



*PRECISION RUBIDIUM OSCILLATOR*

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## Developer's Kit



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# 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, the Designer's Reference manual, 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 is provided in the demonstration kit.

**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. The adapter cards are available in 3.5 inch and 1.740 inch lengths.

### **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 to the main. Users may provide their own +12 Vdc source as long as proper polarity is observed.

## X72 Rubidium Oscillator

### Using the Datum Serial Interface protocol (DSIP):

Setting up and interacting with the X72 unit using DSIP is covered in *Section 1.4. Using the DSIP protocol* of the Developer's Kit document.

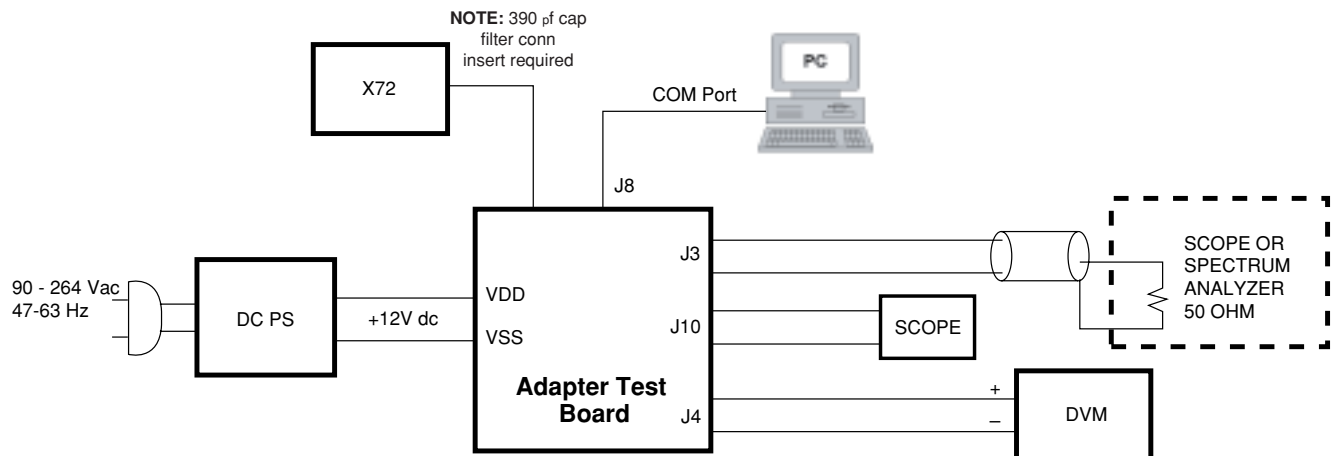
## 2.0 Turn-on Procedure

**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.
- 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.

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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).

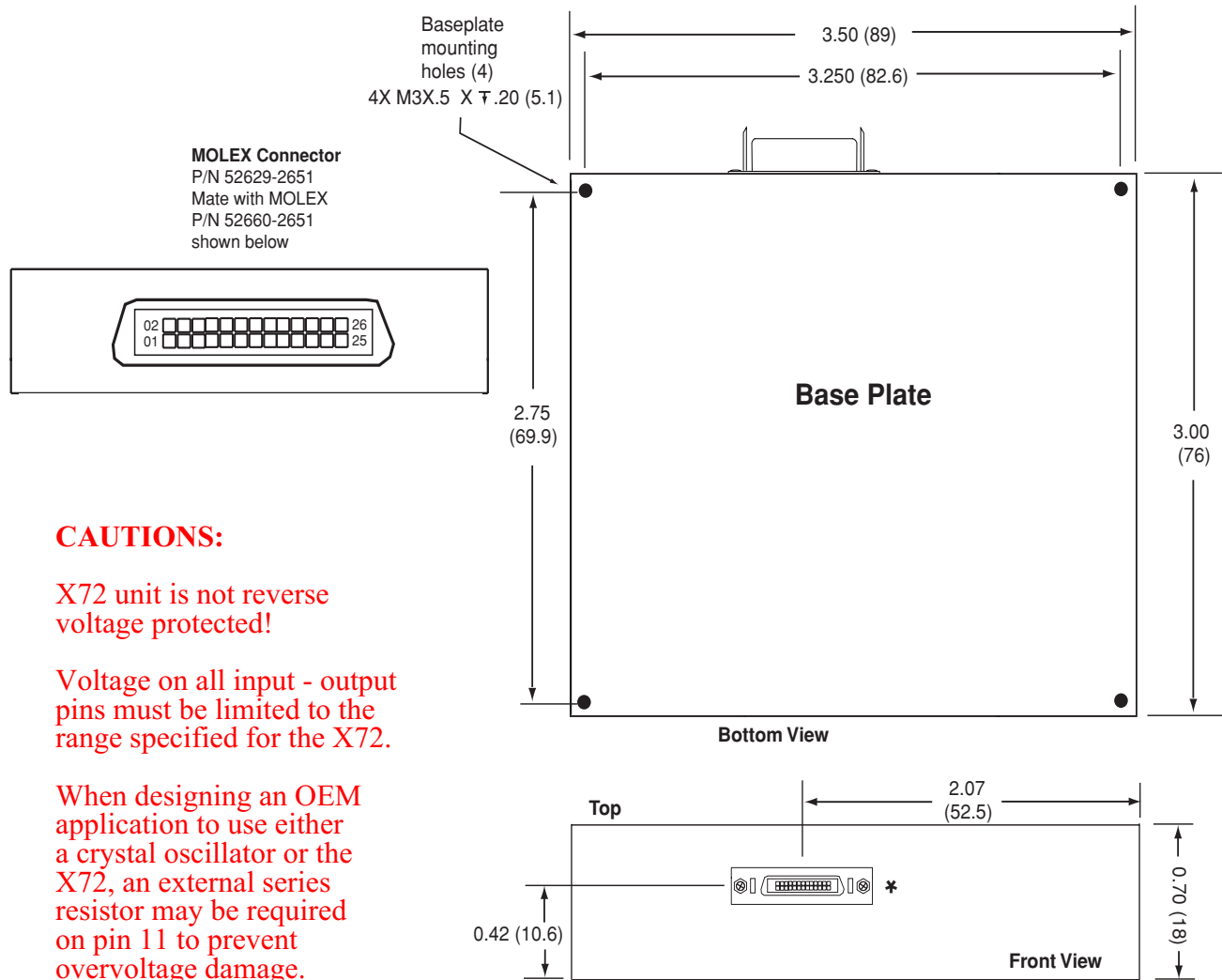
**NOTE:** the output frequency of the X72 is more accurate than most counters. Appropriate measurement equipment can be obtained from Datum. Inquire with Datum Irvine Marketing, or your local sales representative, about Datum's line of test and measurement standards, which includes the PRFS portable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

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**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.

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### 3.0 Start-up Sequence

The accuracy at shipment is  $<\pm 5E-11$  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 its 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  $\pm 2E-6$  until after the oscillator has locked.

After 7.5 minutes the accuracy 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.



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### 4.0 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.

#### 4.1 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. Baud rates between 150 and 57.6 K are available. The X72 has auto baud rate detection.

After power is applied (or after a soft reset) and the unit has output its Banner Header Information at 57.6 kbaud per second after power up, type an upper or lower case ‘a’ to set the baud rate (this must be the first character sent after power up).

**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.

If any character is sent in the first 6 seconds after power is applied (the banner is output at 6 seconds) the X72 enters Factory Mode. This mode is purely for downloading Datum supplied firmware (refer to Tables 2-3 and 2-4).

#### 4.2 Data Format

##### 4.2.1 Run Mode Data Format (Customer Mode)

X72 outputs are all decimal DATA as “ASCII Coded Hex” except for echoed characters. 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.

## X72 Rubidium Oscillator

Example of output from unit.

If no character is sent in the first 6 seconds after power is applied, the unit enters run mode. Once in run mode the unit will not exit run mode until power is removed.

### Example 1 (actual unit output)

```
X72 by Datum, Inc., Copyright 2000
  DSIP Version 3.11k of 3/2000; Loader Version 2
  Mode FNN0  Flag 0004  [3439]ok

Unit serial code is 7-h, current tuning state is 6
Crystal: 60000000hz, AC MOS: 10000000.0000hz, Sine: 10000000.0000hz
Ctl Reg: 004C, Res temp off: -1.5410, FC: disabled, Srvc: high

Enter Run Mode
  FC mode is disabled
```

Example of output from unit if a character is sent in the first 6 seconds after power applied to the unit the unit enters factory mode.

### Example 2 (actual unit output)

```
X72 by Datum, Inc., Copyright 2000
  DSIP Version 3.11k of 3/2000; Loader Version 2
  Mode FNN0  Flag 0004  Size C556 (50518)  Heap 7401 (29697)  [3439]ok

Unit serial code is 7-h, current tuning state is 6
Crystal: 60000000hz, AC MOS: 10000000.0000hz, Sine: 10000000.0000hz
Ctl Reg: 004C, Res temp off: -1.5410, FC: disabled, Srvc: high

User Detected
Enter Factory Mode
f>
```

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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 2000
      SDCP Version 3.21 of 5/2000; Loader Version 2
      Mode CNN0  Flag 0004  [ 8E03] ok
```

```
Unit serial code is 101-h, current tuning state is 6
Crystal: 3938700hz, ACMOS: 989680.0000hz, Sine: 989680.0000hz
Ctl Reg: 029C, Res temp off: BFC53F7D, FC: disabled, 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: Toggle FC Mode
f: Adjust DDS Frequency (delta e-11)
i: Info (show program info)
o: Set ACMOS Output Frequency `N`
p: Display Control Reg
q: Set Control Reg
w: Display Health Data
```

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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
```

---

The following print out shows how entering the letter “a” toggles the “*enable/disable*” feature of FC mode:

```
r>a
FC mode enabled
r>a
FC mode disabled
```

---

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

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

---

## X72 Rubidium Oscillator

### 4.2.2 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.

### 4.2.3 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 1-2.** 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)

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The serial interface is initialized as follows:

Table 1-3 defines the X72's Run Mode Commands.

Table 1-4 defines the bit functions of the factory mode commands of the X72.

Table 1-5 defines the administrative mode commands.

Table 1-6 defines the bit functions and controlling agent of the output control register of the X72.

**Table 1-3. X72 Run Mode Commands**

USER OUTPUT TO X72		RESPONSE TO HOST	NAME & DESCRIPTION OF COMMAND
Command	DATA		
a	None	<i>To be Specified</i>	<b>Toggle Analog Frequency Control Mode</b> 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: "f100<CR>" Example: for a -100E-11 change: "f-100<CR>"	<i>To be Specified</i>	<b>Adjust Frequency</b> Adjust Unit output frequency. Used to discipline the unit. The smallest incremental frequency change is 2E-12 (or ".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	<i>To be Specified</i>	<b>HELP command</b> Displays menu.
i	None	<i>To be Specified</i>	<b>Outputs Unit information.</b> 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").	<i>To be Specified</i>	<b>Loads the value of N to set the ACMOS output frequency.</b> 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	<i>To be Specified</i>	<b>Displays Control Register (See Table 3).</b>
q	Hex data to set or reset bits in the Control Register immediately follows the command (example "q3A")	<i>To be Specified</i>	<b>Set Control Register.</b> Allows enabling or disabling of outputs. See Table 3.
w	None	<i>To be Specified</i>	<b>Displays Health Monitor data</b>

## X72 Rubidium Oscillator

**Table 1-4. X72 Factory Mode Commands**

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 1-5. 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)	<i>To be Specified</i>	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.

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

**Table 1-6. 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".



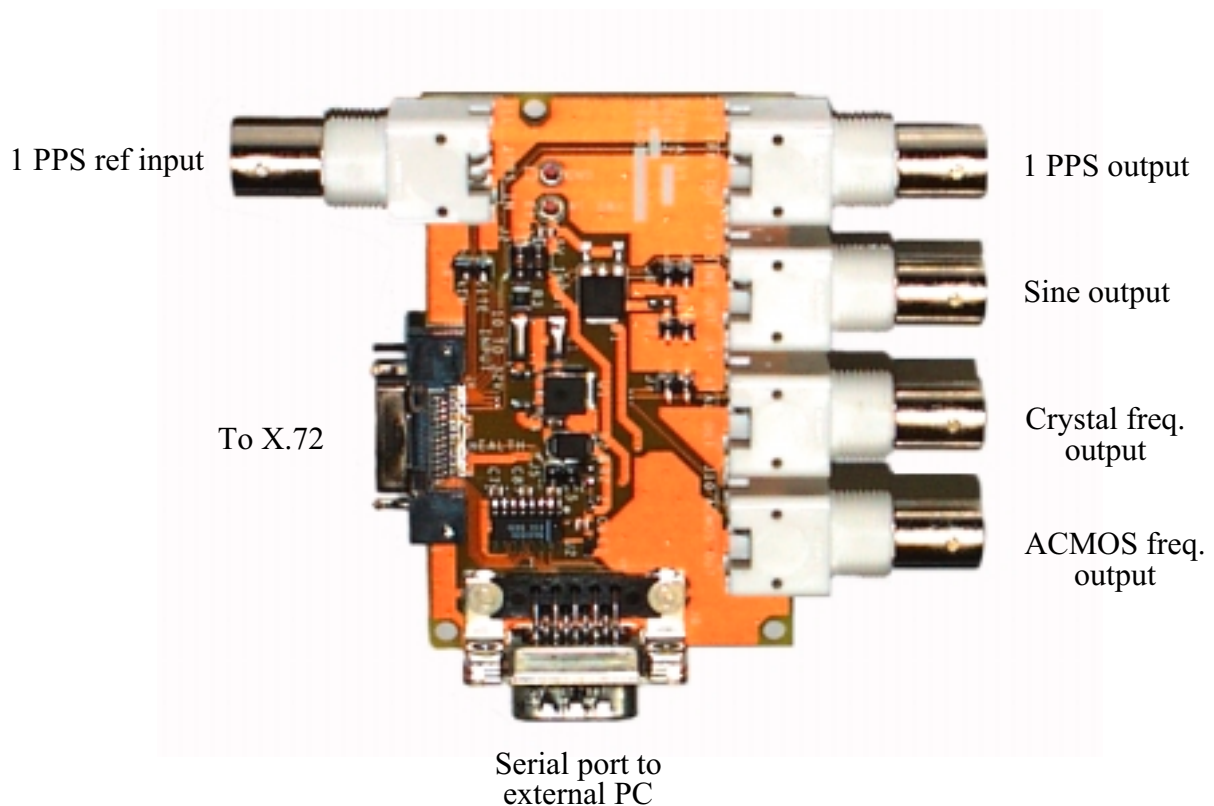
## X72 Rubidium Oscillator

### 5.0 The Datum X72 Development Kit Hardware

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

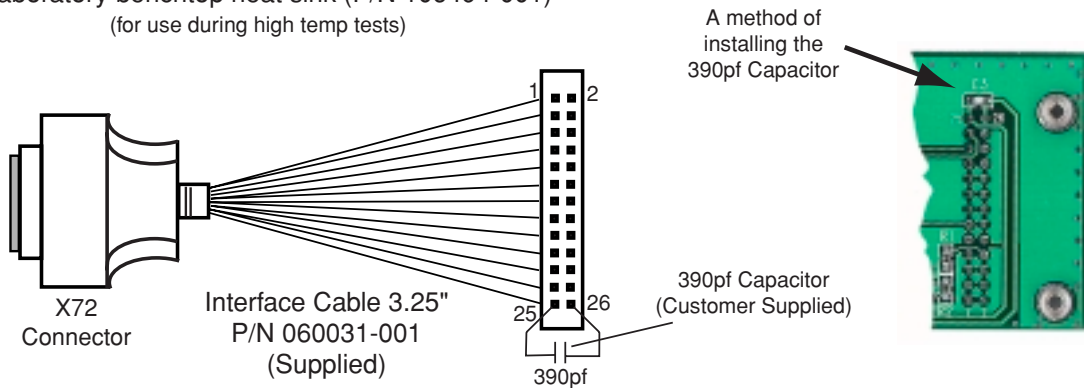
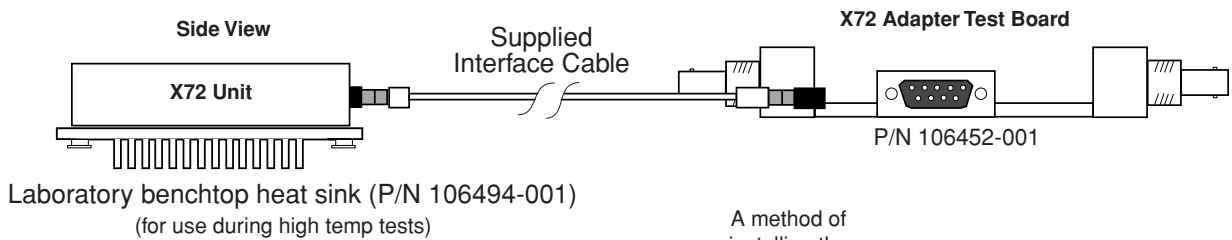
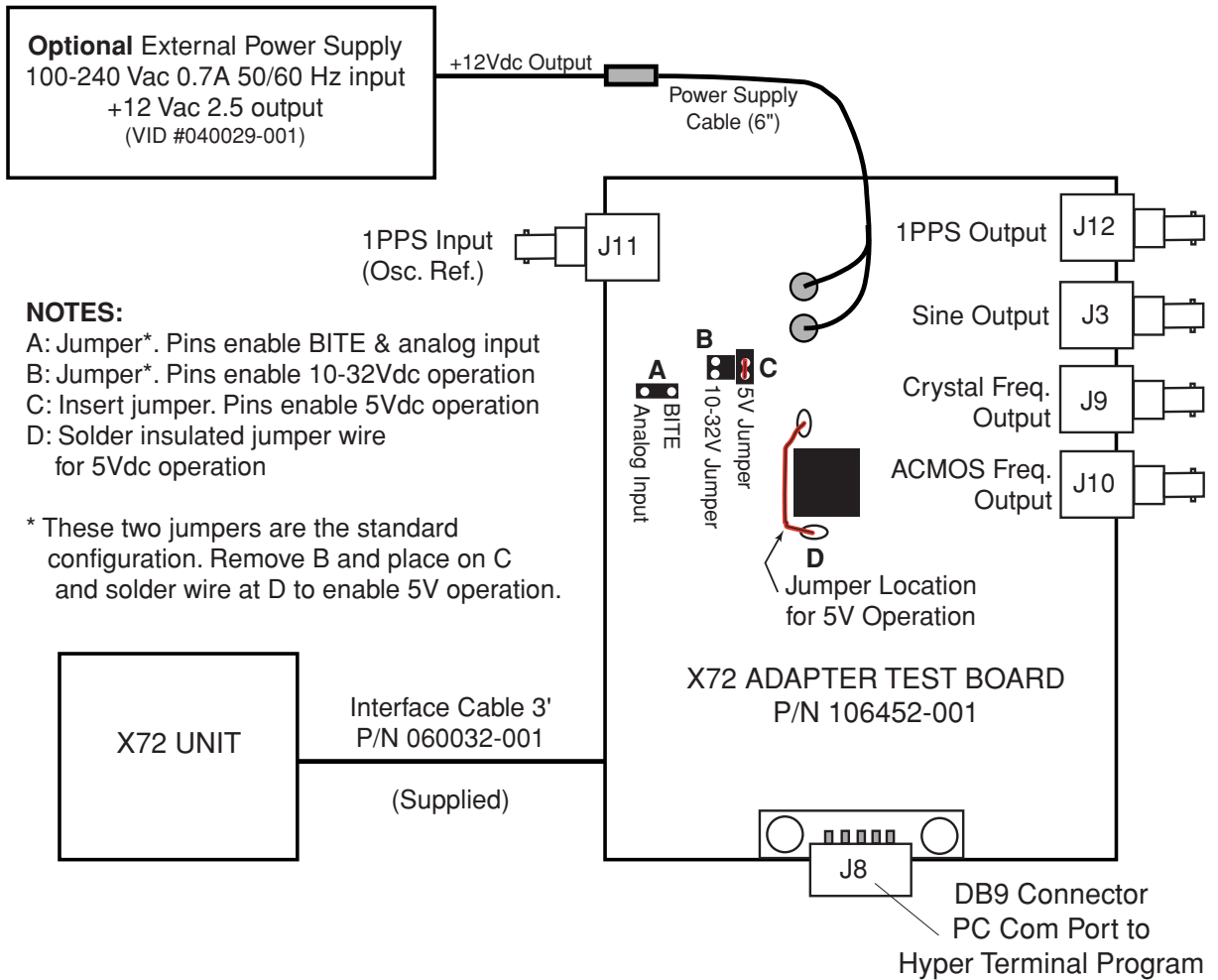
The development kit consists of an interface board with connectors, a heat sink, a 3.25 inch cable, a 3 foot interface cable and product documentation. An optional power supply can be ordered. The output (or input) of each connector is identified on the board. A photo of the interface board is shown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

To use the DSIP firmware of the X72, connect the serial port of the interface 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 Development Kit

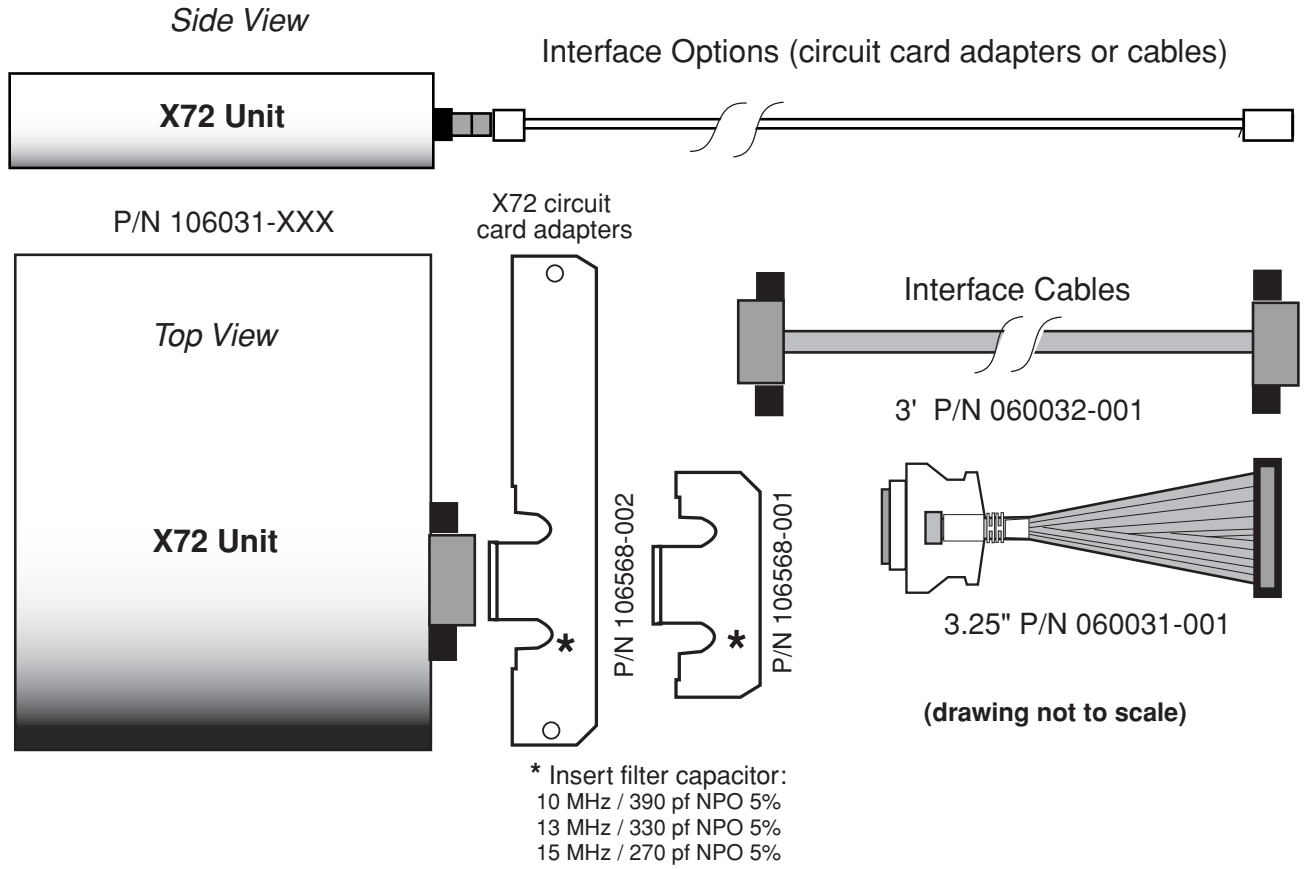
## X72 Rubidium Oscillator



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.**

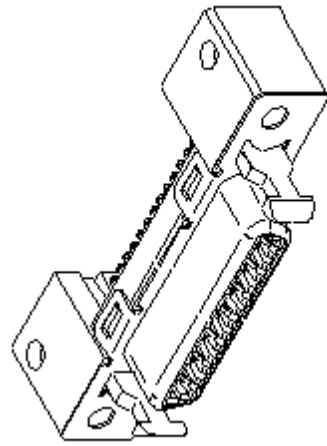
**Figure 1-5. Developer's Kit (P/N 106495-001) Interconnect Diagram**

## X72 Rubidium Oscillator

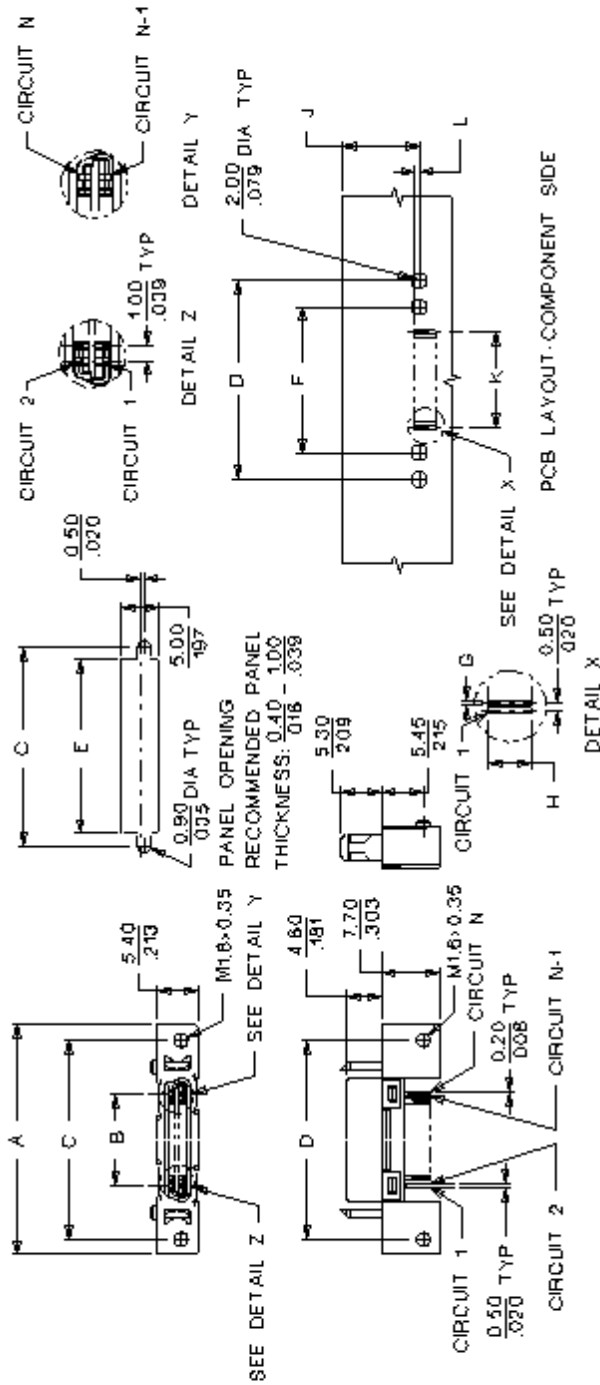


**Figure 1-6.** X72 Interface Options

# X72 Rubidium Oscillator



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



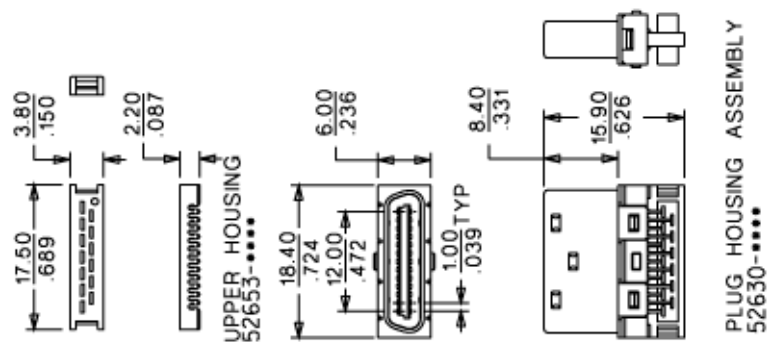
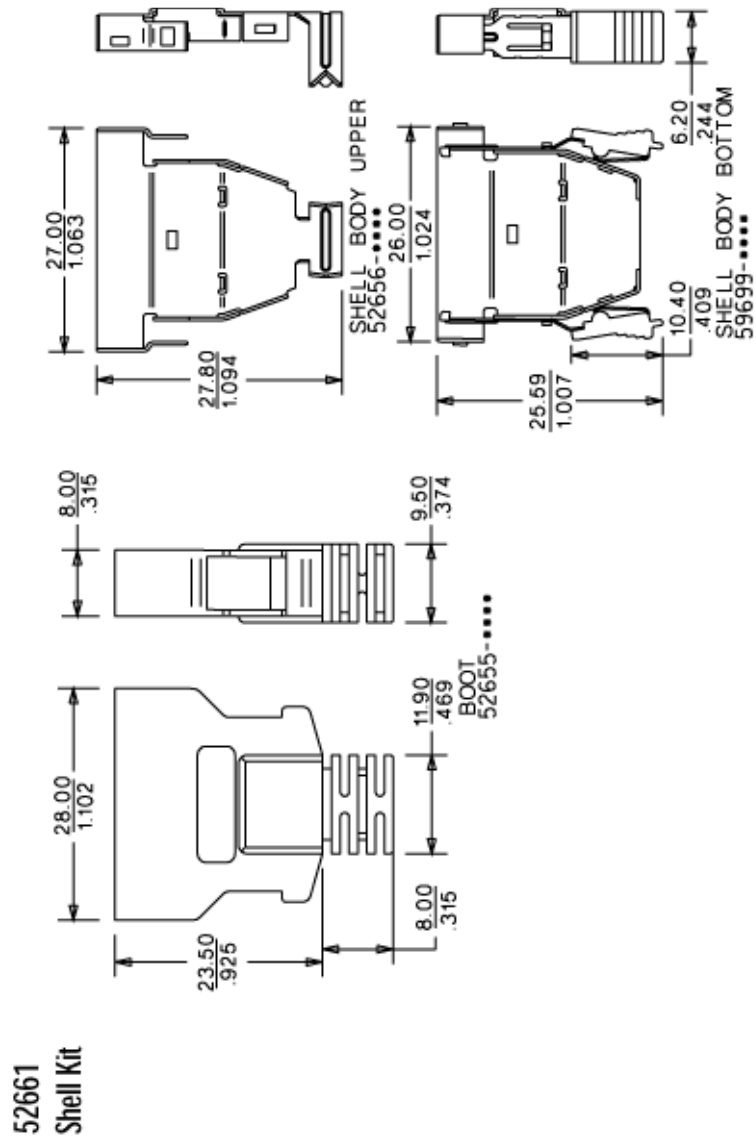
Ordering Information [Exp ↑](#)

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

Figure 1-6. X72 Molex Connector

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**Figure 1-7. X72 Molex Mating Connector**