

5015/5019 Frequency Synthesizer Module

Operations Manual

Version 1.09

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1 Introduction

This manual includes the specifications and operations of the 5015 and 5019 RF frequency synthesizers.

1.1 Overview

The Valon Technology 5015/5019 Frequency Synthesizer Module is a versatile, PLL-synthesized, RF signal source programmable from 10MHz to 15GHz (19GHz) with calibrated output power control from less than -30dBm to over +13dBm. The synthesizer includes an internal VCTCXO reference or can be locked to an external frequency reference. The module is fully shielded by a machined aluminum, RF-tight, multi-cavity housing which not only provides enhanced noise immunity to external sources but also minimizes internal signal leakage.

The 5015/5019 can be controlled using simple human-readable commands either through the micro-USB port or the direct TTL-User port. Alternatively, the 5015/5019 can be configured using the V5015CM.exe downloadable MS-Windows based graphical user interface. The 5015/5019 settings can all be saved to non-volatile flash memory for automatic recall on power-up.

1.2 Detailed Description

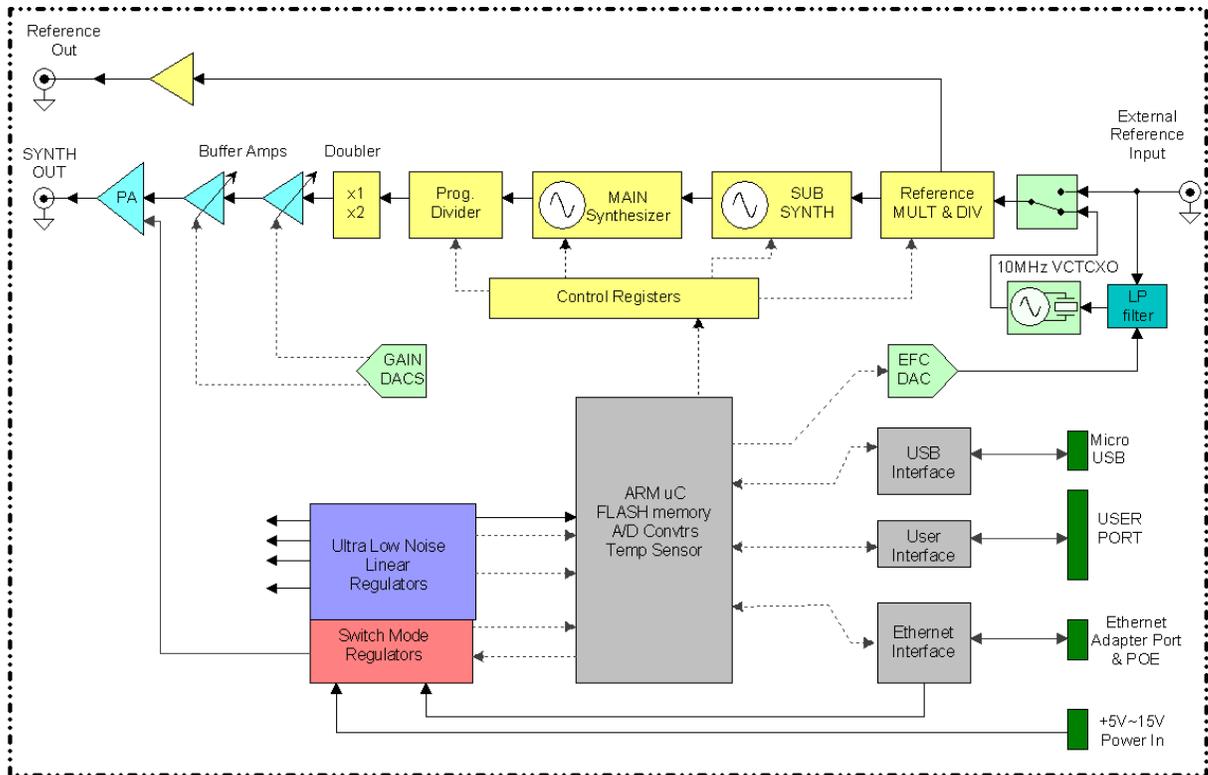


Figure 1 Simplified block diagram of the 5015/5019

Figure-1 above shows a simplified block diagram of the 5015/5019 system topology. The 32-bit ARM processor controls the operation of the synthesizer as well as storing user settings in non-volatile flash memory.

Control can be through either the micro-USB serial port, the 3.3V TTL USER port, or through the Ethernet port using the external ETH-1 adapter.

The ARM processor is the master controller for the synthesizer. It monitors all the synthesizer internal functions, maintains the non-volatile memory, performs tuning algorithms, and supervises the communications interfaces. When the processor receives a command it calculates the internal register values required for setting the main and sub-synthesizers, sets the power control, and all other necessary hardware to complete the command. The ARM processor can make these calculation very quickly which allows for fast sweep operation by simply setting the start and stop frequencies.

The synthesizer topology is designed with the main goal of providing very low phase noise while minimizing spurious output signals. The main synthesizer consists of multiple VCOs in the 7.5GHz to 15GHz range. The main PLL is then phase locked to a sub-synthesizer operating in the

100MHz range. The sub-synthesizer consists of multiple VCOs that are phase locked to either the internal 10MHz VCTCXO or an external reference in the 5MHz to 120MHz range. Subsequent lower frequencies are created by dividing the main synthesizer output by cascaded digital dividers. Since these dividers are digital, the output frequency will not be a sine wave and will have high harmonic content. The 5019 version has an additional frequency doubler.

The output of the divider (and doubler in the 5019) is amplified by gain controlled amplifiers which provide calibrated output power control. This gain control provides over 40dB of level control in less than 0.1dB steps from over +13dBm to less than -30dBm.

The internal reference is a 10MHz precision analog compensated VCTCXO. The initial accuracy is better than 2ppm and the stability over temperature and time is better than 2ppm. Typical initial frequency error is less than 1ppm while the stability over the -30deg. C. to +70deg. C is less than 0.5ppm. The reference select controller module allows the user to correct any frequency error of internal reference to within about 0.010ppm using a reference trim function. The internal VCTCXO reference can also be electronically frequency controlled (EFC) by applying a dc tune voltage to the external reference input. This allows the 5015/5019 to act as a precise voltage controlled oscillator which is useful for certain system applications. And for even better stability, the user can select an external reference in the range of 5MHz to 120MHz.

The 5015/5019 uses multiple, low-noise, low dropout voltage regulators. Separate regulators provide the necessary isolation between the main synthesizer and the sub-synthesizers which improves close-in phase noise performance and minimizes spurious output signals due to cross-coupling. Ultra-low noise LDOs are used to power main and sub-synthesizers PLL/VCOs while separate low-noise LDOs regulate power for the output power amplifier. The ARM processor, Ethernet, and USB interfaces have a separate logic level LDOs which further isolate digital processor noise from the synthesizers. The VCTCXO and associated tuning and buffers have a separate ultra-low noise regulator.

The synthesizer uses an efficient switching power pre-regulator so that a wide range of input voltages can be applied. The pre-regulator provides an internal voltage with adequate headroom to power multiple ultra low noise linear regulators. No special power supply is required and most switching power supplies will work without degrading the noise performance of the synthesizers. The synthesizer can accept a command that will place the synthesizer in a low power standby mode when desired. The power input is reverse voltage protected. **The 5015/5019 cannot be USB powered.**

When using the synthesizer at any input voltage it will be necessary to provide some minimal heat sinking or cooling depending upon the operating environment temperature. In most laboratory conditions, it is only necessary to rest or attach the synthesizer to a metal or even dense non-metallic substrate and avoid covering the module with anything that will prevent circulating air to flow.

Raising the input voltage above the Hardware Reset Threshold for more than 10sec will reset all of the synthesizer stored settings to the factory default values. This is similar to the software

RST command, but provides a means to "cleans" the synthesizer user programmed setting without having to use a host computer.

Communications can be established with the 5015/5019 using the USB port, or the Ethernet port (with adapter). A direct 3.3V TTL serial communications port is also available on the USER PORT for convenient machine to machine interfacing. The USER PORT is also used for the LIST mode to allow remote switches to select preset frequencies. In SWEEP mode the USER PORT has sweep trigger and sweep enable signals preset.

1.3 Electrical Specifications

Note: The 5015/5019 is **NOT** USB powered. See Valon **PS6V-1** power supply kit.

DC Input

Input Voltage Range Absolute Max Operational Max Operational Min Very low voltage operation Hardware Reset Threshold	+16V to -16V (reverse protected) +15v +4.5V (minimum voltage at the module power connector) +3.5V (synthesizer remains locked and serial port ok) 16V for >10sec resets the synthesizer to factory default settings
Input Power	5 Watts normal operation 500mW Standby (power down)
DC Input Connector	Hirose DF3A-2P-2DS Mates with Hirose DF3-2S-2C plug and pre-crimped wire H2BXT-10112-R4 (red) and H2BXT-10112-B4 (black). 20" dc cables supplied with synthesizer, additional cables available.

RF Synthesizer Specifications

Frequency Range	10MHz to 15GHz							
Frequency Increment	1Hz for frequency less than 4294.967MHz 10 Hz for frequency greater than 4294.967MHz							
Frequency Lock Time	<400uS Lock time is from the time the frequency command is sent, or a frequency step in sweep mode, or input from User Port in List mode to a stable Lock Detector output.							
Phase Noise	Typical phase noise (+6dB max.) *Note that phase noise at <100Hz offset can be improved typically > 15dB with external high stability reference.							
	10Hz	100Hz	1kHz	10kHz	100kHz	1MHz	10MHz	
0.5GHz	-75	-90	-118	-130	-132	-143	-155	dBc/Hz
1GHz	-70	-84	-114	-125	-127	-138	-150	dBc/Hz
2GHz	-61	-77	-108	-118	-122	-132	-150	dBc/Hz
3GHz	-58	-78	-105	-116	-120	-127	-148	dBc/Hz
4GHz	-53	-74	-102	-114	-117	-126	-144	dBc/Hz
6GHz	-50	-70	-98	-109	-112	-121	-142	dBc/Hz
8GHz	-51	-70	-95	-105	-108	-120	-141	dBc/Hz
10GHz	-50	-68	-94	-104	-107	-120	-140	dBc/Hz
13GHz	-40	-68	-91	-102	-106	-112	-134	dBc/Hz
15GHz	-35	-66	-90	-101	-104	-112	-133	dBc/Hz
17GHz	-30	-64	-88	-99	-102	-110	-130	dBc/Hz
19GHz	-30	-64	-88	-99	-101	-110	-130	dBc/Hz
Harmonics	The 5015 /5019 output waveform is a clipped sine wave. Odd harmonics are typically <-12dBc, even harmonics are typically <-20dBc.							
Sub Harmonics	Sub harmonics(f/2 and f/4) are typically <-90dBc for output frequencies up to 15GHz (5015) Sub harmonics (f/2)are typically <-10dBc for output frequencies from 15GHz to 19GHz (5019)							
Spurious	Non-Harmonic spurious typically <-60dBc including fraction-N spurs and boundary spurs. The 5015/5019 also has four user selectable spur reduction modes. See section 6.10.4.							
Output Return loss	Min.(dB)				Typical(dB)			
10~ 100MHz	>6				10dB			
50MHz ~ 10GHz	>10				12			
10GHz ~ 15GHz	>6				8			
15GHz ~19GHz	>8				12			
RF Connectors	SMA Female							

RF Output Power Range	Max dBm	Min dBm	
10MHz ~ 100MHz	>+10	<-30	
1GHz ~ 10GHz	>+16	<-30	
10GHz ~ 15GHz	>+14	<-30	
15GHz~19GHz	>+12	<-30	
RF Output Power Accuracy			
1GHz~15GHz	±0.7dBm +10dBm ~ -20dBm and ±0.9dBm > +10dBm or <-20dBm		
15GHz ~ 19GHz	±1.0dBm +10dBm ~ -20dBm and ±1.5dBm > +10dBm or <-20dBm		
RF Output Power Resolution	<0.1dB		

AM Depth	Modulation depth adjustable from 0.0dB (CW) 20dB
AM Frequency	1Hz to 1kHz, 1Hz resolution
AM Waveform	50% duty cycle square wave

Reference Frequency	
Internal Reference	
Frequency	10.000MHz
Initial Accuracy	± 2ppm (23°C)
Temperature Stability	±0.5ppm -20°C to +70°C (case temp)
Reference Trim Range	± 10ppm
Reference Trim Resolution	0.02ppm
External Reference Input	
Frequency Range	5MHz to 100MHz, typical max 120MHz
Input power range	-10dBm min. +13dBm max.
	SMA Female 50Ω nominal impedance
	Note: Ext input is ac coupled to synthesizer but dc coupled to internal VCTCXO control circuit. See section 2 for details.
Reference Output	
	10MHz buffered internal reference +9dBm ± 1dB
	SMA Female 50Ω nominal impedance ac coupled
	5MHz to 120 MHz +9dBm buffered external reference when external reference is selected
EFC	
Electronic frequency Control at external reference input	Pulling range >±10ppm
	Voltage ±3V
	Input resistance 20kΩ
	Frequency response 0Hz~>5kHz

Interface

USB	Micro-B socket FTDI virtual com port 9600, 8, N,1,N default, see selectable baud rates below See FTDI for drivers for your computer. Note: The Configuration Manager GUI will automatically configure the USB port and switch to 115200 baud rate.
USER PORT	3.3V TTL TXD & RXD 115200,8,N,1,N default Lock detect External Sweep Trigger Input: 3.3V TTL Hi-Z input LSW-1 LIST Mode switch and cable accessory is also available. (see section 5) (see section 8 for connector mating information)
Selectable Baud Rates	USB, serial TTL: 9600, 19200, 38400, 57600,115200, 230400, 460800, 921600

Environmental

Operational full specifications:	-0°C~+60°C (case temperature, heat sink required)
No damage functional:	-20°C~+70°C (case temperature)
Humidity:	5%~95% minimal condensation allowed
IP rating:	50 No water protection.

2 Connections

2.1 Power Connections

Power connections are made to the dc power supply using the provided Hirose 2-pin plug and 20" pig-tail cable assembly. The input voltage for full performance is 5 Volts to 15 Volts and will require typically 5 Watts (Amps = Watts/V). When using a power supply at or near 5V, the input current will be over 1.0A. Therefore, it is very important to keep the total power supply leads as short as possible. The red wire is the positive input and correct polarity is required. The 5015/5019 is reverse polarity protected and no damage will occur if reverse connected to dc power supplies of less than 15V. There is no provision for power to be supplied by USB.

2.2 RF Output

The RF Output port provides the synthesizer output signal. This signal can be programmed to be in the range from 10MHz to 15GHz for the 5015 and up to 19GHz with the 5019. The output level is programmable from less than -30dBm to over +13dBm in less than 0.1dB steps. The nominal output impedance is 50 ohms.

This port is directly connected to the internal broadband microwave power amplifier and is static sensitive. Care should be taken to only use this port as an output. **Do not apply any signal to this port.** Be especially careful in connecting long, un-terminated, coaxial cables that might contain a static charge as this can easily damage the amplifier.

2.3 External Reference Input

The external reference input can be used to provide a more stable reference frequency for the synthesizer. The quality of the external reference will have little effect on the synthesizer phase noise at offsets frequencies greater than $\sim 50\text{Hz}$. The phase noise at offsets below 50Hz may be improved by 15dB or more if a low phase noise ($< -85\text{dBc/Hz}$ @ 10Hz for 10MHz external reference) external reference is used. The reference frequency should be in the range of 5MHz to 120MHz . The optimum input level is approximately 0dBm to $+10\text{dBm}$ (50ohms).

The external reference input also serves as an Electronic Frequency Control (EFC) input. The EFC can be used to adjust the synthesizer frequency $\pm 10\text{ppm}$ with an analog voltage in the $0\text{V}\sim 3.3\text{V}$ range. This is a convenient control for phase locking or frequency locking the synthesizer to an external system when a suitable external reference frequency is not applicable.

The external reference signal can be either ac or dc coupled. The external reference input on the synthesizer is ac coupled for the RF reference signal but dc coupled for the EFC control **Figure-2**. Any non-ac coupled source or load connected to the external reference input will pull the internal reference frequency slightly.

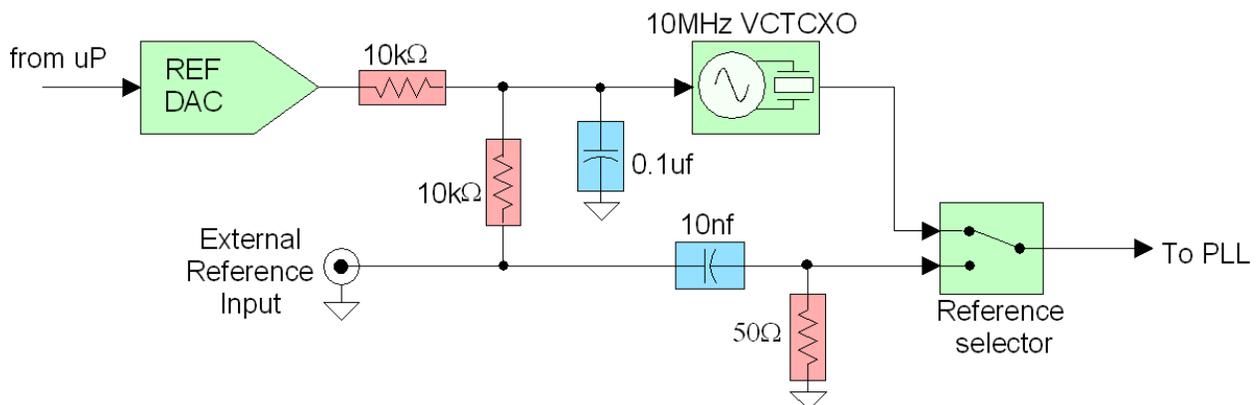


Figure-2: Block diagram of the internal / external reference input circuit.

2.4 Reference Output

The reference output is a buffered replica of either the internal or external reference depending on which is selected. Reference output frequency will be the same as the internal (10MHz) reference or the external reference frequency if present and selected. The reference output is phase coherent with internal or external reference and lags either by approximately 10ns . The reference output impedance is nominally 50ohms , ac coupled, with a typical level of $+9\text{dBm}$.

2.5 User interface USB and TTL User Port

The simplest way to set frequencies and configure the 5015/5019 synthesizer module is to use the USB port with the Valon Technology downloadable V5015CM.exe Configuration Manager (GUI). The Configuration Manager is an MS Windows compatible graphic user interface. No programming knowledge is required. The V5015CM will automatically detect a connected 5015/5019 synthesizer and configure the USB port. Multiple 5015/5019 synthesizers can be supported simultaneously with multiple instances of the V5015CM GUI.

Alternatively, the user can also use our 5000term.exe terminal program, **Figure-3**, to control and configure the synthesizer using simple text commands. 5000term.exe will support multiple 5015/5019 synthesizers. If you have more than one 5015/5019 connected, you can simply start a new instance of 5000term which will connect to the next 5015/5019 synthesizer found. Alternatively, you can type: 5000term -S <serial_num> where <serial_num> is the serial number of the 5015/5019. You can find the serial number of the 5015/5019 by using the ID or STATUS command. (Note: use upper case S and the exact case for the serial number).

The Configuration Manager and 5000term.exe can be found on the Valonrf.com web site in the 5015 DOWNLOADS section.

Any other terminal emulator program should also work well, however 5000term.exe will automatically detect the 5015/5019 and configure the virtual serial port. A list of available commands appears in section 4.

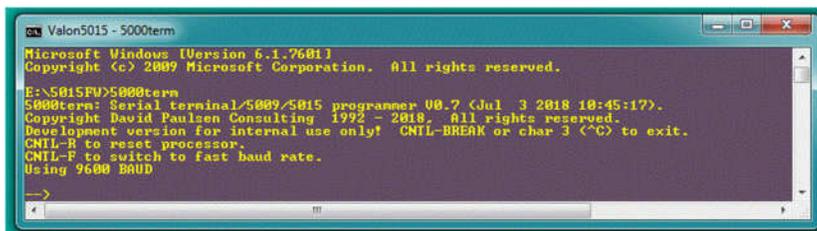


Figure 3: The Valon 5000term.exe terminal program provides a simple command line user interface for controlling the synthesizer. Type “help” for a list of commands.

Links to our GUI and terminal program are shown below in the [Quick-Start section 4.0](#).

Also available is a direct 3.3V-TTL serial interface at the USER PORT. This allows the same command set to be sent directly to the synthesizer processor from a host processor without requiring any USB connection. This port can also be used with the optional external RS-232 to TTL serial adapter. This 3V TTL/CMOS port is also 5V tolerant. For more information on this port, see Section 5.

The default baud rates are 9600 for the USB port and 115200 for the USER PORT. Either port can be set to 9600, 19200, 38400, 57600, 115200, 230400, 460800, or 921600.

2.6 Setting the Baud Rate

The USB baud rate can be changed using the baud command as in "baud 230400" which would change the baud rate from the default value of 9600 to 230400. However, once the baud rate has been change it will be necessary to exit out using ^C since communication will no longer be possible. To reestablish communication, restart the terminal program with the corresponding baud rate. With 5000term the staring command then in this example is: 5000term -r230400

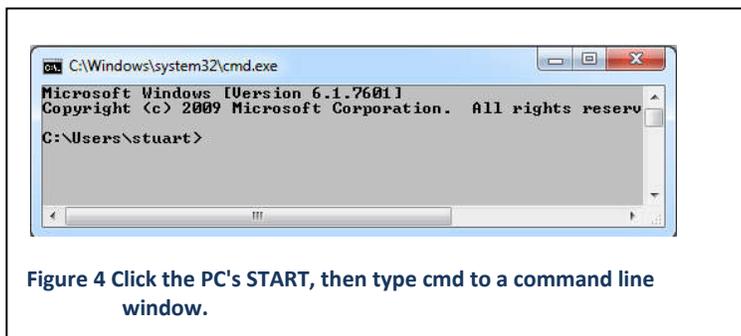
2.7 Using the Ethernet port with Telnet

The Valon Ethernet Adapter **ETH-1** is required if network connectivity is desired. The ETH-1 is available from Valon Technology as an optional accessory. You may use a standard Telnet session for a command line terminal interface similar to using the USB port with a terminal emulator application as shown in **Figure-4**. Note it may be necessary to install or turn on the Telnet Client in your particular computer.

The default Ethernet address is **10.0.0.15**. To change the IP address, set the IP address using the **USB port** connection with a terminal program or the GUI. Use the command: **eth set_ip** followed the desired IP address. Then be sure to use the **SAVE** command in order to keep the IP address. To discover which IP addresses may be available on the local network, type: **arp -a** in dos command widow.

You can make a Telnet connection using a Command-line interface. In MS Windows:

1. Click **Start**
2. In the Search or Run line, type **cmd** (for command), press Enter. A command line window will be displayed as shown in **Figure-4**.



3. At the prompt, type “telnet” (and Enter). A Telnet prompt will appear as shown in **Figure-5**.

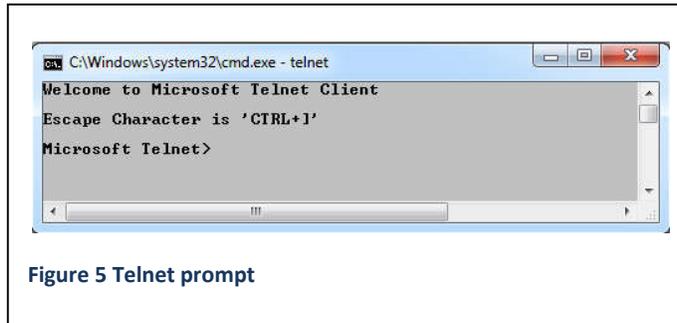


Figure 5 Telnet prompt

4. At the Telenet prompt, type “o” for open and then the synthesizer IP address as shown in **Figure-6**.

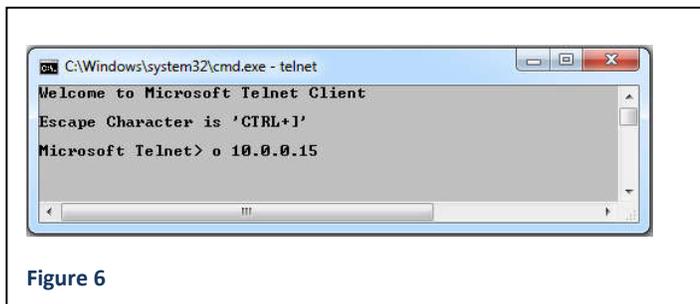


Figure 6

A successful connection will respond with synthesizer status displayed as shown in **Figure-7**.

Once connected, it will be necessary to the suppress (turn off) the local echo by using the command: “ETH echo off”.

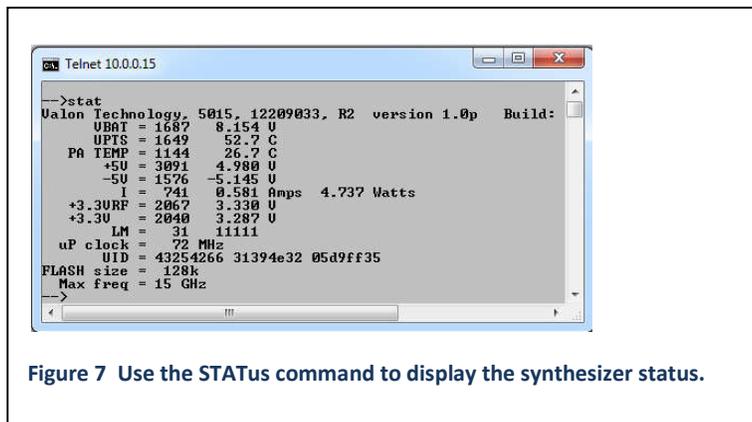


Figure 7 Use the STATus command to display the synthesizer status.

2.8 Using the Ethernet Port with the Built-in Web Server

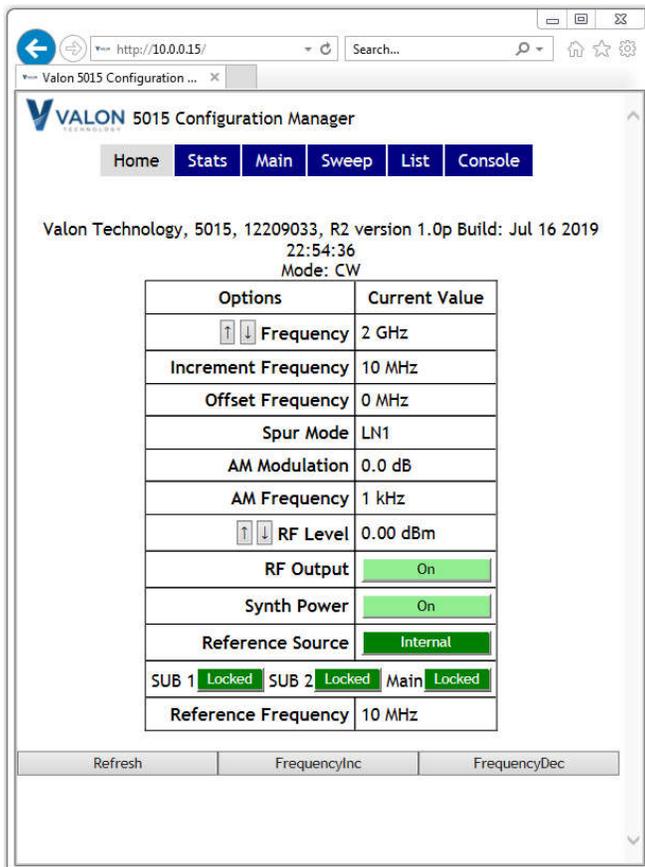


Figure 8: Web Server GUI

The 5015/5019 synthesizers have a built-in web server that provides a control GUI that will run on any computer platform that has a web browser. If the synthesizer is connected to a local network using the ETH-1 adapter, all that is necessary is to enter the synthesizer IP address into the address bar on the browser. **Figure-8** shows an example of the 5015 connected at 10.0.0.15 using the built-in web server. The web server Configuration Manager is very similar in operation to the Valon Configuration Manager GUI that run on a MS Windows platform. See Section 5 for operation and settings.

3 General Information

3.1 Safety

The 5015/5019 Dual Frequency Synthesizer operates on an external, user provided, low-voltage power supply. The user is responsible for ensuring the safety of the power source and any components or equipment connected to it including this one. The 5015/5019 can be connected to any number of external components and care should be taken to fully understand the safety issues with these connections. Valon Technology is not responsible for any damage this equipment causes to any other equipment connected to or used with it in any way.

3.2 RoHS (Restriction of the use of certain Hazardous Substances)

The 5015/5019 module is manufactured using all RoHS compliant components and RoHS compliant printed circuit board processing. The case is manufactured using only aluminum with steel fasteners.

Valon Technology, LLC certifies that the 5015/5019 is RoHS compliant and conforms with the requirements of EC directive 2002/95/EC (RoHS) by having no intentional addition of Lead (Pb), Cadmium (Cd), Mercury (Hg), Hexavalent Chromium (Cr), Polybrominated Biphenyls (PBB), Polybrominated Diphenyl Ethers (PBDE), and any trace impurities of these substances are below the threshold limits as specified by the RoHS directive, specifically Cr+6, Hg, Pb, PBB, PBDE do not exceed 1000 ppm (0.1%) and Cd does not exceed 100 ppm (0.01%).

3.3 FCC Part 15

The 5015/5019 is considered an industrial component and is intended to be incorporated into customer supplied equipment and is therefore exempt from FCC Part 15.

3.4 Default Frequency Setting

The table in section 2 shows the default settings.

3.5 Cleans (Sanitize)

The Cleans function completely erases all stored user entries including frequency settings, LIST settings, and Sweep Start and Stop settings and restores the default frequencies. The Cleans function can be set by selecting Cleans from the Configuration Manager drop down **Synthesizer** menu tab, or in the case where no serial interface is available, the input voltage can be raised to just above 16V until the blue LED flash rapidly for 10 seconds. After 10 seconds the blue LED will flash four times per second for 1 second and then remain off for 1 second and then repeat. This indicates the Cleans function was successful.

3.6 Place of Manufacture

The Valon 5015/5019 printed circuit boards are fabricated and assembled in Northern California. All components are sourced from U.S.A. vendors and distributors. Final assembly and test is performed at Valon Technology.

4 Quick-Start Instructions

The 5015/5019 Frequency Synthesizer module has been pre-programmed to 2440MHz at an output of power of +1dBm. Apply 5Vdc ~15Vdc (requires 5W) using the supplied power cable (red +, black -). Within 2 seconds, the two blue LED STATUS and LOCK lights should be illuminated (see note at end). The 5015/5019 requires some heat sinking or airflow; a quick solution is to simply place the module on a heat conduction surface.

In order to control the synthesizer you may use any terminal emulator program or the Valon **Configuration Manager GUI**. The Valon V5015CM (GUI) and 5000term terminal programs are available as a download at:

<http://valontechnology.com/5015users/5015.htm>.

Note: If you don't want to use the GUI and would prefer to use a terminal program to send commands directly, see Section 6.

The download website above will also have a link to our **5000term.exe** terminal emulator program. This terminal emulator program can be as a standard terminal emulator for controlling the 5015/5019 and is also necessary for reprogramming the 5015/5019 with any updated firmware.

1. From the website link, click the V5015CM.exe and save the program to your desktop or any other folder.
2. Connect the micro-USB cable to your PC and the synthesizer module. Your computer should automatically start to detect the new USB device. If it does not you may need to install the FTDI driver. <http://www.ftdichip.com/Drivers/VCP.htm>.
3. Launch the V5015CM GUI program by double-clicking the icon. At the start of the launch process a Windows dialog box will appear that verifies that a Valon 5015/5019 synthesizer is connected. The serial number will be displayed as shown in **Figure-9**. More than one 5015/5019 synthesizer may be connected. The dialog box allows the selection of the desired synthesizer. To control another synthesizer, start another instance of the configuration manager.



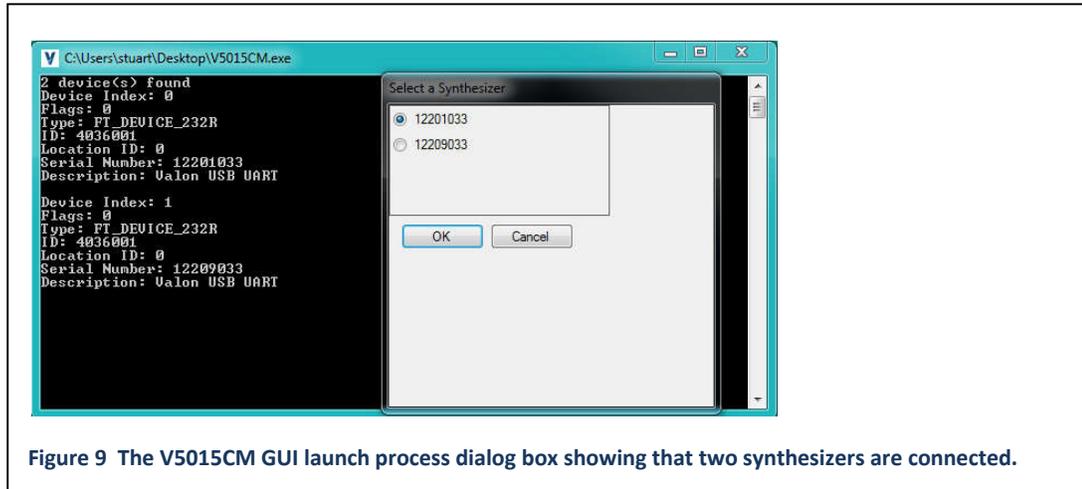


Figure 9 The V5015CM GUI launch process dialog box showing that two synthesizers are connected.

4. Once the connection to the synthesizer is established, it is recommended that you select **Synthesizer/Read Registers** command before you perform any other operation. That will update the Configuration Manager with all the initial register values that were programmed into your synthesizer as it was shipped. Make a note of the serial number for future reference. You may want to save these original setting by using the **File/Save Config** command. This will save your synthesizer's register setting to a disk file.

5. Now you are ready to change your frequency settings using the CM. Once you are satisfied with your settings use the **Synthesizer/ Save to Flash** command to store your settings in non-volatile flash memory.

6. Your 5015/5019 is initialized to use the internal 10MHz reference. You can easily change to an external reference by clicking the **External** button in the **Reference Source** section of the Configuration Manager. When an external reference has been connected and selected, it may be necessary to update the synthesizer with a **File/Write Registers** command.

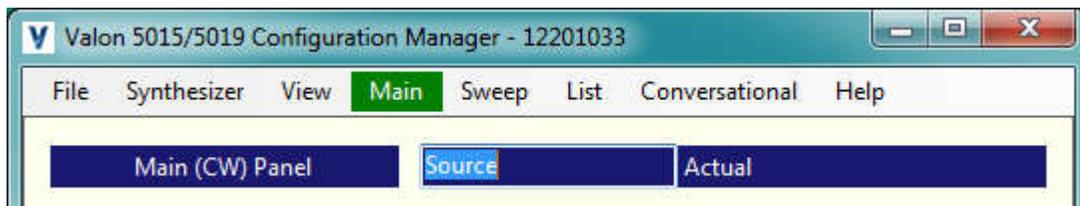
Note: Supply Voltage and Current at 6.0V and typically 800mA. You may experience startup and lock problems if you are using additional clip leads to connect the supplied power cable to a power supply. The supplied leads should be connected directly to a low impedance dc power supply.

5 Configuration Manager (CM) graphical user interface (GUI)

The **Configuration Manager** can be used to quickly and easily set the 5015/5019 synthesizer frequencies and mode of operation. The Configuration Manager is available as a free download from the Valon Technology Products web site. Install the V5015CM.exe in any directory or on the desktop.

5.1 Configuration Manager Menu Bar

The CM menu bar provides quick access to the 5015/5019's various operational modes.



File: The File drop-down menu item provides.

File/Load Config; Loads all the previously saved CM configuration parameters from a .VRO file to the active CM.

File/Save; Saves the all the current CM configuration parameters to a file.

File/Toggle LogFile; Creates a log5015.txt log file in the directory that the CM is in and captures all CM commands and responses.

File/Exit; Closes the CM.



Synthesizer:

Synthesizer/Read Registers; Read registers will fill the CM with the all the parameter data of the connected synthesizer model. Do this when first connecting to a synthesizer model.

Synthesizer/Write Registers; Write registers will transfer all CM data to the synthesizer module. Do this if you just loaded a configuration from a file and want to update the synthesizer with the new parameters.

Synthesizer/Reset; Resets the synthesizer to the factory presets.

Synthesizer/Save to Flash; Saves all synthesizer setting to non-volatile flash memory. Next power up will restore these settings.

Synthesizer/Recall from Flash; Recalls synthesizer settings from flash memory.

Synthesizer/Cleanse; Completely clears all edited synthesizer setting and information including synthesizer names. Does not clear internal calibration data.

View:

View /Small Font; Smaller screen size and fonts.

View /Large Font; Larger screen size and fonts.

5.2 Configuration Manager Main Page

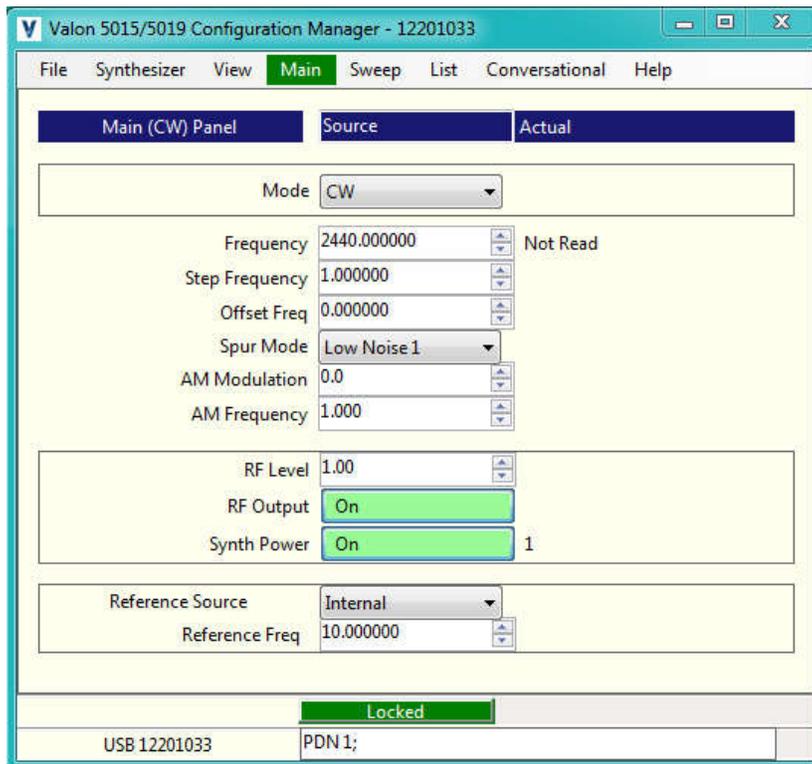


Figure 10 Configuration Manager Main Page

Clicking **Main** button on the Configuration Manger allows the user to enter the desired operating frequencies and output power attenuation levels. The Main page also has a number of useful secondary functions.

Main/Frequency: Enter the desired operating frequency here. The up and down arrows in the Frequency window will increment or decrement the displayed frequency by the Step Frequency amount.

Main/Step Frequency: Amount the Frequency will change with the Frequency up and down arrows.

Main/Offset/ Frequency: This can be either a positive or negative number and is useful added to the Frequency value. Use an offset frequency when it is desired to automatically account for an IF frequency in a super heterodyne system. For example, if the Offset frequency is 10.7MHz (a standard FM broadcast receiver IF) and the desired 88.5MHz (KQED), the actually synthesizer frequency will be 99.2MHz (LO).

Main/Spur Mode: The default spur reduction mode is LN1. LN1 is the lowest phase noise mode. LN2 is a low phase noise mode with lower spurs. LS1 is a low-spur mode with high phase noise. LS2 is the lowest spur mode but with higher phase noise. (see SDN command elsewhere in this document).

Main/AM Modulation: AM modulation is available by setting the AM Modulation value to any value other than 0.0dB. AM Modulation changes the RF output power at the AM frequency rate using the RF attenuator. For example: If the attenuator is set to 15dB (approximately 0dBm output) and the AM Modulation set to 10dB, the then attenuator is switched between 10dB and 20dB at the modulation rate. 0.0dB turns the modulation off.

Main/AM Frequency: The AM frequency range is 0.5Hz to 10kHz. The frequency setting resolution is 1Hz. The AM waveform is 50% duty cycle square wave.

Main/RF Level: Sets the output power level in dBm.

Main/RF Output: Enables the main RF power amplifier. Setting to off will decrease the output RF power to the lowest possible level while the synthesizer is powered on. RF Output off or on does not significantly change the input dc power required.

Main/Synth Power: Off completely disables the synthesizer RF signal and no output will appear at the output connector. When Off, the unlocked notification will appear. The synthesizer will continue to maintain communications on the USB, Serial, and Ethernet connections.

Reference Source: Internal selects the internal 10MHz VCTCXO. External selects the external reference frequency.

Main/Reference Frequency: Set to actual external reference frequency. Setting this to a frequency other than the actual external reference frequency will cause unpredictable results. The internal reference frequency cannot be changed. This setting only takes effect when the Reference Source is set to external.

Main/Reference Trim: Provides ± 10 ppm trimming range to the internal VCTCXO with 10-bit resolution. Reference Trim is useful when it's desirable to "spot" 5015/5019 frequency to an external frequency when an external reference source is not available. Reference trim can also be used to provide a fine frequency control. For example, with an output frequency of setting of 1GHz, the 10-bit reference trim range would be ± 10 kHz in 20Hz steps.

Main/Lock: Lock indicator is shown at the bottom of the main page. Normally, the Lock indicator will be green if the synthesizer is functioning correctly. If the Lock indicator is red, then the synthesizer is malfunctioning. If an unlocked condition is detected (red Lock indicator), check for the following conditions:

1. **Synth Power** is **On**.
2. **Reference Source** is set to **Internal**.
3. **If** Reference source is set to **External**, then check to see that external reference is connected and available.
4. **Reference Freq** setting matches actual internal or external reference frequency in use.

5.3 Configuration Manager Sweep Page

Controls for operating sweep mode are found on this page. Sweep is implemented by stepping from the Start Frequency to the Stop Frequency by an incremental Step Frequency at the sweep step Rate. The Mode has to be set to Sweep for sweep setting to take effect.

Sweep/Mode; CW, Sweep, or List modes are selected and displayed. This bar is a global element of the CM and will be shown on the Main and List pages as well.

Sweep/Start Freq; Set sweep start frequency.

Sweep/Stop Freq; Set sweep stop frequency.

Sweep/Step Freq; Set sweep step size.

Sweep/Rate; Set sweep step rate (milliseconds). **Sweep/ Frac / Int;** Set sweep mode to Fractional or Integer mode.

Sweep/Trigger Mode; Start sweep trigger modes are Auto (continuous sweep), Manual Trigger, External Trigger, and External Step (See USER PORT).

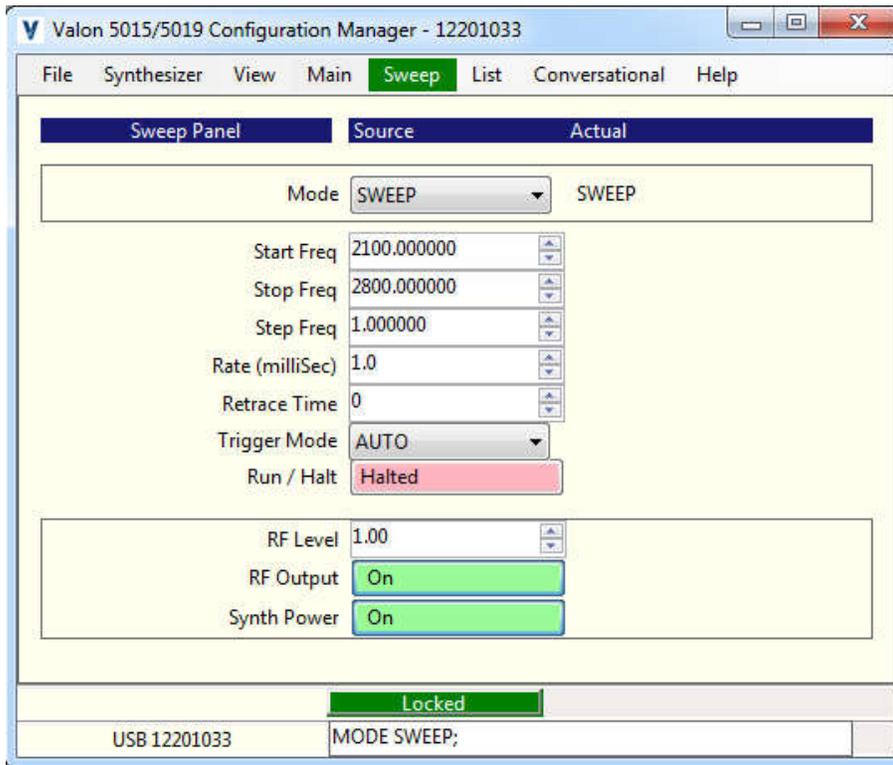


Figure 12 Sweep Page

5.4 Configuration Manager LIST page

Selecting **List** in the CM menu bar presents the frequency list tables for both sources. To edit the table, click on the table entry and enter the desired frequency and attenuation.

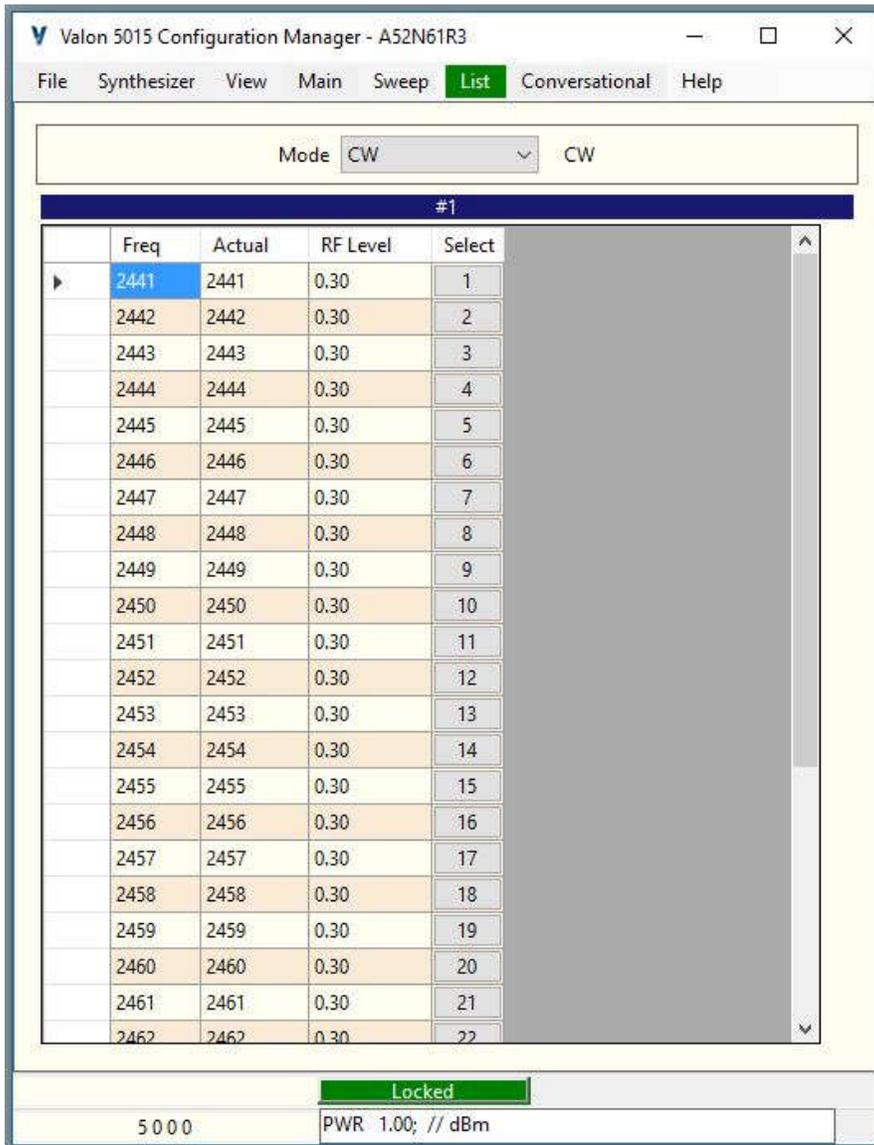


Figure 13 List Page

The List page provides a convenient method for quickly selecting preset frequency and attenuation setting. While in CW mode, clicking on any of the "radio" buttons in the Select column, will program the synthesizer to the preset frequency and attenuation. When the Mode is set to List, the synthesizer presets will be selected by the state of the USER PORT input (see USER PORT for more details).

6 Programming With a Terminal Program

In some instances the user will not want to use the MS-Windows based V5015CM GUI and will prefer to communicate directly with the synthesizer using a terminal program to send and simple commands. The following section describes the available commands.

6.1 Introduction to Commands

The synthesizer can be programmed using a set of simple commands accessed by the micro-USB serial interface or TTL USER Port and either a terminal emulator program such as Putty, TeraTerm or the recommended 5000term.exe. The 5000term.exe is a download available on the valonrf.com website. A direct digital TTL interface is also available at the 14-pin User Port.

Once connection to the serial port has been established, type "help" in the terminal program for a list of the latest available commands.

6.2 Syntax notes:

[] means optional entry may be used. f ;[CW];2550 MHz.

< > String value to be entered: Frequency ;CW <2550> <MHz>.

Upper-case lettering indicates that the upper-case portion of the command is the minimum required for the command. For example, F is the minimum required for the Frequency command. Note: The minimum required character does not have to be sent as upper case.

Lower-case lettering indicates that the lower-case portion of the command is optional; it can either be included with the minimum required upper-case portion of the command or omitted.

Commands must be separated by a semi-colon (;) and no action is taken until a carriage return is sent. If only a single command is being sent then the semicolon is not required.

Spaces between command entries are not required and are ignored.

Units: When entering frequency numbers the units <U> entry is optional. You can specify M for MHz, G for Gigahertz or K for kilohertz. You can also specify H for Hertz. If you do not specify the units, the synthesizer will make logical assumptions. For example, if you entered 2450 with no units, the synthesizer would know you meant MHz since it can't produce 2450Hz, or 2450kHz, or 2450GHz.

Parameters: Certain command inputs are binary in nature. In most cases a binary input parameter such as Enable can also be a "1" and Disable a "0". Also references to External can be a "1" while internal is a "0".

6.3 Query syntax

Query syntax is used to check the state or parameter of a command function. If a command has a query mode, and most do, enter the command with no parameters or with a "?" .

6.4 General Commands

6.4.1 Baud

Note: Baud has a query, the command "baud or baud?" followed by a RETURN will display //Available rates = 9600, 19200, 38400, 57600, 115200, 230400, 460800, 921600.

You may send the command "baud" followed by any of the allowable baud rates, 9600, 19200, 38400,57600, 115200, 230400, 460800, and 921600. Once the baud rate has been changed the terminal program will no longer be able to communicate. Close the terminal program, change the terminal program baud rate to match the synthesizer's baud rate previously changed, and then reconnect at the new baud rate.

6.4.2 STATus

Returns the Manufacturer's name, model, serial number, firmware version, firmware build date and time, uP clock rate, power supply voltage (VBAT), internal temperature, LM, and UID.

6.4.3 Lock

Returns the status of the PLL lock condition from Main and Sub PLLS.

6.4.4 ID <n>

This query returns an identifying string. The response will show the following information: Valon Technology, 5015/5019, serial number, firmware revision. Adding a number to the ID command will flash the STATus LED in short burst of 1 second for the number of times entered for n. The STATus LED is located just above the USB connector and visible through the label. Use the ID with the flash LED number in order to physically identify a particular synthesizer when many are simultaneously connected.

6.4.5 Help

Help, or just h, List all the commands available for the 5015/5019. Note: Help with commands is not available from the UI.

6.4.6 RCL

Recalls the synthesizer state from flash memory. All setting stored in flash memory will be loaded into the synthesizers. This function is useful when it is desirable to restore previously stored flash settings. The RCL command performs the same function as power-up.

Recall is also under the File menu drop-down box in the UI.

6.4.7 RST

This command resets both synthesizers to default factory settings. RST does not change the Reference trim value.

6.4.8 SAV

The SAV command writes the current synthesizer state to flash memory. This is the state the synthesizer will be in on the next power-up.

6.4.9 CLEans

This command cleanses all user saved data in flash (non-volatile) memory. Use this command to "sanitize" the synthesizer. Same as RST except also removes any user synthesizer names.

If a terminal program or Valon Configuration Manager GUI is not available then use the following procedure to cleanse the non-volatile memory: Connect the synthesizer to a variable power supply, then increase the input voltage to 16 .5V for >10 seconds. The blue LED LOCK indicators will flash off and then back on indicating that the cleansing operation was successful.

6.5 MODe

Three mode types are available. The three MODe(s) are: CW, SWEep, and LIST. MODe can be sent as a single command or combined with other commands. Typically, the synthesizer will be set to a specific mode and then subsequent commands will be interpreted for that mode.

6.5.1 MODe <CW >

Sets the synthesizer to the normal default CW, or single tone, mode. All subsequent commands will be assumed to be single frequency commands. See Frequency Setting Commands for more information.

6.5.2 MODE SWEep

Sets the synthesizer to sweep mode. A START frequency, STOP frequency, STEP frequency, sweep RATE will also have to be set.

6.5.3 MODE LIST

Sets the synthesizer to the list mode. When set to list, the synthesizer frequency is set to preset values much like radio push-buttons. The specific list value from the list is selected by the hardware bit selected by the user port.

6.6 Frequency Setting Commands (CW)

The frequency setting commands are listed below.

6.6.1 Frequency <F> <U>

Frequency is the method for setting the single tone frequency. The range of <F> is 10MHz to 15000MHz for the 5015 and 19000MHz for the 5019 but can be expressed as Hz or GHz. Specifying the units is only required when there is an ambiguity. For example, F4 would set the frequency to 4GHz since 4Hz, 4kHz, 4MHz, and 4tHz are all out of range. The only range where there is a possible ambiguity is between 10MHz to 15MHz and 10GHz to 15GHz or 19GHz.

6.6.2 OFFset <F> <U>

An offset frequency value can be added or subtracted to the Frequency. This command is useful for heterodyned frequency conversion systems, i.e. systems that employ an RF mixer. For example, if the frequency is set to 8GHz and the offset set to 4GHz, the actual frequency from the synthesizer would be 12GHz.

Note: UI may accept offsets that result in an out of range frequency. However firmware will check and report an error condition. The maximum offset is limited to approximately 4295MHz to -4295MHz with 1Hz resolution.

6.6.3 FrequencyStep <F> <U>

Sets the frequency step size in CW mode. Used with INCRement and DECRement command.

Note: Step size can be any value however it may be more practical to limit the maximum acceptable step size to 100MHz.

6.6.4 FrequencyINCRement <F> <U>

Increases the CW frequency by the amount set by the STEP command.

6.6.5 FrequencyDECRement <F> <U>

Decreases the CW frequency by the amount set by the STEP command.

6.7 Sweep Mode

6.7.1 SWEep

Sweep from a Start frequency to Stop frequency by setting the mode to SWEep. Example:

```
MODE SWEep
```

6.7.2 START <F> <U>

Sweep Start frequency. Example:

```
START 2000M
```

6.7.3 STOP <F> <U>

Sweep Stop frequency. Example:

```
STOP 2400M
```

6.7.4 STEP <F> <U>

Frequency step size <Frequency> <Units>. Example STEP 10 M will sweep in 10MHz steps at the step RATE.

6.7.5 RATE<ms>

Sweep step rate in milliseconds . Step rates of 10ms to 200ms are typically optimum.

6.7.6 RTIME <ms>

Sweep retrace time. Use for blanking external display devices .

6.7.7 Run

Sweeping begins with a Run command.

6.7.8 Halt

Sweeping stops with the Halt command.

6.7.9 TMODE <AUTO|MANual|EXTRmal|EXTstep>

Three sweep trigger mode (TMOD) options are available. Auto trigger is a continuous, free-running mode where the trigger is supplied by the internal controller. Manual trigger is a single-sweep mode occurring once with every TRG command. External trigger is provided by a positive edge on pin-6 of the USER PORT connector. EXTERNAL trigger will trigger one sweep for every trigger input. EXTstep increments the frequency by the value of the STEP.

Setting the MODE to CW or LIST will disable the SWEep mode.

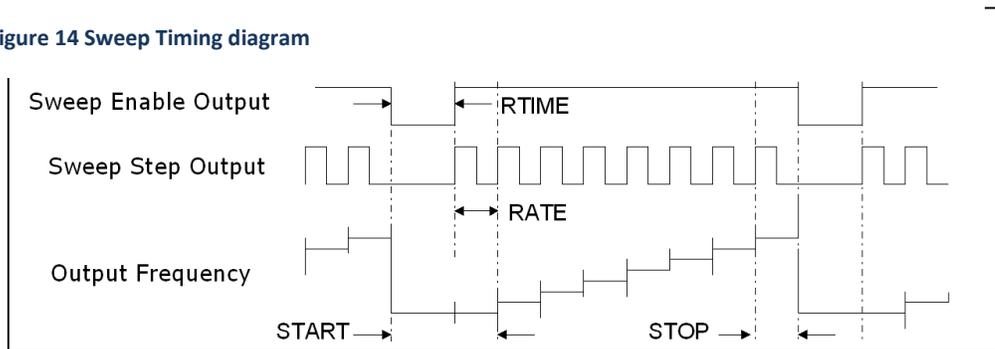
6.7.10 TRGR

This command must be sent to start the sweep in Manual mode. One sweep will occur each time the command is sent.

6.7.11 RetraceTIME ; <ms>

Retrace time or RTIME allows the user to set a dwell interval of 0ms to over 100 seconds before the start of a new sweep.

Figure 14 Sweep Timing diagram



6.8 List Mode

The List mode is useful in production or automatic test environments where it is desirable to switch between a number of preset frequencies or "markers" under hardware control. Once in list mode, a terminal or host computer is no longer required to set the output frequencies.

The List Mode allows the setting of the 32 preset frequencies. When the list mode is set using the MODE LIST command, the source output frequency is set by the list frequency settings and the 5-bit logic state of the USER PORT. Not all 32 preset entries have to be set. Unless user modified, the default list frequency settings for all 32 settings is 2441MHz to 2472MHz.

6.8.1 List entry

List <N> <Fn> [<U>] [<PWR>];

This mode sets synthesizer frequency to the values set in the list table. The list table can have up to 32 entries. N is the list number.

An example of the list command: list 5 2155m would set LIST frequency number 5 to 2155MHz.

List?, List will return the 32 list entries.

LIST? <N> [<U>] will return only the frequency of the **n**th entry in the units specified.

After setting the list frequencies, remember to use the SAVE command to store the list frequencies to flash memory.

Power entries may also be set with the list frequency. The method below shows how to set a power value for a specific LIST entry. If the power value is not specified after the LIST command, then the power value set globally by the POWER command will be retained.

6.8.2 List Hardware Control

See Section USER Port for information on hardware control of the List selection. The List selection can either be done with a switch closure to ground or by TTL logic level.

6.9 Power Level and Amplitude Modulation

6.9.1 PoWeR<PWR>

Sets the power level in dBm. PoWeR or PoWeR? returns the value PoWeR in dBm.

6.9.2 OEN <0|1| or OFF|ON>

Enables or disables the RF output buffer amplifiers while leaving the synthesizer PLL locked. This command does not completely extinguish the RF output signal level but reduces the level by approximately 50dB. This command can be used with the POWER command to reduce the output level by 80dB. ON turns the buffer amplifiers on.

6.9.3 PDN <0|1 or OFF|ON>

PDN is a complete power down of the synthesizer.

6.9.4 AMD<dB>

Enables AM modulation. The default modulation rate is 1 kHz square wave. The AM modulator uses the PoWeR function modulate the CW power setting to AM is enabled when the AM is set to any value other than 0(dB). For example to turn on 20dB modulation the command would be AMD 20.

6.9.5 AMF<f>

AMF sets the AM frequency from 1Hz to 1KHz with 1Hz resolution.

6.10 Configuration Commands

Configuration commands are used to control settings that are secondary to the operation of the synthesizers or affect operation of both synthesizers together.

6.10.1 REFerence; <F> <U>

REF sets the expected value of the external reference frequency. The reference frequency is the used by the PLL circuitry in the sub synthesizers and is the fundamental clock that determines the accuracy, stability, phase noise, and overall quality of the output signals. The default internal reference frequency is 10MHz. If an external reference is being used, that is not 10MHz then the reference, **REF** must be set to correspond to that frequency. Setting **REF** to something other than the actual internal or external frequency will result in indeterminate or unstable performance.

The query form is **REF?** [U]

This query returns the value of the expected external reference frequency.

6.10.2 REFTrim; <0|1|2|...255>

REFerence Trim command can be used to trim or "spot" the synthesizers' frequency when using the internal reference. Reference trim changes the voltage sent to the VCTCXO by setting the reference DAC output voltage. Reference trimming can be used to minimize the internal reference frequency error. Reference trim can also be used when a small frequency offset is desired. The trimming range is $>\pm 10\text{ppm}$.

Note: The EFC circuit is connected to the external reference input through a lowpass filter networks. The EFC voltage is summed with the REFTrim DAC. Any dc path such as a termination or dc coupled source on the external reference input will shunt part of the REFTrim voltage to ground. A dc coupled external reference should be disconnected when using the internal reference.

6.10.3 REFerenceSource;

REFS sets the reference source to either internal or external. **REFS 0** set the reference to internal **REFS 1** set the reference source to external.

REFS? returns the state of the reference source.

6.10.4 SDN<LN1|LN2|LS1|LS2>

The 5015 synthesizer is based on fractional-N architecture. Fractional-N synthesizers will produce spurious frequency products at certain frequencies throughout frequency range. The SDN command has four spur mitigation modes. LN1=Lowest phase noise default mode, LN2=Low phase noise reduced spur, LS1=low-spur mode, LS2= Lowest spur mode with higher phase noise.



6.10.5 NAME <name>

Allows the user to specify an alias name of up to 48 characters long.

6.10.6 ETH SET_IP

Eth set_IP is used to set the Ethernet IP address using either the USB connection or the TTL serial port.

eth ip; Will display the IP address.

eth echo; Sent from telnet will turn echoing off.

eth noecho; Sent from telnet will turn echoing on.

7 User Port

The user port is a 14-pin male Hirose 2mm connector DF11-14P-2DS(52) located on the back edge of the synthesizer module. This port can be used as the List Mode hardware control input or an auxiliary 3.3V TTL serial port.

The User Port also provides sweep trigger, sweep active, and sweep step signals. All signals are TTL 3.3V compatible.

Note that all inputs are 5V tolerant. The TTL outputs are 3.3 V but 5V logic inputs should be compatible and recognize 3V at a TTL HIGH.

7.1 User Port Pin Assignments

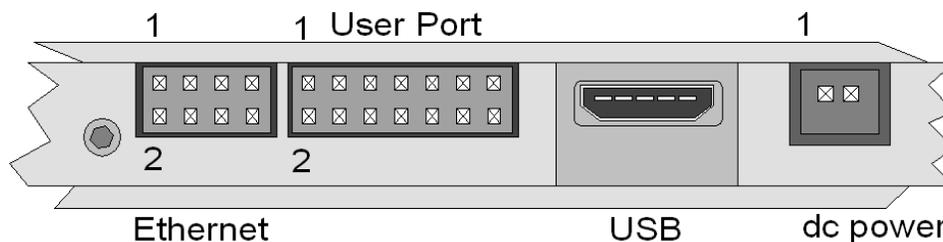


Figure 15 USER PORT PIN assignment and Location

USER PORT Pin	Name	Description
1	L0	List bit 0 Input
2	L1	List bit 1 Input
3	L2	List bit 2 Input
4	L3	List bit 3 Input
5	L4	List bit 4 Input
6	Sweep Trigger In	Input
7	Sweep Enable Out	Output, high level when sweep is active
8	Sweep Step Out	Output, pulse for each sweep step
9		Not used (factory test)
10	Serial RXD	Input, serial data input from host computer
11	Serial TXD	Output, serial data output to host computer
12	Lock Detector	Output, LOW when synthesizer is in a locked condition
13	GND	Common ground (same as chassis)
14	Not Used	

User Port Pin Assignment Table



The USER PORT mating connector is a Hirose DF11-14DS-2C with pre-terminated cables H3BBT-10112-W4. All available from Digikey or you can ordered the 5015 (which works with the 5019) List Mode Selector switch.

7.2 Lock Detector/Sweep Sync/ Sweep Trigger

Sweep Trigger In: Sweep trigger input for external trigger mode.

Sweep Enable Out: Output high during active sweep cycle.

Sweep Step Out: Output pulse for each frequency change step of sweep.

Serial RXD: Input serial data from host.

Serial TXD: Output serial data to host.

Lock Detector: High when synthesizer is operating normally.

GND: Common ground connection for User Port

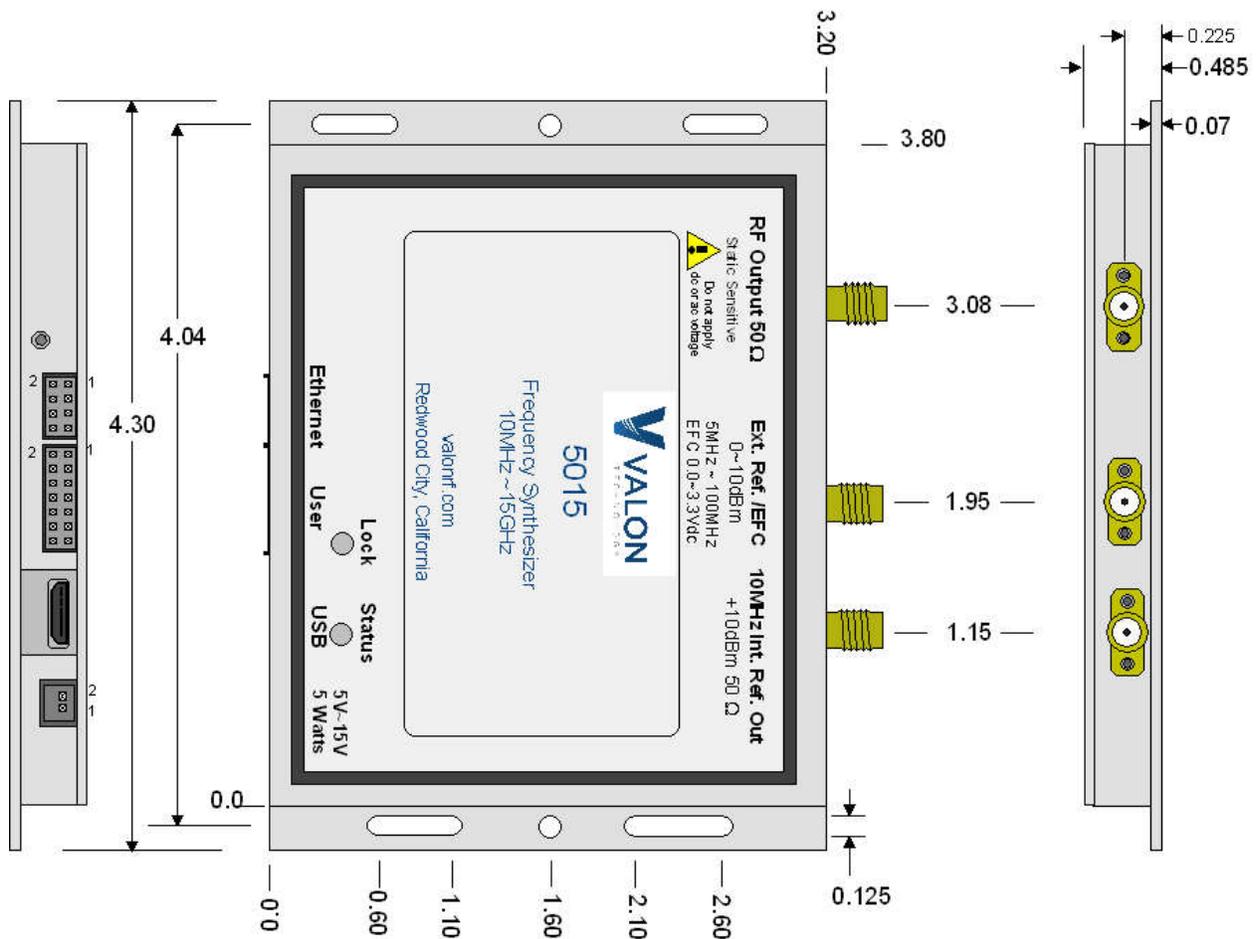
8 Mechanical Dimensions

3.625"W x 2.685"L x 0.55"H

Weight: 0.2lbs, 91g

Material: AL-6061-T6

Finish: Clear Alodine (conductive)





Change History

Version 1.02 replaces term5009 with term 5000

Version 1.08 Updates Sweep mode timing. Revises maximum output power. Revises frequency lock time. Revises User Port Pin Assignment Table. 20190208.

Version 1.09 Correction to 10GHz to 15GHz power spec. Adds 5019 specifications. Modification to AMD and AMF commands.