Installation and User's Guide

Diarcy Technologies

DS-1000/DS-2000 GPS Disciplined Frequency Sources
FR-1000/FR-2000 Highly-Stable Frequency Sources, Bench-calibrated to GPS Accuracy

This guide applies to the following signal generator models:

DS-1000 10 MHz Frequency Standard, GPS Disciplined, Single Front Output
DS-1030 10 MHz Frequency Standard, GPS Disciplined, Three Rear Outputs
DS-1050 10 MHz Frequency Standard, GPS Disciplined, Five Rear Outputs
DS-2000 Frequency Standard (4 MHz to 35 MHz), GPS Disciplined, Single Front Output
DS-2030 Frequency Standard (4 MHz to 35 MHz), GPS Disciplined, Three Rear Outputs
DS-2050 Frequency Standard (4 MHz to 35 MHz), GPS Disciplined, Five Rear Outputs
FR-1000 10 MHz Frequency Standard, GPS Calibrated, Single Front Output
FR-1030 10 MHz Frequency Standard, GPS Calibrated, Three Rear Outputs
FR-1050 10 MHz Frequency Standard, GPS Calibrated, Five Rear Outputs
FR-2000 Frequency Standard (4 MHz to 35 MHz), GPS Calibrated, Single Front Output
FR-2030 Frequency Standard (4 MHz to 35 MHz), GPS Calibrated, Three Rear Outputs
FR-2050 Frequency Standard (4 MHz to 35 MHz), GPS Calibrated, Five Rear Outputs

June 2011

Notice

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Contents

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1 Safety Information

Warnings, Cautions, and Notes

Review the following safety precautions to avoid injury and prevent damage to this product or any products connected to it. To avoid potential hazards, use this product only as specified.

Use the AC/DC Power Adapter provided. This adapter has been tested and found to meet our low-noise requirements. If using an external 12 VDC power source, ensure the power supply noise spectra is sufficiently low so as to not to degrade the oscillator's performance. A low-noise linear power supply with adequate filtering is preferred. However, a switching power supply can be use provided sufficient filtering is provided.

General Safety Considerations

Only qualified service personnel should perform service procedures.

To Avoid Fire or Personal Injury

- Use Proper Power Adapter. Use only the power module provided with this product.
- Connect and Disconnect Properly. Do not connect or disconnect GPS antenna while unit is powered on.
- Do Not Operate Without Covers. Do not operate this product with the covers removed.
- Do Not Operate With Suspected Failures. If you suspect there is damage to this product, have it inspected by qualified service personnel.
- Operate Within Operating Range. Do not operate this product outside the operating ranges specified on the manual.
- Do not Operate in Wet/Damp Conditions.
- Do Not Operate in Explosive Atmosphere.
- Keep Product Surfaces Clean and Dry.
- Do not Remove Covers. Removing the covers will VOID the Warranty and Calibration.

2 Getting Started

There are two classes of Frequency Standards described in this manual. The DS-series (Disciplined Source) Frequency Standard uses an available GPS signal to correct frequency errors in the internal oscillator circuitry. The FR-series (Free Running) Frequency Standard has been calibrated to within 10ppb frequency error (or better) by our factory at the time of manufacture.

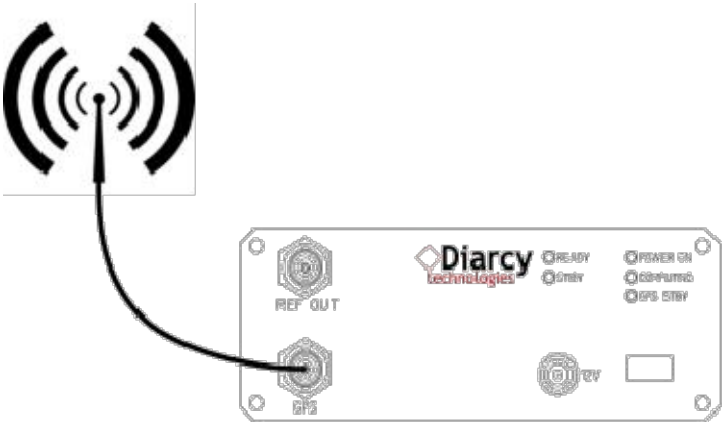
The DS-series Frequency Standard uses an available active GPS antenna to receiving information from the GPS (Global Positioning Satellite) system to measure and correct the Standard's frequency error. The DS-series Standards have also been calibrated to within 10ppb frequency error (or better) by our factory at the time of manufacture. If an active GPS signal is available, this correction continues to be applied by using our proprietary frequency correction algorithm. If no GPS signal is available, the Frequency Standard will continue to use the last correction update applied (typically, within 1 to 10 ppb error).

NOTE: Removing the front or back panel will void the warranty and calibration. The unit is equipped with tampering detectors. Please contact Diarcy Technologies if the covers need to be removed.

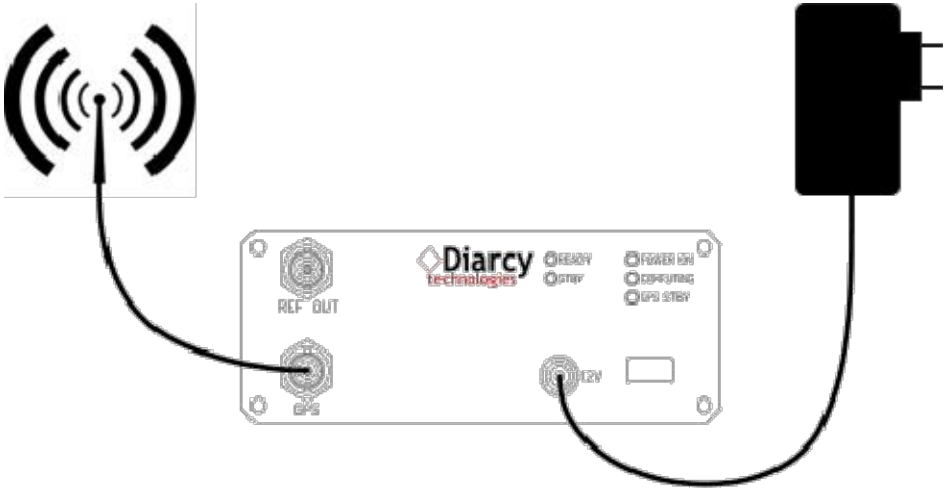
DS-1000 & DS-2000

For DS-series Frequency Standard, connect an active GPS antenna using a 50Ω coaxial cable. The active antenna bias is configured for 5 VDC unless the unit was optionally configured at the factory prior to order.

Step 1 -- Connect GPS Active Antenna with power off:



Step 2 -- Connect supplied AC/DC Power Adapter



Step 3 -- Connect “Ref Out” to your load (e.g. test equipment’s reference input)

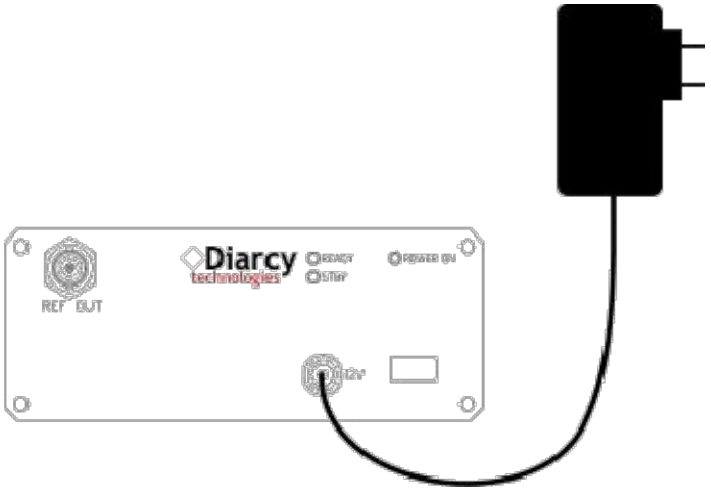
Step 4 -- Turn Unit on with Pushbutton Switch

The Panel Indicators (LED’s) should begin to blink as the internal Self Test is initiated. See next section for Operational Verification.

FR-1000 & FR-2000

For the FR-series Frequency Standard, no GPS Antenna is required. The unit has been calibrated prior to shipment to within 10ppb accuracy.

Step 1 -- Connect supplied AC/DC Power Adapter



Step 2 -- Connect "Ref Out" to your load (e.g. test equipment's reference input)

Step 3 -- Turn Unit on with Pushbutton Switch

The Panel Indicators (LED's) should begin to blink as the internal Self Test is initiated. See next section for Operational Verification.

3 Operational Verification

DS-1000 & DS-2000

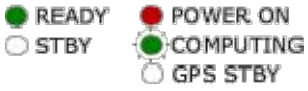
Self Test

When the unit is initially turned on, the Panel Indicators will cycle on and off in a circular pattern while the unit is in Self Test. After a few seconds (about 5 seconds), the unit will exit Self Test and begin it's Initial Warm-up and the GPS Acquisition period. Both the unit STBY and GPS STBY LED's will be on.

GPS Acquisition

Immediately after Self-Test, the Power On LED will be on and the unit's STBY and GPS STBY LED's will also be on. The GPS system will begin to acquire sufficient satellites to achieve a timing solution. When a timing solution is achieved (typically within 2 minutes with good GPS reception), the GPS STBY LED will turn off. If the GPS system does not have enough satellites for a timing solution or if there is a problem with the GPS system, the GPS STBY LED will remain on until the problem is resolved.

Initial Warm-up



The unit STBY LED will be active for 10 minutes regardless of the GPS status. This is simply a reminder to the user that the internal oscillator circuitry is undergoing it's own warm-up period. While the unit is in this standby mode, no error corrections are being applied. The unit's output is available immediately after Self Test and can be used. However, since the internal oscillator system is still warming up, the frequency error cannot be guaranteed but is generally within the desired frequency output to 50 ppb error (0.5 Hz for a 10 MHz Frequency Standard) or better within 3 minutes. Once the unit has completed its initial warm-up period, the READY LED will be on and remain on until the unit is powered off. The COMPUTING LED will then flash for about 10 seconds as the unit prepares the error algorithm. This will only occur if the GPS STBY LED is not on, that is, there are no GPS problems (e.g. sufficient satellites in view).

Normal Operation

During normal operation, the READY and COMPUTING LED's will be on indicating the unit is computing the internal oscillator frequency error as measured against the GPS signals. Periodically, the COMPUTING LED will flash indicating an error correction has been applied. If the GPS system does not have enough satellites to compute a timing solution, the GPS STBY LED will turn on and the unit will remain in standby until the problem is resolved. The unit will then flash the COMPUTING LED for about 10 seconds and the error algorithm will again be computed. Please note that even if the GPS STBY LED is on, as long as a correction has previously been made, the frequency output is, typically, within 10 ppb error. See the Signal Generator Details section for more information.

FR-1000 & FR-2000

Self Test and Initial Warm-up

When the unit is initially turned on, the Panel Indicators will cycle on and off in a circular pattern while the unit is in Self Test. After a few seconds (about 5 seconds), the unit will exit Self Test and begin it's Initial Warm-up-period. The unit's STBY LED will be on for 30 minutes. This is simply a reminder to the user that the internal oscillator circuitry is undergoing it's own warm-up period. The unit's output is available immediately after Self Test and can be used. However, since the internal oscillator system is still warming up, the frequency error cannot be guaranteed but is generally within the desired frequency output to 50 ppb error (0.5 Hz for a 10 MHz Frequency Standard) or better within 3 minutes. Once the unit has completed its initial warm-up period, the READY LED will be on and remain on until the unit is powered off.

Normal Operation

During normal operation, the READY LED will be on indicating the unit is ready for use. The frequency errors within the unit have been calibrated out at the time of manufacture to better than 10 ppb (typically 1 ppb). Over time, the internal oscillator's aging may introduce additional error. If needed, the unit can be recalibrated by the factory for a nominal cost. See the Signal Generator Details section for more information.

4 Signal Generator Detail

The Problem with Frequency Sources & Generators

There are many frequency sources commercially available in the market place. Many frequency sources are in the class of Function Generators, Sweep Generators, and the like. These frequency sources are very flexible and should be part of any electronic developer's tools. However, if one is in the business of telecommunications, Cellular or RF engineering, a frequency source with a higher degree of accuracy is needed.

A frequency standard is a stable oscillator used for frequency calibration or reference. A frequency standard generates a fundamental frequency with a high degree of accuracy and precision. A frequency reference is an instrument used for providing a stable frequency of some kind.

Among the most stable frequency references in the world are cesium standards and rubidium standard or rubidium atomic clocks. However, these can be expensive. Since the 1980's, the GPS satellite system has been in use and provides the means for obtaining, not only position and altitude information, but very accurate timing information. By monitoring the GPS system, one can compute the frequency error from any frequency source. Once this error is known, corrections can be applied to adjust the frequency output.

Severity of the Frequency Error

Today's RF and Cellular systems require very accurate frequency settings due to narrowing and precisely controlled bandwidths. A typical crystal oscillator may be specified at having a 100 ppm, 50 ppm, or even 25 ppm error. A typical frequency reference value is 10 MHz and is commonly used in almost all commercial test equipment. This frequency error translates to 1000 Hz, 500 Hz, or 250 Hz error for a 10 MHz source.

While this is generally not a problem for typical electronics development, this is catastrophic for Cellular or RF engineering applications. This error propagates throughout the entire design. That is, if one has a Cellular system that is operating at 881.5 MHz (center of the GSM band), the resulting error is 88,150 Hz, 44,075 Hz, and 22,038 Hz, respectively for the above errors. The GSM channel bandwidth is 200 kHz. Thus, one could be off by as much as 88 kHz error.
This error is due to four major sources:

- Environmental temperature
- Load variations
- Voltage variations
- Inherent Frequency error (crystal cut)

There are various means to control the errors. One of the more common ways is to use a temperature-compensated crystal oscillator (TCXO) or an oven-controlled crystal oscillator (OCXO). While these oscillator types provide a significant improvement in the temperature stability, there is still the issue with the inherent frequency accuracy.

Frequency Stability vs. Frequency Accuracy

While both the TCXO and OCXO oscillator can provide frequency stability on the order of 100's of parts per billion (ppb), the frequency accuracy is still in error due to the ability to precisely cut the crystal. A typical TCXO may have a frequency accuracy of 5 ppm to 1 ppm with stabilities on the order of 300 ppb. This may still be too ambiguous for Cellular or RF Engineering applications. Using the above GSM example, this would translate to 4408 Hz and 882 Hz error, respectively. Still, too much for most Cellular or RF applications.

Low-cost Approach for Stable, Accurate Frequency

Since frequency stability is extremely important in any Telecommunications, Cellular or RF Engineering application, the solution must begin with a highly stable solution. A well-designed OCXO will guard against temperature, voltage and load variations. But there is still the fundamental problem of frequency accuracy.

By comparing the frequency output from the OCXO oscillator against a known, highly accurate frequency source, corrections can be applied to the OCXO so that the frequency can be corrected to within 1 ppb. For the above GSM example, this would translate to 0.88 Hz frequency error. So now we have the means to correct environmental and inherent errors in a well-designed OCXO oscillator. This is the basis for our DS-1000 and FR-1000 series Frequency Standards.

However, what if one needs a frequency other than 10 MHz? That's where our DS-2000 and FR–2000 series Frequency Standards come in. At the time of manufacture, we can calibrate and adjust the frequency output to any frequency desired in the 4 MHz to 35 MHz range to within, typically, 1 Hz of your desired output.

Different Solutions to a Common Problem

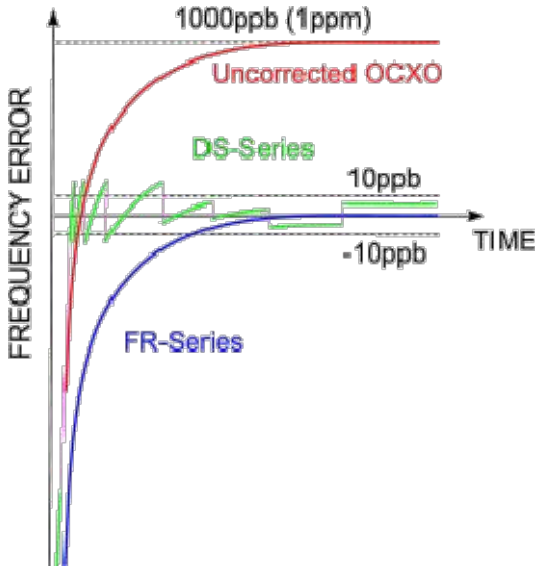
The GPS system provides the means for obtaining the frequency error in any oscillator. However, the GPS system is not always as accurate as it claims to be at all times during the day. This is due to various reasons but primarily it is due to the satellite constellation used to obtained a timing solution at a given time.

The GPS system accuracy is further degraded by a poorly located GPS antenna and other radio interference from nearby sources. While an indoor GPS antenna can be used to obtain signals from the GPS system, the resulting solution is not suitable for making frequency error corrections. Thus, in our proprietary error correcting algorithm, we monitor the GPS health

status and make error corrections only when certain conditions are available, most notably, the position of the GPS constellation to give a timing solution. Further, since the GPS constellation is always changing, the timing solution is also going to change. Thus, one can envision different strategies to achieve the desired error so the OCXO oscillator's frequency can be corrected.

Frequency Error Correction

If one were to monitor a typical Signal Generator output from a cold start to thermal steady-state conditions, one would see a significant frequency shift (many kilohertz). Even with a stable OCXO Source, the frequency error over time would look something like the red trace shown here. Although the OCXO warms up quickly, the absolute error can still be off from 5 ppm to 1 ppm depending on the model. At a 1 ppm error, the frequency error is still too large to be used in RF communication systems.



Our FR-Series Frequency Standards "shift" this error by calibrating the various errors seen by the oscillator as shown in the blue trace. This "correction factor" is stored within each unit and is unique to each system. Thus, every time the FR-Series Frequency Standard is turned on, the unit's STBY LED is active to indicate to the user that the internal circuitry is still in the "warm-up" phase.

The only error that remains after calibration of an FR-Series Frequency Standard is the aging of the internal OCXO. This error is common to all oscillator systems. However, the error is bounded by the specifications of the OCXO, typically less than 4.5 ppm over a 10 year period. Thus, depending on the application, the FR-Series may not need recalibrating. However, if it does, Diarcy Technologies can re-calibrate the unit for a nominal cost.

Our DS-Series Frequency Standards take a different approach as shown in the green trace. Since GPS signals are available, the DS-Series Frequency Standards are constantly computing the error in the oscillator system. Every time a new correction factor is computed, it is applied to the oscillator system and also stored in memory. This stored value is used on subsequent power-ups. This can also be useful if the GPS system is not active since the latest correction factor has already been applied. Any long-term aging of the internal OCXO is

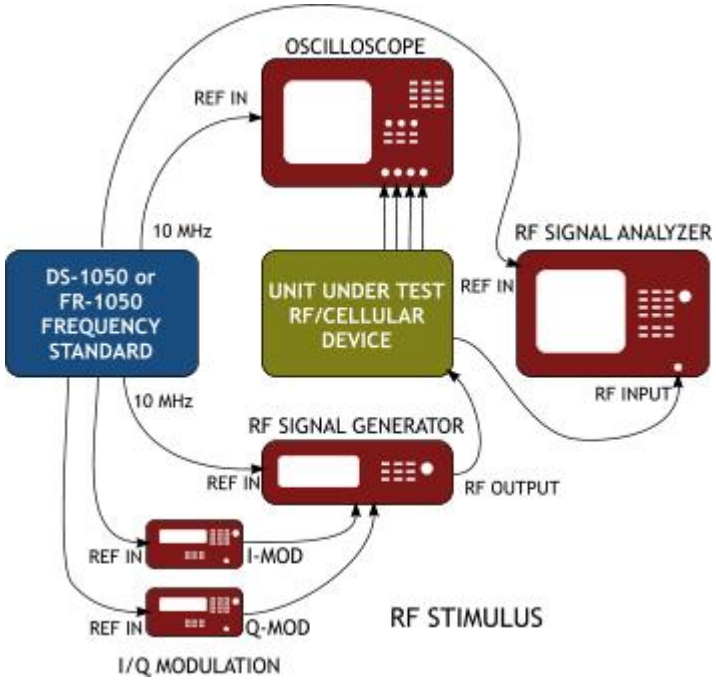
accounted for in the constantly updating algorithm. Even after 10 years, the internal oscillator system continues to be updated as long as the GPS signals are available.

Since the DS-Series and FR-Series take different approaches to removing the frequency and thermal errors, different calibration algorithms are used within each series. In both cases, the GPS system error must also be taken into account. This error is inherent in the GPS system, usually dominated by the satellite geometry at a given time. However, over a long period of time (hours or days), the GPS system is very accurate.

Thus, in the FR-Series Frequency Standard, the calibration used takes many hours, sometimes up to 5 to 10 hours. Whereas in the DS-Frequency Series Frequency Standard, the integration time is less.

Applications

For more applications, see our Application Note, AN-1104: GPS Disciplined Sources (www.diarcy.com/appnotes/an1104.pdf).



5 Troubleshooting

DS-1000 & DS-2000

Continuous Self-Test. If the unit remains in Self-Test for more than 10 seconds, it is likely the GPS system failed to synchronize on power up. This event should rarely occur, if at all. If it does occur, simply power down the unit for 10 seconds and then power back on. If this occurs always, the GPS system is likely damaged. Please contact Diarcy Technologies for further information.

GPS Standby LED always Active. If the GPS system never advances from GPS STBY to COMPUTING, this is likely a problem with the GPS reception. Make sure an ACTIVE GPS antenna is being used and it is compatible with the voltage bias provided by DS-series Frequency Standard. In addition, make sure the GPS antenna is not being physically blocked by metal or other objects that would impede good satellite reception. If an indoor GPS antenna is being used, try moving the antenna to another position or even outside temporarily to determine if this is the cause. Other causes may be radio interference from nearby sources, a damaged GPS system, or attempting to use an improper antenna. Please contact Diarcy Technologies for further information.

GPS Standby LED sometimes Active. If the GPS system advances from GPS STBY to COMPUTING, but occasionally reverts back to GPS STBY, this is likely due to poor GPS satellite reception. If you are using an indoor GPS antenna, first try repositioning the antenna to another location to see if this fixes the problem. Other causes may be radio interference from nearby sources. It is not uncommon for the unit to revert back to GPS STBY as our timing algorithm has stringent requirements on the GPS system to ensure a high quality timing solution is obtained. If you believe this is a problem, contact Diarcy Technologies for further information.

FR-1000 & FR-2000

Frequency Accuracy. If you suspect the frequency accuracy may be off, make sure the enclosure covers are secure to prevent air flow through the enclosure body. Environmental temperature changes within the operating range may cause the frequency to shift slightly, but not significantly since the internal oscillator is oven-controlled to keep the temperature constant. Operating the unit without the panels attached (i.e. open-air) will have a significant impact on the frequency accuracy.

6 Specifications

Electronic Specifications

Note, unless otherwise specified:

- Model reference to DS-1000 includes DS-1030 and DS-1050
- Model reference to DS-2000 includes DS-2030 and DS-2050
- Model reference to FR-1000 includes FR-1030 and FR-1050
- Model reference to FR-2000 includes FR-2030 and FR-2050

Frequency Output	DS-1000, FR-1000 DS-2000, FR-2000	10,000,000 Hz Specified at time of order within the range of 4 MHz to 35 MHz
Frequency Accuracy	< 10 ppb, typical, at shipment	Limited by GPS timing accuracies
Internal Oscillator	Stratum III OCXO (Oven-Controlled Crystal Oscillator)	
Frequency Aging	DS-1000, DS-2000 FR-1000, FR-2000	Constantly updated to within 10ppb (typical) when GPS is available Specified by OCXO aging: < 10ppb per day; <±0.75 ppm 1st year; <±4.5 ppm 10th year.
Standard Power Output (dBm)	0 dBm ± 1 dB into 50Ω	Specified at time of order within the range of -10dBm to +10dBm into 50Ω.
Warm-up Time	DS-1000, DS-2000 FR-1000, FR-2000	<10 minutes <30 minutes
Spurious Signals		>50dBc, >65dBc, typical
Harmonics	Single Output models Three or Five Output models	>50dBc, >65dBc, typical >50dBc
Power Supply	12 VDC, typical	11 VDC to 14 VDC (see Caution)
Supply Current	<300 mA at 12 VDC (warm-up)	

GPS Specifications (DS-1000 & DS-2000)

GPS Antenna Connector	BNC Jack	
GPS Active Antenna Bias	5VDC at 120mA, maximum	Standard configuration
	3.3VDC at 120mA, maximum	Optional. Specified at time of order
GPS Active Antenna	DS-1000, DS-2000	User provided. If needed, contact Diarcy Technologies for suggested models
	FR-1000, FR-2000	Not required

Physical Specifications

Power Jack	2.1mm/5.5mm DC Jack	AC/DC adapter included
RF Connector(s)	DS-1000, DS-2000, FR-1000, FR-2000	BNC Jack, single front mounted
	DS-1030, DS-2030, FR-1030, FR-2030	BNC Jack, three rear mounted
	DS-1050, DS-2050, FR-1050, FR-2050	BNC Jack, five rear mounted
Size	DS-1000, DS-2000, FR-1000, FR-2000	2” x 5.5” x 7”
	FR-1030, FR-1050, FR-2030, FR-2050	2” x 5.5” x 7.25”
	DS-1030, DS-1050, DS-2030, DS-2050	2” x 5.5” x 7.5”
Weight	< 2 lbs.	
Enclosure Finish	Black Power Coat, body Aluminum, anodized, panels	

Environmental Specifications

Intended location	Indoor use	Contact Diarcy Technologies if you have other requirements
Temperature	0 to 50°C	Standard Configuration, Extended Temperature range available, contact Diarcy Technologies
Relative Humidity	<80%, non-condensing	Contact Diarcy Technologies if you have other requirements
Altitude	DS-1000, DS-2000	Limited by GPS operation. Not intended for airborne use.
	FR-1000, FR-2000	Not intended for airborne use.
Vibration and Shock	None	Not intended for any environment where vibration and shock may be experienced.

7 Unit Definitions and Conversions

db	Decibels	The ratio between two powers or voltages using logarithms to the base 10. A relative measure. Note: $P(dBm) = 10 \log_{10}(P1/P2)$ $P(dBm) = 20 \log_{10}(V1/V2)$
dbc	Decibels, relative to carrier	The ratio between the carrier power and a second power. That is, how small one signal is with respect to the (main) signal of interest (i.e., the carrier). A positive value indicates a smaller power than the carrier. A relative measure.
dbm	Decibels, relative to 1mW	The ratio between a signal and 1mW of power as measured in a 50Ω system. An absolute measure of power. Note: +30dBm equals 1000mW 10dBm equals 10 mW 0dBm equals 1 mW -10dBm equals 100mW
ppb	Parts per Billion	$x/10^9$ is x parts per billion. In this manual, used to indicate frequency error relative to a given frequency: 1 ppb of 4MHz equals 0.004 Hz 1 ppb of 10MHz equals 0.010 Hz 1 ppb of 35MHz equals 0.035 Hz
ppm	Parts per Million	$x/10^6$ is x parts per million. In this manual, used to indicate frequency error relative to a given frequency: 1 ppm of 4MHz equals 4 Hz 1 ppm of 10MHz equals 10 Hz 1 ppm of 35MHz equals 35 Hz

8 Warranty and Service

Diarcy Technologies warrants this product to be free from defects in materials and workmanship for a period of one (1) year from the date of shipment. If the product proves defective within this period, Diarcy Technologies will repair or replacement the product without charge.

NOTE: Removing the front or back panel will void the warranty and calibration. The unit is equipped with tampering detectors. Please contact Diarcy Technologies if the covers need to be removed.

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Should the unit require service, please first contact us at:

TECHNICAL SUPPORT
support@diarcy.com
+1-512-238-6840

If the unit requires factory service, first obtain a Return Merchandise Authorization (RMA) from Diarcy Technologies using the above contact information.

Diarcy Technologies
RMA # (provide number given here)
3804 Tamarack Trail
Austin, Texas 78727 USA