

Application Note AN6007

Analog Inputs of APVSGs

Purpose

This application note describes the configuration options for the analog input ports and analog IQ modulation of the APVSG. The correction options and commands for all configurations regarding the analog inputs are provided at the end of this document.

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Introduction

The APVSG can be used for analog IQ modulation. For this purpose, the APVSG is equipped with two analog input ports for each RF channel. The analog IQ signals are fed to these ports and internally connected to the digital IQ modulator.

Analog input ports are an option for the APVSG devices. Please contact your AnaPico representative for details on ordering an APVSG outfitted with this option.

The analog inputs of APVSG devices feature an input signal correction for each input channel individually. It can be applied to adjust the signal and thereby decrease imperfections in the analog transmission.

After correction, the signals received on the analog inputs can be configured to be interpreted as I and Q data. The resulting IQ data can then be used in the internal modulation block of the APVSG device to modulate the carrier frequency. Thereby, streamed analog IQ modulation is possible through the analog input ports.

Most important SCPI commands

[SOURCE<ch>:]AIN[:STATE] 0|1|OFF|ON

Enable/Disable the state of the analog input (AIN) port.

[SOURCE<ch>:]AIN<ch>:OFFSet <float>

Set the channel specific offset. The value is in Volts and is applied in addition to the calibration.

[SOURCE<ch>:]AIN<ch>:GAIN <float>

Set a scalar gain on the selected AIN channel which is applied to the input before being used by any modulation subsystem.

[SOURCE<ch>:]BB:ARbitrary:AIQ[:STATE] 0|1|OFF|ON

Enable/Disable the arbitrary baseband modulation, using the analog IQ modulation signals.

Analog Input Port Configuration

The APVSG devices have the option to be equipped with two analog input ports for each RF channel of the device. These input ports receive an analog signal with its voltage in a specified range, defined in [1]. Each port is configured individually as shown in Figure 1 and can be adjusted by applying an offset voltage and gain. The altered AIN signals are then ready to be used as IQ data for analog IQ modulation.

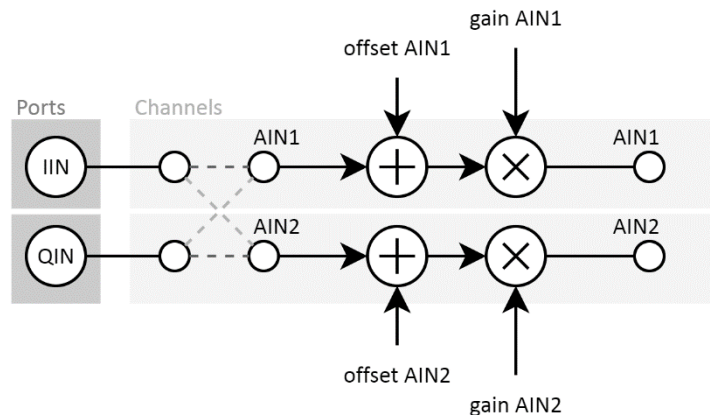


Figure 1: Analog input port flow with source, gain and offset configuration

The APVSG distinguishes between the analog input ports IIN and QIN and the analog input channels AIN<ch>. The analog input connector ports of the device are labeled I IN and Q IN. Therefore, the analog input ports are referred to as IIN and QIN. The analog input signal inside the device is called AIN. Since there are multiple different AIN signals, each AIN signal is described with a unique channel number $\in \{1,2\}$.

The abstract concept of AIN channels allows for one IIN/QIN port to be connected to multiple AIN channels at once or to switch between IIN and QIN ports while keeping offset and gain settings.

Setup Analog Input Port

To successfully use the analog input ports, the AIN channels must be activated and the port source for all AIN channels in operation must be defined. The following SCPI commands are required to set these configuration properties.

- **[SOURCE<ch>:]AIN[:STATe] 0|1|OFF|ON**
Enable/Disable the analog input (AIN) ports and channels. When not in use, they should be disabled to minimize the power usage of the device. This command is disabled by default.
- **[SOURCE<ch>:]AIN<ch>:SOURCE IIN|QIN**
Set the port source for analog input channels AIN1 or AIN2, using the corresponding channel <ch> numbers. Per default, AIN1 and AIN2 are connected to IIN and QIN respectively.

Analog Input Sampling

The analog input ports IIN and QIN each sample data with 125 Mega samples per second. Therefore, analog input frequencies higher than 61.5 MHz cannot be detected by the analog input ports of the APVSG device. This naturally limits the modulation bandwidth for IQ modulation with analog signals.

The sampling rate of the APVSG device is automatically set to 125 MHz for arbitrary analog IQ modulation.

Offset and Gain Adjustment

Each analog input channel can be adjusted in terms of offset and gain. Offset and gain are configured for each AIN channel separately and applied digitally (after the analog to digital conversion). This modification is further referred to as the analog input signal correction.

The correction is intended to account for imperfect transmission of the analog input signal and can be deployed to reduce carrier leakage, mirror image rejection and similar effects.

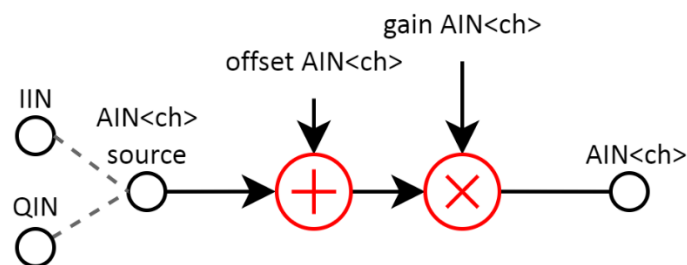


Figure 2: Offset and gain are applied to each AIN signal after the input source is selected.

The offset and gain configuration of each AIN channel is done with the following SCPI commands. In case the configuration results in the final signal exceeding the allowed range for AIN signals, the signal is simply clipped at its maximum or minimum value respectively.

- [SOURCE<ch>:]AIN<ch>:OFFSet <double>**
 Set the channel specific offset. The value is in Volts and must not exceed the allowed voltage range of the analog input port.
 Range: specified input range of the analog input in [1].
 *RST: 0.0V
- [SOURCE<ch>:]AIN<ch>:GAIN <double>**
 Set a scalar gain on the selected AIN channel which is applied to the input before being used by any modulation subsystem.
 Range: [-2.0, 2.0]
 *RST: 1.0

The APVSG also supports an automatic offset correction for each AIN channel. For this automatic zero calibration, a 0.0V DC signal with 50 Ohm termination is expected at the connected analog input port. The offset value of the selected AIN channel is then reset to counter the mean value of the input during this calibration process. The process takes less than 1s.

- [SOURCE<ch>:]AIN<ch>:CALibrate:ZERO**
 Expects an input of 0.0V DC at the AIN channel. Calibrates the zero offset for an analog input AIN channel. The value of the AIN<ch>:OFFS command is overwritten. The new calibrated value can be acquired by querying AIN<ch>:OFFS?

Input Monitoring

The analog input of the APVSG comes with several SCPI commands that provide information about the signal on each AIN channel. The available information consists of the following signal properties:

- Input voltage value
- Input voltage overload (min or max)
- Corrected AIN signal overrange (min or max)

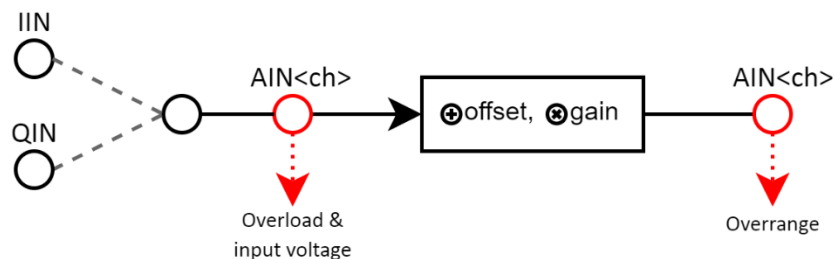


Figure 3: Relation of the overload and overrange status to the analog input data.

The input voltage information reports on the mean value collected over 1024 samples. The values are gathered before any correction offset or gain is applied to the signal.

- **[SOURCE<ch>:]AIN<ch>:VOLTage? [MIN | MAX]**
Get the mean input voltage of the selected AIN channel.
The command can also optionally return the specified minimal and maximal voltage that are allowed at the AIN ports.

The overload information reports on the input voltage of the AIN signal before any correction is applied. It indicates if the input voltage exceeded the allowed input voltage range. If an overload is detected, the state is held high until reset by the user.

- **[SOURCE<ch>:]AIN<ch>:OLOad:HOLD:STATE?**
Query if the AIN port has reached the maximum or minimum limit of allowed voltages at the port since the last reset, meaning the signal went past the allowed range of voltages and was clipped at the allowed max/min value.
returns 1: overload detected.
returns 0: no overload detected.
- **[SOURCE<ch>:]AIN:OLOad:HOLD:RESet**
Reset the overload hold state for all AIN channels.

The overrange is the counterpart of the overload, after offset and gain correction are applied to the signal. This information is essential to determine if offset and gain are configured well.

- **[SOURCE<ch>:]AIN<ch>:OVR:HOLD:STATE?**
Query if the AIN signal created with offset and gain went overrange since the last reset
- **[SOURCE<ch>:]AIN:OVR:HOLD:RESet**
Reset the overload hold state for all AIN channels.

Further related commands can be found in section *List of SCPI Commands* at the end of this document.

Analog IQ Streaming

The input signals at the analog input port can be configured to be used as I and Q modulation signals that then modulate the carrier frequency of the APVSG device.

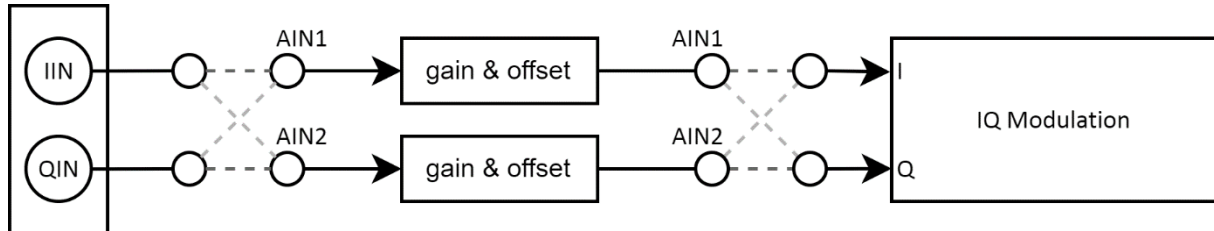


Figure 4: Signal path from IIN&QIN port through AIN correction to analog IQ (AIQ) modulation.

Limitations

- 125 MHz sampling rate, as described in section *Analog Input Sampling*.
- Limited modulation bandwidth to ± 61.5 MHz
- No simultaneous other modulation except for [option] AWGN.

Configuration Options

To feed the AIN signals as I and Q modulation data to the device, several configuration options must be set correctly. These are

- Activate arbitrary baseband modulation with analog IQ.
- Select which AIN channels feed into the I and Q data for the IQ modulation.

The following command is used to enable or disable analog IQ modulation. AIQ modulation is only available if no other modulation (except for AWGN) is enabled concurrently.

- **[SOURCE<ch>]:BB:ARbitrary:AIQ[:STATe] 0|1|OFF|ON**
Enable/Disable the arbitrary baseband modulation, using the analog IQ modulation signals.

The I and Q modulation data each must be sourced from one of the AIN channels. With following SCPI commands the source for the I and Q data are each selected individually. The SCPI commands get the AIN channel number as an input.

- **[SOURCE<ch>]:BB:ARbitrary:AIQ:SOURce:I <ch>**
Set the AIN channel source for the I (in-phase) part of the analog IQ modulation signal.
- **[SOURCE<ch>]:BB:ARbitrary:AIQ:SOURce:Q <ch>**
Set the AIN channel source for the Q (quadrature) part of the analog IQ modulation signal.

AIQ Example

The following SCPI command sequence is an example for setting up AIQ modulation with analog I and Q data being sent to ports IIN and QIN of the device respectively.

FREQ 1e9	Set initial RF output frequency to 1GHz
AIN:STAT ON	Enable the analog input ports
AIN1:SOUR IIN	Set the source of AIN1 to the IIN port
AIN1:GAIN 0.5	Set the gain of AIN1 to half
AIN1:OFFS -0.2	Set the offset of AIN1 to -0.2V
AIN2:SOUR QIN	Set the source of AIN2 to the QIN port
AIN2:OFFS 0.1	Set the offset of AIN2 to 0.1V
BB:ARB:AIQ:SOUR:I 1	Select AIN1 as source for I data
BB:ARB:AIQ:SOUR:Q 2	Select AIN2 as source for Q data
BB:ARB:AIQ:STAT ON	Enable AIQ modulation
OUTP:STAT ON	Enable RF output

List of SCPI Commands

Analog Input Port Configuration

[SOUR:]AIN[:STAT]?

[SOUR<x>:]AIN[:STATe] 0|1|OFF|ON

Enable/Disable both analog inputs (AIN).

*RST: OFF

Example: AIN:STAT ON

[SOUR:]AIN<ch>:SOUR?

[SOUR<x>:]AIN<ch>:SOURce IIN|QIN

Set the source for a specific AIN channel <ch>.

*RST: AIN1 connected to IIN and AIN2 connected to QIN

Example: AIN1:SOUR QIN

[SOUR:]AIN<ch>:OFFS?

[SOUR<x>:]AIN<ch>:OFFSet <float>

Set the channel specific offset. The value is in Volts and is applied in addition to the calibration.

*RST: 0.0V

Example: AIN2:OFFS 0.02

[SOUR<x>:]AIN<ch>:CALibrate:ZERO

Expects an input of 0.0V DC at the AIN channel. Calibrates the zero offset for an analog input AIN channel.

[SOUR:]AIN<ch>:GAIN?

[SOUR<x>:]AIN<ch>:GAIN <float>

Set a scalar gain on the selected AIN channel which is applied to the input before being used by any modulation subsystem.

Range: [-2.0, 2.0]

*RST: 1.0

[SOUR<x>:]AIN<ch>:VOLTage? [MIN|MAX]

Get the current input voltage of an AIN channel. The returned value does not include the calibrated offset correction.

The command can also optionally return the specified minimal and maximal voltage that are allowed at the AIN ports.

[SOURce<x>:]AIN<ch>:OLOad:STATe?

Query if the AIN port is at overload, meaning the maximum or minimum limit of allowed voltages at the port in this moment.

*RST: 0

[SOURce<x>:]AIN<ch>:OLOad:HOLD:STATE?

Query if the AIN port has reached the maximum or minimum limit of allowed voltages at the port since the last reset, meaning the signal went past the allowed range of voltages and was clipped at the allowed max/min value.

returns 1: overload detected.

returns 0: no overload detected.

*RST: 0

[SOURce<x>:]AIN:OLOad:HOLD:RESet

Reset the overload hold state for all AIN channels.

[SOURce<x>:]AIN<ch>:OVR:STATE?

Query if the AIN signal created with gain and offset is overrange, meaning the signal is out of the the allowed range of voltages for the port in this moment.

*RST: 0

[SOURce<x>:]AIN<ch>:OVR:HOLD:STATE?

Query if the AIN signal created with offset and gain went overrange since the last reset, meaning the signal went past the allowed range of voltages and was clipped at the allowed max/min value.

returns 1: overload detected.

returns 0: no overload detected.

*RST: 0

[SOURce<x>:]AIN:OVR:HOLD:RESet

Reset the overrange hold state for all AIN channels.

Analog IQ Modulation

[SOUR:]BB:ARB:AIQ[:STAT]?

[SOURce<x>:]BB:ARBitrary:AIQ[:STATE] 0|1|OFF|ON

Enable/Disable the arbitrary baseband modulation, using the analog IQ modulation signals.

*RST: OFF|0

[SOUR:]BB:ARB:AIQ:SOUR:I?

[SOURce<x>:]BB:ARBitrary:AIQ:SOURce:I 1|2

Set the AIN channel source for the I (in-phase) part of the analog IQ modulation signal.

*RST: 1

[SOUR:]BB:ARB:AIQ:SOUR:Q?

[SOURce<x>:]BB:ARBitrary:AIQ:SOURce:Q 1|2

Set the AIN channel source for the Q (quadrature) part of the analog IQ modulation signal.

*RST: 2

[SOUR:]BB:ARB:AIQ:CLOC?

Get the Sampling Rate for AIQ modulation, which is constantly 125 MHz.

Further related documentation

- APVSG Datasheet [1]
with specifications for APVSG devices.
- Programmer's Manual [2]
with a description of all SCPI commands
- AN6005 [4]
for Additive White Gaussian Noise
- AN6006 [5]
for RF Output Modes