Application Note AN6003

APVSG Memory Segmentation

Purpose

This Application Note gives an overview of the definitions for IQ samples, segments, and sequences and then describes the different options for storing and replaying multiple sets of IQ modulation data in the memory.

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Introduction

The memory segmentation in APVSG devices allows the user to freely switch between stored waveforms. To that end, multiple sets of IQ modulation data are stored separately in the memory of the device. Each set of IQ data can then be replayed and employed to modulate the internal carrier frequency to result in the desired RF output. The user is able to select which set of stored IQ modulation data is replayed.

This Application Note first gives a brief introduction into the nomenclature of samples, segments and sequences and then describes the different options for storing and replaying the IQ data in the memory. As for storing options, the user can choose between

- The graphical user interface (GUI) or
- SCPI commands.

Selecting the replayed IQ data can be done with the same methods as storing. Additionally, if the device supports the fast control port (FCP) interface option, the FCP can be configured to control the selected data for replay in real-time which can be important for time critical applications.

The most important SCPI commands for memory segments are:

BB:ARBitrary:WSEGment:SOURce INTernal|FCPort

Set the source for selecting segments from the memory.

BB:ARBitrary:WSEGment <segment ID>

Select an IQ waveform segment with the specific segment ID in the memory for replay.

All SCPI commands related to memory segmentation are listed and described at the end of this Application Note in section *SCPI Command Overview*.

Additional related commands can be found at the end of this Application Note. Further associated documentation is:

- Programmer's Manual [1]
  with a description of all SCPI commands
- APVSG Datasheet [2]
  with specifications on the APVSG devices.
- AN6001 [3]
  Application Note on the AnaPico IQ file format.
- AN6002 [4]
  Application Note on the Fast Control Port (FCP) interface

Nomenclature

IQ Sample

With AnaPico APVSG devices, an IQ sample is defined to consist of three parts. These are:

- 16 bits I (in-phase) data
- 16 bits Q (quadrature) data
- Optionally 8 marker bits (0 or 8 bits, depending on the configuration)

8 bits	16 bits	16 bits
[Marker]	Q	I

Figure 1: IQ Sample format

The details on IQ samples, qid and qim format are described in AN6001 [3].

The marker bits can be utilized to mark specific IQ samples and thereby distinguish them from others. The marker bits can be freely set to represent a user-defined behavior to distinguish the desired IQ samples from others.

Imagine for instance a set of consecutive IQ samples that represent a period of a sine wave. One could then configure the IQ samples to contain 8 marker bits each, out of which one marks the start of the period and one to denote the sample with the maximum amplitude of Q. The former marker bit will then be 0 in all samples except for the one that starts the period. Similarly, the latter will only be 1 for the sample with the maximal amplitude. In Figure 2 this example is illustrated with M0 and M1 representing the markers corresponding to the start and the maximum amplitude of Q respectively.

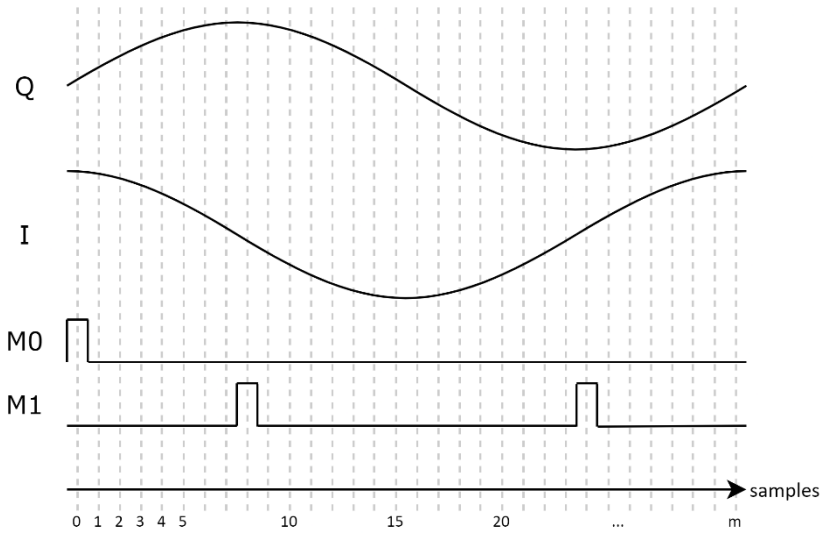

Figure 2: Example of an IQ sample that represents a period of a sin wave with marker bits. Only two out of eight marker bits are displayed, the others are omitted.

Segment

With AnaPico devices and applications, a segment is defined as a set of multiple IQ samples. Typically, one segment represents one period of a waveform for IQ modulation of a carrier frequency. Each segment has the following properties:

- Variable size of m samples (see datasheet [2] for specifics on min/max samples per segment)
- Assigned segment ID

The segments are stored in the memory of the APVSG. Figure 3 visualizes how several segments are stored in the memory, with each segment containing multiple IQ samples.

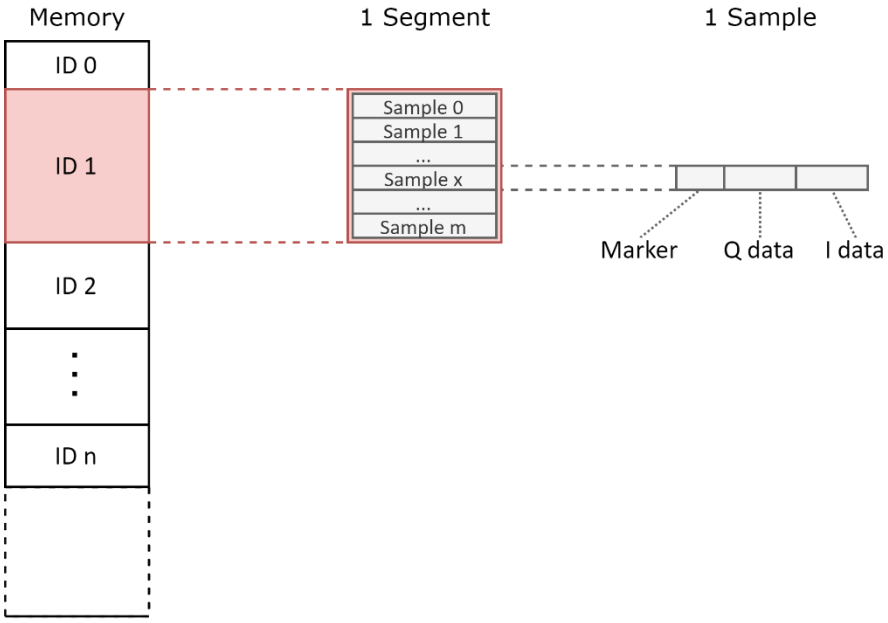

Figure 3: Illustration of a memory filled with segments that each consist of multiple IQ samples.

Sequence

For replaying different segments sequentially, they can be combined into a sequence. A sequence determines which segments are to be replayed how often and in which order.

Example:

Four segments are stored in the memory with segment IDs ranging from 0 to 3. A sequence then defines how often and in what order these segments are replayed. Figure 4 illustrates two examples of sequences that can be defined with the four stored segments.

Note that sequences can be repeated and combined with different sequences to be replayed consecutively in any desired order. For more information on replaying segments, have a look at section *Choose and Replay Segments.*

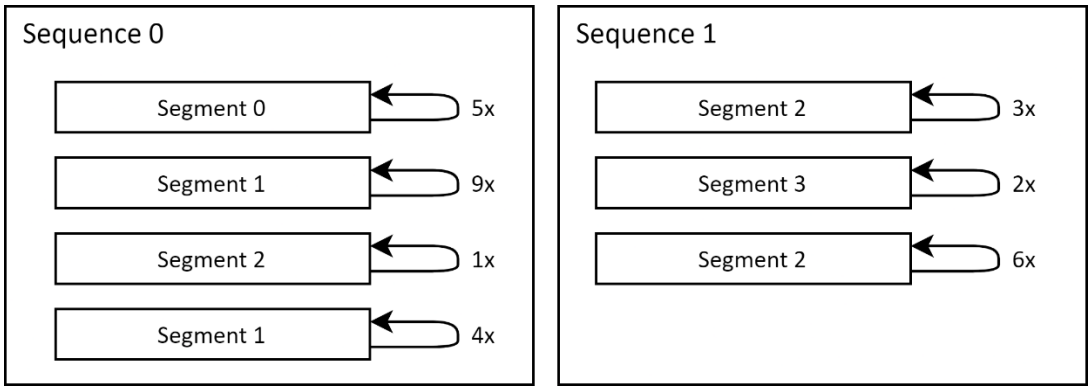

Figure 4: Example of two different sequences

Store Segments

There are two possible ways to write segments to the memory of the signal generator. Either the segments are uploaded using the graphical user interface (GUI) or the segment data is sent to the device with SCPI commands.

Requirements and limitations:

- Each segment that is stored on the device requires a unique segment ID. It is the responsibility of the user to keep track of the IDs and assure they are existing and unique for each segment.
- Segments have a minimal number of samples required for them to be successfully stored in the memory. In case the number of samples in a segment go below this limit however, the segment is simply repeated periodically until the requirement is met and the enlarged segment is then written to the memory. Users should be aware of this limitation, especially if the concerning segment is to be replayed in a sequence.

For information on the data format used for IQ sample files, please refer to AN6001 [3].

Upload files with the GUI

Segments can conveniently be loaded to the memory of the signal generator by loading a file with the graphical user interface (GUI).

Note that the QI files need to be loaded in the segment tab in the RF modulation section to be assigned a unique segment ID. The AnaPico APVSG GUI supports the following features related to segment loading:

- Upload QI files (see AN6001 [3] for details on the file format) to the memory.
- Upload all QI files of a folder to a segment each.
- Progress bar with full and empty space of the memory.
- ID of each segment displayed.

Load Block Data with SCPI Commands

The Application Note AN6001 on QI file formats [3] contains both explanations and an example on how to load data to the device's memory with SCPI commands. The most important SCPI commands for this endeavour are listed below for the reader's convenience.

BB:ARBritrary:WAVeform:MARKer:STATe ON|OFF|1|0

Enable/disable the usage of optional marker bits. It is very important to set the state of the marker bits before any data is uploaded or the samples stored in memory will not be interpreted correctly.

BB:ARBitrary:WAVeform:DATA [<segment ID>] <data block>
Transfer the IQ modulation samples of the data block to the device and store them with the segment ID. If the optional segment ID is not set, it is set to zero per default. Note that segments are appended in the memory, so it is important to keep track of the remaining empty space.

BB:ARBitrary:WAVeform:DATA:FREE?

Query that returns the remaining number of samples that may be written to the device.

BB:ARBitrary:WAVeform:DATA:DELete ALL

Clears the entire waveforms memory.

Choose and Replay Segments

The segments stored in the memory can be replayed to modulate the carrier frequency with the IQ data. The modulated signal can then for example be monitored at the RF output of the signal generator. Please note that the IQ modulation must be enabled for the selected segment to modulate the carrier frequency. If marker mode is enabled, two user-defined markers can be connected to the multi-function output.

Exactly one segment at a time is selected for replaying the IQ data. The user is responsible to make sure only segments existing in the memory are replayed. Selecting segments with IDs that have not been previously loaded to the memory may result in unexpected memory behaviour and unpredictable modulation of the carrier frequency. When a new segment is selected, the transition to the new segment is seamless. This means that the former segment is fully replayed up to the last sample before switching to the first sample of the consecutive segment. Switching segments involves an undefined latency during which the state of the memory is undefined.

There are three different ways to select a new segment for replay:

- in the GUI
- SCPI commands
- Directly through the fast control port (FCP)

Pick a Segment in the GUI

Before selecting a segment in the GUI, make sure all the desired segments are uploaded. The successfully loaded segments are shown in the GUI and can be selected for replay. To modulate the output frequency with the selected segment, the modulation must be turned on.

Select Segments with SCPI Commands

For selecting a segment with SCPI commands, use the following SCPI commands:

BB:ARBitrary:CLOCk <frequency>
Set the playback rate to <frequency> for all replayed samples. Should be configured before selecting the memory segment.

BB:ARBitrary:WSEGment:SOURce INTernal|FCPort
Set the segment selection source to either of the following:

Internal:	Segments are selected individually in the GUI or with SCPI commands.
FCP:	Segments can either be selected like in the internal mode and through segments IDs transferred through the FCP interface. New selections automatically overwrite any prior existing ones.

BB:ARBitrary:WSEGment <segment ID>
Select a segment in the memory with the specific segment ID for replay.

BB:ARBitrary:WSEGment?
Query that returns the currently selected segment, or zero if no segment is selected.

BB:ARBitrary:WSEGment:COUNt?
Query that returns the number of currently stored segments in the memory

Example

1. Load a segment to the memory with your favourite method. Let us assume the ID of the uploaded segment is 3.
2. SCPI command sequence for selecting a segment and modulating the carrier frequency:

SOUR:SEL 1	Sets the source to channel 1
FREQ 50e6	Sets initial RF output frequency to 50 MHz
BB:ARB:WSEG:SOUR INT	Set the segment selection to internal
BB:ARB:CLOC 500e6	Set the sample clock to 500 MHz
BB:ARB:WSEG 3	Select segment with ID 3
BB:ARB:WSEG?	Expected answer: 3 (ID of selected segment)
BB:ARB:WSEG:COUN?	Expected answer: 1 (stored segments)
BB:ARB:WAV:STAT ON	Enable the IQ modulation with memory data
OUTP:STAT ON	Enables the RF output

For more information on the individual SCPI commands, consult the Programmer's Manual [1].

[Option] Sequencing with the Fast Control Port

One way of controlling the sequences[1] of segments is by deploying the fast control port (FCP) interface. FCP is an optional feature that is not included in the basic APVSG devices, so please check first if your signal generator supports it. The FCP can be used to select segments in conjunction with selecting the segments internally. The most recent selection always determines the selected segment. Note that the source of the segment selection must be set correctly, or the selection will not be acknowledged as a valid command.

[1] Refer to section *Sequence* at the beginning of this Application Noe for more information about sequences.

Sending segment IDs to the APVSG through the FCP interface allows the user to replay a desired sequence of segments.

For details on the transmission over FCP, see the Application Note AN6002 for FCP [4] and refer to the APVSG datasheet [2] for specifications.

For a successful transmission of segment IDs over FCP, consider:

1. Load at least one segment to the memory (see section *Store Segments*) and check that the segment IDs are set as intended.
2. Connect the FCP interface to an external source that sends Segment IDs.
3. Use the GUI or SCPI commands to enable the FCP segment mode as well as IQ modulation.

   SCPI commands sequence example:

FREQ 1e9	Set initial RF output frequency to 1 GHz
BB:ARB:WSEG:SOUR FCP	Set the segment selection source to FCP
FCP:STR:SEG ON	Enable segment ID streaming through FCP
BB:ARB:CLOC 500e6	Set the sample clock to 500 MHz
BB:ARB:WAV:STAT ON	Enable the IQ modulation with memory data
OUTP:STAT ON	Enable the RF output

4. Stream an arbitrary sequence of segment IDs to the FCP interface in order to switch the selected segment in the memory remotely.

Further Documentation

[1] AnaPico Programmer's Manual for Signal Generators
https://www.anapico.com/downloads/manuals/
Includes description of all SCPI commands.

[2] APVSG Datasheet
https://www.anapico.com/downloads/brochures-and-data-sheets/
Specifications of APVSG devices

[3] AN6001 APVSG - AnaPico IQ File Format
https://www.anapico.com/downloads/application-notes-and-videos/
Includes information on the QI data file formats and their applications.

[4] AN6002 APVSG – Fast Control Port Interface
https://www.anapico.com/downloads/application-notes-and-videos/
Includes Segment Transmission over the Fast Control Port Interface