Valon Synthesizer for VEGAS

VEGAS-002-A-REP

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Prepared By:		
Name(s) and Signature(s)	**Organization**	**Date**
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Change Record

Version	Date	Affected Section(s)	Change Request #	Reason/Initiation/Remarks
A	2013-03-13	All	–	First release.

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1 Introduction and Scope

1.1 Scope

This document describes the use of the Valon 5007 dual synthesizer, manufactured by Valon Technology, as the clock source for the ADC boards, and ultimately, the Roach2 board FPGA in the VErsatile GBT Astronomical Spectrometer (VEGAS) **[AD 01]**.

This document includes the RFI enclosure design, board configuration, assembly, and testing of the Valon synthesizer unit.

1.2 Introduction

VEGAS will be capable of processing up to 1.25 GHz bandwidth from 8 dual polarized beams or a bandwidth up to 10 GHz from a dual polarized beam.

The performance of VEGAS relies on a stable, reliable, remotely configurable clock source and the Valon 5007 was chosen for this task.

1.3 Abbreviations and Acronyms

ADC	Analog to Digital Converter
ASIAA	Academia Sinica Institute of Astronomy and Astrophysics
CASPER	Collaboration for Astronomy Signal Processing and Electronics Research
FPGA	Field Programmable Gate Array
GBT	Green Bank Telescope
GSPS	Giga Samples Per Second
IF	Intermediate Frequency
M&C	Monitor and Control
NRAO	National Radio Astronomy Observatory
RFI	Radio Frequency Interference
VEGAS	VErsatile GBT Astronomical Spectrometer

2 Documentation

2.1 Applicable documents

No	Document Title	Reference
AD01	VEGAS Design Report	VEGAS-001-A-REP
AD02	Valon Synthesizer RFI Test Report	VEGAS-003-A-REP
AD03	VEGAS Shielded Rack Cabling	B35215S002

AD04	Valon RFI Enclosure mechanical drawing	D35215M006
AD05	Valon RFI Enclosure Lid mechanical drawing	D35215M007
AD06	Valon RFI Enclosure Assembly Schematic	B35216S003

2.2 Reference Documents

No	Document Title	Reference
RD01	VEGAS Specification Document	link
RD02	Valon 5007 Datasheet	link

3 Electronics Design

3.1 Valon 5007 Dual Synthesizer Board

Each Roach2 board in VEGAS has a dedicated Valon 5007 dual synthesizer unit to provide the clock to the ADC boards. The 5007 has two RF outputs that have a range of 137.5 MHz to 4400 MHz. It can accept an external reference frequency, or use its own internal reference. The output level can be adjusted to 0, +3, +6, or +8dBm. It also has on-board flash that can retain the desired settings when power cycled. Figure 1 shows the Valon 5007 as normally purchased.

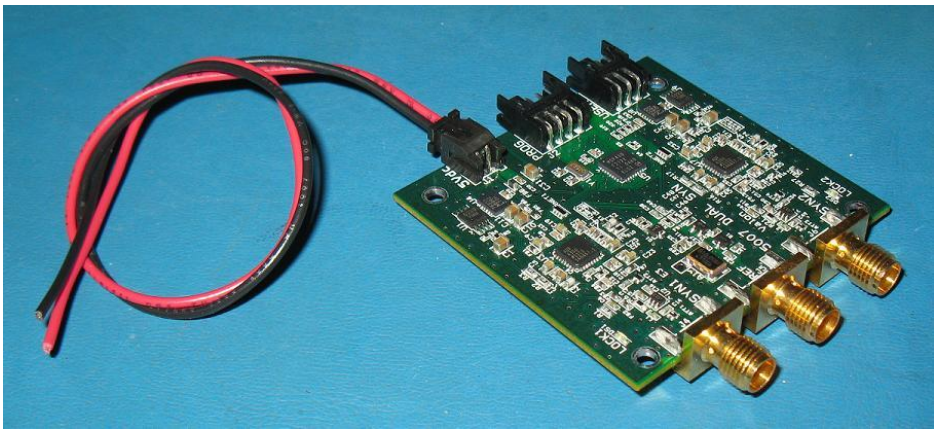


Figure 1 - Valon 5007 Synthesizer Board

3.2 RS232 Adapter Board

There is a serial interface adapter board for the 5007 that allows users to remotely adjust the various parameters of the unit, which makes it very useful for VEGAS because of the need to change the ADC clock frequency. The RS232 boards in this design have a Spectrum Control filtered DB-9 connector installed in place of the standard connector. Figure 2 shows the RS232 adapter board.

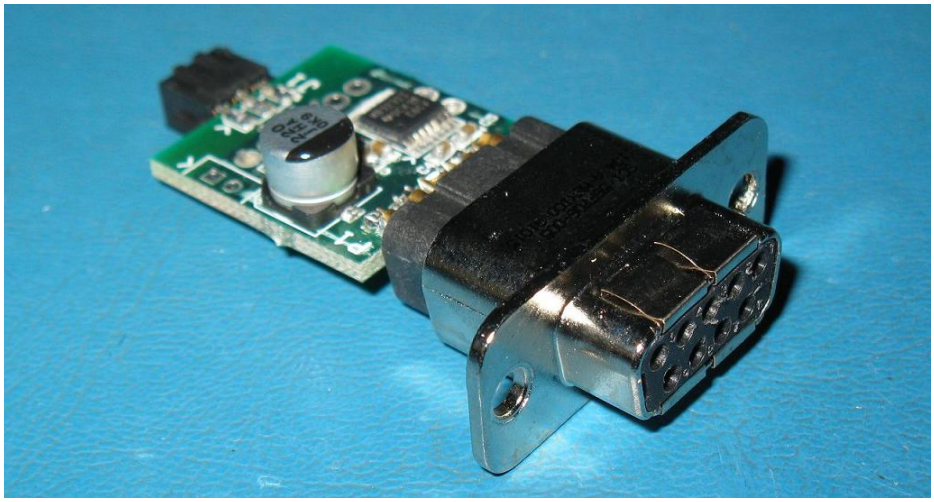


Figure 2 - Valon RS232 Adapter Board

3.3 DC Power Input

The 5007 board requires a +5VDC power supply input. For the packaged synthesizer used in VEGAS, a +12VDC supply is the power input to the unit. Inside the enclosure is a +5VDC voltage regulator to provide power to the Valon. The regulator is attached to the inside wall of the enclosure to help dissipate the heat. The bypass capacitors are soldered directly to the legs of the TO-220 regulator device, as shown in Figure 3.

Figure 3 - Valon 5V Regulator Wiring

3.4 RFI Enclosure Internal Wiring

There are several connections that need to be made to the Valon 5007 inside the enclosure. Refer to **[AD 06]** and Figure 4 below for the schematic diagram detailing these connections.

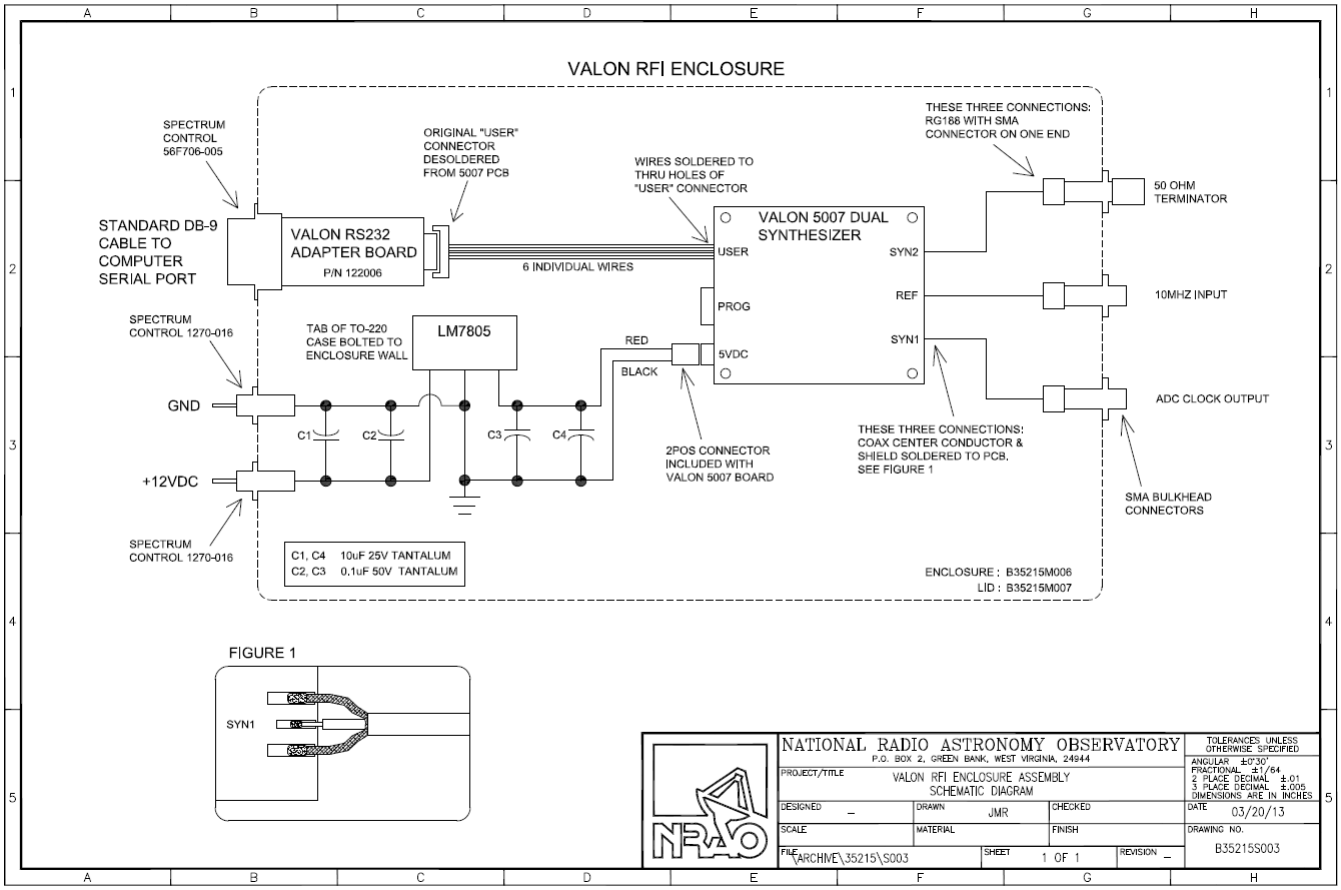


Figure 4 - Valon Synthesizer Assembly Schematic

The REF input and RF outputs are connected from the 5007 board to SMA bulkhead connectors in the enclosure. This is accomplished using short RG188 cables with an SMA connector on one end, and bare center conductor and shield on the other end. The bare wires are soldered directly to the 5007 where SMA connectors would normally reside, as shown in Figure 5.

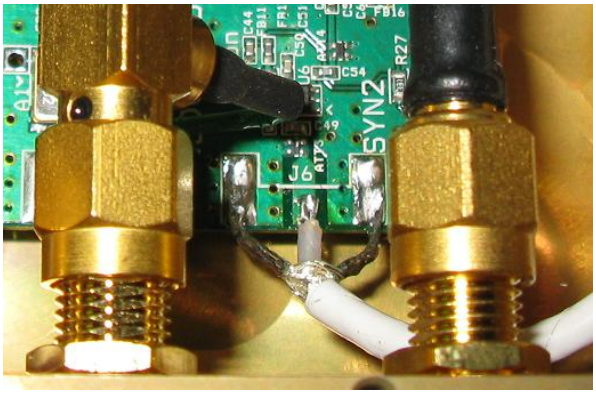


Figure 5 - Valon 5007 SMA Connections

The DC power wires are connected from the tubular feedthru PI filters in the box to the input of the +5V regulator, then from the output of the regulator to the 5007, using the pigtail cable provided by Valon.

The RS232 adapter board typically attaches directly to the 5007 using the small 6-pin connector labeled "USER". This synthesizer package was originally designed to fit in the standard 1.3U Roach1 chassis. Attaching the RS232 board directly to the 5007 would have made the form factor too large to fit inside the Roach1 chassis, so the decision was made to mount the RS232 board above the level of the 5007 and attach it with a short cable. The original PCB-mount 6-pin connector was de-soldered from the 5007, and short wires were used to make the cable to connect the pins back to the PCB, as shown in Figure 6.

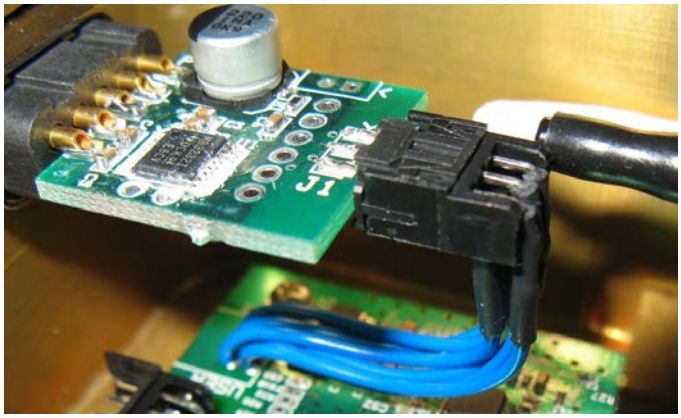


Figure 6 - Valon RS232 Wiring

3.5 Board Configuration

An RS232 serial connection is used to communicate with the Valon synthesizer, providing a way to control and monitor several parameters such as output frequency, reference select, lock status, output level, and many others.

3.5.1 Using the Valon 5007 Configuration Manager

The initial bench testing of the synthesizers was performed using the "*Valon 5007 Configuration Manager*" application, downloaded from the Valon Technology website. A serial cable is attached between a computer and the 5007. The serial connection is opened when the application is launched.

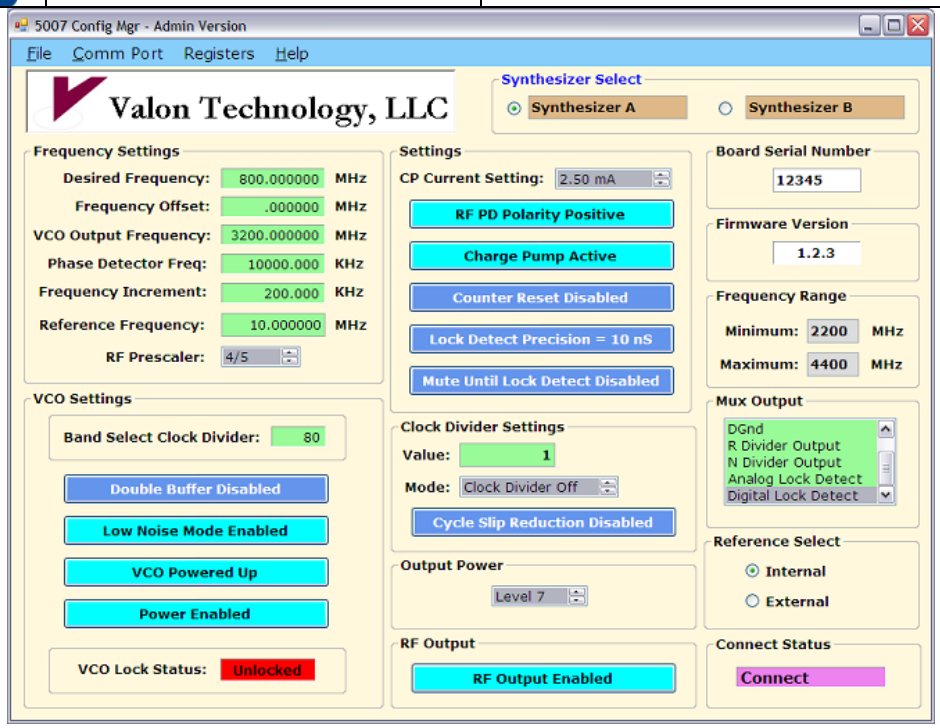
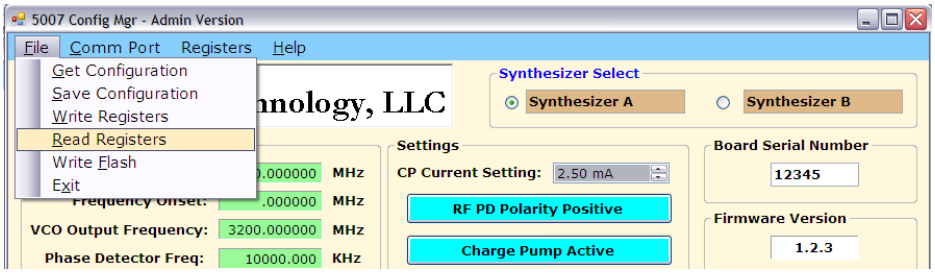
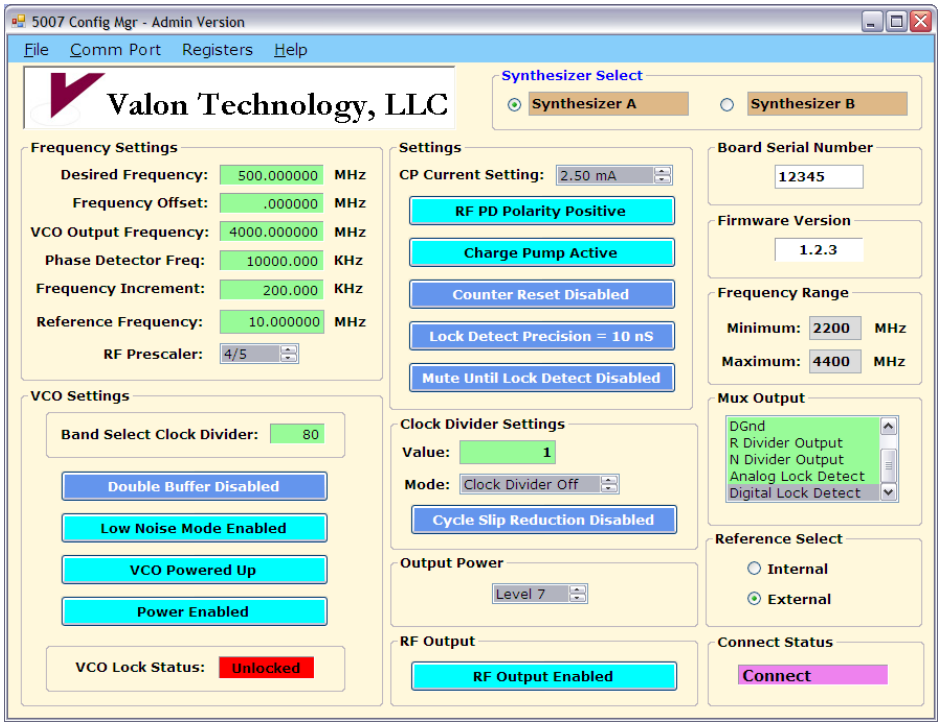


Figure 7 - Valon 5007 Configuration Manager

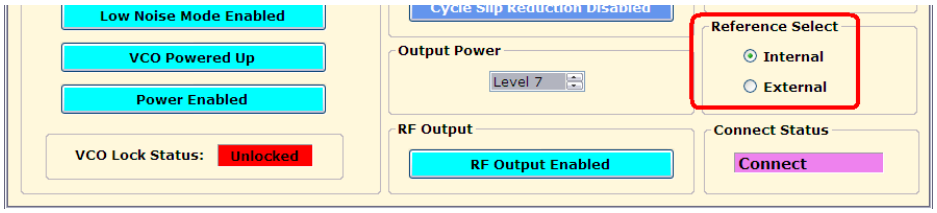
Once the connection is established, go to **File -> Read Registers** to read the current configuration of the attached 5007.



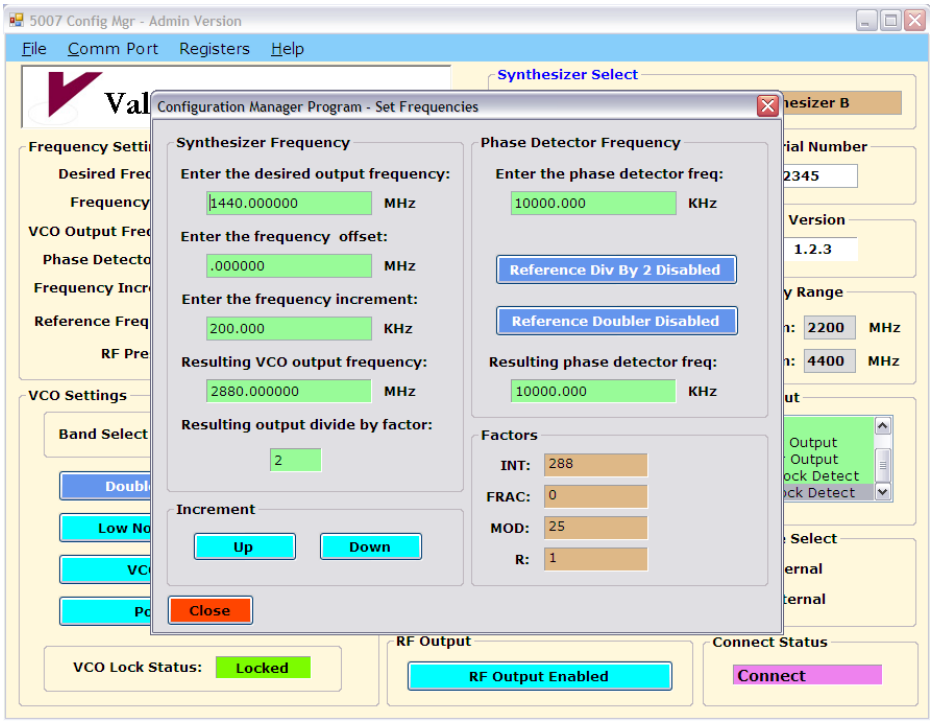
This will update the fields in the GUI to display the current Valon settings.

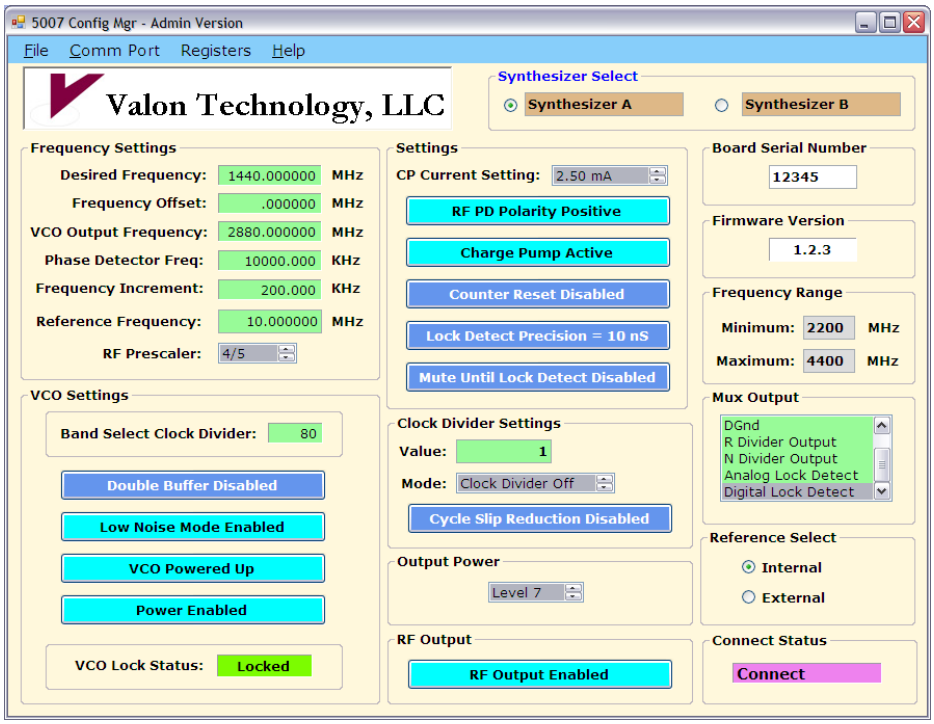


Now, the user can change settings such as the reference select, by selecting the desired radio button.



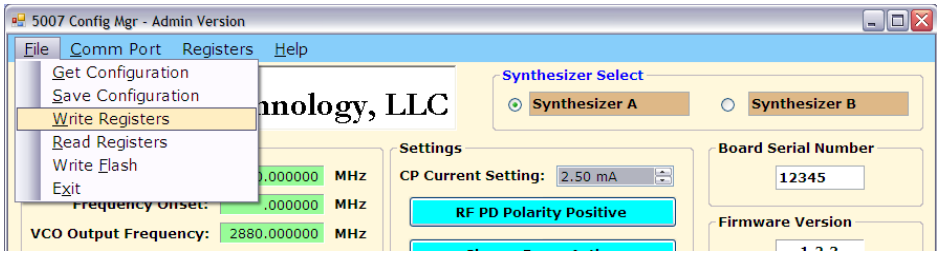
The desired frequency can be changed by clicking in the “desired frequency” field, and entering the new frequency and clicking the close button.





Once the testing and configuration is complete, the user must click on **File -> Write Registers**, and then **File -> Write Flash** so that the new settings will be stored in flash, and the unit will power on

with the desired settings by default. These steps aren't necessary for the VEGAS synthesizers because the M&C manager will adjust the parameters as necessary for the different instrument configurations. However, for other, more static instruments, it is desirable to have the default configuration stored so that the Valon powers up in the correct state in the event of power interruptions.



3.5.2 Using the Python Interface

The CASPER based instruments at NRAO-GB all make use of a python program to interface with the Valon synthesizers. This program is loaded into the Roach2 Linux and can be accessed via logging into the Roach2 as root. The serial port **ttyS1** of the Roach2 is used for this. Figure 8 below shows how to load python and check the output frequency, the phase lock status, and the reference select. There are a number of other commands for interfacing with the Valon.

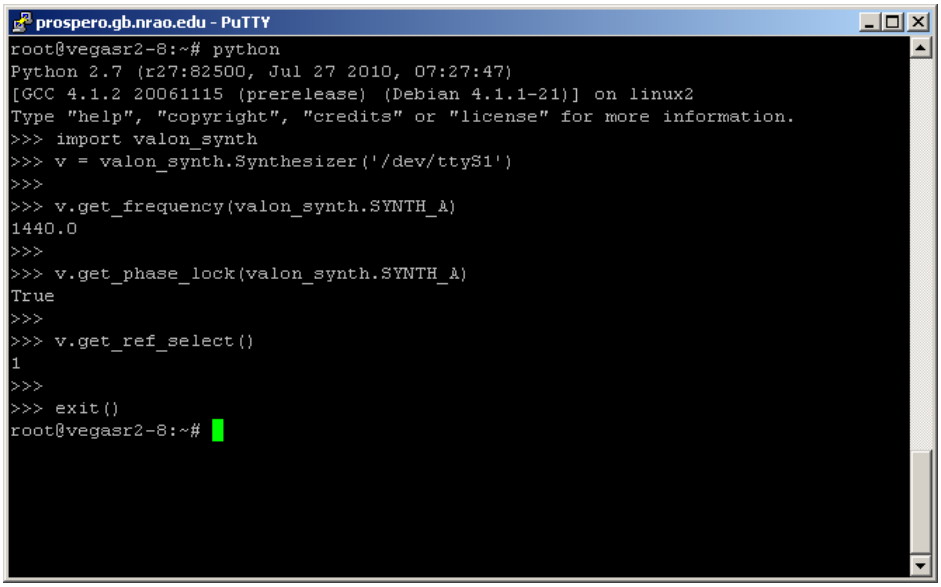


Figure 8 - Python Interface for Valon Synthesizer

The default mode is for ttyS1 is to present a login prompt after bootup. In order to ensure that there would be no problems with the Valon synthesizer because of this, the login prompt was disabled by editing the file **/etc/inittab** and commenting out the following line:

```
#T1:23:respawn:/sbin/getty -L ttyS1 115200 vt100
```

After the next reboot, the Roach2 will not issue a login prompt on ttyS1.

3.6 Connections to the Roach2 Board

Special cabling is required to connect the Valon synthesizer DB-9 connector to the Roach2 P6 connector, to use the serial port. Details of this cable are shown in Figure 9 below, as well as **[AD 03]**.

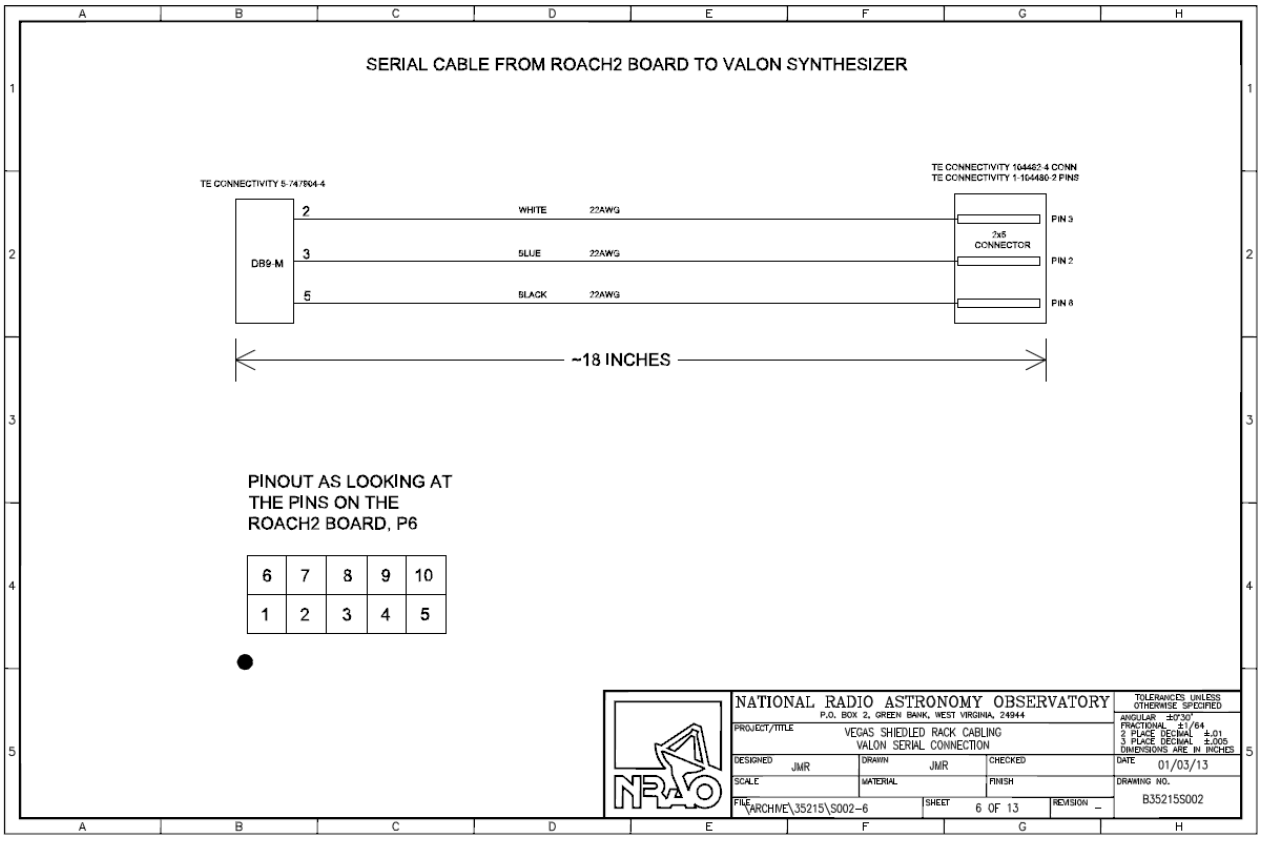


Figure 9 - VEGAS RS232 Cabling

3.7 Connections to the ADC Board

VEGAS uses the 5GSPS V2.0 DMUX 1:1 ADC board developed by the group at ASIAA. This board attaches to the Roach2 ZDOK connectors and converts the input signal to 8-bit samples.

The ADC board has four SMA connectors for attaching the IF inputs (I and/or Q), the ADC clock, and the sync (1PPS) signal. There are two of these boards per Roach2 in VEGAS. Figure 10 below is an image of the board, with the SMA connectors labeled.

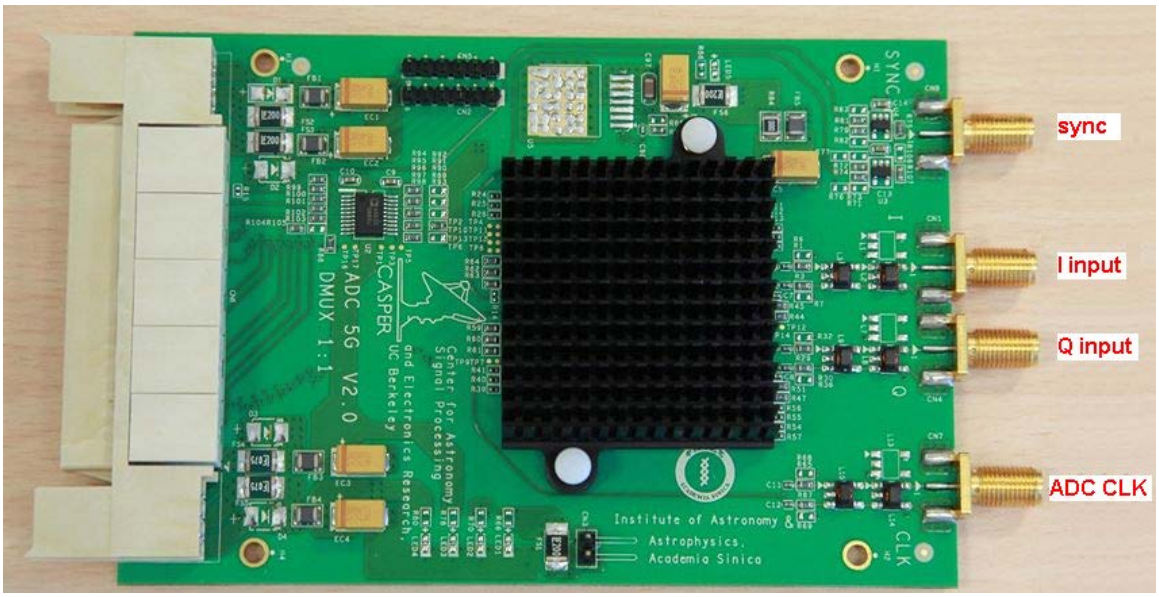


Figure 10 - 5GSPS ADC Board

Each of the ADC boards require an ADC clock signal input. The SYN1 output from the Valon is used to provide the clock signal to both ADC boards. The SYN1 output is split using a Mini Circuits ZX10-2-20-S+ power divider. All of the ADC clock signals travel on RG402 semi-flex SMA coax cables **[AD 03]**.

3.8 Custom Order Requirements

Due to the form factor requirements mentioned above, the Valon 5007 units required a few custom order options that were provided by Valon Technology for a minimal additional fee, per unit.

One option is that the SMA connectors on the 5007 boards need to be removed to allow the cables to be soldered to the board. Trying to remove them in-house was a bit difficult given the small trace sizes, and the heat required to overcome the large ground plane. The decision was made to order them with the connectors already removed, as shown in Figure 11.

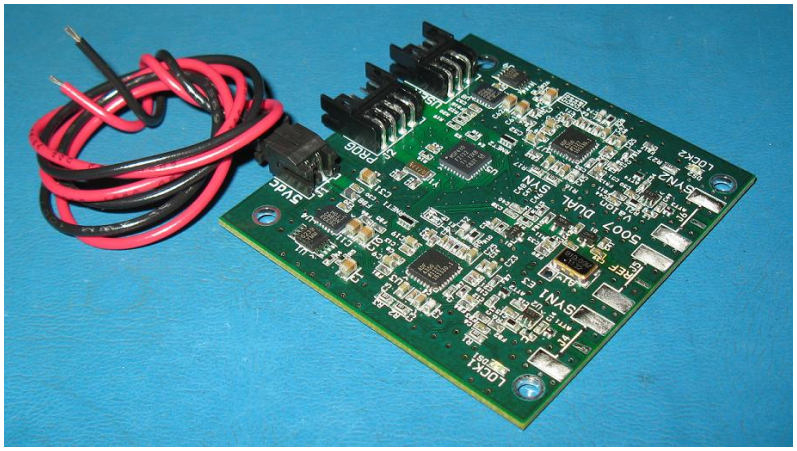


Figure 11 - Valon 5007 As Purchased

Another option required is that the RS232 adapter boards must have filtered DB-9 connectors in place of the standard connectors. NRAO provided the filter connectors to Valon Technology, which they used to assemble the RS232 boards.

4 Testing

Once the Valon synthesizer assembly is complete, several tests are performed to verify functionality. For the following tests, the 5007 Configuration Manager, discussed above, is used.

To start with, the DC power output from the regulator is checked prior to connecting it to the 5007 board, to ensure the voltage is ok.

Next, a simple communications test is performed by launching the Configuration Manager and selecting **File-> Read Registers**. This verifies the RS232 wiring and basic functionality of the board.

The next test involves connecting a spectrum analyzer to the two outputs to verify the frequency and output levels are ok. This test is performed at a few different frequencies between 200MHz and 3GHz and at a few different output level settings, with the reference select set to “internal reference”.

The last test involves connecting an external 10MHz (at around 0dBm) reference to the REF port, changing the configuration to use the external reference, and then verifying that the unit is still reporting “locked “ for the VCO lock status in the configuration manager.

Once these tests are complete, both outputs are set to 500MHz and back to “internal reference”. This default configuration is written to the registers and to the flash.

5 Mechanical Design

This section describes the mechanical design of the Valon synthesizer assembly.

5.1 RFI Enclosure

The body of the RFI enclosure housing **[AD 04]** is constructed from a solid block of aluminum, with the cavity milled out. One interesting feature of this enclosure is that the standoffs for the 5007 board were incorporated into the machining process. Small, 3/16" bosses were left in the aluminum, and tapped for 2-56 screws. These features are shown in Figure 12 below.

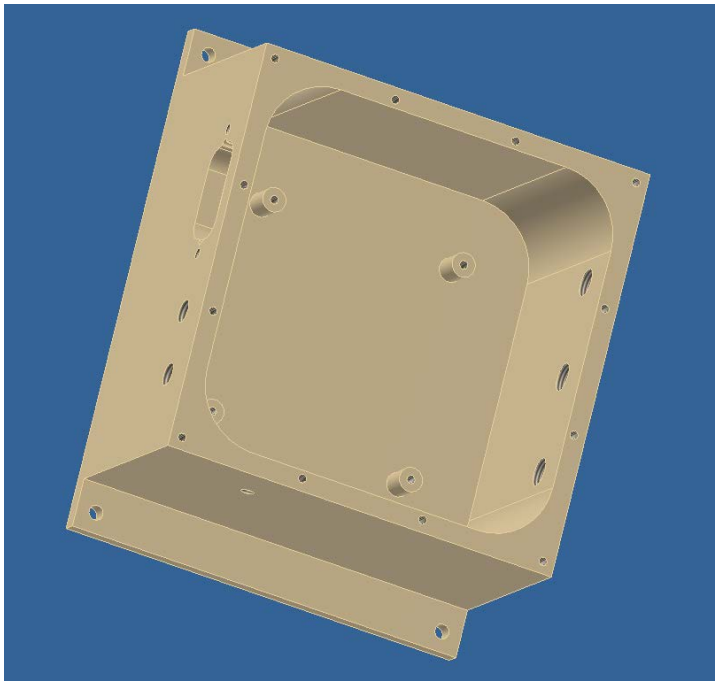


Figure 12 - Valon Board Standoffs

The cutout for the DB-9 connector has small slots on the left and right side to allow the RS232 board assembly to slide into the housing. Figure 13 below shows these slots.

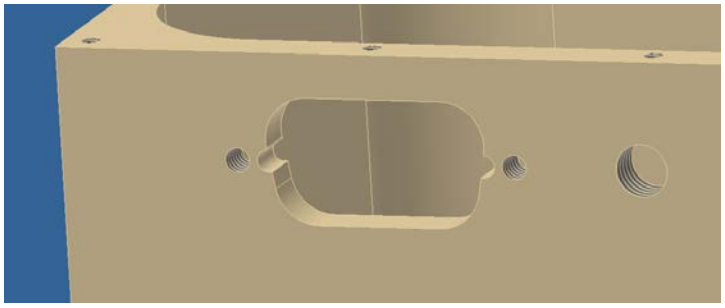


Figure 13 - RS232 Board Slots

The remaining features of the enclosure are thru holes for mounting and tapped holes for the filter connectors, SMA bulkhead connectors, +5V regulator, and the lid.

The lid **[AD 05]** is constructed from 1/16“ thick aluminum and has 12 thru holes to mount it to the enclosure.

The enclosure body and the lid are both finished with yellow chromate conversion.

6 RFI/EMI Considerations

Since these synthesizer units will be primarily used in CASPER hardware based instruments, they will inherently be installed close to the sensitive ADC sampler boards. Due to this close proximity, the RFI emissions from the 5007 boards could couple into, and degrade, the input signals to the ADC boards. This made it necessary to fully shield the synthesizer electronics.

An RFI enclosure was developed to house the Valon 5007. The RFI enclosure consists of a custom aluminum housing with an RFI-gasketed aluminum lid. The gasket material used for the lid is “SRF gasket material” made by Compac Development Corporation. Figure 14 below shows this gasket installed on the lid.

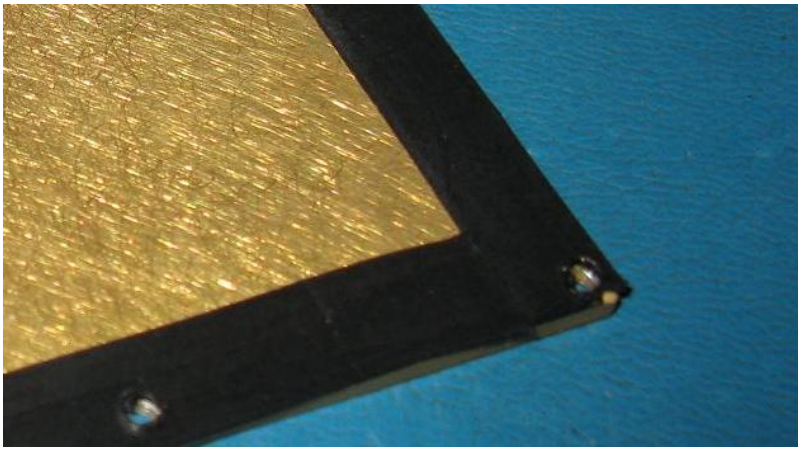


Figure 14 - SRF Gasket Material

Tubular feedthru PI filters are used to bring +12VDC into the box. A filtered DB-9 connector is used for the RS232 connection.

SMA bulkhead connectors are used for the reference input and RF outputs of the 5007. Fully shielded cables are used to connect to these ports, and any unused ports are capped off with a 50ohm terminator.

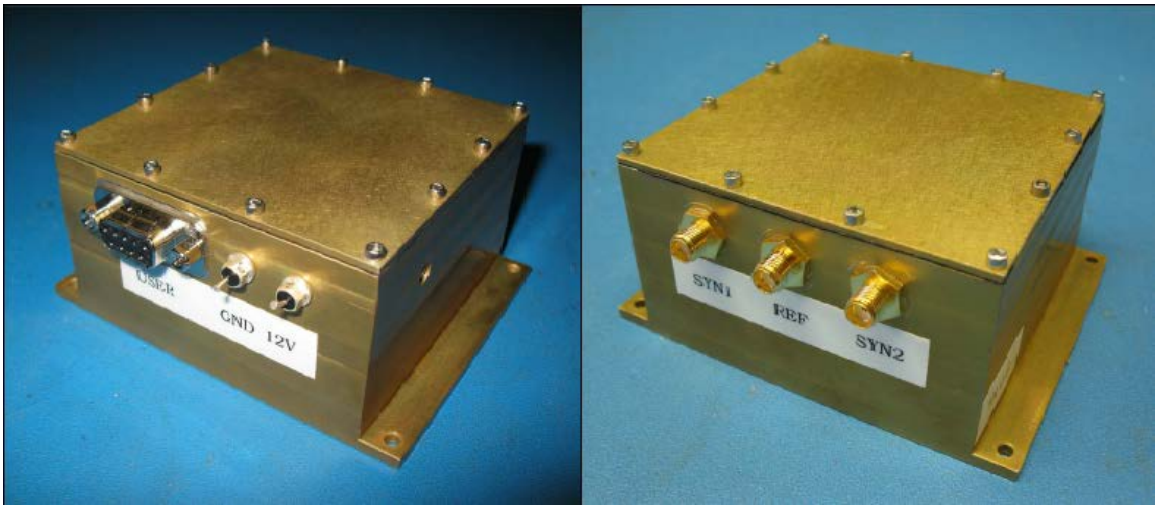


Figure 15 - Valon 5007 RFI Enclosure

An RFI test was performed on this assembly, in the anechoic chamber at NRAO GB, and it was found that there were no detectable emissions from the unit **[AD 02]**.

7 Bill of Materials

Item	Qty	Description	Notes	Manufacturer	Mfg PN	Vendor	Vendor PN	Cost	Ext Cost
1	1	Valon RFI Enclosure	Housing	NRAO	D35215M006	NRAO	D35215M006	0.000	0.00
2	1	Valon RFI Enclosure Lid	Housing Lid	NRAO	D35215M007	NRAO	D35215M007	0.000	0.00
3	3	RG188 cable, ~6" long	For SMA cables to Valon 5007	NRAO	-	NRAO	-	0.000	0.00
4	1	Valon 5007 Dual Synthesizer	Synthesizer PCB	Valon Technology	5007	Valon Technology	5007	295.000	295.00
5	1	Valon Power Cable	Included with the synthesizer	Valon Technology	-	Valon Technology	-	0.000	0.00
6	1	Valon RS232 Adapter	Programming Adapter PCB	Valon Technology	122006	Valon Technology	122006	39.000	39.00
7	1	SMA connector removal rework	Required for RFI box installation	Valon Technology	-	Valon Technology	-	6.000	6.00
8	1	Filtered DB-9 Connector, female, 4000pf pi	RS232 Connector	Spectrum Control	56F706-005	Mouser	657-56F706-005	51.050	51.05
9	1	Wavy metal gasket, DB-9 front mount	For RS232 Connector	Spectrum Control	572019-00100-NI	Mouser	657-572019-100-NI	1.670	1.67
10	3	SMA feedthru adapter	For REF in and two outputs	Amphenol Connex	132170	Mouser	523-132170	6.160	18.48
11	1	50ohm terminator, SMA	For unused syn2 output	Amphenol Connex	132360	Mouser	523-132360	2.140	2.14
12	1	+5V Regulator, TO-220	For +5V to Valon 5007	Fairchild Semi	LM7805CT	Mouser	512-LM7805CT	0.540	0.54
13	2	Power line filter, 10A	For +12V Power Input	Spectrum Control	1270-016	TTI Inc	1270-016	4.737	9.47
14	2	D connector jackpost	For RS232 Connector	SPC Technology	SPC15292	Newark	79K4887	1.400	2.80
15	2	10uf 25V capacitor, tantalum	Regulator decoupling	AVX Corporation	TAP106K025SCS	Digikey	478-1841-ND	0.900	1.80
16	2	0.1uf 50V capacitor, tantalum	Regulator decoupling	AVX Corporation	TAP104K050SCS	Digikey	478-1832-ND	0.560	1.12
17	3	RG188 to cable SMA connectors	SMA feedthru's to Valon 5007	TE Connectivity	1051654-1	TTI Inc	1051654-1	7.250	21.75
18	1	SRF gasket material, ~12"	Housing to lid interface	Compac RF	.250 SRF GASKET	Compac RF	.250 SRF GASKET	8.750	8.75
19	12	2-56 x 3/16" socket head cap screws (25pk)	Housing lid to box	-	-	McMaster Carr	92185A073	0.180	2.16
20	4	2-56 x 3/16" pan head screws w/ washer (50pk)	Valon PCB to box	-	-	McMaster Carr	95345A012	0.216	0.86

Figure 16 - Valon Synthesizer Bill of Materials

8 Valon 5007 Datasheet

5007 Dual Synthesizer Data Sheet

rev4 revised 08-08-12

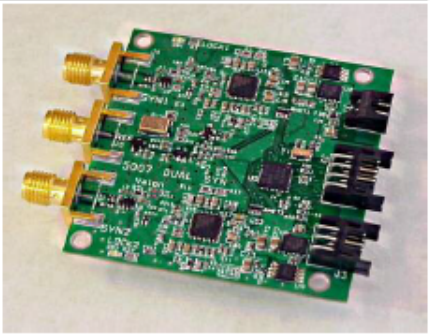
5007 Dual 137.5-4400MHz Frequency Synthesizer Module

Valon Technology, LLC

The 5007 Dual Synthesizer module provides two independent frequency sources suitable for high quality clock, carrier, or local oscillator frequency generation applications. The unique feature of our synthesizers is our microprocessor controller with FLASH memory that lets you retain your frequency setting after power down. This makes these synthesizers ideal for portable equipment or in any application where user programmable and non-volatile frequency settings are desirable.

An RS-232 or USB serial interface and our intuitive user configuration software allows the user to program the desired operating frequency of each synthesizer and save to the on-board FLASH memory. The synthesizer will then power up using the FLASH memory to reload the last saved frequencies.

Either output can be independently set to any frequency in the 137.5-4400MHz range. The synthesizer can be used with the on-board TCXO or an external reference.



Note: Specifications apply to both synthesizers

Parameter			Min	Typical	Max	Units	Notes
RF outputs							
RF output frequency range			137.5	-	4400	MHz	Basic range is 2200-4400MHz, Output divide-by-1,2,4,8, & 16 automatic range selection
Frequency increment (2200-4400MHz)			2.5		10000	kHz	
Output Impedance 50 ohm nominal	137-1500 MHz			-24	<-20	dB	Output return loss
	1500-4400MHz			-15	<-12		
Output RF power	Level 7		7	8	9	dBm	RF output power level can be set to one of 4 output power levels.
	Level 4		5	6	7		
	Level 1		2	3	4		
	Level -2		-1	0	1		
RF Output Disabled	<2200MHz			-30	-20		Disabling the output buffer allows the synthesizer to run with some output leakage power present
	>2200MHz			-45	-40		
Output power flatness				1	2.5	dB	Output power variation over the 140MHz to 3.1GHz range. Output roll-off at 4.4GHz <4dB
Harmonics levels	2nd			-28	<25	dBc	relative to carrier output
	3rd			-20			
	>3rd			-43	<-40		
Synthesizer Isolation				-62	<-60	dB	Relative amount of synthesizer signal from one synthesizer appearing in the output of the other
Phase Noise							
Frequency	3GHz	10kHz offset		-90	<-85	dBc/Hz	Using low noise mode. Internal 10MHz TCXO, Phase Detector Frequency =10MHz, Frequency Increment = 1000KHz, CP Current Setting: 5.00mA, (Note; 10kHz typical and max. values below -106dBc are projected estimates, 100kHz typical and max values are projected estimates below -116dBc)
		100kHz offset		-102	<-100		
	1.5GHz	10kHz offset		-96	<-91		
		100kHz offset		-108	<-105		
	750MHz	10kHz offset		-102	<-97		
		100kHz offset		-114	<-110		
	375MHz	10kHz offset		-108	<-103		
		100kHz offset		-120	<-115		
	187MHz	10kHz offset		-114	<-109		
		100kHz offset		-126	<-120		
Non-harmonic spurious output							
PFD Reference spurs				<-90	<-75	dBc	In low noise mode, lower in low-spur mode (10MHz to 200MHz at output)
Ext or TCXO reference spurs				-105	<-90	dBc	
Internal Reference	10MHz						
Calibration				2	<+/-2.5	ppm	
Temp. stability (0-70deg. C.)				2	<+/-2.5	ppm	
Reference Input	Input frequency range		5	10	150	MHz	External reference frequency must be integer divisible to 10MHz, 5MHz input uses internal doubler.
	Input amplitude		-10		10	dBm	
	Input amplitude			0.275	1	Vpk-pk	
	Input 50 ohm return loss			-10	<-6	dB	
Reference Output	Output amplitude		2	2.2	2.4	Vpk-pk	Square wave, Open circuit
	Output amplitude		0.8	1	1.1	Vpk-pk	Into 50 ohms
reference output 50 ohm return loss				-20	<-15	dBm	1-150MHz
Power Requirements			5.0	5.1	6.5	Vdc	Recommended operating range
			-20		20	Vdc	Brief over voltage without damage
			3.5		5.0	Vdc	Reduced output power (increased 2nd harmonic)
Max current					340	mA	Both synthesizers operating
					170	mA	One synthesizer operating
Connectors							
RF Outputs and External Reference			SMA Female				
dc power input			2-pin Hirose DF3A-2P-2DS				Power cable supplied
TTL serial			6-pin Hirose DF11-6DP-2DS(24)				For our RS-232 Serial or USB adapters only
Dimensions	Length		1.925			Inches	Dimensions refer to board size but does not include connectors.
	Width		2.04				
	Height		0.32				

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5007 Description

The synthesizer module consists of two separate fractional/integer-N synthesizers chips. The RF output of the synthesizer chips are each buffered by a wide-band MMIC RF amplifier followed by an output attenuator.

Each synthesizer chip has its own 3.3V low-noise, LDO voltage regulator. A separate 5V LDO is used to power the output buffer amplifier. The recommended input voltage is 5.0V in order to ensure the LDOs are in regulation.

Both synthesizers are referenced to a common 10MHz temperature stabilized crystal oscillator (TCXO). A software controlled switch also lets the user select an external reference. When the internal reference is selected, a sample of the reference signal is available at the reference connector. External reference input should be ac coupled and between -10 and 10dBm. The external reference frequency should be an integer multiple of 10MHz, such as 10, 20, 50, 100, or 150MHz. A 5MHz external reference frequency can be used by enabling the reference doubler function with the Configuration Manager software.

Both synthesizers will operate either in the fractional-N or integer-N mode depending on the user selected frequency. Since the internal phase-frequency detectors and loop filters are set operate at 10MHz, the synthesizers will be operating in the factional-N mode whenever a channel frequency is selected that is not an integer multiple of 10MHz. The Configuration Manager allows the user to set the frequency increment to channel spacing as small as 5kHz in the divide-by-1 range with the reference doubler on. The frequency increment will be smaller by the divide-by factor on lower frequencies. In order to minimize phase noise and spurs its best to use the largest possible frequency increment setting that will provide the desired output frequency.

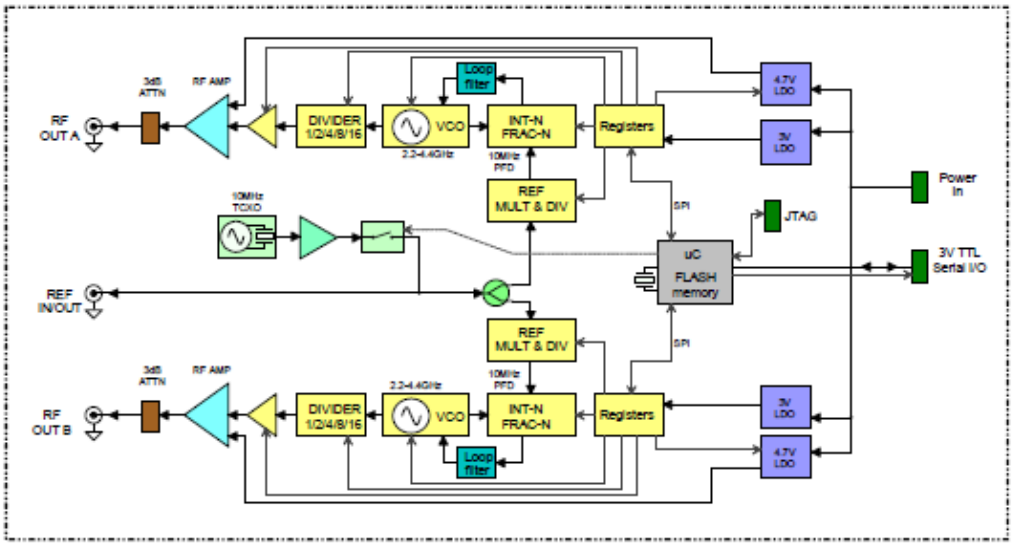
The Configuration Manager software along with the serial adapter allows the user to set the desired output frequency and channel spacing directly. The Configuration Manager can also store any offset frequency and sign. This allows direct entry of the desired frequency if the synthesizer is used as a local oscillator in a heterodyne system. For example, if the synthesizer is used as the first LO in a high-side receiver with a 160MHz IF and 1045MHz is the desired tuned frequency, then the user would simply set the desired frequency to 1045MHz and the offset to 160MHz. The Configuration Manager calculates the correct LO output frequency.

The low-power on-board microcontroller (uC) is used to load the multiple control and frequency registers of each synthesizer with the data stored in either its RAM or FLASH memory. The uC is also used to manage bi-directional communications over the serial interface.

On power-up, the uC reads the previously saved frequency and control setting for each synthesizer out of FLASH memory. The uC then loads this data using the internal serial bus to each of the synthesizers. The synthesizer will then lock and pass the lock detect signal back to the uC.

After power-up, the Configuration Manager software can communicate with the synthesizer module and control all the synthesizer frequency and control settings. The Write Registers command can be used at any time to update the register settings. The Read Registers command can be used to see what the frequency and control settings are. The Write FLASH command is used to store the setting into the non-volatile FLASH memory. The Configuration Manager can also Save and Get synthesizer's setting to and from a local disk.

5007 Block Diagram



Connectors

do Power In

J1-1	dc power input positive	5.0 to 6.5V dc input
J1-2	dc power input ground	

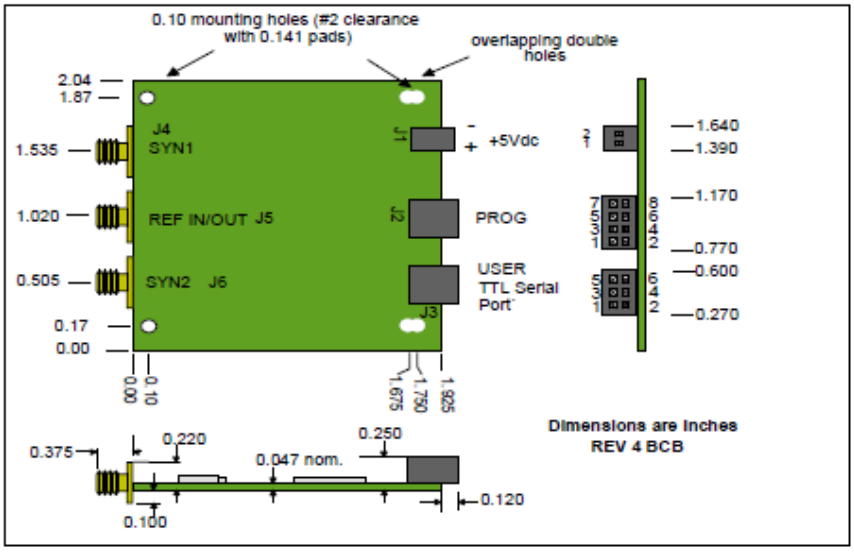
JTAG

J2-1	TDO	JTAG Programming port (no user functions)
J2-2	Lock detector output	
J2-3	TDI	
J2-4	Reset, active low	
J2-5	TMS	
J2-6	TEST MODE SELECT	
J2-7	TCK	
J2-8	Ground	

Serial I/O

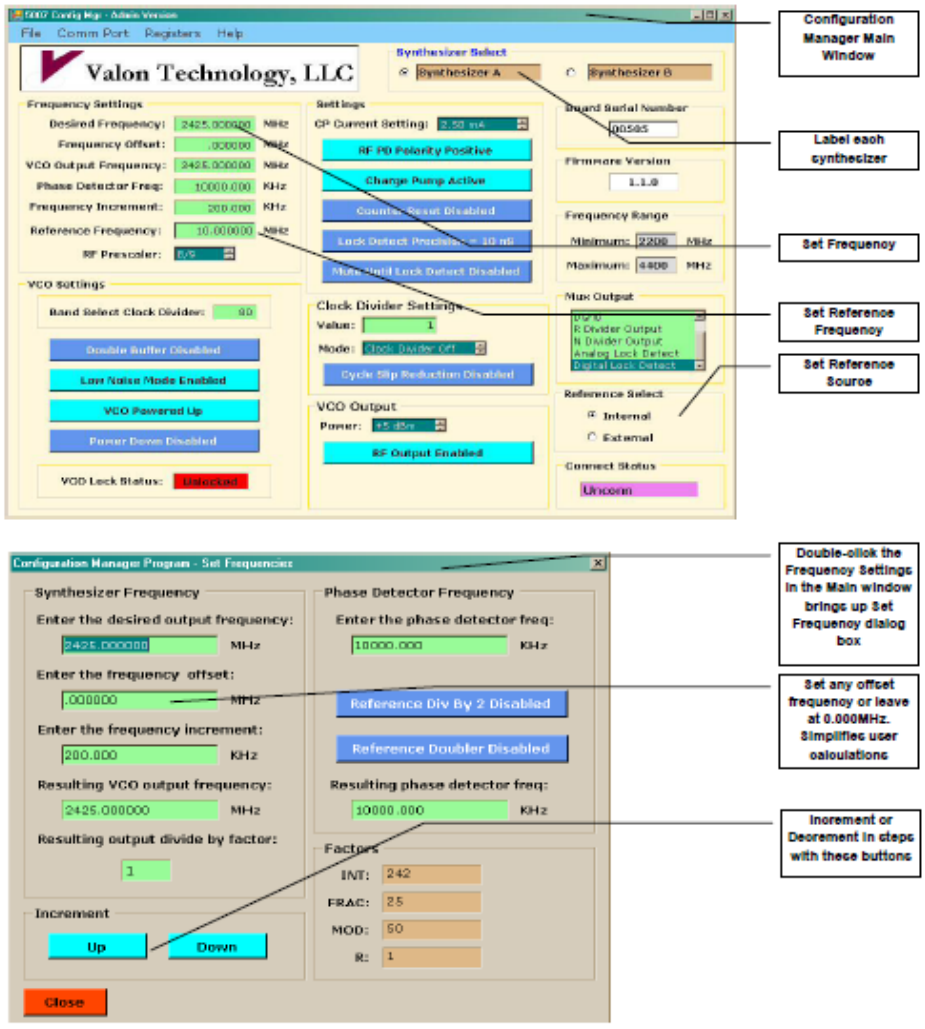
J3-1	TXD	Transmit asynchronous data output	
J3-2	VBAT	dc power input positive	
J3-3	RXD	Receive asynchronous data input	
J3-4	Ground	ground	
J3-5	+3.3V output	10mA maximum load current	Auxiliary supply
J3-6	Lock detector output	Combined lock indicator	0V unlocked / +3V locked

Dimensions and Mounting locations

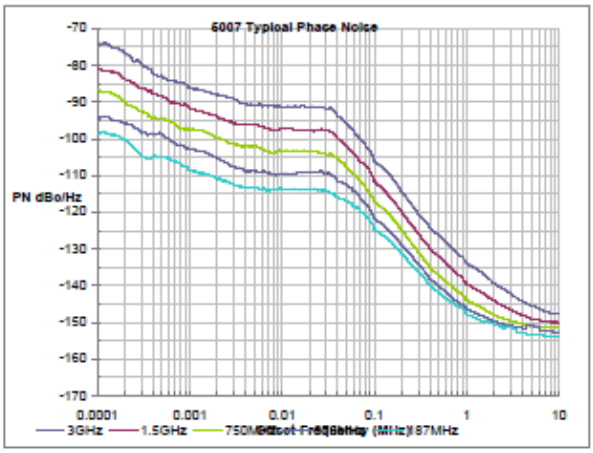


The Configuration Manager software, is an easy to use Windows application, supplied via free download from our web site. The **Configuration Manager** allows the user to control the operation of each synthesizer independently.

Set each synthesizer frequency and assign a unique label or name.
Set the frequency increment and provides a push-button increment or Decrement function.
Check Lock condition of each synthesizer with the Read command.
Enable or disable either or both synthesizers for low power operation when only one or neither synthesizer operation is needed.
Set an offset frequency which makes direct frequency entry easier when used in a heterodyne scheme.
Set the reference source to either internal TCXO or external local standard. Set the reference frequency.
Save and recall setups to your computer files.
Write to synthesizer FLASH to save all setting in non-volatile memory.
Set the synthesizer output power.



Typical phase noise performance



Phase noise was measured using the internal 10MHz reference with the Phase Detector Frequency set to 10MHz. The Frequency Increment was set to 1000kHz. The Charge Pump Current setting was 5mA.

The phase noise data was taken at the center of the 5 frequency bands. The phase noise will be slightly higher at the top of each band and slightly lower at the bottom.

Using an external low phase noise frequency reference will also improve phase noise.

Agilent E4440A PSA used to acquire phase noise plots using the built-in phase noise measurement utility.