Programmer's Manual V0.3
SPI Interface

APMQS

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IMPORTANT! PLEASE READ CAREFULLY

Table of Contents

Introduction

This manual provides information for remote operation of the AnaPico Signal Sources using commands sent from an external controller via the SPI interface. It includes the following:

- A general description of the SPI hardware interface and its communication specifications
- A complete listing and description of the native command set that can be used to control signal generator operation with examples of command usage

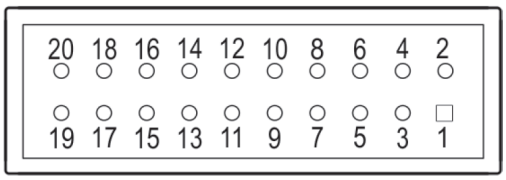
Further native commands are available on customer request!

SPI Hardware Interface

All instruments mentioned on the front page of this manual can be accessed through the SPI interface. This interface uses a native command set to pass commands to and reads queries from the device.

SPI Interface Connector

The SPI hardware Interface consists of a standard SPI interface plus additionally assigned lines as defined below.



Signal	Pin	Type	Description
SPI_CLK	11	Input	SPI clock. Supplied by the controlling host. The controlling host is the SPI master, the signal source device is the SPI slave.
SPI_SS#	13	Input	SPI Slave Select. This signal is an active low input from the host to the signal source device. 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
SPI_MISO	7	Output	Master In/Slave Out. Data line from the signal source device to the host.
SPI_MOSI	9	Input	Master Out/Slave In. Command/Data line from the host to the signal source device.
TRIGGER	17	Input	Edge sensitive input. The trigger signal of +3.3 V can be configured for multiple trigger modes (see also the datasheet of the device).
LOCK	15	Output	Output indicates the RF output of the synthesizer is locked on its current setting (+3.3 V locked, 0 V unlocked).
REF_LOCK	16	Output	Output indicates the signal source device has detected an external reference signal and locked on that signal (+3.3 V locked, 0 V unlocked).
RESET#	18	Input	Internally pulled up to +3.3 V with 100 kΩ resistor. Active low signal, which has a minimum width of 1 ms, will reset the signal source device to a default state.
DC IN	3, 4		External power supply (see also the datasheet of the device). Redundant power supply input to the DC IN interface (supply with higher voltage will be chosen).
GND	8, 10, 19, 20		Ground.
DNC	1, 2, 5, 6, 12, 14		Do not connect. Reserved for factory / future use.

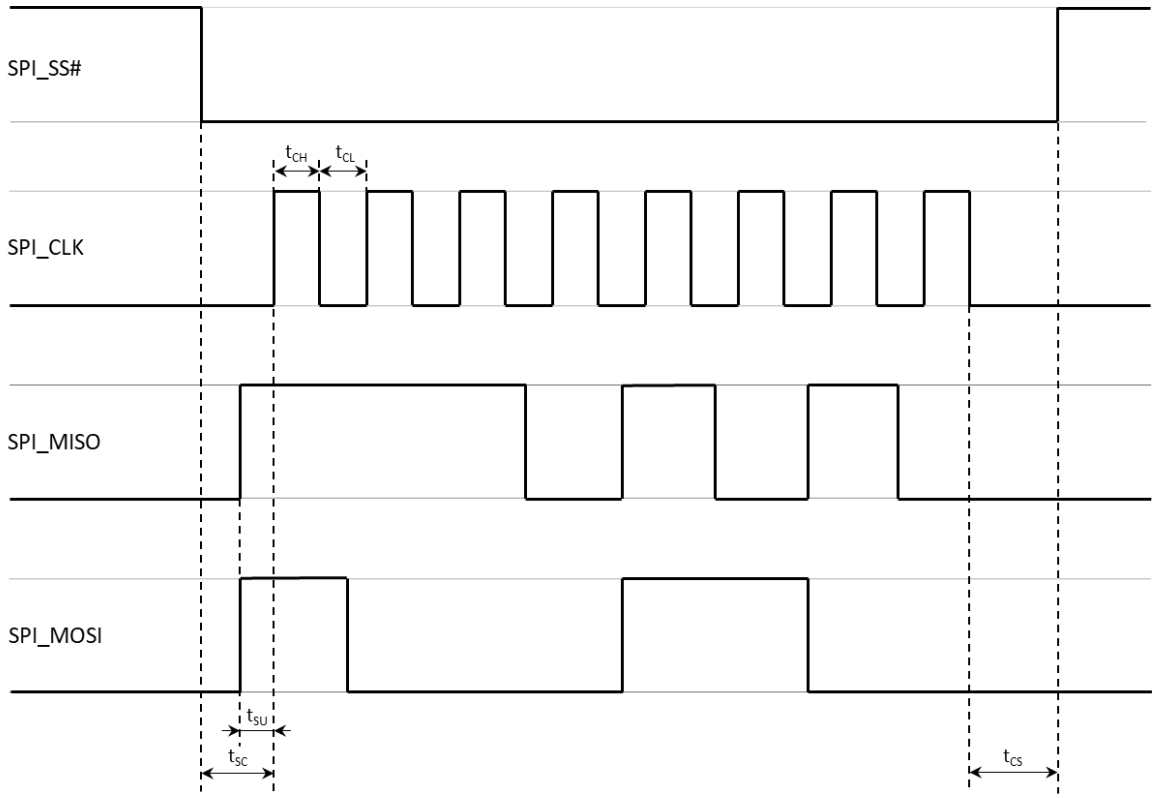
The SPI interface connector is a 20 pin, 2.50 mm spaced double-row header. AnaPico recommends HIROSE manufactured socket DF1B-20DS-2.5RC and corresponding contacts from its DF1B series.

SPI Signals and Timing

For the communication over the SPI Interface of the device minimum timing requirements needed to be observed as it is shown in the diagram and the table below. A high level of a signal corresponds to +3.3 V and a low level to 0 V.

Starting transferring a byte, SPI_CLK needs to be low when SPI_SS# is asserted. After that, the data signals will be set up to a stable state before the first rising edge of the clock will occur (SPI_MOSI for data from host to device and SPI_MISO for data from device to host). Data will be sampled at every rising edge of SPI_CLK.

Data will be transferred with MSB (most significant bit) first. SPI_SS# needs to be asserted during the complete transmission process. After all data bits are transferred and SPI_CLK remains low, SPI_SS# will go high and the transfer of a data byte is completed. After that, next data transfer could be started.



t_{SC}	SPI_SS# to be low before first clock edge
t_{CS}	SPI_CLK to be low before releasing SPI_SS#
t_{SU}	SPI_MISO/MOSI to be stable before rising edge of clock
t_{CH}	Minimum high time of a clock pulse
t_{CL}	Minimum low time of a clock pulse

SPI Native Commands

The communication over the SPI interface of a device is using a specific native command set which is defined and described in this Programmer's Manual document.

The native command set consists of commands, parameters and return data on a binary definition (in some cases data can be ASCII interpreted which is separately noted). A communication is always started with a command byte sent by the host. Command specific data is followed with a number of bytes as it is needed for the command and as it is specified and defined in this document in the specific command section.

There are two different types of commands which are further described below.

Control Commands

Control commands are used to control the device like setting the RF output frequency or the RF output power. These commands are a one-way communication from host to device without return or acknowledge data.

A command is starting with a 1-byte command code followed by the parameter data which is needed for the command. Therefore, the length of the sent data varies between the different commands.

Query Commands

Query commands are used to read data back from device like the current status of the device or the device ID. These commands are always needs to be executed twice. When sending the command for the first time, the host is sending the command byte starting with a 1-byte command code followed by the number of bytes which needs to be read back (data of these bytes doesn't care). In this time, the device is preparing the requested data to be read back. While sending the command for the second time, the return data of the device can be received by the host.

The number of bytes to read back differs between the different commands, therefore the length of the sent data varies between the commands.

SPI Native Commands Description

Control Commands

Command	Command Code	Parameters	Unit	Default
Set Output Frequency	0x0C	<integer>	0.001 Hz	100 MHz
Set Output Power	0x03	<integer>	0.1 dBm	0 dBm
Blanking Mode	0x05	OFF | ON	-	ON
Select Reference Source	0x06	INT | EXT	-	INT
Reference Output	0x08	OFF | ON	-	ON
RF Output	0x0F	OFF | ON	-	OFF
Pulse Modulation	0x09	OFF | ON	-	OFF
ALC Enable	0x60	OFF | ON	-	ON
Power Search	0x67	-	-	-
SPI Disable	0x96	<integer>	ms	-

Set Output Frequency

Size (Bytes)	Header		Parameter		
	Code	Bits	Size (Bytes)	Bits	Value
7	0x0C	[55:48]	6	[47:0]	Frequency

This command sets the RF output frequency of the device.

Command Parameters

Parameters	Size (Bytes)	Bits	Value
Frequency	6	[47:0]	Frequency in 0.001 Hz

Default Values

Parameter	Default Value	Value (Hex)
Frequency	100 MHz	0x00174876E800

Set Output Power

Size (Bytes)	Header		Parameter		
	Code	Bits	Size (Bytes)	Bits	Value
3	0x03	[23:16]	2	[15:0]	Power

This command sets the RF output power of the device.

Command Parameters

Parameters	Size (Bytes)	Bits	Value
Power	2	[15:0]	Power in 0.1 dBm, negative values in two's complement

Default Values

Parameter	Default Value	Value (Hex)
Power	0 dBm	0x0000

Blanking Mode

Size (Bytes)	Header		Parameter		
	Code	**Bits**	**Size (Bytes)**	**Bits**	**Value**
2	0x05	[15:8]	1	[7:0]	Enable

This command enables (blanked) or disables (unblanked) RF output during frequency changes.

Command Parameters

Parameters	Size (Bytes)	Bits	Value
Enable	1	[7:0]	OFF (unblanked): 0x00 ON (blanked): 0x01

Default Values

Parameter	Default Value	Value (Hex)
Enable	ON (blanked)	0x01

Select Reference Source

Size (Bytes)	Header		Parameter		
	Code	**Bits**	**Size (Bytes)**	**Bits**	**Value**
2	0x06	[15:8]	1	[7:0]	Reference Source

This command selects internal or external source as reference signal. If external reference source is selected, external reference frequency is set to 10 MHz per default.

Command Parameters

Parameters	Size (Bytes)	Bits	Value
Reference Source	1	[7:0]	Internal Source: 0x00 External Source: 0x01

Default Values

Parameter	Default Value	Value (Hex)
Reference Source	Internal Source	0x00

Reference Output

Size (Bytes)	Header		Parameter		
	Code	Bits	Size (Bytes)	Bits	Value
2	0x08	[15:8]	1	[7:0]	Enable

This command enables (ON) or disables (OFF) reference output port. If enabled, reference output frequency is set to 10 MHz per default.

Command Parameters

Parameters	Size (Bytes)	Bits	Value
Enable	1	[7:0]	OFF: 0x00 ON: 0x01

Default Values

Parameter	Default Value	Value (Hex)
Enable	ON	0x01

RF Output

Size (Bytes)	Header		Parameter		
	Code	Bits	Size (Bytes)	Bits	Value
2	0x0F	[15:8]	1	[7:0]	Enable

This command enables (ON) or disables (OFF) RF output.

Command Parameters

Parameters	Size (Bytes)	Bits	Value
Enable	1	[7:0]	OFF: 0x00 ON: 0x01

Default Values

Parameter	Default Value	Value (Hex)
Enable	OFF	0x00

Pulse Modulation

Size (Bytes)	Header		Parameter		
	Code	Bits	Size (Bytes)	Bits	Value
2	0x09	[15:8]	1	[7:0]	Enable

This command enables (ON) or disables (OFF) pulse modulation, controlled by the external PULSE / TRIGGER port.

Command Parameters

Parameters	Size (Bytes)	Bits	Value
Enable	1	[7:0]	OFF: 0x00 ON: 0x01

Default Values

Parameter	Default Value	Value (Hex)
Enable	OFF	0x00

ALC Enable

Size (Bytes)	Header		Parameter		
	Code	**Bits**	**Size (Bytes)**	**Bits**	**Value**
2	0x60	[15:8]	1	[7:0]	Enable

This command enables (ON) or disables (OFF) RF output level control. If ALC is disabled, the amplitude level control loop is open. This can improve power stability when fast sweeps or modulations are active.

Command Parameters

Parameters	Size (Bytes)	Bits	Value
Enable	1	[7:0]	OFF: 0x00 ON: 0x01

Default Values

Parameter	Default Value	Value (Hex)
Enable	ON	0x01

Power Search

Size (Bytes)	Header		Parameter		
	Code	**Bits**	**Size (Bytes)**	**Bits**	**Value**
1	0x67	[7:0]	-	-	-

Sending this command will manually trigger an ALC search while ALC is disabled. During this time, the RF output varies randomly. This command can be used before enabling pulse modulation where the ALC is disabled, as an example.

SPI Disable

Size (Bytes)	Header		Parameter		
	Code	**Bits**	**Size (Bytes)**	**Bits**	**Value**
3	0x96	[23:16]	1	[15:0]	Off-time

This command disables the SPI Interface of the device for a set amount of time.

Command Parameters

Parameters	Size (Bytes)	Bits	Value
Off-time	2	[15:0]	Off-time in ms

Examples

- **Set output frequency to 6.791 GHz**
  1. Convert frequency to mHz: 6’791’000’000’000 mHz
  2. Convert frequency in mHz to 48-bit hexadecimal: 06 2D 27 24 86 00
  3. Append command header in front of the frequency: 0C 06 2D 27 24 86 00
  4. Send command: **0C 06 2D 27 24 86 00**

- **Set output power to -10 dBm**
  1. Convert power to dBm/10: -100 dBm/10
  2. Convert power in dBm/10 to 16-bit hexadecimal: FF 9C
  3. Append command header in front of the power: 03 FF 9C
  4. Send command: **03 FF 9C**

- **Enable RF output**
  1. Set parameter byte to enable RF output: 01
  2. Append command header in front of the parameter: 0F 01
  3. Send command: **0F 01**

Query Commands

Command	Command Code	Return Data	Unit
Get ID	0x01	Model# | Option# | SW Version | Device#	-
Get Device Status	0x02	Ext Ref | RF Lock | Ref Lock | RF Out | Ref Out | Blanking	-
Get Output Frequency	0x04	<integer>	0.001 Hz
Get Output Power	0x0D	<integer>	0.1 dBm

Get ID

Command			Return Data		
Size (Bytes)	Code	Bits	Size (Bytes)	Bits	Value
12	0x01	[95:88]	12	[87:0]	Model# | Option | SW Version | Device#

This command returns the identification data of the device, including model number, options, software version and device number.

Command Parameters

Parameters	Size (Bytes)	Bits	Value
Don't care	11	[87:0]	-

Return Data

Parameters	Size (Bytes)	Bits	Value
Don't care	1	[95:88]	-
Model#	2	[87:72]	Two digit ASCII model number (constant for each device of the same model)
Option	2	[71:56]	Two digit ASCII options indicator
SW Version	2	[55:40]	Binary software version number
Device#	5	[39:0]	Five digit ASCII device number (unique for each device of the same model)

Get Device Status

Command			Return Data		
Size (Bytes)	Code	Bits	Size (Bytes)	Bits	Value
2	0x02	[15:8]	2	[7:0]	Ext Ref | RF Lock | Ref Lock | RF Out | Ref Out | Blanking

This command returns the status bits of the device, including external reference status, RF and reference lock status, RF and reference output status and blanking status.

Command Parameters

Parameters	Size (Bytes)	Bits	Value
Don't care	2	[15:8]	-

Return Data

Parameters	Size (Bytes)	Bits	Value
Don't care	1	[15:8]	-
Ext Ref	1	[0]	Internal Reference (0); External Reference (1)
RF Lock		[1]	RF locked (0), RF unlocked (1)
Ref Lock		[2]	Reference locked (0), reference unlocked (1)
RF Out		[3]	RF output disabled (0), RF output enabled (1)
		[4]	0
Ref Out		[5]	Ref output disabled (0), ref output enabled (1)
Blanking		[6]	Blanking disabled (0), blanking enabled (1)
		[7]	0

Get Output Frequency

Command			Return Data		
Size (Bytes)	Code	Bits	Size (Bytes)	Bits	Value
7	0x04	[55:48]	7	[47:0]	Frequency

This command reads the current RF output frequency of the device.

Command Parameters

Parameters	Size (Bytes)	Bits	Value
Don't care	6	[47:0]	-

Return Data

Parameters	Size (Bytes)	Bits	Value
Don't care	1	[55:48]	-
Frequency	6	[47:0]	Frequency in 0.001 Hz

Get Output Power

Command			Return Data		
Size (Bytes)	Code	Bits	Size (Bytes)	Bits	Value
3	0x0D	[23:16]	3	[15:0]	Power

This command reads the current RF output power of the device.

Command Parameters

Parameters	Size (Bytes)	Bits	Value
Don't care	2	[15:0]	-

Return Data

Parameters	Size (Bytes)	Bits	Value
Don't care	1	[23:16]	-
Power	2	[15:0]	Power in 0.1 dBm, negative values in two's complement

Examples

- **Get output frequency**
  1. Send command: **04 00 00 00 00 00 00**
  2. Send command: **04 00 00 00 00 00 00**
  3. Read return data: 00 06 2D 27 24 86 00
  4. Disregard "Don't Care" bits from received data: 06 2D 27 24 86 00
  5. Convert data to mHz: 6'791'000'000'000 mHz
  6. Convert data to Hz: **6.791 GHz**

- **Get device status**
  1. Send command: **02 00**
  2. Send command: **02 00**
  3. Read return data: 00 29
  4. Disregard "Don't Care" bits from received data: 2E
  5. Interpret status bits:
     - Bit 0: 1 -> **External reference**
     - Bit 1: 0 -> **RF locked**
     - Bit 2: 0 -> **Reference locked**
     - Bit 3: 1 -> **RF output enabled**
     - Bit 5: 1 -> **Reference output enabled**
     - Bit 6: 0 -> **Blanking off**

Document History

Version	Date	Author	Notes
0.1	05.10.2023	DD	First draft
0.2	05.12.2023	DD	SPI timing added, modified open points
0.3	29.01.2024	DD	Review corrections

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