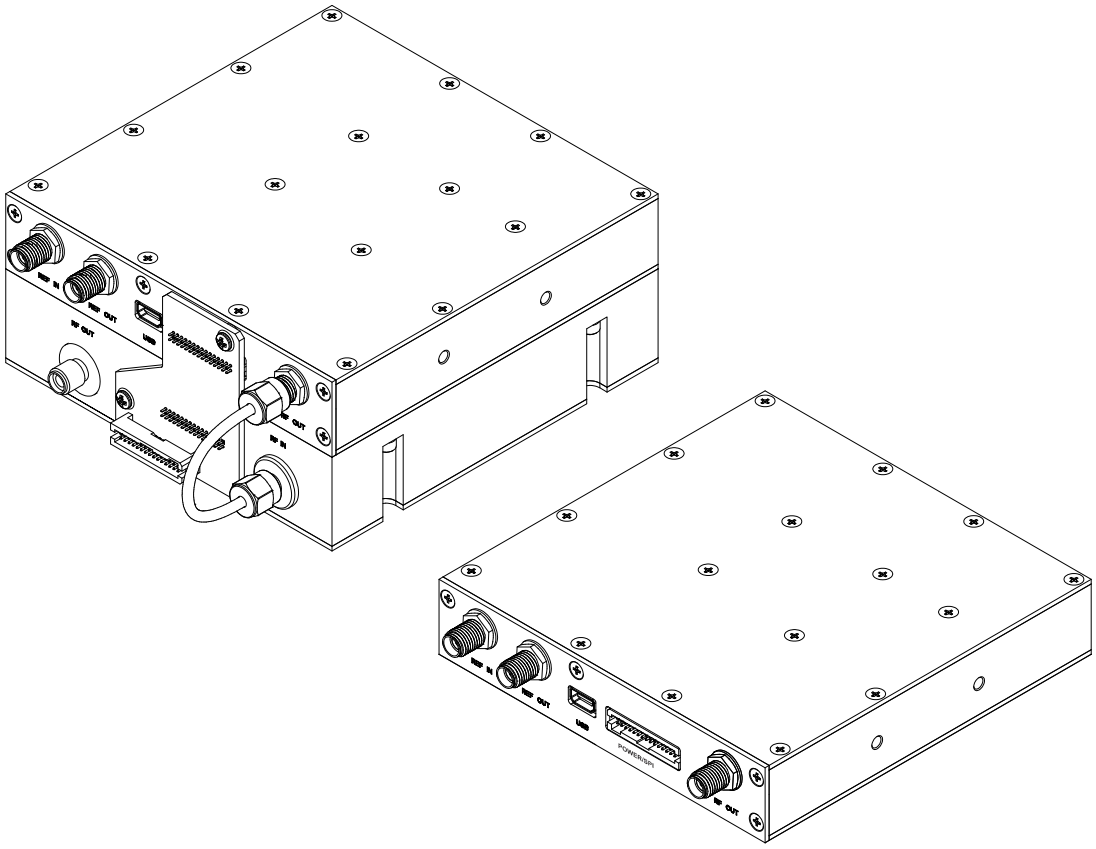
COMMUNICATIONS SPECIFICATIONS

QuickSyn Lite Frequency Synthesizer



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NATIONAL INSTRUMENTS™

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Introduction

In this document...

The scope of this document is to define the communication between the QuickSyn Lite series of frequency synthesizers (Models FSL-0010, FSL-0020, FSL-2740, FSL-5067, FSL-7682, and FSL-E020) and the controlling system. This document describes the QuickSyn control and query commands. The commands listed in this document may be sent through the SPI and USB.

Goals

The primary goal for command communication is to allow fast, easy setup for basic operations. In particular, it should permit easy establishment of a new frequency setting. The commands must support frequency specifications up to 20 GHz in 0.001 Hz steps.

Secondary goals include: support for very fast change to pre-computed settings, support for traversal of a list of pre-computed settings with a specified dwell, and support for computed sweeps of frequency with a specified dwell.

Hardware Interface

The hardware includes a multi-purpose SPI connector and a USB connector located on the front panel.

SPI Interface

The SPI hardware interface consists of a standard SPI interface plus additionally assigned lines as defined in Table 1.

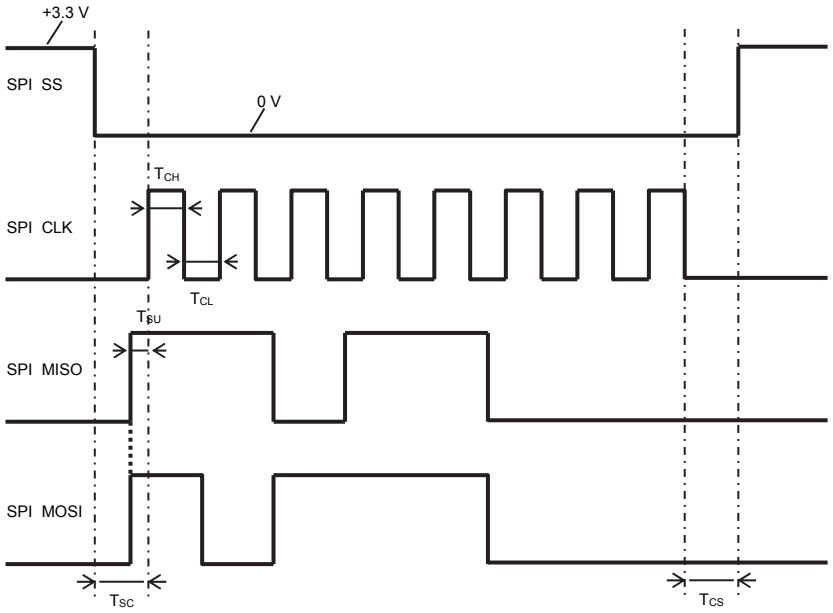
Table 1 Synthesizer Interface

Signal	Description	Connector
SPI_CLK	SPI clock, supplied by the controlling computer (not the synthesizer). The controlling computer is the SPI master, the synthesizer is the SPI slave.	Pin 20
SPI_SS	SPI Slave Select. This signal is an active low input to the synthesizer. It frames command communications. For each command, SPI_SS goes low before the first bit is sent and goes high after the last bit is sent.	Pin 18
SPI_MISO	Master in, Slave out. Status and other returned info. from the synthesizer to the controlling computer.	Pin 24
SPI_MOSI	Master out, Slave in. Command data from the controlling computer to the synthesizer.	Pin 22
TRIGGER	Rising edge active input. When enabled, the trigger signal can initiate frequency change or step through lists or sweeps.	Pin 14
LOCK	Output indicating that the synthesizer is locked on its current setting (+3.3V - locked, 0 V - unlocked).	Pin 16
REF_LOCK	Output indicating that the synthesizer has detected an external reference signal and locked on that signal (+3.3V - locked, 0 V - unlocked).	Pin 13
PWR_+12V	External +12V DC Supply.	Pin 26, 28, 30
NOTE: The QuckSyn synthesizer requires a 15-second delay to reboot before it is ready to accept commands.		
RESET	Internally pulled-up to +3.3V with 100 kOhm resistor. Active “LOW” signal will reset the synthesizer to a default state.	Pin 1
GND	Ground.	Pin 2, 15, 25, 27, 29
N/C	Not connected.	Pin 3, 4, 5, 6, 7 8, 9, 10, 11, 12 17, 19, 21, 23

SPI is a standard first introduced by Motorola (now Freescale) for low-cost communications among semiconductor devices. It allows for four different possible clocking schemes defined by the polarity and phase of the clock. SPI mode 0 is used to communicate to the QuickSyn synthesizer. The synthesizer expects the CLK signal to be low at the time that the SPI_SS signal is asserted. At this time, the first MOSI bit will be set up. The synthesizer will sample incoming MOSI data at the rising edge of the CLK and expects that the controlling computer will also sample MISO at that edge. Subsequent MISO transitions will occur on the falling edges of the CLK signal.

Transfers are always initiated with the most significant bit of the full transfer and are ended with the least significant bit. The SPI_SS signal is expected to remain asserted for the duration of the transfer. After the last bit is transferred, the SPI_SS signal will go high.

Figure 1 SPI Timing



T_{SC} > 25 nSec – select low before first clock

T_{CS} > 25 nSec – clock low before slave select high

T_{SU} > 15 nSec – data stable before rising edge of clock

T_{CH} > 25 nSec – minimum clock high time

T_{CL} > 25 nSec – minimum clock low time

$F_{CLK} \leq 12$ MHz – maximum clock frequency

USB Interface

The USB hardware interface consists of a standard female mini USB B-type connector. This port is USB 2.0 compatible and is utilized as a standard COM port (serial port) on the host PC. The serial data buffer for this port is 64-bytes long (including the terminator); thus, it is important not to exceed this length on any command data. All commands must be terminated by a termination character (13, 0X0D). The serial port parameters on the host PC must be set as 8 bits, no parity, 1 stop bit, 115200 baud, no flow control.

NOTE

Install software driver first to control the QuickSyn synthesizer via the USB connector. Device drivers are available from the NI Microwave Components website (ni-microwavecomponents.com). Instructions for installing the device drivers are in the QuickSyn user guide, which is also available from the website.

Main Commands

Two command sets are available for controlling the QuickSyn synthesizer—QuickSyn native commands and SCPI commands. The SPI interface will only accept the native command set while the USB interface will accept both the native commands and SCPI commands. The synthesizer's operation modes, output frequency, and power are controlled by the main commands listed in Tables 2a, 2b, 2c, 2d, and 5. Query commands are listed in Table 3 (SPI), Table 4 (other interfaces), and Table 5 (SCPI).

Native commands for the USB interface are formatted the same as SPI commands. However, these commands are formatted as ASCII representations of hexadecimal values (i.e., each hexadecimal character is one ASCII character). Thus, twice as many bytes are sent for each command. Note that only single-byte characters may be used for these commands because double-byte characters will not be interpreted correctly by the QuickSyn module. Furthermore, these commands must be sent separately with each command terminated by a termination character (13, 0x0D). The query commands differ from SPI query commands; therefore, refer to the applicable query command table in this document.

Table 2a Control Commands (no return data)

Description	Size (Bytes)	Header Code	Header Bits	Parameter Bytes	Parameter Bits	Parameter Values
Set Output Frequency	7	0C	[55:48]	6	[47:0]	Units of 0.001Hz
This commands sets the frequency with no change in power or other parameters.						
Reset	1	0E	[7:0]			

The Reset command sets the unit to one of the following three states:

1. Factory default
   a. Frequency: center freq. →

GHz	Model
10	FSL-0010
10	FSL-0020
10	FSL-E020
33.5	FSL-2740
58.5	FSL-5067
79	FSL-7082

   b. Power: ON
   c. Reference source: internal
   d. Reference output: ON
   e. Triggering: disabled
2. User defined default 1

   See command Save Current State in Flash below
3. User defined default 2

   See command Save Current State in Flash below

Note: A delay or wait period of 2 ms is required after the Reset command is sent.

Select Ref. Source:	2	06	[15:8]	1	[7:0]	Int(0) / Ext(1)
Reference Output	2	08	[15:8]	1	[7:0]	OFF(0) / ON(1)
RF Output	2	0F	[15:8]	1	[7:0]	OFF(0) / ON(1)
Adjust Internal Ref.	3	1B	[23:16]	2	[15:0]	Units from 0 to FFFF
This requires a few seconds for hardware to update.						
Save current state in Flash	2	26	[15:8]	1	[0:7]	1 or 2 only
This command saves current settings as user-defined default 1 or 2 (see Reset command) and requires a 100 ms wait delay. When unit is power cycled, the last saved default settings will be used to initialize.						
Restore current state from Flash	2	27	[15:8]	1	[0:7]	0, 1 or 2 only. 0 - default
This command restores settings to the factory default 0, user-defined default 1, or user-defined default 2 and requires a 50 ms wait delay. When unit is power cycled, the last restored default settings will be used to initialize the unit.						
Lock Recovery	2	28	[15:8]	1	[0:7]	OFF(0) / ON(1)
This command allows/disallows retry if lock fails. Only one retry per frequency is allowed						

NOTE The Synthesizer Reset command executes a full instrument re-initialization, which is functionally equivalent to a power up. All commands in progress will be aborted. The synthesizer will reset to a default state.

NOTE If the SPI interface is used, each query command needs to be executed twice.

Examples:

1. Set Output Frequency to **9.876543210 GHz**
   - Convert 9.876543210 GHz to milliHertz: **9,876,543,210,000**.
   - Convert 9,876,543,210,000 to 48-bit Hex: **08 FB 8F D9 82 10**
   - Append Command Header (0C) in front of the Frequency: **0C** 08 FB 8F D9 82 10
   - Send command: **0C 08 FB 8F D9 82 10**

Table 2b Control Commands

Description	Size (Bytes)	Header Code	Header Bits	Parameter Bytes	Parameter Bits	Parameter Values
List Point Setup and Write to Flash	16	13	[127:120]	2 6 2 4 1	[119:104] [103:56] [55:40] [39:08] [0]	List point # (1 to 32767) Freq in milliHertz Reserved! Must be 0 Dwell time in usec (5 to 4,294,967,295(~1hr)) in 5us increments. RF Output: On(1)/Off(0)
This command places each point in temporary and permanent memory and requires a 300 ms wait delay.						
List Point Setup and Write to RAM only - Fast	16	4A	[127:120]	2 6 2 4 1	[119:104] [103:56] [55:40] [39:08] [0]	List point # (1 to 32767) Freq in milliHertz Reserved! Must be 0 Dwell time in usec (5 to 4,294,967,295(~1hr)) in 5us increments. RF Output: On(1)/Off(0)
This command only places each point in temporary memory and requires 100 µs wait delay.						
Save List Table	1	4B	[07:00]			Saves the entire List Table
This command saves the list to permanent memory. A delay of at least 50 ms plus 2.5 ms per list_point is required before sending next command.						
Run List Point	3	14	[23:16]	2	[15:0]	List point # (1 to 32767)
List Setup And Run	8	15	[63:56]	4 2 1 	[55:24] [23:08] [03:02] [01:00]	Dwell time in usec (5 to 4,294,967,295(~1hr)) in 5us increments. If 0, List Point Dwell Time is used # of times to run list 1 to 32767, 0 - infinite Enable List Trigger(1) Enable List Point Trig(2)* Software Trigger (0) Direction Up(0) – Lo to Hi Down(1) – Hi to Lo Up & Down(2)
List points must be loaded first. A list command cannot be executed with FM on. *The minimum period of pulses in list-point-trigger mode is 150 µs						
Stop List	1	20	[07:00]			
Erase List	1	22	[07:00]			
This command requires a wait delay of 200 ms. Always send the Stop List command before sending Erase List.						

NOTE Before re-programming List Points, execute Erase List Command (0x22). Send a Reset command followed by an RF Output On command upon exiting List Mode to return to normal mode.

Examples:

1. Set List Point 1 with Output Frequency of **9.111222333 GHz**, Dwell Time **3 sec**, RF Output **ON**, Pulse Modulation **OFF**

Field	List Point	Frequency	Reserved	Dwell time
Units	No.	milliHertz		microseconds
Decimal	1	9111222333000	0	3000000
Hex	0001	08495F2BAE48	0000	002DC6C0

Command **13 00 01 08 49 5F 2B AE 48 00 00 00 2D C6 C0 01**

2. Run List Point 2: **14 00 02**

3. List Setup and Run applies to entire list. The List parameters are: Dwell Time: **10sec**, Number of times to execute list: **3**, List Point Trigger: ON, Direction: **UP**.

Field	Dwell time	Times to Execute	List Point Trigger	Direction
Units	µs	No.	Boolean	No.
Decimal	10000000	3	Yes	Up
Hex	00989680	0003	————08————	

Command **15 00 98 96 80 00 03 08**

4. Wait 100 µs.

   After this command is executed, external trigger signals should be applied for each List Point.

5. List Setup and Run applies to the entire list. The list parameters are: Dwell Time: **5sec**, Number of times to execute list: **1**, List Trigger: **ON**, List Point Trigger: **OFF**, Direction: **Down**.

Field	Dwell time	Times to Execute	List Trigger	Direction
Units	µs	No.	Boolean	No.
Decimal	50000000	1	Yes	
Hex	004C4B40	0001	————05————	

Command **15 00 4C 4B 40 00 01 05**

Table 2c Control Commands (fast sweep)

Description	Size (Bytes)	Header Code	Header Bits	Parameter Bytes	Parameter Bits	Parameter Values
Fast Frequency Sweep Setup and Run	24	17	191:184	6	[183:136]	Start Freq in mlHz
				6	[135:88]	Stop Freq in mlHz
				2	[87:72]	# of points (1 to 32767)
				2	[71:56]	Reserved! Must be 0
				4	[55:24]	Dwell time in usec (0 to 4,294,967,295(~1hr)) In 5us increments
				2	[23:08]	# of times to run sweep 1 to 32767, 0 - infinite
					[03:02]	Enable Sweep trigger(1) Enable Sweep Point trg(2)*
				1		Software Trigger (0)
					[01:00]	Direction Up(0) – Lo to Hi Down(1) – Hi to Lo Up & Down(2)

*The minimum period of pulses in sweep-point-trigger mode is 150 µs.

Example:

1. Fast Frequency Sweep Setup and Run command.

   Settings:

   Start Frequency: 5 GHz

   Stop Frequency: 8 GHz

   Number of Points Between Frequencies (inclusive): 30

   Power: 18 dBm

   Dwell Time: 3 sec

   Number of times to run sweep: 2

   Enable Sweep Trigger: Yes

   Enable Sweep Point Triggers: No

   Direction: Up

Field	Start Frequency	Stop Frequency	Num points	Reserved	Dwell time	Num Runs	Trig	Dir
Units	milliHertz	milliHertz			µs		Bool	
Decimal	5000000000000	8000000000000	30	0	3000000	2	Yes	Up
Hex	048C27395000	0746A5288000	001E	0000	002DC6C0	0002	—04—	

17 04 8C 27 39 50 00 07 46 A5 28 80 00 00 1E 00 00 00 2D C6 C0 00 02 04

After this command is executed, ONE Sweep trigger signal should be applied.

Table 2d Control Commands (normal sweep)

Description	Size (Bytes)	Header Code	Header Bits	Parameter Bytes	Parameter Bits	Parameter Values
Normal Frequency Sweep Setup and Run	28	1C	223:216	6	[215:168]	Start Freq in mlHz
				6	[167:120]	Stop Freq in mlHz
				6	[119:72]	Step Freq in mlHz *
				2	[71:56]	Reserved! Must be 0
				4	[55:24]	Dwell time in usec (0 to 4,294,967,295(~1hr)) In 5us increments
				2	[23:08]	# of times to run sweep 1 to 32767
					[03:02]	Enable Sweep trigger(1) Enable Sweep Point trg(2)
				1		Software Trigger (0)
					[01:00]	Direction Up(0) – Lo to Hi Down(1) – Hi to Lo Up & Down(2)
Stop Sweep	1	21	[07:00]			

* The frequency span between start and stop frequencies must be evenly divisible by step frequency; otherwise, the sweep will never reach stop frequency.

NOTE

All query commands must be sent twice. Data output from the unit can be read back after the second query command.

Table 3 SPI Query Commands (with return data)

Description	Command				Return Data			
		Header		Don't care				
	Size (Bytes)	Code	Bits	Bits	Total Bytes	Bytes	Data bits	Values
Get ID	12	01	[95:88]	[87:0]	12	1	[95:88]	'Don't Care'
						2	[87:72]	Model#
						2	[71:56]	Option#
						2	[55:40]	Soft.ver.
						5	[39:00]	Serial#
Get Status	2	02	[15:8]	[7:0]	2	1	[15:8]	'Don't Care'
							[0]	No Ext Ref Detected(0)*
								Ext Ref Detected(1)*
							[1]	RF locked(0)
								RF unlocked(1)
							[2]	Ref locked(0)
						1		Ref unlocked(1)
							[3]	RF Outp On(1)
							[4]	Voltage OK(0)
								Voltage Err(1)
							[5]	REF outp off(0)
								REF outp on(1)
							[6]	Not used
							[7]	Lock recovery on(1)/off(0
* Only valid when Ext Ref is selected.								
Get Freq	7	04	[55:48]	[47:0]	7	1	[55:48]	'Don't Care'
						6	[47:0]	mlHz
Ref Source Query	2	07	[15:8]	[7:0]	2	1	[15:8]	'Don't Care'
						1	[0:7]	Int(0)/Ext(1)
Get Temperature	3	10	[23:16]	[15:0]	3	1	[23:16]	'Don't Care'
						2	[15:0]	Temper. x10

Example:

Get Output Frequency

- Send command: **04 00 00 00 00 00 00**
- Send command: **04 00 00 00 00 00 00**
- Read Data: 00 **08 FB 8F D9 82 10**
- Disregard 'Don't Care' bits [55:48] - 00. Convert **08 FB 8F D9 82 10** to decimal to get frequency in milliHertz: **9,876,543,210,000**

NOTE Only the Get Temperature command must be sent twice. All other data output from the unit can be read back after the first query command.

Table 4 Query Commands (with return data) for Native USB

Command			Return Data			
Description	**Size (Bytes)**	**Code**	**Total Bytes**	**Bytes**	**Data bits**	**Values**
Get ID	2	01	22	2 2 2 5	[87:72] [71:56] [55:40] [39:00]	Model# Option# Soft.ver. Serial#
Get Status	2	02	2	1	[0] [1] [2] [3] [4] [5] [6] [7]	No Ext Ref Detected(0)* Ext Ref Detected(1)* RF locked(0) RF unlocked(1) Ref locked(0) Ref unlocked(1) RF Outp Off(0) RF Outp On(1) Voltage OK(0) Voltage Err(1) REF outp off(0) REF outp on(1) Not used Lock recovery on(1)/off(0)
* Only valid when Ext Ref is selected.						
Get Freq	2	04	12	6	[47:0]	mlHz
Ref Source Query	2	07	2	1	[0:7]	Int(0)/Ext(1)
Get Temperature	2	10	4	2	[15:0]	Temper. x10

Example:

Get Output Frequency

- Send command: **04**
- Read Data: **08 FB 8F D9 82 10**
- Convert **08 FB 8F D9 82 10** to decimal to get frequency in milliHertz: **9,876,543,210,000**

NOTE SCPI commands can only be used with QuickSyn synthesizers that have version 100 or higher firmware.

Table 5 SCPI Commands for USB

Command	Parameter	Result	Description	Example
FREQ	Value GHz, MHz, KHz, mlHz[default]		Set Output Frequency	FREQ 2.2GHz
FREQ?		Value in mlHz	Get Output Frequency	FREQ? 2200000000000
*RST	NONE		Reset	*RST
ROSC:SOUR	EXT/INT		Select Ref. Source	ROSC:SOUR EXT
ROSC:SOUR?		EXT/INT	Get Ref. Source	ROSC:SOUR? EXT
OUTP:ROSC: STAT	ON/OFF		Reference Output Enable/Disable	OUTP:ROSC:STAT ON
OUTP:ROSC: STAT?		1(ON)/0(OFF)	Get Reference Output Status	OUTP:ROSC:STAT? 1
OUTP:STAT	ON/OFF		RF Output Enable/Disable	OUTP:STAT ON
OUTP:STAT?		1(ON)/0(OFF)		OUTP:STAT 1
DIAG:CAL:REF:DAC	0 TO 65535 – DAC Value		Adjust Internal Ref. DAC Value	DIAG:CAL:REF:DAC 30000
DIAG:CAL:REF:DAC?		0 TO 65535 – DAC Value	Get Internal Ref. DAC Value	DIAG:CAL:REF:DAC? 30000
*SAV	1,2 - States		Save current state in Flash	*SAV 1
*RCL	0 – factory default 1 – setting 1 2 – setting 2		Restore current state from Flash	*RCL 0
FREQ:LRSTAT	ON/OFF		Lock Recovery Enable/Disable	FREQ:LRSTAT ON
FREQ:LRSTAT?		1(ON)/0(OFF)	Get Lock Recovery Status	FREQ:LRSTAT? 1
LIST:PVEC	1) List point # (1 to 32767), 2) Freq, 3) Reserved! Must be 0 4) Dwell time in us, ms, s (from 5us to 4,294 s (~1hr)), default - us 5) Pulse Mod (On/OFF) 6) RF Output (On/Off) 7) Save to Flash (F or f) – Optional field		List Point Setup	LIST:PVEC 1,3GHz,0,1s, OFF,ON,F
LIST:SAV	None		Save List Table to Flash	LIST:SAV
LIST:PVEC:RUN	List point # (1 to 32767)		Run List Point	LIST:PVEC:RUN 1

Table 5 SCPI Commands for USB (continued)

Command	Parameter	Result	Description	Example
LIST:SETUP	1) Dwell time in us, ms, s (from 5us to 4,294 s (~1hr)) , default - us 2) # of times to run list (1 to 32767), 0 - infinite 3) Trigger: 0 – Software Trig 1 – List Trig 2 – List Point Trig 4) Direction: 0 – Lo to Hi 1 – Hi to Lo 2 – Up & Down 5) Optional field 'RUN' – run list, Don't otherwise		List Setup (And Run – Opt)	LIST:SETUP 2s,0,2,2,RUN
LIST:STAR(T)	# of times to run list (1 to 32767), 0 - infinite		Start List Execution	LIST:STAR 5
LIST:STOP	None		Stop List	LIST:STOP
LIST:ERAS	None		Erase List	LIST:ERAS
SWE:FAST:FREQ:SETUP	1) Start Freq 2) Stop Freq 3) # of points (1 to 32767) in the sweep 4) Reserved! Must be 0 5) Dwell time in us, ms, s (from 5us to 4,294 s (~1hr)) , default - us 6) # of times to run sweep 1 to 32767, 0 – infinite 7) Trigger: 0 – Software Trig 1 – Sweep Trig 2 – Sweep Point Trig 8) Direction: 0 – Lo to Hi 1 – Hi to Lo 2 – Up & Down 9) Optional field 'RUN' – run sweep, Don't otherwise		Fast Frequency Sweep Setup (and Run – Opt)	SWE:FAST:FREQ:SETUP 2GHz,10GHz,800,1s, 10,0,0
SWE:FAST:FREQ:STAR(T)	# of times to run sweep 1 to 32767, 0 - infinite		Start FF Sweep	SWE:FAST:FREQ:STAR 0

Table 5 SCPI Commands for USB (continued)

Command	Parameter	Result	Description	Example
SWE:NORM: FREQ:SETUP	1) Start Freq 2) Stop Freq 3) Step Freq 4) Reserved! Must be 0 5 Dwell time in us, ms, s (from 5us to 4,294 s (~1hr)), default - us 6) # of times to run sweep 1 to 32767, 0 – infinite 7) Trigger: 0 – Software Trig 1 – Sweep Trig 2 – Sweep Point Trig 8) Direction: 0 – Lo to Hi 1 – Hi to Lo 2 – Up & Down 9) Optional field 'RUN' – run sweep, Don't otherwise		Normal Frequency Sweep Setup (and Run – Opt)	SWE:NORM:FREQ:SETUP 2GHz,8GHz,1GHz,0,5ms, 200,2,2,RUN
SWE:NORM:FREQ:STAR(T)	# of times to run sweep 1 to 32767, 0 - infinite		Start NF Sweep	SWE:NORM:FREQ:SETUP 1
SWE:NORM:POW:STAR(T)	# of times to run sweep 1 to 32767, 0 - infinite		Start NP Sweep	SWE:NORM:POW:STAR 3
SWE:STOP	None		Stop Sweep	SWE:STOP
*IDN?		Character String	Get ID	*IDN? Phase Matrix,FSW-0010, 0000007f,0,300a
STAT?	[15:8] - 'Don't Care' [0] - No Ext Ref Detected(0)* Ext Ref Detected(1)* [1] - RF locked(0) RF unlocked(1) [2] - Ref locked(0) Ref unlocked(1) [3] - RF Outp Off(0) RF Outp On(1) [4] - Voltage OK(0) Voltage Err(1) [5] - REF outp off(0) REF outp on(1) [6] - Not used [7] - Lock recovery on(1)/off(0) * Only valid when Ext Ref is selected.		Get Status	STAT? 00A8
DIAG:MEAS? 21		Value Deg. C	Get Temperature	DIAG:MEAS? 21 38.9