Thomas M. Alldread, VA7TA

7056 Railway Ave, Courtenay, BC V9J 1N4, CANADA; va7ta@telus.net

NimbleSig III—A Dual Output DDS RF Generator and Low Level RF Power Meter—Part 3

Learn about the control software commands and how to calibrate the various sections of NimbleSig III.

Parts 1 and 2 of this article described the hardware design, construction details, software design, computer interfacing, MPU programming and initial testing procedures for NimbleSig III (NS3). NS3 is a frequency agile, direct digital synthesizer (DDS) based RF signal source with independent dual outputs that have a frequency range of 100KHz – 200 MHz. Included within the module is a wide dynamic range RF level meter. Part 3 of this article will describe the NimbleSigIII command set in detail and provide the final calibration procedures.

The NimbleSig III connection daisy chain shows the parallel port JTAG interface connected to the 20 pin side of the cross-connection board and the NimbleSig III 10 pin JTAG programming cable connected to the 10 pin side.

NimbleSig III Command Set

At first glance the nearly 140 NimbleSig III commands might seem like an excessive number to memorize. More than half of the commands are seldom used, however, as they are utility in nature. They are just needed to either directly access DDS registers or to initiate calibration procedures. Thus, there is no need to memorize them. The frequently used commands are duplicated for generators A and B, so they have similar syntax. As there are eight help screens similar to Figure 1 available which display the commands alphabetically a refresher list is close at hand. Of course when NS3 is utilized as an internal signal source module as part of a larger project this somewhat cryptic syntax command set would typically be masked by a more friendly host computer user interface.

The command set is categorized by prefixes as follows:

- "A" Attenuator commands for fine adjusting output levels in 0.1dB steps.
- "B" Output level control mode commands.
- "C" DDS register single bit clear commands.
- "D" EEPROM read/write access.
- "E" Host communications echo control.
- "F" Frequency set commands.
- "H" Help screen commands.
- "K" Kill/restore generator outputs.
- "L" RF level measurement commands.
- "M" Modulation Commands.
- "P" Phase offset commands.
- "Q" Reserved prefix for bypassing a host MPU for direct external PC control.

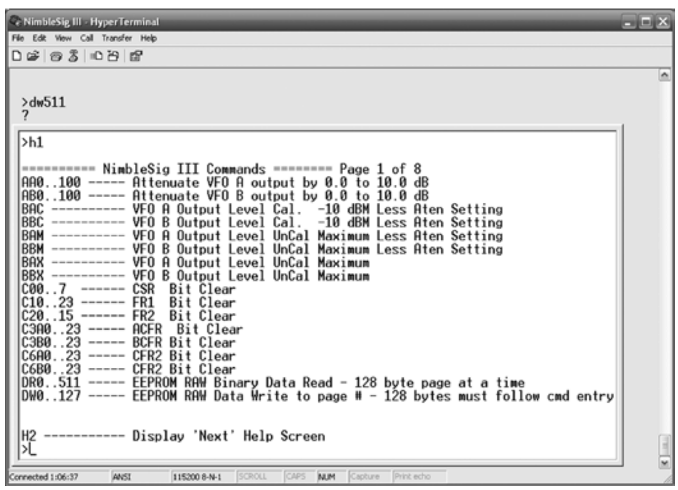

Figure 1 — NimbleSig III Help1 Screen.

[1]Notes appear on page 20.

• "R" DDS register read commands.
• "S" DDS register bit set commands.
• "W" DDS register full word set commands.
• "X" NimbleSig III calibration functions.
• "Y" Re-initialize DDS to default values.

"A" Commands (Fine Step Attenuator Control):

AA0..100 — Attenuate VFO A output by 0.0 to 10.0 dB
AB0..100 — Attenuate VFO B output by 0.0 to 10.0 dB

The format of the "A" command is typical of most of the commands that have numeric suffixes and thus the "A" command is by coincidence a good example to describe first. The "A" command provides a means to reduce the output level of either generator in 0.1dB steps, up to a maximum of 10.0 dB. The "AA" command is for generator "A" and similarly the "AB" command applies to generator "B". The 0..100 suffix indicates the desired level reduction in tenths of a decibel. Thus to reduce the output of generator "A" by 5.5 dB one would enter "AA55" followed by the "Enter" key (note that all commands must be completed with "Enter").

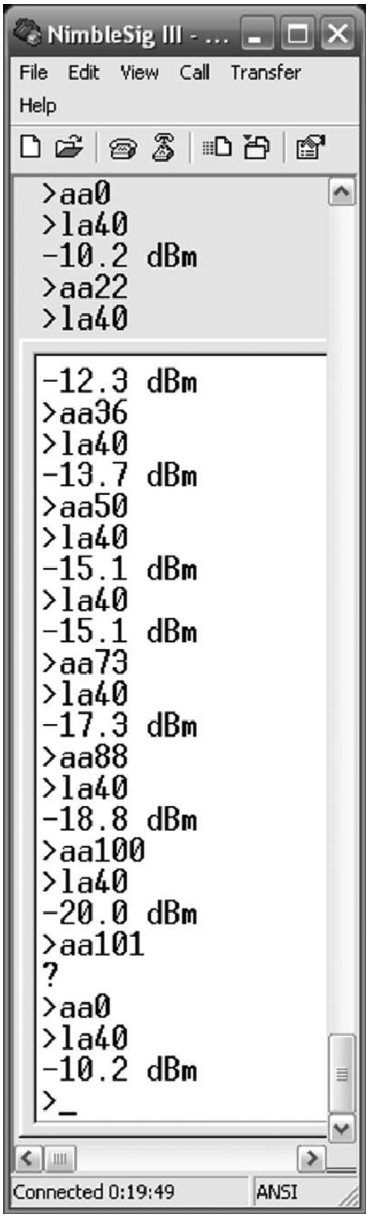

Figure 2 — "AA" command example illustrates typical NimbleSig III command entry and associated level changes.

The HyperTerminal window shown in Figure 2 illustrates some examples of the "AA" command followed by level measurements to show the resulting level shifts. The 40 MHz output of generator "A" was looped into the RF level detector input during this procedure. Note that the ">" is the command prompt sent from NimbleSig III and also note that NS3 accepts lower case alpha characters and converts them to upper case. The "aa0" entry shown at the top (in the HyperTerminal buffer zone) is entered to set the output level to the nominal –10.0 ± 0.5 dBm. The following "la40" command, which repeats throughout this example, is the command for measuring and displaying the average of 1024 power level readings. The 40 suffix is provided to select the 40 MHz calibration factor for correcting the level reading for the frequency of measurement. As shown the output with zero attenuation is measured at –10.2 dBm which is close to the expected –10.0 dBm level. I then decided to set the generator "A" output level to –12.2 dBm by attenuating the generator output by 2.2 dB with the "aa22" command. The resulting output level measurement was –12.3 dBm. As shown in the repetitive command sequences that follow, the measured level shifts remain within about 0.2 dB of the desired shift. Since the output of the DDS is controlled with digital accuracy the variation of shift from nominal is most likely due to the very slight inaccuracies of the analog level detector response in combination with the resolution limitations of the 10 bit ADC in the MPU, which is approximately 0.13 dB.

Following the 3rd command entry ("aa50") example in Figure 2, I entered two consecutive "la40" commands to demonstrate the stability of an averaged 1024 sample RF level measurement. Notice that the two readings are exactly the same at –15.1 dBm.

In the second last sequence I entered "AA101" to demonstrate the range checking done by the NS3 firmware. 101 is out of the range specified for the numeric suffix associated with the "AA" command. The acceptable range is shown in the Figure 1 help screen as 0..100 indicating the maximum value allowed is 100. NS3 performs similar range checking on all commands and retorts with a "?" in the event of a command entry error. The last "AA0" entry which completes this example restores the level back to the initial value of –10.2 dBm.

"B" Commands (Output Level Control):

BAC	—	VFO A Output Level Cal. –10 dBm Less Aten Setting
BBC	—	VFO B Output Level Cal. –10 dBm Less Aten Setting
BAM	—	VFO A Output Level UnCal Maximum Less Aten Setting
BBM	—	VFO B Output Level UnCal Maximum Less Aten Setting
BAX	—	VFO A Output Level UnCal Maximum
BBX	—	VFO B Output Level UnCal Maximum

The "B" commands provide a means to obtain the maximum possible output level from the DDS generators by removing the calibration factor that is used to flatten the output level to approximately –10 dBm across the whole output frequency range. The maximum output level across most of the output range is about –4 dBm however this rolls off as the corner frequency of the associated low pass filter is approached. The maximum output level can be useful for applications where the maximum dynamic range or extra signal power is more important than a calibrated absolute level. For example the maximum output level would usually be desirable for sweeping the response of a relatively narrow passive bandpass filter. In this case the output level from the DDS would typically be sufficiently flat across the bandwidth of interest without level correction and the extra generator level could be useful for extending the dynamic range of the measurement. Here the relative loss between the passband and the rejection bands would be the criteria of importance whilst the absolute level used for the measurement would be of little interest.

There are three pairs of "B" commands provided. "BAM" and "BBM" switch generator A and generator B respectively to maximum level with the "A" command (previously described) left active to provide a means to step the level down in 0.1 dBm increments. The "BAX" and "BBX" commands simply run the respective generator output levels at maximum irrespective of the "A" command setting. The "BAC" and "BBC" commands restore the respective generator output levels to the initial default –10 dBm calibrated output operation.

"C" and "S" Commands (Bit Clear and Bit Set):

C00..7	—	CSR Bit Clear	S00..7	—	CSR Bit Set
C10..23	—	FR1 Bit Clear	S10..23	—	FR1 Bit Set
C20..15	—	FR2 Bit Clear	S20..15	—	FR2 Bit Set
C3A0..23	—	ACFR Bit Clear	S3A0..23	—	ACFR Bit Set
C3B0..23	—	BCFR Bit Clear	S3B0..23	—	BCFR Bit Set
C6A0..23	—	CFR2 Bit Clear	S6A0..23	—	CFR2 Bit Set
C6B0..23	—	CFR2 Bit Clear	S6B0..23	—	CFR2 Bit Set

The NS3 firmware is designed to provide the user full control of the AD9958 DDS register contents. Some of the DDS registers use individual bits to configure, set modes or in general control the device

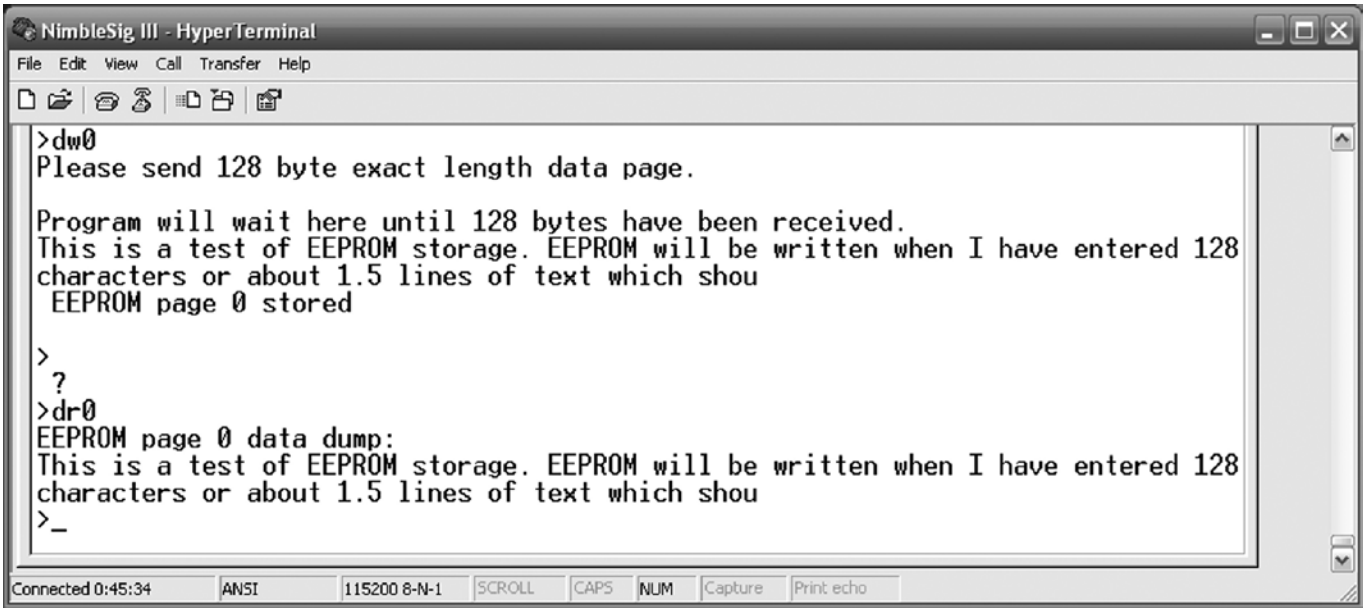

Figure 3 — Non-volatile EEPROM storage "DW" and "DR" command examples.

operation. Other registers are word registers that, when changed, require that the whole word be replaced. Thus there is need for two types of register content adjustment commands – "single bit toggle" or "word replacement." The "C" and "S" commands are used to toggle single bits whilst the "W" command described below has been provided for the replacement of full register words.

NS3 permits the changing of all the control bits except those bits that are deemed unchangeable by the DDS data sheet or those bits that could cause the MPU-DDS control communications to fail.[1] Any attempts to change the bits critical to the operation and control are ignored by the NS3 firmware.

The "C" command is a single bit command used to clear single bits in select DDS registers. The "S" command, which is provided for setting single bits, is the complement to the "C" command. As described in detail within the AD9958 data sheet the CSR, FR1, FR2 and CFR registers use single bits to control DDS configurations and functions. (See Note 1.) Thus there are "C" and "S" commands for each of these registers. Note there are separate CFR and FR2 registers for each DDS generator thus there are "A" and "B" selection suffixes added to the "C" and "S" commands for unique selection of these registers.

The second character in the syntax for the "C" and "S" commands is numeric and it refers to the register address within the DDS register bank. The remaining numeric suffixes for the "C" and "S" commands point to the bit to be changed. Note the length of these AD9958 control registers varies from 8 to 24 bits thus the maximum value of the suffix varies accordingly. The following are examples of the "C" and "S" commands:

"C122" would clear bit 22 in register FR1 which is at DDS register bank address 1.

"C3A14" would clear bit 14 in the generator A, CFR register which is at address 3 of the "0" bank.

"s06" would set bit 6 in the CSR register which is at address 0 in the DDS register bank.

"C01" which points to bit 1 of the CSR register would do nothing as this bit must be left in the one state as it configures the serial communications to the DDS.

"S3B2" which points to bit 2 of the generator "B" CFR register would also do nothing as according to the DDS data sheet this bit must be left in the zero state.

Refer to the "**Register Map**" section of the AD9958 data sheet for the bit function assignments, address assignments and other detailed information on the DDS register bank which contains a total of 45 registers.

"D" Commands (EEPROM Data Read/Write):

DR0..511 — EEPROM RAW Binary Data Read - 128 byte page at a time

DW0..127 — EEPROM RAW Data Write to page # - 128 bytes must follow cmd entry

The "D" commands permit the storing/recalling of non-volatile data to/from the EEPROM. This can be useful for initialization data such as last used frequencies or channel frequency assignments. Although the intent is to provide non-volatile storage for a host controller this feature could be useful for storing any data. However since the EEPROM device is organized with page lengths of 128 bytes any entries must also have a length of exactly 128 bytes. Thus one must use fill characters as needed. Please note the entire destination page will be overwritten.

The "DW" command permits the non-volatile storage of data to any one of the first 128 pages of the EEPROM. Each page is 128 bytes long thus 16 KB of external data can be stored. The remaining 384 upper pages are reserved for internal use. However the data they contain can be dumped one page at a time with the "DR" command (described below). Please note as mentioned above the EEPROM access is restricted to one full page at a time thus to save just one byte 127 additional fill bytes must be written. To save more than 128 bytes the data must be broken up into 128 byte segments and the last segment appended to 128 bytes as necessary. In the process the data must be saved one page at a time.

The "DR" command may be used to dump any of the 512 pages of data, one page at a time. Please also note that the data dumped is in binary format thus if there are no ASCII equivalents the characters may not print or may appear as garble on a typical ASCII terminal screen. The binary data may be viewed properly with the very powerful and excellent terminal program called *RealTerm* that is available free on the Internet.[2] *RealTerm* can be used to display the data in hexadecimal format as shown in Figure 4. Note that in this example the NimbleSig user friendly verbose mode (to be described next) was previously disabled, which prevented the human interface frill "EEPROM data page dump" text title from being sent first. In cases of nontext data, such as program initialization variables that often need to be stored in nonvolatile memory, the ability to read only the 128 bytes of raw data from the EEPROM page without any extra clutter is often desirable.

"E" Commands (Echo control):

EA	—	Enable All Human Interface functions
ED	—	Disable Character Echo
EE	—	Enable Character Echo
EP	—	Enable Prompt
EQ	—	Disable Verbose Mode
ES	—	Enable Space Bar Command Repeat
ET	—	Disable Space Bar Command Repeat
EV	—	Enable Verbose Mode
EX	—	Disable All Human Interface functions
EZ	—	Disable Prompt

Although the plain language messages and unsolicited prompts are usually very desirable when directly controlling NS3 from a keyboard they can get in the way and slow down communications to a host controller. In some cases the echo should be limited to just the prompt which could be utilized as an indicator that NS3 is ready for the next command. In other cases even the prompt character string might disrupt the host which may not always be able to tolerate the incoming prompt messages. The "E" commands provide a means to disable some or all of the human interface text statements for streamlining machine-to-machine communications. These commands, which are listed on the help screen, are pretty much self explanatory. The "EX" command may be used to disable all the human interface frills while "EA" may be used to re-enable them all. With the human interface message frills disabled, NS3 will still respond to all valid commands and respond with data when appropriate.

"F" Commands (Frequency Entry):

FAH1.200000000	—	VFO A Freq = # Hz
FAK1..200000	—	VFO A Freq = # kHz
FAM1..200	—	VFO A Freq = # MHz
FBH1.200000000	—	VFO B Freq = # Hz
FBK1..200000	—	VFO B Freq = # kHz
FBM1..200	—	VFO B Freq = # MHz
FXH1.200000000	—	VFO A/B Freq = # Hz
FXK1..200000	—	VFO A/B Freq = # kHz
FXM1..200	—	VFO A/B Freq = # MHz

There are three groups of the "F" frequency entry commands with three flavors each. The "FA" group is for entering generator "A" frequencies, "FB" for generator "B" and "FX" for entering the same frequency into both generators with a relative phase offset defined by the phase offset register values. The "H" suffix specifies frequency entry in hertz, the "K" suffix in kilohertz and the "M" suffix in megahertz. For example the commands:

- "FAH201015" — would set the generator "A" frequency to 201,015 Hz
- "FBK455" — would set the generator "B" frequency to 455 kHz
- "FAM146" — would set the generator "A" frequency to 146 MHz
- "FXM10" — would set the frequencies of both generators "A" and "B" to 10 MHz with a defined relative phase offset.

"K" Commands (RF Output Kill/Restore Control):

KA	—	Kill VFO A Output
KB	—	Kill VFO B Output
KK	—	Restore VFO A Output
KL	—	Restore VFO B Output

The "K" commands are used to toggle either output off and on.

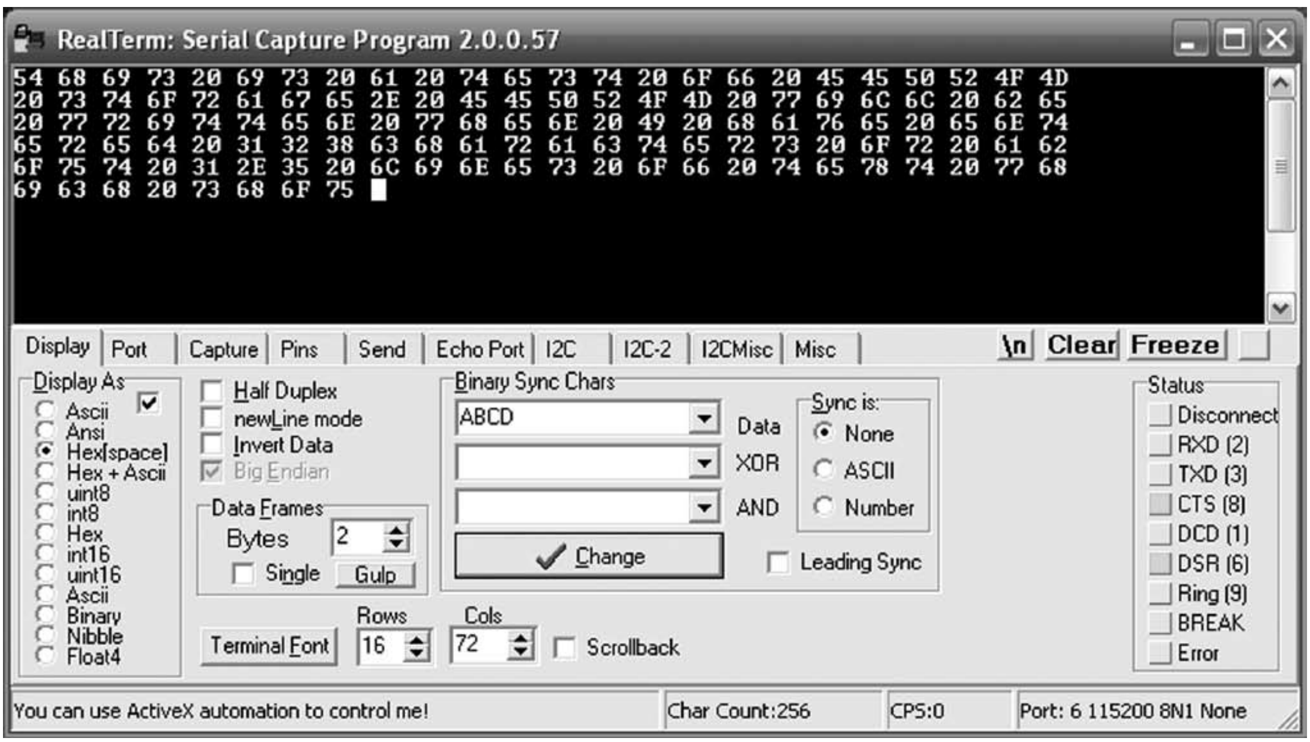

Figure 4 — RealTerm HexDump of EEPROM page 0 text shown in Figure 3 with Verbose mode disabled.

"L" Commands (RF Power Level Measurement):

LA1..500 — RF Detector Average Level 1024 samples
LC1..500 — RF Detector Average Level 128 samples
LL1..500 — RF Realtime Detector Level 1 sample
LM1..500 — RF Detector Minimum Level 1024 samples
LP1..500 — RF Detector Peak Level 1024 samples

The suffix for all of the "L" commands is provided to specify the frequency of the signal being measured to the nearest MHz. The value given is used for the selection of the appropriate frequency response calibration correction factor. If the suffix is left blank the measurement will be flagged as uncalibrated.

The "LA" command averages 1024 samples taken over a period of about 60mS and responds with the output level in dBm. The "LC" command is similar to the "LA" command but averages 128 samples taken over a period of about 0.75mS. This command is intended for swept frequency response measurements where faster, but reasonably well averaged measurements are needed. The LL command provides the level of a single sample which maybe useful for sampling the amplitude of a signal for digital processing. The "LM" and "LP" measure the minimum and peak power of a signal over a period of 1024 samples taken in 60 mS. The two measurements could be used to measure the percentage of amplitude modulation. The "LP" command could be used to measure the peak envelope level of an SSB signal source.

"M" Commands (Modulation Control):

MA — vfoA AM Mod. On
MB — vfoB AM Mod. On
MD1..100000 — FM Deviation 1 Hz-100 kHz
MF — vfoA FM Mod. On
MG — vfoB FM Mod. On
MP1..99 — AM Mod. Depth 1-99
MQ1..20000 — Mod. Freq. 1 Hz – 20 kHz
MX — Modulation Off

The "M" commands, which provide modulation control, are pretty much self explained by the help page information as shown above. Note that modulation is only permitted on one channel at a time. If one channel is currently modulated and a command request is sent to modulate the alternate channel, the modulation is first turned off and then applied to the most recently requested, alternate channel.

"P" Commands (Phase Offset Control):

PA0..360000 — Absolute Set VFO A phase offset millidegrees
PB0..360000 — Absolute Set VFO B phase offset millidegrees
PP — Print VFO A phase Offset in degrees
PQ — Print VFO B phase Offset in degrees
PS22..10000 — Set A/B phase step size – millidegrees
P+A — Increment VFO A phase offset by one step
P+B — Increment VFO B phase offset by one step
P-A — Reduce VFO A phase offset by one step
P-B — Reduce VFO B phase offset by one step

The "P" commands are provided for controlling the relative phase of the two generator outputs after the generator pair has been set to the same frequency with the "FX" command. The "FX" command initially places the two generators into relative phase with each other in accordance with the values within the phase offset registers. Thus if the generator A offset is set at 90 degrees and the generator B offset is set at 0 degrees when the "FX" command is implemented then generator A output will lead generator B by 90 degrees following the "FX" command execution. Consequently the "FX" command can be used to change the frequency whilst keeping the phase offset between the two RF outputs constant.

I decided to use millidegrees for the phase offset entry "PA" and "PB" command suffixes to provide an easy data entry means for harnessing the 22 millidegree step resolution, the finest step resolution offered by the AD9958. The entry in millidegrees is rounded off to the nearest step. The "PP" and "PQ" commands provide a means to interrogate the current phase offset values (in degrees decimal format) for either generator. The reply format is in conventional, easy-to-read degrees, decimal degrees notation.

The "P+A"/"P-A" and "P+B"/"P-B" command pairs provide a means to tune the offset in steps. The size of the steps is defined by the "PS" command and is entered in millidegrees. The step size can be varied from 22 millidegrees to 10 degrees. These commands are useful for optimizing the phase offset for the best results. For example, in the case of a phasing type of single sideband generator, one could use these commands to find the optimum phase offset for the best cancellation of an opposite sideband.

"R" Commands (Register Read):

RA0..24 — VFO A DDS Register Read in Hex
RB0..24 — VFO B DDS Register Read in Hex
RX0..24 — Current VFO DDS Register Read in Hex

The "R" commands are provided for reading the DDS register values. The displayed value is in hexadecimal format. The numeric suffix refers to the internal address of the register to be read within the DDS register address map described in the AD9958 datasheet. (See Note 1.) As the first three registers, addresses 0 to 2, are common to both generators, the "RA0"/"RA1"/"RA2" and "RB0"/"RB2"/"RB3" commands would respectively access the same registers. For the higher addresses in the range of 3 to 24 the "RA" and "RB" commands uniquely select the individual registers within the banks assigned to generator A and generator B respectively. As described in the data sheet the selection of register bank 0 or register bank 1 (corresponding to generators A or B respectively) depends on the setting of steering bits in the CSR register at address 0. The "RX" command is provided to read the currently selected register bank without changing the steering bits in the CSR register. This can be useful for determining which register bank is currently selected as the "RX" command does not disturb the steering bits.

"S" Commands (Register Bit Set):

S00..7 — CSR Bit Set

The "S" commands are described above with the complementary bit clear "C" commands.

"W" Commands (Write Register Word):

WA0H0..FF — ACSRW0 Hexadecimal Word Set
.
.
WBOH0..FFFFFFFF — BPROF15 Hexadecimal Word Set

The 48 variations of the "W", "write register word" commands, permit one to write any DDS register with a full data word with a bit length equal to the size of the target register. As described in the "C" command section above any attempt to change bits critical to the control and operation of the DDS will be blocked. Otherwise any register content can be changed. To determine the desired register data to be written by this command one should refer to the "Register Maps" section on page 36 of the AD9958, "Rev. A"(July 2008) data sheet. (See Note 1.)

The generator A or B register bank is selected with the second character of the command.

The register address within the generator A or B register bank is selected with the third character. This third character is assigned numeric values in the range of '0' to '9' for pointing to the first ten registers which are described within tables 28 and 29 of the AD9958 "Rev. A" data sheet. To target the profile registers (data sheet table 30) which have addresses from 10 to 24 the third character is assigned an alphabet character in the range 'A' to 'O' as defined in the associated help page list.

The binary data to be written must be entered in the hexadecimal format with the 'H' prefix. Thus the fourth character of the command is always an H as the prefix identifier for the hex format. The length of the hexadecimal data must match the length of the target register.

For example to write the value 19,462,008(128F778 hex) to the generator B, profile register 10 one would first look at the NS3 help page 7 (by entering the "h7" command at the NS3 prompt) which lists the command prefix for the BPROF10 register as "WBJH". This prefix would be followed with the 128F778 hexadecimal data value to be written. However note that a leading 0 must be added to make the value match the length of the 32 bit profile register which requires 8 hex character words to be fully defined.

(Note that a hex character represents 4 bits, thus it takes 8 hex characters to make up a 32 bit word. To write decimal number 10 to an NS3 32 bit register in hexadecimal, one must enter seven leading zeros, resulting in "0000000A" hex.)

For this example the required command syntax is: WBJH0128F778

"X" Commands (Setup and Calibration):

XA — CALIBRATION - VFO A Freq Response
XB — CALIBRATION - VFO B Freq Response
XC — Set DDS Reference Clock Nominal Frequency in Hz
XD — Dump Power Meter Freq Response Cal Factors
XE — Activate New EEPROM with Approximate Power Meter Data
XF — CALIBRATION - Power Meter Freq Response
XHz — CALIBRATION - Generator Frequency
XI — DDS Register Initialization SetUp
XK — Activate New EEPROM with Approximate VFO A/B Data
XL — CALIBRATION - Log Detector Amplitude Response
XP — Dump Log Detector Amplitude Response
XR — Dump DDS Registers All Current Data

The "X" commands are used to perform the initial setup and calibration (or recalibration) of the NimbleSig III module. The use of these commands will be described in detail in the EEPROM initialization and calibration sections below.

"Y" Command (Restore DDS Settings):

Y — Re-Initialize the DDS to EEPROM stored values

In case of difficulties, the "Y" command can be used to restore the DDS to the initialized state.

"Space Bar Repeat"

The space bar may be used to repeat any previous command. This is very useful for phase tuning and for the calibration procedure, which can be quite repetitive. Striking the space bar repeatedly can increment or decrement a value repeatedly as defined by the previous command.

EEPROM Initial Programming

As the NimbleSig III firmware needs initialization values from EEPROM during start up or after reset it will not function properly if the EEPROM is blank. The only time this will normally happen is when a new NimbleSig III module is run for the first time. It is thus necessary to pre-program the EEPROM to default values prior to calibrating a new module for the first time. The XC, XE, XI and XK commands are provided for this purpose.

Enter the "XC" command which will ask for the nominal DDS clock frequency which normally is 500 MHz. This frequency must be entered in Hz. When requested enter 500000000 (a number five followed by eight zeros). The software will acknowledge that the clock value is saved.

Next enter the "XE" command and confirm that you wish to proceed. Again the software will acknowledge the saving of approximate calibration data.

Next enter the "XI" command and confirm that you wish to proceed with a "c" when requested followed by "19" to load the default register settings. Again the software will acknowledge the saving of approximate calibration data.

Finally enter the "XK" command and again confirm you wish to proceed. And again acknowledgement of data saved will be given for approximate calibration of both generators.

Once the above EEPROM initialization steps are completed, restart the NS3 module by either power cycling or reseting. This re-start is needed to load the default data from the EEPROM into the MPU data memory.

For confirmation enter the "XR" command which provides a screen dump of the DDS registers. A screen dump similar to that shown in Figure 15 should follow. Note values for registers A and B at addresses 4h should be 147AE148h and 1999999Ah respectively. The values for registers at 6h are output level calibration sensitive thus may vary but they should be in the range of 1100h to 1200h. There should be 40 and 50 MHz signals present at the outputs of generators "A" and "B" respectively at levels close to –10 dBm. The "LA10" power level command should report a level less than –50 dBm. If both generator

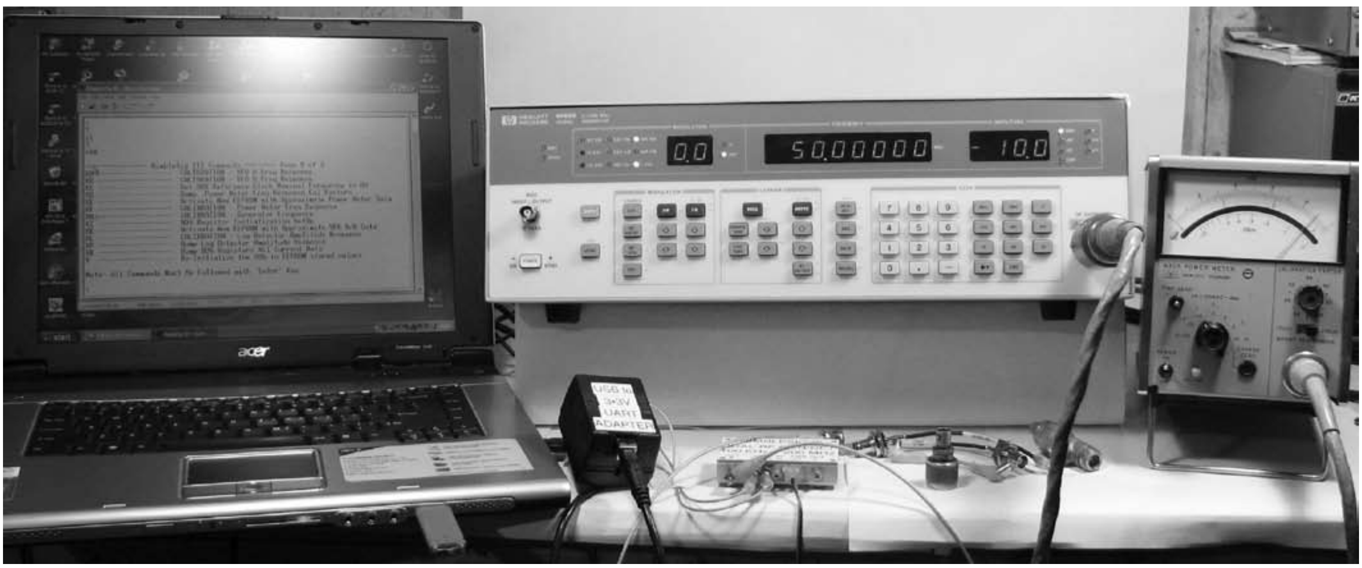

Figure 5 — Calibration check of HP8656B signal generator.

outputs and power meter indications are normal, plus the screen dump compares favorably to Figure 15 the module is ready for calibration.

Calibration Procedure

Figure 5 is a view of my signal generator being checked for output level accuracy against my RF power meter. I had the good fortune of being able to acquire and successfully repair this surplus HP8656B lab-quality signal generator. It works well for performing the NS3 calibration procedures. The HP8656B permits one to increment or decrement either the output level or frequency by a specified amount with just the single push of a button which is certainly a convenient feature for calibrating an NS3 module. As an attempt to confirm the absolute level accuracy of my generator I decided to measure the output level with my rather old HP432 power meter. As shown in Figure 5 the power meter measured the 50 MHz, –10 dBm output level of the signal generator at –10.5 dBm. When two instruments with different calibration lab history match this close I think one can be fairly confident in the accuracy. I am not sure which instrument is closest but considering the difference was minor and my generator is decades newer than my power meter I decided to place my trust in the generator.

```
>XL
NimbleSig III RF Power Detector Calibration procedure
!!! CAUTION !!! - this will change instrument calibration !!!
Be prepared to inject RF signals at known levels into RF power detector input.
 Press 'c' to continue - any other key to abort.
c

Set 10 MHz generator output level to pre-defined calibration step amplitude

Power Level Step # 1: Set RF Power Detector input level to -30.00 dBm
  Press <ENTER>  when ready

Power Level Step # 2: Set RF Power Detector input level to -28.00 dBm
  Press <ENTER>  when ready

Power Level Step # 3: Set RF Power Detector input level to -26.00 dBm
  Press <ENTER>  when ready
...
...
...
Power Level Step # 14: Set RF Power Detector input level to -4.00 dBm
  Press <ENTER>  when ready

Power Level Step # 15: Set RF Power Detector input level to -2.00 dBm
  Press <ENTER>  when ready

Power Level Step # 16: Set RF Power Detector input level to 0.00 dBm
  Press <ENTER>  when ready

Power Meter Amplitude Response Calibration Values Table

 Value    Power    Slope
(Volts)   (dBm)   (mV/dB)
1.431    -30.00
1.479    -28.00    24.2
1.528    -26.00    24.2
1.579    -24.00    25.8
1.631    -22.00    25.8
1.685    -20.00    27.4
1.740    -18.00    27.4
1.792    -16.00    25.8
1.840    -14.00    24.2
1.892    -12.00    25.8
1.943    -10.00    25.8
1.995    -8.00    25.8
2.050    -6.00    27.4
2.104    -4.00    27.4
2.156    -2.00    25.8
2.204    0.00    24.2

A = -85.100487
B = 0.124075

Press 'y' if you wish to SAVE this calibration - any other key to discard it.
Y
NimbleSig III RF Detector Amplitude Response Cal Saved to Non-Volatile Memory!
```

Figure 6 — NimbleSig III power detector logarithmic response calibration dialog.

Power Detector Logarithmic Response Calibration

The NS3 calibration is done by first calibrating the internal power detector. Once calibrated the power detector will later be used for automatically determining the frequency dependent output level response flattening factors for the two generators. There are two calibration procedures that must be done for the power detector. Both require the reference signal generator output to be connected to the detector input. First the logarithmic response of the detector is calibrated at 10 MHz from –30 dBm to 0 dBm in 2 dB steps. Figure 6 is an abbreviated capture of the dialog which occurs during the calibration procedure.

The logarithmic response calibration sub routine is started with the "XL" command which, as shown in Figure 6, first requests confirmation from the operator that this procedure is in fact desired. Upon confirmation the procedure requires that the reference signal generator be set to 10 MHz at –30 dBm. Once the input signal is set up accordingly the operator simply presses the <Enter> key then NS3 makes the level measurement and moves on to the next step with a request for a 2 dB increase in signal level. Once the level is increased <Enter> is again pressed and the process repeats until all 16 steps are completed at which point the level will have reached 0 dBm. When this last signal level setting is measured, the calibration subroutine displays, for review purposes, the table of values acquired during the procedure. Upon confirmation from the operator the new calibration values are then saved to the EEPROM for non-volatile storage.

The specified nominal output slope for the AD8307 is 25 mV per dB. As shown in Figure 6, in this case the steps varied from 24.2 mV to 27.4 mV. Most of this variation is probably caused by the resolution of the 10 bit A-D converter used here which is (3.3 V / 1024) = 3.22 mV per step. This corresponds to about 0.13 dB, or on a power scale 3% per step, which is the resolution limit for this power meter. This is usually good enough for practical purposes, but I think if I were to do this project over again I would look for an MPU with a 12-bit ADC, which if set up with a 2.5 V reference could offer 0.025 dB or roughly 0.5% power scale resolution. Nevertheless, the accuracy as show in Figure 7 seems more than adequate for most purposes.

Figure 7 shows the dynamic range accuracy obtained when I checked this unit against the step attenuator of my signal generator. At the top end of +10 dBm the detector appears to be on the verge of satu-

Input Level dBm	NS3 Read -ing	Error dB	Input Level dBm	NS3 Read-ing	Error dB	Input Level dBm	NS3 Read-ing	Error dB
+10	+9.5	-0.5	-18	-17.9	+0.1	-46	-45.7	+0.3
+8	+7.7	-0.3	-20	-20.0	0.0	-48	-47.7	+0.3
+6	+5.7	-0.3	-22	-22.1	-0.1	-50	-49.8	+0.2
+4	+3.7	-0.3	-24	-24.1	-0.1	-52	-51.7	+0.3
+2	+1.7	-0.3	-26	-26.1	-0.1	-54	-53.9	+0.1
0	0.0	0.0	-28	-27.9	+0.1	-56	-55.7	+0.3
-2	-1.9	+0.1	-30	-29.8	+0.2	-58	-57.7	+0.3
-4	-3.9	+0.1	-32	-31.8	+0.2	-60	-59.6	+0.4
-6	-6.0	0.0	-34	-33.9	+0.1	-62	-61.7	+0.3
-8	-8.1	-0.1	-36	-35.9	+0.1	-64	-63.8	+0.2
-10	-10.1	-0.1	-38	-37.9	+0.1	-66	-65.6	+0.4
-12	-12.0	0.0	-40	-39.8	+0.2	-68	-67.4	+0.6
-14	-14.0	0.0	-42	-41.7	+0.3	-70	-68.9	+1.1
-16	-15.9	+0.1	-44	-43.7	+0.3	-72	-70.0	+2.0

Figure 7 — Power detector 10 MHz dynamic range accuracy.

ration with a 0.5 dB error. From +8 dBm down to –58 dBm, the unit is within 0.3 dB of the step attenuator. It remains within 0.4 dB down to –66 dBm (about ¼ of a nanowatt) below which the noise floor starts to contribute. At –72 dBm the error is a full 2 dB, indicating a large proportion of the power being measured is noise.

Note that since the power meter was calibrated at 10 MHz, it will be most accurate in the HF part of the spectrum. According to the AD8307 specification sheet, the dynamic range logarithmic tracking varies somewhat with frequency. Additionally the detector loses sensitivity as the frequency increases. Although the frequency calibration to be done next compensates for the sensitivity drop off, the net effect is that the power meter is about 10 dB less sensitive at 500 MHz than at the HF end of the spectrum.

Power Detector Frequency Response Calibration

The next step is to calibrate the frequency response of the power detector by entering the “xf” command. I decided to calibrate the detector all the way up to 500 MHz which is well beyond the frequency range of the two generators. Please note that although the detector input SWR should remain at less than 1.5:1 up to 200 MHz at 500 MHz the SWR will deteriorate to about 2:1. This may affect the measurement accuracy within the UHF range. At a cost of input sensitivity, the UHF input mismatch could be improved with a 6 dB attenuator connected directly to the input connector. As mentioned above, the detector sensitivity rolls off by about 10 dB at 500 MHz and although the internal NS3 firmware calibration factors correct for this roll off the sensitivity of the detector is correspondingly less at higher frequencies. Thus don’t expect to be able to measure levels below about –50 dBm at 500 MHz without a preamplifier.

The frequency response measurement is done in 10 MHz increments starting at 5 MHz, thus there are 50 steps to this procedure by the time 495 MHz is reached. This multi-step procedure is similar to that for the dynamic range logarithmic response calibration except in this case the level is left constant and the frequency is stepped. The NS3 procedure dialog is shown in Figure 8. The generator output level is first set to –10.0 dBm and the frequency is set to 5 MHz. Then step-by-step the dialog asks the operator for frequency increments of 10 MHz until 495 MHz at step 50 is reached.

Once step 50 is completed the frequency calibration values table shown in Figure 9 is generated for review. If the operator chooses to accept the calibration, the new calibration values are saved in the external EEPROM. This completes the calibration of the NS3 power detector.

RF Generator Frequency Response Level Calibration

The frequency response flattening procedure is done automatically which, unlike the power meter calibration, requires very little operator intervention. All the operator needs to do is connect the generator outputs, one-at-a-time, to the power detector input as requested by the sub routine. Then the embedded NS3 software completes the calibration.

The dialog for the generator A calibration procedure is shown in Figure 10. After entering the “xa” command and providing confirmation to proceed, the operator must ensure the Generator A output is connected to the power detector input. Then after the <Enter> key is pressed the NS3 firmware will step the Generator A frequency, in 1 MHz increments, across the 200 MHz spectrum. At each step it will hesitate to measure the maximum output level from the DDS engine and then calculate the required level reduction factor needed to produce the desired –10 dBm output level for the current 1 MHz frequency segment. As this process proceeds, the measured output levels scroll down the terminal program screen which provides the operator a view as shown in Figure 10 of the calibration in progress.

Note that as shown in Figure 10 the last five measurements, in this case, fall below –10 dBm which indicates that this particular

```
>xf
     NimbleSig III RF Power Detector Frequency Response Cal procedure
    !!! CAUTION !!!  -  this will change instrument calibration !!!
Prepare to inject 5 to 500 MHz RF sigs at -10.0 dBm into RF detector input.

Press 'c' to continue - any other key to abort.
c

Set RF signal generator unmodulated output level to -10 dBm amplitude

Frequency Step #  1:
Set RF Generator Signal Frequency to 5 MHz, at -10.0 dBm
                         Press <ENTER>  when ready
Calibration factor for this step is:  0.3 dB

Frequency Step #  2:
Set RF Generator Signal Frequency to 15 MHz, at -10.0 dBm
                         Press <ENTER>  when ready
Calibration factor for this step is:  0.5 dB
.
.
.
Frequency Step #  49:
Set RF Generator Signal Frequency to 485 MHz, at -10.0 dBm
                         Press <ENTER>  when ready
Calibration factor for this step is:  9.9 dB

Frequency Step #  50:
Set RF Generator Signal Frequency to 495 MHz, at -10.0 dBm
                         Press <ENTER>  when ready
Calibration factor for this step is:  10.2 dB
```

Figure 8 — Power detector frequency response calibration dialog.

```
Power Meter Frequency Response Calibration Values Table
Freq. Factor Freq.   Factor   Freq. Factor   Freq. Factor   Freq.   Factor
(MHz)  (dB)  (MHz)    (dB)    (MHz)   (dB)   (MHz)   (dB)   (MHz)   (dB)
  5....0.3     15....0.5       25....0.8      35....1.0      45....1.2
 55....1.4     65....1.7       75....1.9      85....2.0      95....2.3
105....2.6    115....2.6      125....2.4     135....2.6     145....2.7
155....2.9    165....3.1      175....3.2     185....3.4     195....3.7
205....4.0    215....4.1      225....4.2     235....4.5     245....4.7
255....5.0    265....5.1      275....5.4     285....5.5     295....5.7
305....6.0    315....6.2      325....6.4     335....6.6     345....6.9
355....7.0    365....7.3      375....7.5     385....7.8     395....8.0
405....8.2    415....8.4      425....8.5     435....8.8     445....9.0
455....9.2    465....9.4      475....9.6     485....9.9     495....10.2

Press 'y' if you wish to SAVE this calibration - any other key to discard it.
y

NimbleSig III RF Detector Frequency Response Cal Saved to Non-Volatile Memory!

>h8
```

Figure 9 — Power detector frequency response calibration factors table.

```
>xa
     NimbleSig III RF Generator A Frequency Response Cal procedure
    !!! CAUTION !!!  -  this will change instrument calibration !!!
Prepare to loop Generator A output into RF power meter detector input.
Press 'c' to continue - any other key to abort.
c

Loop signal generator A output to RF power detector input
Starting Generator A Scan and Calibrate
-2.2 dBm*
-2.2 dBm*
-2.2 dBm*
.
.
.
-9.9 dBm*
-10.3 dBm*
-10.5 dBm*
-10.9 dBm*
-11.3 dBm*
-11.4 dBm*
```

Figure 10 — Generator “A” frequency response calibration dialog.

module is not capable of generating the desired –10 dBm level above 195 MHz. This is mainly due to the roll off of the low pass filter which may vary slightly from unit-to-unit due to component tolerances. I decided the output level of –11.3 dBm at 200 MHz is still very usable, and thus worthwhile to support with the firmware. It should be kept in mind however that the generator output levels may fall below the flatness calibration target of –10 dBm ±0.5 dB above 190 MHz. Note that tests have now been completed on a new 230 MHz LPF design which resolves this upper corner limitation. The design details along with test results for the new filter can be found on my Web page. I thank the ARRL technical review staff for suggesting this design improvement. Note that the parts list on the NS3 Web site provides ordering information for the new 230 MHz filter design. (See Note 2.)

Once this ~Frequency Step and Calibrate~ automatic sequence completes, the calibration factor table shown in Figure 11 is generated. This table of values lists the algebraic level adjustment that is needed for each 1 MHz segment up to 200 MHz.

The output levels of the DDS generators are adjusted by changing the associated Amplitude Scale Factor (ASF) which sets the maximum output voltage from the associated Digital to Analog Converter (DAC) within the AD9958 chip. In this case this is a 10 bit value thus the scale maximum is 1023. Upon displaying the calibration factor table of Figure 11 the calibration procedure pauses and prompts the operator prior to displaying the ASF factor percentage table shown in Figure 12. Note that from 196 to 200 MHz, the ASF is set to 100% which indicates the generator set to maximum output level has reached the end of its calibration range. This corresponds to the 0.0 dB correction factors listed for 196 to 200 MHz in Figure 11. With the new 230 MHz filter design this end-of-range situation has been eliminated as there is still plenty of calibration head room at 200 MHz.

Finally the operator is prompted to accept and save the new calibration values to the EEPROM chip for non-volatile storage.

Next this same procedure is implemented for Generator "B" by connecting the Generator "B" output to the power detector input and entering the "xb" command. This completes the output level calibrating for the signal generator pair.

Reference Clock Frequency Calibration

This procedure involves adjusting the actual DDS output frequency to match a frequency standard such as WWV or a highly accurate frequency counter. More traditionally the reference clock frequency is usually adjusted to achieve the desired synthesized generator output frequency. In the case of a phase lock loop based generator or a frequency counter this is the only option. However a convenience associated with a DDS generator is that one has the option to leave the reference frequency as it is and instead adjust the reference numeric value used by the DDS for calculating the frequency tuning word to match the frequency of the reference clock. For this example I am using the 25 MHz TCXO for the reference which is not adjustable. It is multiplied by 20 with the AD9958 internal PLL to obtain a nominal 500 MHz reference for the DDS engines. However after completing the frequency adjustment I found the actual DDS reference frequency needed to generate exactly 10 MHz was 500,000,120.0 Hz which indicates the actual TCXO frequency is approximately 25,000,006.0 Hz. Please note that although the NS3 firmware will support any nominal reference frequency between 400 and 500 MHz a frequency close to 500 MHz is needed to generate signals as high as 200 MHz.

The first step as shown in the Figure 14 dialog is to enter the "xc" command which will provide a means for setting the nominal design reference frequency. In this example 500000000 is entered for the nominal 500 MHz which provides the starting point.

If you wish to use the AM receiver with WWV as a reference method, tune the receiver to WWV at 10 MHz. Then set the DDS

RF Generator A Amplitude Response Calibration Values Table

Freq (MHz)	Correction Factor (dBm) 0	1	2	3	4	5	6	7	8	9
0	-7.8	-7.8	-7.8	-7.8	-7.8	-7.8	-7.8	-7.8	-7.8	-7.6
1	-7.9	-7.9	-7.9	-7.8	-7.8	-7.8	-7.6	-7.6	-7.6	-7.5
2	-7.8	-7.8	-7.6	-7.6	-7.6	-7.5	-7.5	-7.5	-7.4	-7.4
3	-7.5	-7.5	-7.5	-7.4	-7.4	-7.4	-7.3	-7.3	-7.1	-7.1
4	-7.3	-7.1	-7.1	-7.1	-7.0	-7.0	-7.0	-6.9	-6.9	-6.9
5	-7.0	-7.0	-7.0	-7.0	-6.9	-6.9	-6.9	-6.7	-6.7	-6.7
6	-7.0	-6.9	-6.9	-6.9	-6.9	-6.7	-6.7	-6.7	-6.7	-6.7
7	-6.9	-6.9	-6.9	-6.9	-6.9	-6.9	-6.7	-6.7	-6.7	-6.7
8	-6.9	-6.9	-6.9	-6.7	-6.7	-6.7	-6.7	-6.7	-6.7	-6.7
9	-6.9	-6.9	-6.9	-6.9	-6.9	-6.9	-6.7	-6.7	-6.7	-6.7
10	-7.0	-6.9	-6.9	-6.9	-6.9	-6.7	-6.7	-6.7	-6.7	-6.6
11	-6.6	-6.6	-6.6	-6.5	-6.5	-6.4	-6.4	-6.4	-6.4	-6.2
12	-6.1	-6.0	-6.0	-6.0	-5.9	-5.9	-5.7	-5.7	-5.7	-5.6
13	-5.7	-5.6	-5.6	-5.5	-5.5	-5.3	-5.3	-5.2	-5.1	-5.1
14	-5.1	-5.1	-5.0	-5.0	-4.8	-4.7	-4.7	-4.6	-4.6	-4.5
15	-4.6	-4.6	-4.5	-4.5	-4.3	-4.2	-4.2	-4.1	-3.9	-3.9
16	-3.9	-3.9	-3.8	-3.7	-3.7	-3.6	-3.4	-3.4	-3.3	-3.3
17	-3.3	-3.2	-3.2	-3.1	-2.9	-2.9	-2.8	-2.7	-2.5	-2.4
18	-2.7	-2.4	-2.4	-2.3	-2.0	-1.9	-1.8	-1.7	-1.4	-1.3
19	-1.3	-1.1	-0.9	-0.6	-0.4	-0.1	0.0	0.0	0.0	0.0
20	0.0									

Figure 11 — Generator "A" frequency response flattening adjustment values table.

Press <ENTER> to display Amplitude Scale Factors.

RF Gen. A Amplitude Response Calibration ASF() Table

Freq (MHz)	Amplitude Scale Factor (ASF) Percentage of Maximum 0	1	2	3	4	5	6	7	8	9
0	40.9	40.9	40.9	40.9	40.9	40.9	40.9	40.9	40.9	41.4
1	40.3	40.3	40.3	40.9	40.9	40.9	41.4	41.4	41.4	42.0
2	40.9	40.9	41.4	41.4	41.4	42.0	42.0	42.0	42.7	42.7
3	42.0	42.0	42.0	42.7	42.7	42.7	43.3	43.3	44.0	44.0
4	43.3	44.0	44.0	44.0	44.6	44.6	44.6	45.3	45.3	45.3
5	44.6	44.6	44.6	44.6	45.3	45.3	45.3	45.9	45.9	45.9
6	44.6	45.3	45.3	45.3	45.3	45.9	45.9	45.9	45.9	45.9
7	45.3	45.3	45.3	45.3	45.3	45.3	45.9	45.9	45.9	45.9
8	45.3	45.3	45.3	45.9	45.9	45.9	45.9	45.9	45.9	45.9
9	45.3	45.3	45.3	45.3	45.3	45.3	45.9	45.9	45.9	45.9
10	44.6	45.3	45.3	45.3	45.3	45.9	45.9	45.9	45.9	46.6
11	46.6	46.6	46.6	47.3	47.3	48.0	48.0	48.0	48.0	48.7
12	49.5	50.1	50.1	50.1	50.9	50.9	51.7	51.7	51.7	52.4
13	51.7	52.4	52.4	53.2	53.2	54.0	54.0	54.8	55.6	55.6
14	55.6	55.6	56.4	56.4	57.3	58.1	58.1	58.9	58.9	59.8
15	58.9	58.9	59.8	59.8	60.7	61.6	61.6	62.6	63.4	63.4
16	63.4	63.4	64.4	65.3	65.3	66.3	67.3	67.3	68.2	68.2
17	68.2	69.3	69.3	70.3	71.4	71.4	72.4	73.5	74.6	75.7
18	73.5	75.7	75.7	76.7	79.1	80.3	81.4	82.6	85.0	86.3
19	86.3	87.6	90.2	92.9	95.7	98.5	100.0	100.0	100.0	100.0
20	100.0									

Press 'y' if you wish to SAVE this calibration - any other key to discard it.
y
NimbleSig III RF Gen A Frequency Response Cal Saved to Non-Volatile Memory!

Figure 12 — Generator "A" frequency response flattening amplitude scale factor table.

```
>fan10
>xc
NimbleSig III DDS Reference Frequency Setup

Enter Nominal DDS Reference Clock Frequency in Hertz for this design

Example:
 If reference oscillator is 25MHz and multiplier is set to 20 enter:
        > 500000000
>500000000
NimbleSig III DDS Reference Frequency Setup Saved to Non-Volatile Memory!

DDS Reference Frequency Setup (Prior to Calibration) = 500000000.0 Hz.
>_
```

Figure 13 — DDS reference frequency setup.

Generator "A" frequency to 10,000,000 Hz with the "fam10" command. Connect a small antenna made from a jumper cord to the center conductor of a coaxial lead connected to the Generator A output. The objective is to be able to radiate just sufficient signal level from the NS3 generator to closely match the amplitude of the WWV signal at the receiver antenna terminals. This will result in cyclic cancellation of the WWV reception as the two signals beat together. You will need to be able to couple the proper amount of signal to clearly hear and/or see the cancellation of the two signals on the receiver S meter as they beat together.

Alternately if you have access to a high quality and well calibrated VHF frequency range counter, just connect the generator A output to the frequency counter input. Set the generator output frequency to 100 MHz and following the procedure below adjust the DDS reference value for an output frequency of 100,000,000 Hz.

The next step is to enter the "xhz" command which brings up the dialog in Figure 14. Press "n" at this point to use the nominal design reference frequency just previously entered as a starting point.

As shown in Figure 14 you will then receive prompts for adjusting the frequency in either ±1, ±0.1 or ±0.01 Hz steps.

If you are using the WWV technique, if the beat rate is greater than 1 beat per second (which will probably be the case) use the "u" or "d" keys to lower the beat rate. One you obtain a beat rate less than 1 per second then use the "I" and "f" keys to lower the beat rate to close to one cancellation every 5 or 10 seconds. As shown in this example, it only took about a half dozen key clicks to establish the reference frequency as 500,000,120 Hz.

The very fine "o" and "g" keys are provided for demanding frequency applications that are referenced to highly accurate frequency standards. When finished press "c" to continue and "y" to save the reference frequency, as desired. NS3 will then report the reference frequency and this completes this calibration procedure. The new reference frequency will subsequently be reported on the NS3 start up welcome screen.

Windows Mouse Button Control for NimbleSig III

At the time of this writing there is a free *Windows* platform terminal program available for download from the Internet called *uCon*, which provides a relatively user friendly interface for controlling an NS3 module.[3] The *uCon* program provides 24 mouse click buttons that are easy to customize for sending predefined character strings. I have written a configuration file for *uCon* called "NimbleSigIIIuCom.ct" that customizes the buttons with the more common command prefixes. Figure 15 is a screen shot of *uCon* illustrating a DDS register dump that was triggered by the mouse click of the F2 "DDSregDump" button. As the top row of buttons also respond to the associated function keys, a single F2 key stroke could alternately have been used to trigger the register dump.

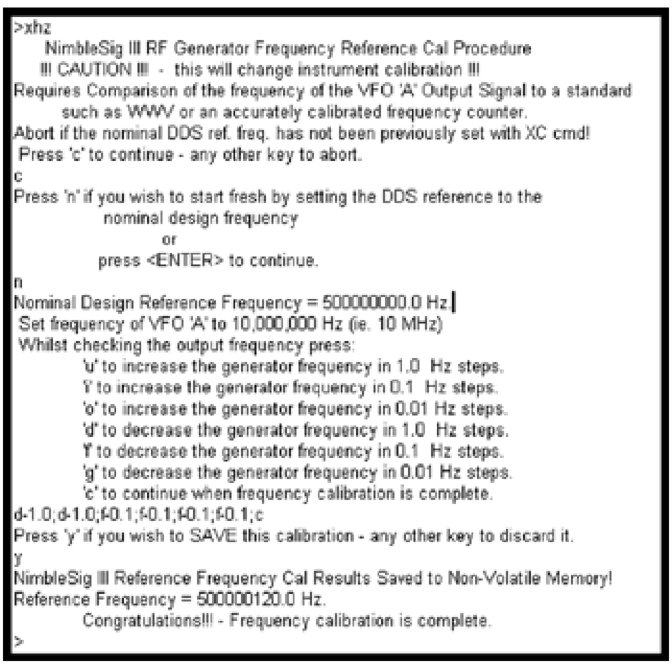

Figure 14 — DDS reference frequency adjustment.

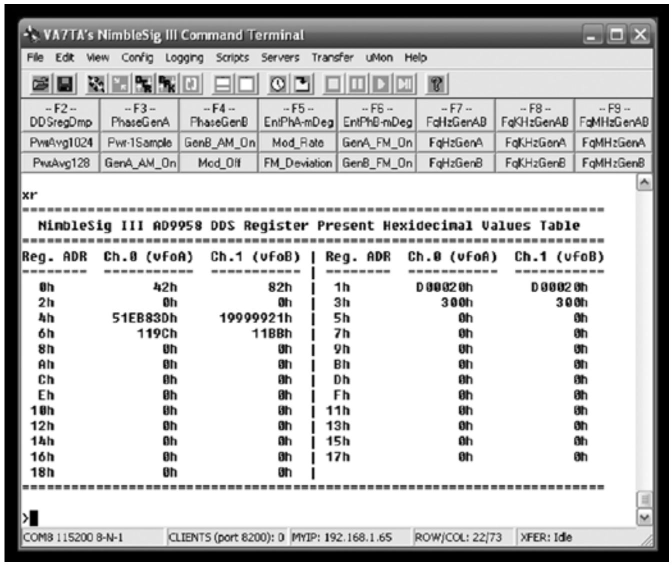

Figure 15 — The *uCon* terminal program is customized for NimbleSig III control.

The "NimbleSigIIIuCom.ct" file is available for download on my Web page.[4] It should be installed in the config folder within the *uCon* install directory on your system (most commonly "C:\Program Files\ucon\config\"). After starting *uCon* you then load the NS3 configuration using the "File/open" menu command, which should provide a selection display for all the ".ct" extension configuration files including "NimbleSigIIIuCom.ct." You will probably need to change my COM8 port assignment to match your NS3 interface COM port assignment. Then save your modified configuration with the "File/Save" menu item.

After installing the "NimbleSigIIIuCom.ct" configuration file and modifying it to match your COM port assignment then you may make a shortcut icon that will start up *uCon* configured and ready for NS3 control. Assuming you have installed *uCon* in the "C:\Program Files\ucon\" folder you may do this by entering the following line in the short cut icon Properties/Target window: "C:\Program Files\ucon\ucon.exe" "..\ucon\config\NimbleSigIIIuCom.ct"

Recent NimbleSig III Update Information

Recently I have completed network analyzer transmission test results on the new 230 MHz low pass filter design. Photos of the 0 to 750 MHz swept frequencies responses for four filters I built up can be found on my Web page.[5] Although I did not find it practical to tune the traps in general I am very pleased with the responses of the filters. The sharpness, depth and consistency between filters within the 200 to 300 MHz cutoff frequency portion of the responses seem quite remarkable.

I have provided some guideline photos for the mounting of the

NS3 PCB into an off-the-shelf die cast aluminum enclosure manufactured by Bud. This information can also be found on my Web page.[6]

There is a minor update to the firmware, which improves the calibration accuracy of the power meter by a few tenths of a dB. The new hex file is available for download on my Web site.[7]

Conclusion

I hope this multi-part article has been of interest to many *QEX* readers. I also hope that RF equipment construction enthusiasts who decide to build a NimbleSig III module enjoy a rewarding experience! If there is sufficient interest shown for NS3 I may be motivated to design a slightly revised PC board that would correct a couple of minor glitches and make ISP programming less awkward to initiate. Bare PC board availability information may be found on my Web site, where I plan to add Nimble Sig III information and software updates as time permits. (See Note 2). I would be pleased to receive comments, questions, bug reports or suggestions.

I wish to again express my appreciation to Analog Devices Inc. for their innovative and excellent RF integrated circuit product line which provided the foundation for this project.

Notes

[1]The AD9958 data sheet is available at: **www.analog.com/static/imported-files/data_sheets/AD9958.pdf**

[2]NimbleSig III Web site: **www3.telus.net/ta/NimbleSig%20III/**

[3]You can download the uCon-Embedded Console Terminal Program at: **www.microcross.com/ucon_install.zip**

[4]You can download the uCon configuration file at: **www3.telus.net/ta/NimbleSig%20III/uConTerminal/**

[5]The 230 MHz bandwidth low pass filter design is given on the NimbleSig III Web site at: **www3.telus.net/ta/NimbleSig%20III/NS3_230%20MHz%20LowPassFilter/NS3_230_MHz_LPF_Network_Analyzer_Test_Results.html**

[6]There are more details about the BudBox enclosure at: **www3.telus.net/ta/NimbleSig%20III/NS3_BudBoxConstruction/index.html**

[7]The latest version of the NimbleSig III program files are available for download from the Nimble Sig III Web site at: **www3.telus.net/ta/NimbleSig%20III/NS3%20HEX%20Code/**

Tom Alldread, VA7TA, became interested in electronics when still in grade school, repaired radio and television sets in his teens, obtained his Amateur Radio ticket at the age of 19, and went on to obtain commercial radio operator certification a year later. He subsequently graduated from the Capitol Radio Engineering Institute Engineering Technology program. His career was in the telecommunications industry where he worked in microwave and VHF radio equipment maintenance, training, engineering standards and design, and long distance network operations management.

Tom is now retired and lives on Vancouver Island with his wife Sylvia, VA7SA. Tom has a history in repeater building and emergency communications, and he enjoys operating mobile CW, building equipment and is currently the net manager for the 20 meter Trans Canada Net. His other interests include microcontroller programming, circuit design, computing, hobby farming, digital photography, bicycling and sailing.

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