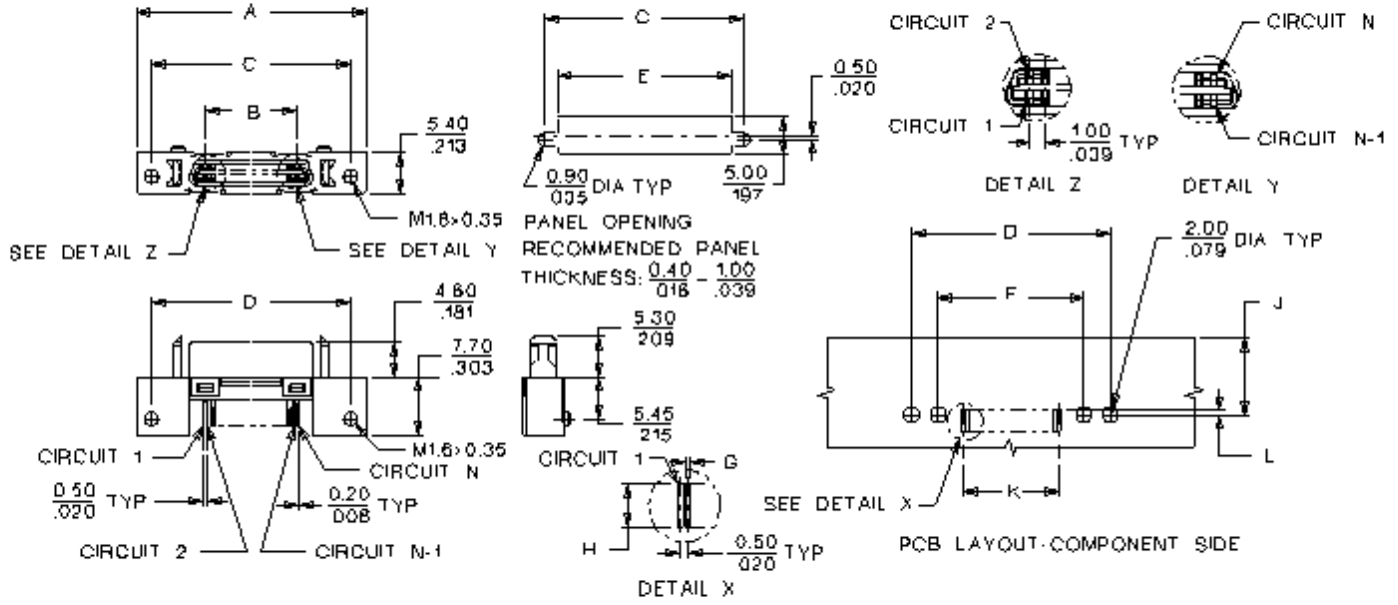


Figure A1: Molex Conector

Ordering Information Top

Circuits	Order No.	Dimension mm (inches)										
		A	B	C	D	E	F	G	H	J	K	L
10	52629-1051	**24.40** (.961)	**4.00** (.157)	**18.00** (.709)	**18.00** (.709)	**14.70** (.579)	**11.00** (.433)	**0.30** (.012)	**2.10** (.083)	**5.45** (.215)	**4.50** (.177)	**0.10** (.004)
26	52629-2651	**30.00** (1.181)	**12.00** (.472)	**26.00** (1.024)	**26.00** (1.024)	**22.70** (.894)	**19.00** (.748)	**0.35** (.014)	**2.80** (.110)	**5.45** (.215)	**12.50** (.492)	**0.55** (.022)

Note:
- Contact Inside Sales for lower profile version in additional circuit sizes
- 52629-**2651** shown in above drawing

MOLEX 52660 Plug Assembly

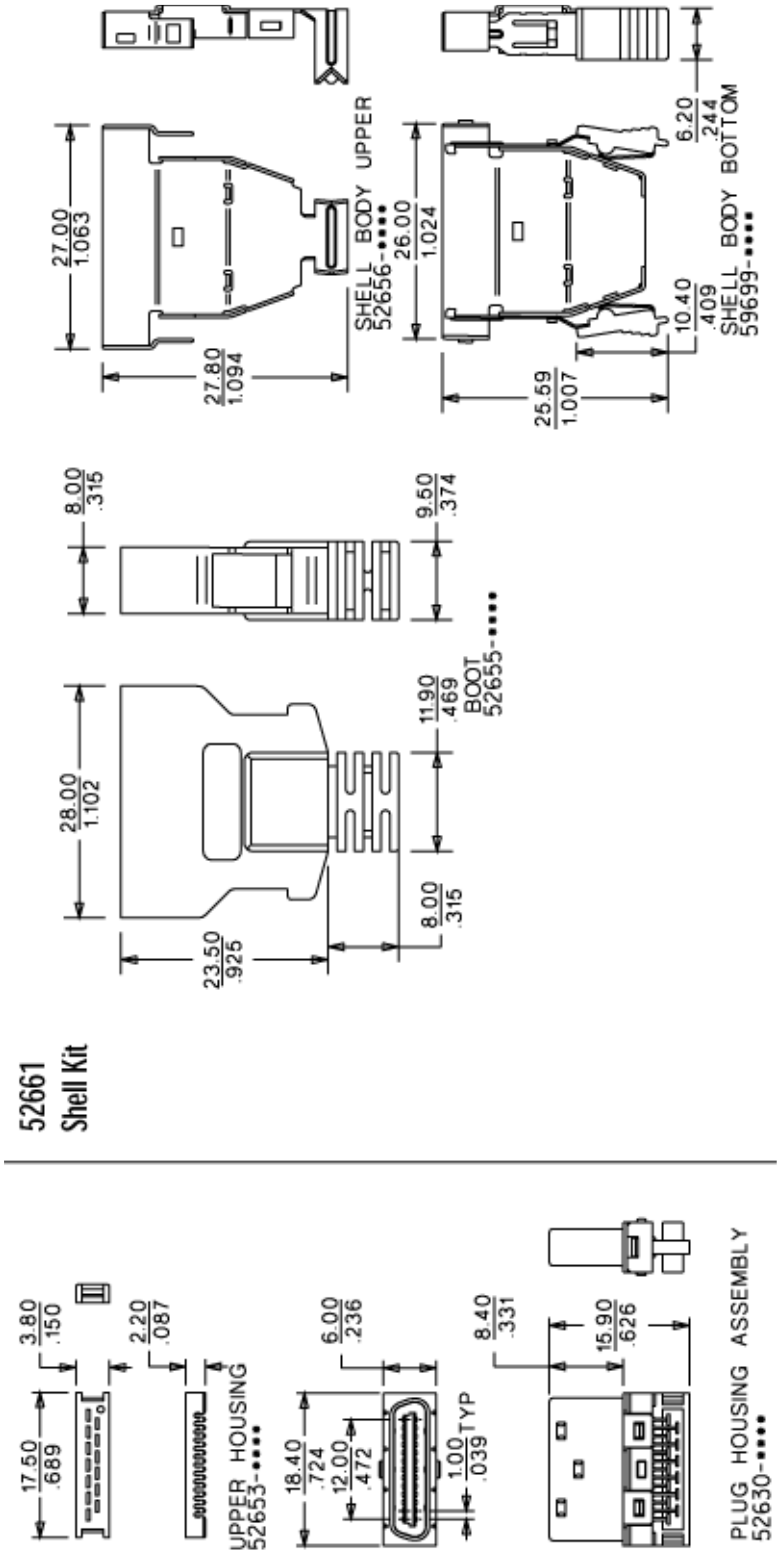


Figure A2: Molex Conector Plug Assembly

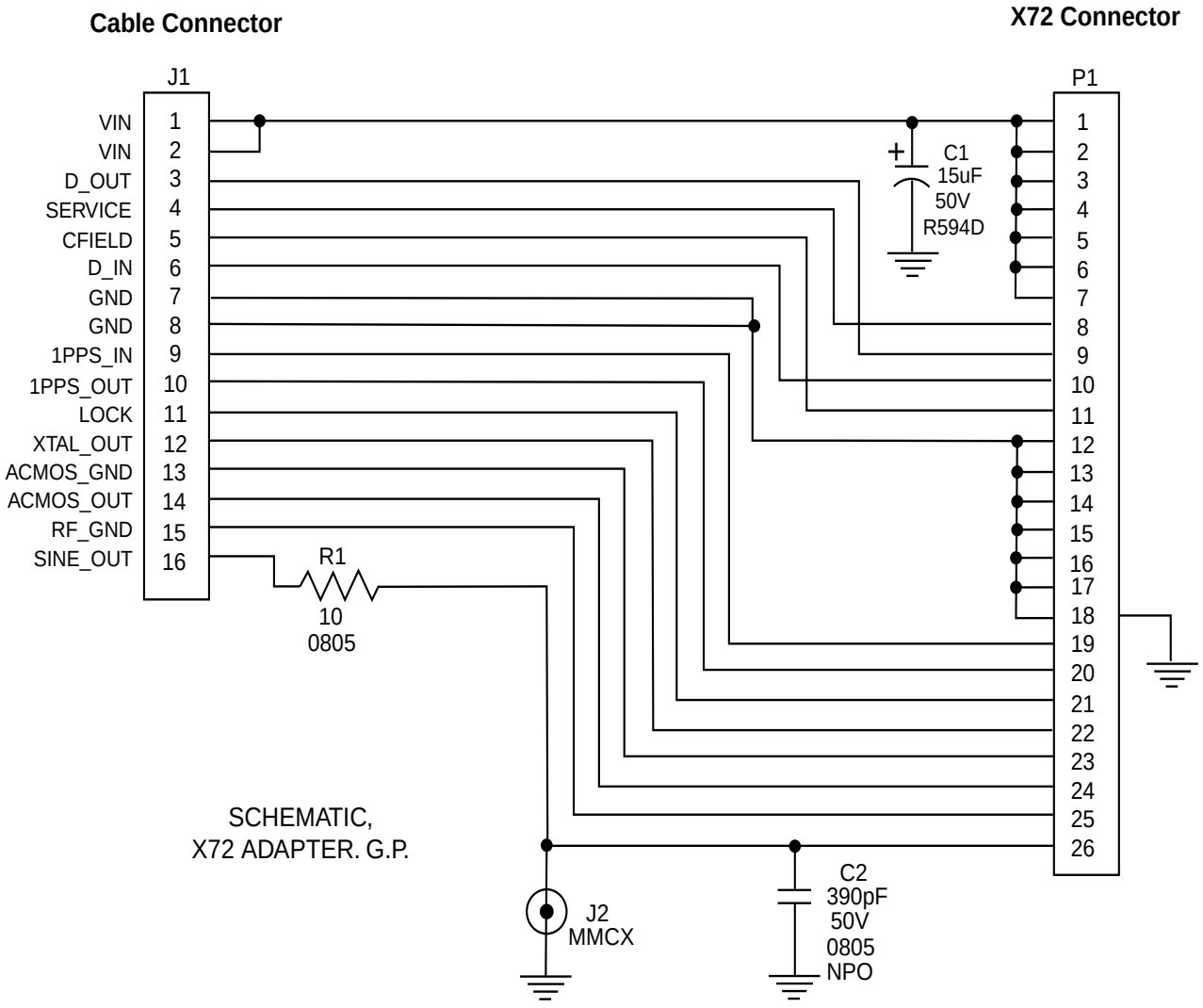


Figure A-3: X72 Edge Board Pinout Comparison

WIRING CHART	
P1	P2
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9
10	10
11	11
12	12
13	13
14	14
15	15
16	16
17	17
18	18
19	19
20	20
21	21
22	22
23	23
24	24
25	25
26	26

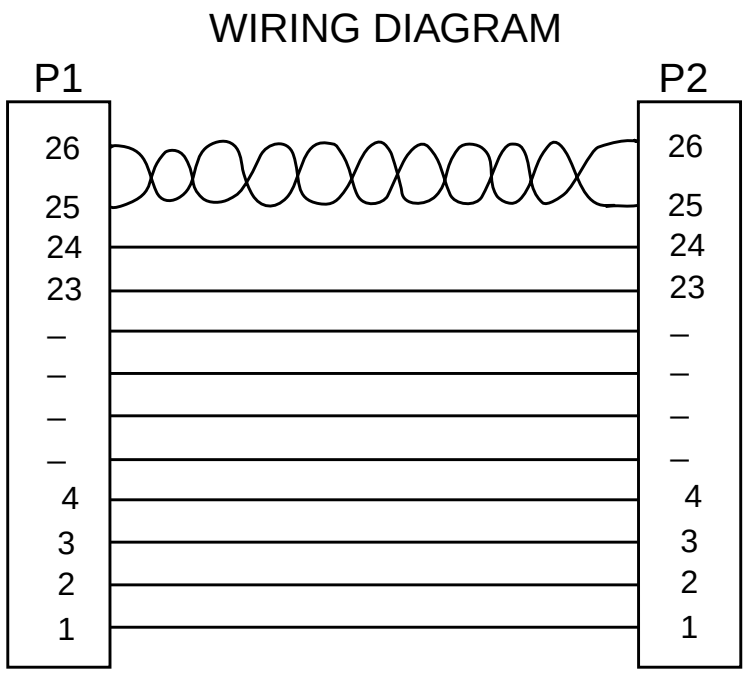
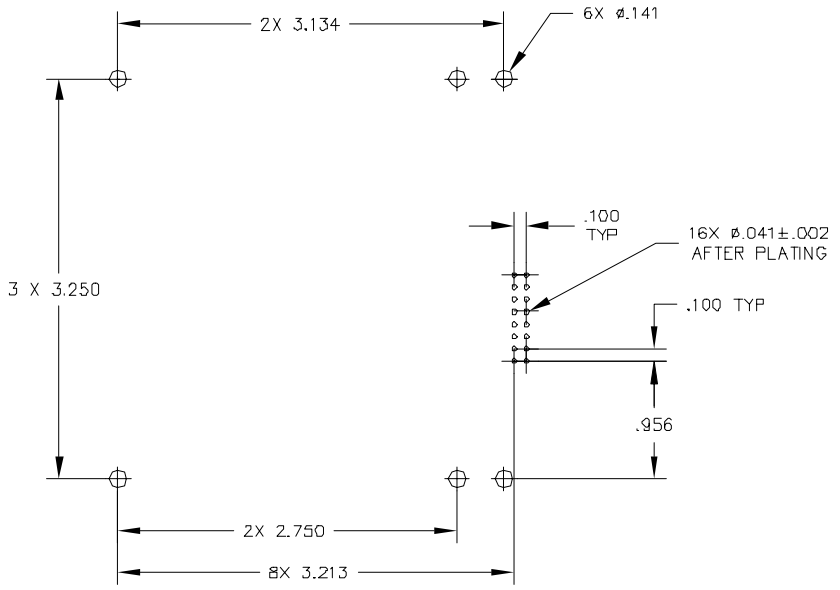


Figure A-4: X72 3.25" Interface Cable Connections



SUGGESTED PCB LAYOUT

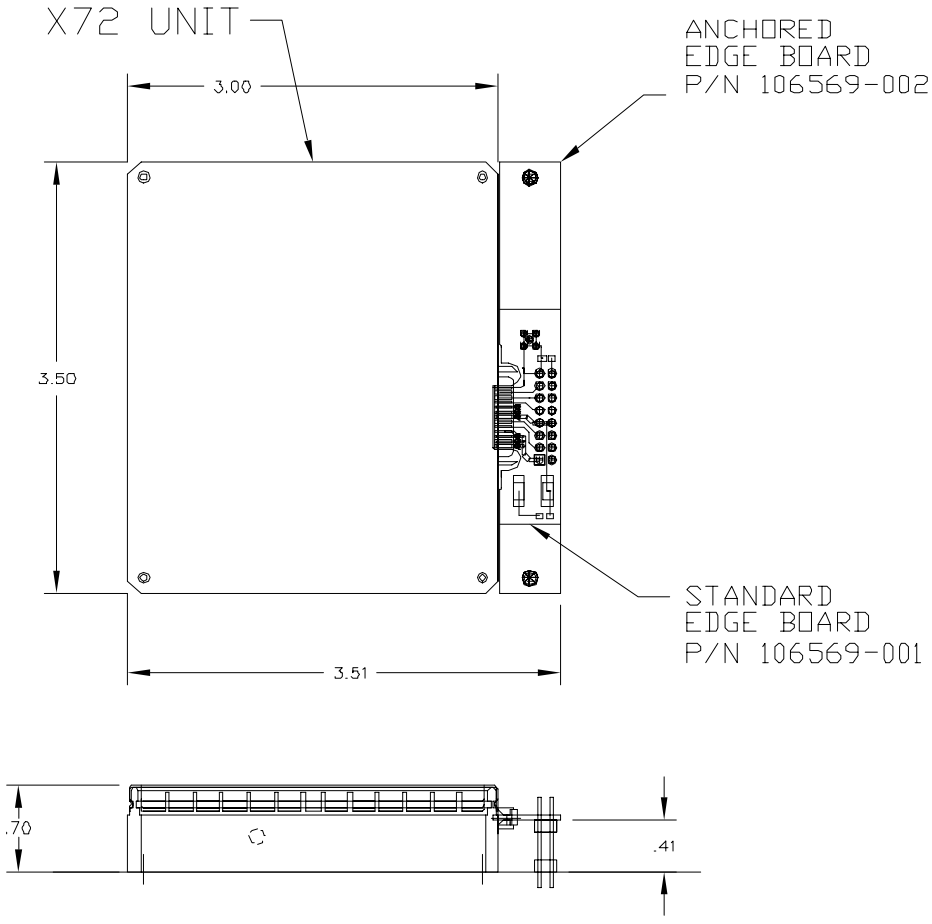


Figure A-5: X72 Layout Drawing for Edge Boards

APPENDIX B

Using the Datum Serial Interface Protocol

Table of Contents

1.0 Using the Datum Serial Interface Protocol

The Datum Serial Interface Protocol (DSIP) permits external communication with the X72 through the serial port included in the J1 connector when the unit is connected to a host PC. All “developer-mode” commands are single letter in format. Of the eight RUN MODE commands three require the host to supply data.

1.1 Host Terminal Emulator Setup

Set up the comm port of the PC with the following configuration:

- Data rate (baud or B.P.S. - see note below)
- No parity
- 8 data bits
- 1 stop bit
- No local echo (unit echoes)
- No hardware or software flow control

All DSIP commands are a single ASCII letter and require no termination. The baud rateof the X72 is 57.6K

NOTE: the X72’s UART connections are based on 5Vdc logic levels. However, the Developer’s Kit contains a TTL-to-RS232 converter that allows interfacing to a PC.

1.2 Data Format

1.2.1 Run Mode Data Format (Customer Mode)

X72 outputs are all decimal DATA as “ASCII Coded Hex” except for echoed chracters. The following example shows how data are encoded. Do not convert data to decimal when transmitting to the X72. All data are sent to the X72 and received back as “ASCII Coded Hex”. The following example shows how data are encoded.

NOTE: flow control is not permitted in “Run Mode”.

Data sent to the X72 in run mode should not be encoded.

Example of output from unit.

Example 1 (actual unit output)

Example of output from X72 after power applied to the unit.

```
X72 by Datum, Inc., Copyright 2001
      SDCP Version 3.75 of 3/2001; Loader Version 2
      Mode CNN1  Flag 0004 [822F]ok

Unit serial code is 0009AB001B-h, current tuning state is 6
Crystal: 60000000hz, ACMOS: 10000000.0hz, Sine: 10000000.0hz
Ctl Reg: 029C, Res temp off: -1.5410, Lamp Temp off: -2.1142 FC: Enabled
Srvc: high

Enter Run Mode
FC Mode is enabled
f>
```

The following print out is an example of the response one gets by entering the letter “i” to get serial number and other facts of “*information*” on the X72:

```
r>i


X 7 2   by Datum, Inc., Copyright 2001
   SDCP Version 3.75 of 3/2001; Loader Version 2
   Mode CNN1  Flag 0004

Unit serial code is 0009AB0018-h, current tuning state is 6
Crystal: 3938700hz, ACMOS: 989680.00000000hz, Sine: 989680.00000000hz
Ctl Reg: 029C, Res temp off: BFC53F7D, lamp temp. off: c0074FOE,
FC: enabled, Srvc: low
```

The following print out is an example of entering the letter “h” to get the “*help menu*” from the X72:

```
r>h
a: Set FC Mode
f: Adjust DDS Frequency (delta e-11)
i: Info (show program info)
j: Display 1pps Delta Reg
k: Set 1pps TIC
l: Set Service Pin Sense
o: Set ACMOS Output Frequency 'N'
p: Display Control Reg
q: Set Control Reg
t: Dave Tuning Data
w: Display Health Data
x: Exit Run Mode
r>
```

The following print out shows the response to the command for “w” for X72 “*Health Data*” (wellness):

```
r>w

AData:
  SCont: 6012
  SerNum: 18C
  PwrHrs: 18A
  PwrTicks: 11A6848
  LHHrs: 17E
  LHTicks: 83DBD0
  RHHrs: 17E
  RHTicks: 83D2E3
  dMP17: 41883621
  dMP5: 40A158E9
  dHtrVolt: 41381AF5
  PLmp: 3FAA43C6
  PRes: 3FA10F45
  dLVthermC: 39500000
  dRVthermC: B9DD8000
  dLVolt: 3F327288
  dMVoutC: 494005E0
  dTempLo: 00000000
  dTempHi: 42928000
  dVoltLo: 4134DC6A
  dVoltHi: 41C1CA16
  iFpgaCtl: 029E
  dCurTemp: 42690000
  dLVoutC: 3E25B538
  dRVoutC: 3E19A67E
  dmv2 demAvg: 3F337D72
```

The following print out shows how entering the letter “a” followed by an integer sets the “*enable/disable*” feature of FC mode. Integer zero followed by <cr> disables FC mode and any nonzero integer followed by <cr> enables the FC mode.

```
r>a
<nonzero integer-><cr>
FC mode enabled
r>a
o<cr>
FC mode disabled
```

The following print out shows the “*control register*” contents by entering the letter “p”:

```
r>p
Control Reg: 029E
```

1.2.2 Factory Mode

Data output from the X72 in factory mode is not intended for user outside the factory and is not described in this document beyond Table 1-4.

CAUTION: use of factory mode could result in the erasure of firmware on the X72, rendering it inoperable, making it necessary to return it to the factory for re-programming.

1.2.3 Floating Point Number Representation

The host PC must convert Floating Point numbers output by the X72 to the host's own floating point using the definition shown in Table 1-2. Likewise, the host's floating point numbers must be converted to X72 coding before being sent to the X72.

Table B-1. Floating Point Number Representation for DSIP

Floating Point Format - Single Precision

31 S	30 E7	29 E6	28 E5	27 E4	26 E3	25 E2	24 E1	23 E0	22 M22	21 M21	20 M20	19 M19	18 M18	17 M17	16 M16
15 M15	14 M14	13 M13	12 M12	11 M11	10 M10	9 M9	8 M8	7 M7	6 M6	5 M5	4 M4	3 M3	2 M2	1 M1	0 M0

Single precision floating point format is a 32-bit format, consisting of a 1-bit sign field, an 8 bit exponent field, and a 23-bit mantissa field. The fields are defined as follows:

Sign <S>: 0 = positive values; 1 = negative value

Exponent <E7-E0>: offset binary format

00 = special cases (i.e. zero)
01 = exponent value + 127 = -126
FE = exponent value + 127 = +127
FF = special cases (not implemented)

Mantissa <M22-M0>: fractional magnitude format with implied 1

1.M22M21. . . M1M0
Range: -1.9999998 e+127 to -1.0000000 e-126
+1.0000000 e-126 to +1.9999998 e+127
(where e represents 2 to the power of)

The serial interface is initialized as follows:

Table B-2 defines the X72's Run Mode Commands.

Table B-3 defines the bit functions of the factory mode commands of the X72.

Table B-4 defines the administrative mode commands.

Table B-5 defines the bit functions and controlling agent of the output control register of the X72.

Table B-2. X72 Run Mode Commands

USER OUTPUT TO X72		RESPONSE TO HOST	NAME & DESCRIPTION OF COMMAND
Command	DATA		
a	Set FC mode Example: a <zero or non zero integer> <cr>	*To be Specified*	Set Analog Frequency Control Mode This command toggles the analog input pin to the unit 'Freq Cntl' between enable and disable. In Factory mode the default is enabled. During factory test the default is set to disable for shipping unless the customer ordered the default to be set enabled.
f	Desired frequency change from free running center frequency in parts to E-11 Example: for a +100E-11 change: "100<cr>" Example: for a –100E-11 change: "-100<cr>"	*To be Specified*	Adjust Frequency Adjust Unit output frequency. Used to discipline the unit. The smallest incremental frequency change is 2E-12 (or "f.2"). Any value less than this will still be used. No illegal values. Unit always powers up at free running factoryset frequency. This command is always relative to the free running frequency.
h	None	*To be Specified*	HELP command Displays menu.
i	None	*To be Specified*	Outputs Unit information. While dumping data, Clock outputs are not guaranteed to meet specifications during the use of this command.
o	N (example of command and data to give 10MHz for a VCXO of 60MHz is: "o3".	*To be Specified*	Loads the value of N to set the ACMOS output frequency. N is 1 to 65536. Output FACMOS is equal to crystal frequency divided by 2N. For values outside range, unit sends an illegal notice. E uses the previous valid setting.
p	None	*To be Specified*	Displays Control Register (See Table 3).
q	Hex data to set or reset bits in the Control Register immediately follows the command (example "q3A")	*To be Specified*	Set Control Register. Allows enabling or disabling of outputs. See Table 3.
w	None	*To be Specified*	Displays Health Monitor data

Table B-3. X72 Factory ModeCommands

USER OUTPUT TO X72		RESPONSE TO HOST	NAME & DESCRIPTION OF COMMAND
Command	DATA		
a	None	*a>*	Goes to Administration mode
i	None	Outputs 6 lines of Banner (same as power-up information)	Displays Unit Information
r	Run Mode	Enter RUN mode. FC mode is disabled (enabled)	Goes to RUN mode

NOTE: This mode and ADMIN mode allow the loading of new code or updates, or reconfiguring defaults in the field. It is not a normal operating mode.

Table B-4. X72 Administrative Mode Commands

USER OUTPUT TO X72		RESPONSE TO HOST	NAME & DESCRIPTION OF COMMAND
Command	DATA		
a	None	Outputs 6 lines of banner - same as power-up	Unit Information Same as the "i" command in FACTORY mode and RUN mode.
b	"File" from Datum (self-burning)	*To be Specified*	Operating this command without valid "file" will not overwrite the existing data stored in FLASH memory.
x	None	x f>	EXIT Administrative mode to FACTORY mode
y	None	Y asks "are you sure?"	Soft reset. Restarts processor.
z	None	Z asks "are you sure?"	Puts unit into a mode where it will wake only when the power is recycled.

NOTE: ADMIN mode allows the loading of new code or updates, or reconfiguring defaults in the field. It is not a normal operating mode.

The output control status register (OSR) bit structure, control features and controlling factors are defined as shown below.

Table B-B. X72 Output Control Status Register Structure

Bit #	Control	Description	Controller
0. *	Lamp Switch Power Boost – internal unit function	0 = Lamp Switch off 1 = Lamp Switch is on	Controlled by firmware – Automated Function
1. *	BIST Output	0 = Unit is locked 1 = Unit is not locked	Controlled by firmware – Automated Function
2.	FXO Enable	0 = Enable FXO output 1 = Disable FXO output	Default is set at Factory per Configuration file that matches customer's selection – Host can alter during operation, however, host cannot alter the default power up condition.
3.	1PPS Output Enable	0 = Enables 1PPS Output 1 = Disables 1PPS Output	Default is set at Factory per Configuration file that matches customer's selection – Host can alter during operation, however, host cannot alter the default power up condition.
4.	ACMOS Output Enable	0 = Enable Output 1 = Disables Output	Default is set at Factory per Configuration file that matches customer's selection – Host can alter during operation, however, host cannot alter the default power up condition.
5. *	C-field Boost	0 = Low C-field 1 = High C-field	Controlled by firmware - an automated function.
6.	SINE Output Enable	0 = Enables Output to 40% of max output 1 = Disables Output	Default is set at Factory per Configuration file that matches customer's selection – Host can disable SINE output, however, host cannot alter the default power up condition. Note – if a SINE filter is not installed then SINE enable will not provide an output.
7. *	SINE Output Level Adjust 1	0 = Zero Level 1 = Adds 30% of max Output	Controlled by firmware - set at factory.
8. *	SINE Output Level Adjust 2	0 = Zero Level 1 = Adds 20% of max Output	Controlled by firmware - set at factory.
9. *	SINE Output Level Adjust 3	0 = Zero Level 1 = Adds 10% of max Output	Controlled by firmware - set at factory.
10.*	SERVICE	0 = Unit is OK 1 = Unit requires Service	Controlled by firmware - Automated Function.
11 - 15.	Reserved - Not Used.		

* When altering the Control Register these bits are masked out by firmware, the Host will consider these bits as "DON'T CARE".

APPENDIX C

Using the X72 Developer's Kit

Table of Contents

X72 Developer's Kit

1.0 Introduction

The X72 Developer's Kit is provided by Datum as a design aid and development tool. It permits a design engineer to experiment with Datum's X72 product in various applications and determine how to implement it in the most advantageous manner.

The developer's kit contains a hardcopy of this document, the X72 unit, a 3' interface cable, the adapter board assembly, application notes, and a CD with electronic files documenting the specifications and performance of the unit. A 90-264 Vac universal power supply with an IEC connector* is optional and can be specified at time of order.

Mounting the X72 unit:

The X72 is designed to mount flush onto a heat absorbing surface using the four mounting holes. If during demonstration testing such a surface is not available, a suitable heat sink can be ordered as an option.

NOTE: The mounting screws for the X72 are metric (not SAE) and are 3 mm in size with 0.5 mm thread pitch. They should penetrate no more than 5.0 mm into the X72 baseplate.

Interface cabling/circuit cards:

The X72 cable is a shielded multi-conductor (26 wires) cable, 3 feet long with molex connectors at each end. Adapter cards are available in 3.5 inch and 1.740 inch lengths. A 3.25" cable is also available.

Connectors:

The unit Molex connector is a 52629-2651, 1.00 mm (.039") pitch, shielded receptacle right angle, SMT connector. The mating connector is a Molex 52660 plug assembly.

Power: ***NOTE: The X72 provided in the Developer's Kit operates on 10 to 32 Vdc.***

The X72 unit included in the kit is configured at the factory to operate at 10 to 32 Vdc; a 5V version of the X72 is also available (jumpers on the Developer's Kit board must be added - refer to Figure 1-5). If the X72 is used without the adapter board a 50 ohm load is required and a 390 pf filter capacitor is recommended to prevent spurs. Additional information on power requirements and precautions can be found in *Section 3.5: Electrical Interfaces* of the Designer's Reference document.

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*Users must supply a power cable to connect the adapter board to main power. Users may provide their own +12 Vdc source as long as proper polarity is observed.

Using the Datum Serial Interface protocol (DSIP):

Setting up and interacting with the X72 unit using DSIP is covered in *Appendix B. Using the DSIP protocol*.

2.0 Turn-on Procedure

CAUTION: The X72 has no reverse voltage protection and damage will occur if power is applied to the unit in reversed direction.

CAUTION: Check the label on the side of the unit BEFORE plugging in the cable. 5V and 10-32V units have the same connector and look alike; inadvertant application of high voltage to a +5V unit will damage it.

- Verify that the X72 is mounted to the heat sink supplied or to a customer supplied heat sink device.
- Verify the X72 voltage option (5V or 10-32Vdc), if a different power supply is used from what is supplied with the kit. The Developer's Kit supports only the 10-32Vdc version unless board jumpers are modified (refer to Figure 1-5).
- Verify that the power supply is set to the correct voltage (if adjustable) and is unplugged.
- Connect the X72 to a properly terminated, shielded cable that does not have power applied. Once the unit has been properly terminated, plug in the cable to the power supply.

Figure 1-1 shows a block diagram of the suggested test X72 set-up.

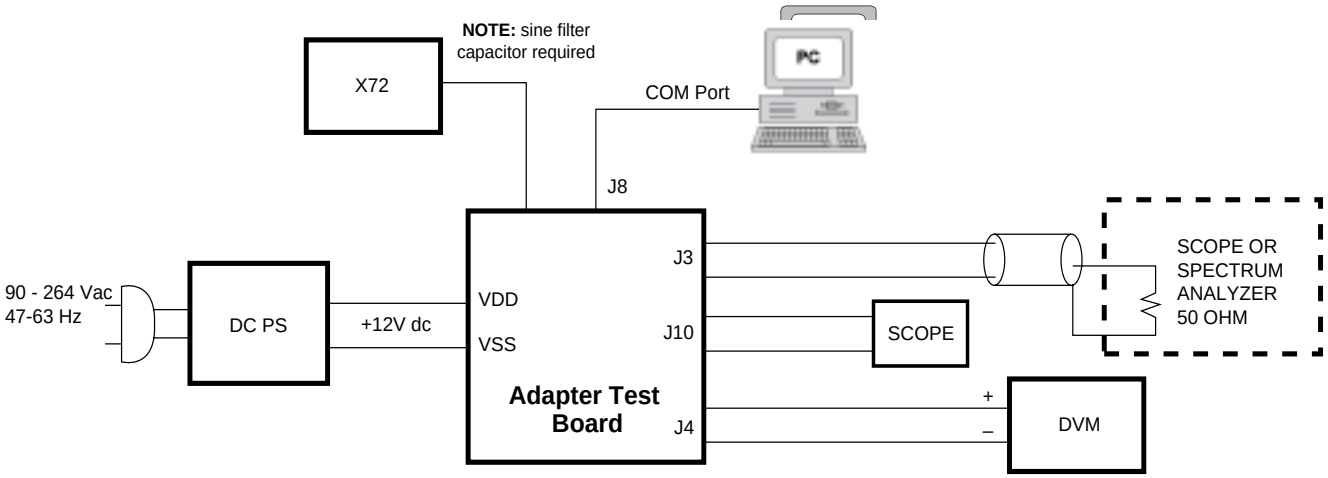


Figure 1-1. Suggested Connections for X72, Initial Turn-on.

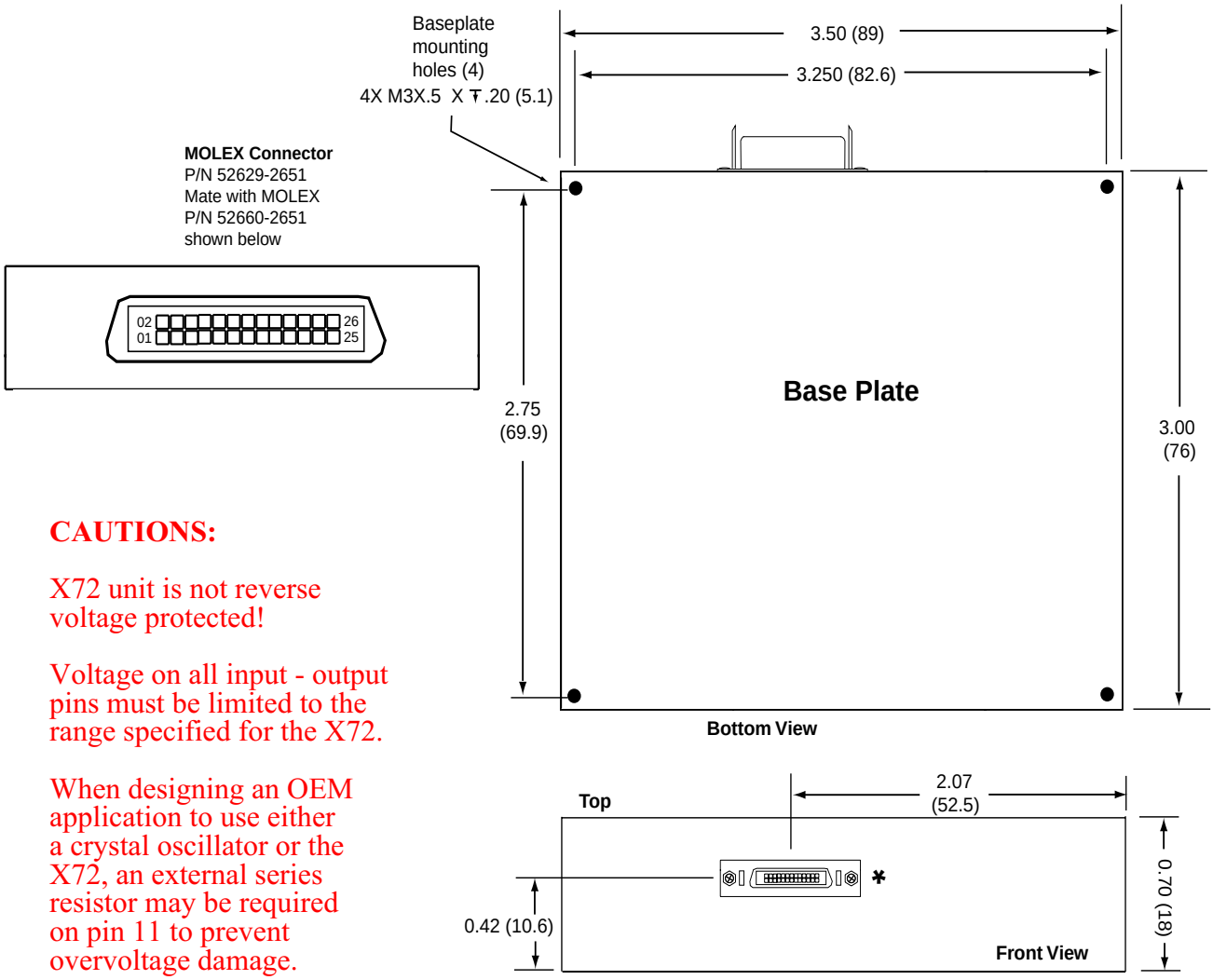
Once The X72 is plugged in and receiving power, wait 3 to 4 minutes while the unit achieves atomic lock. During this period, the monitored LOCK signal should be HIGH. Once the unit achieves atomic lock, the LOCK signal goes LOW.

Depending on baseplate temperature, within 4 to 8 minutes the unit should be within 1E-9 of center frequency. Thirty minutes after applying power to the X72 the rf output frequency will be very close to full accuracy (refer to X72 specifications).

> **NOTE:** the output frequency of the X72 is more accuracte than most counters. Appropriate measurement equipment can be obtained from Datum. Inquire with Datum Irvine Marketing, or your local sales representative, about Datum's line of test and measurement standards, which includes the PRFS portable rubidium frequency standard and the FMS-2000 frequency measurement system.

Figure 1-2 is a top view of the X72 case. Figure 1-3 is a diagram of the baseplate showing mounting holes. Table 1-1 provides signal information for the J1 connector.

Figure 1-2. Top View of X72 Case



CAUTIONS:

X72 unit is not reverse voltage protected!

Voltage on all input - output pins must be limited to the range specified for the X72.

When designing an OEM application to use either a crystal oscillator or the X72, an external series resistor may be required on pin 11 to prevent overvoltage damage.

Figure 1-3. Outline Drawing, X72 unit

Table 1-1. J1 Connector Interface

PIN#	SIGNAL NAME	TYPE**	SIGNAL FUNCTION
1 - 7	VDD (bundled)	PWR	+Power input
8	SERVICE	Output	Service required within 30 days based on unit health
9	DOUT	Output	UART data out ACMOS logic level
10	DIN	Input	UART data in to oscillator
11	FREQ CTRL	Analog	Frequency control - analog input between 0 - 5 Vdc
12 - 18	VSS (bundled)	GND	-Power & signal return
19	1 PPS IN	Input	1 PPS input, positive edge triggered
20	1 PPS OUT	Output	1 PPS output, may be enabled/disabled digitally
21	LOCK	Output	If low, indicates Rb osc. is locked
22	FXO	Output*	(FXO) ACMOS output equalling the VCXO frequency
23	FACMOS RTN	GND	Return for FACMOS & FXO signals
24	FACMOS OUT	Output	(FACMOS) ACMOS output equalling VCXO frequency
25	FSINE RTN	GND	Chassis ground - return signal for FSINE signal
26	FSINE OUT	Output	(FSINE) Sine output option - equals VCXO frequency divided by 2xM (M is set at the factory)

* High impedance ** All inputs and outputs are ESD protected

NOTE: Refer to Appendix A for the listed connector manufacturer's specification sheets.

3.0 Start-up Sequence

The accuracy at shipment is <±5E-11 at 25˚C, typical when power has been connected for the proper amount of time.

After 4 minutes the rubidium oscillator will reach a locked condition and it's output signals will stabilize.

NOTE: Signals will appear at the outputs immediately after power is applied to the unit, but these output signals will swing up to ±2E-6 until after the oscillator has locked.

After 7.5 minutes the acuracy of the X72 oscillator will be at <1E-9.

Aging and temperature coefficient performance of the X72 unit will vary according to the application profile specified by the customer at time of order. Refer to the X72 product specification for information on application profiles and unit performance.

Performance of the unit can be monitored and certain parameters can be selectively modified through the serial DSIP firmware included in the unit. Simply connect the unit to the COM port of a PC running Windows 95, or later versions. There are several software packages available for this purpose, such as Procomm Plus by Symantec or Windows HyperTerminal. The X72 communications interface is described in the following section.

5.0 The Datum X72 Development Kit Hardware

5.1 Test Adapter Board and Edge Adapter Cards

The X72 Development Kit is provided for easy lab setup to evaluate the performance and characteristics of the X72 product.

The development kit consists of an interface test board with connectors, a heat sink, a 3.25 inch cable, a 3 foot interface cable and product documentation. An optional power supply can be ordered. The output (or input) of each connector is identified on the board. A photo of the interface board is shown below.

NOTE: *10 - 32 Vdc is the recommended method of operation*

To use the DSIP firmware of the X72, connect the serial port of the interface test board to a host PC com port (this cable is supplied by the customer). Refer to Section 4.0 for information on DSIP commands and responses.

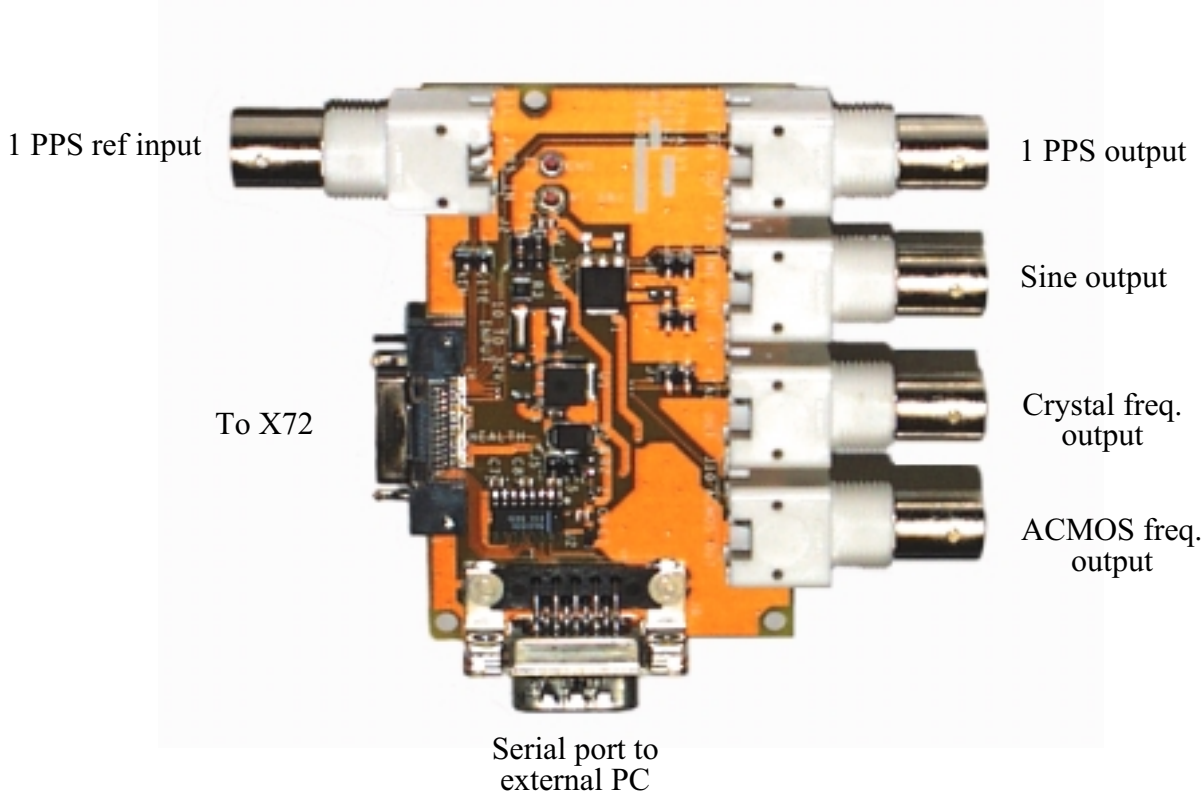


Figure 1-4. Top View of X72 Test Interface Board

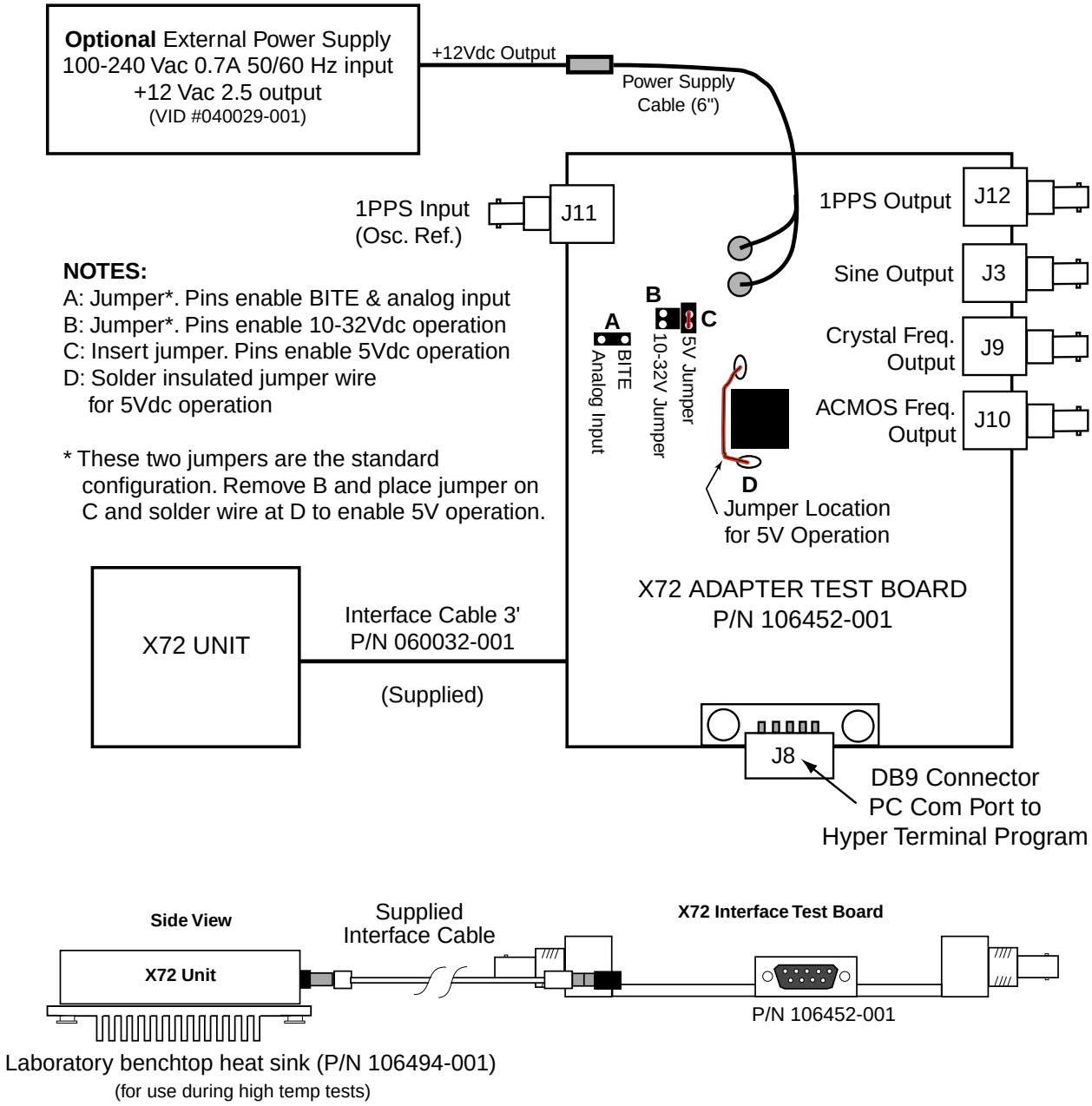
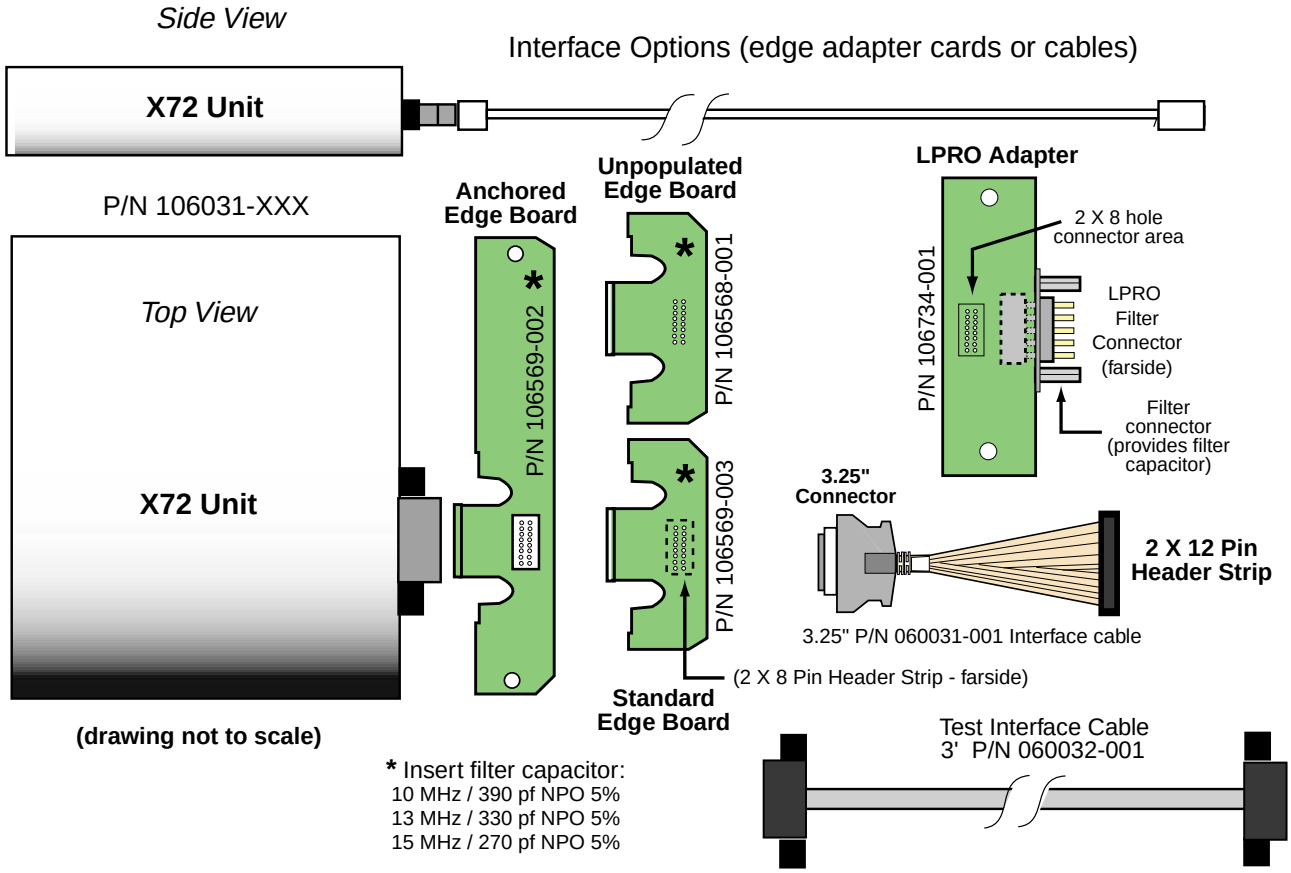
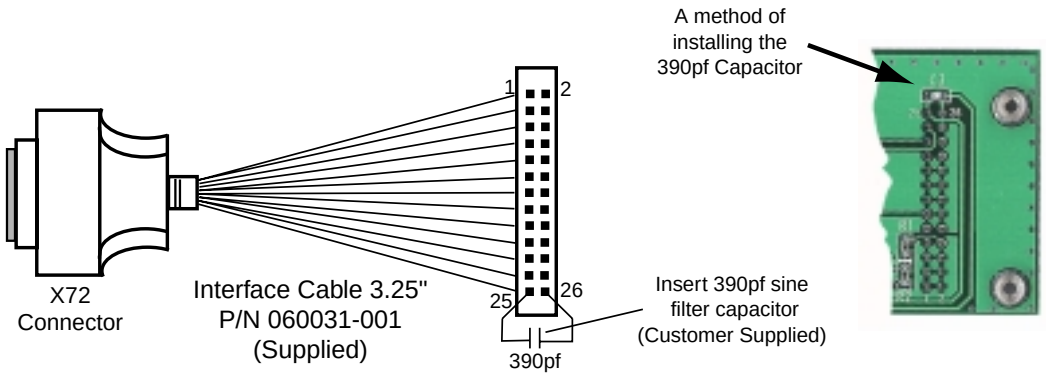


Figure 1-5. Developer's Kit (P/N 106495-001) Interconnect Diagram





For tests involving measurements of the Spur and Sine Amplitude Output, the Datum supplied 3.25" cable must be used with a customer supplied 390pf Capacitor for optimization of the signal. The capacitor must be connected as shown in the diagram above. ***This capacitor is not required for the 3' cable.***

Figure 1-6. X72 Interface Options