Application Note AN6008

Pulse Descriptor Word for APVSG

Important Note

This application note describes the Pulse Descriptor Word (PDW) feature for Anapico's Vector Signal Generator (APVSG) devices. It may contain information about parts of the feature which are not yet supported, but the information of which may be useful for the user for future projects. The contents of this application note are subject to change as the PDW feature is currently under development and thus adapts as more parts of the feature are released. Not yet supported parts of the PDW feature are marked like this throughout the document.

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Pulse Descriptor Word Concept

PDW parameters each describe the behavior or value of a distinct property of the device. Therefore, a PDW consists of a set of PDW parameters that define an output signal. This includes various modulation options, carrier settings and further control of the RF output of the device.

With PDWs the user also gains complete control of the duration and timing between modulations. Hence, PDWs are the perfect modulation control feature for setups and applications that include extensive amounts of different modulations or sophisticated carrier sweeps. Setting modulations with PDWs reduces the required memory space compared to storing IQ modulation data on the device for each modulation.

Parameters and Words

The PDW **Parameters** describe and define different aspects of the RF output signal for the APVSG device. They all consist of a distinct address and a value. A complete list of all PDW Parameters with their respective addresses and descriptions of their properties can be found at the end of this document in section *PDW Structure*.

The Parameters are uploaded to the APVSG device and saved as Pulse Descriptor **Words**. The different PDW upload options are described in section *Data Transfer.* The saved Words form a **List** of PDWs. Depending on the active PDW mode, the PDW List is available for one or multiple playbacks. The consecutive playback of multiple PDWs will henceforth be called **Simulation**.
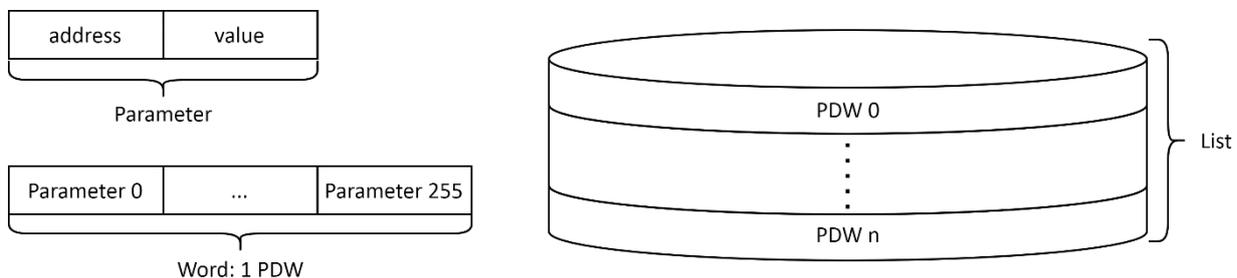

Figure 1: A PDW Parameter, a Word (one PDW) and a PDW List depicted with their relation to each other.

With one PDW, both the carrier and the modulation are configured. This includes settings for the RF output and switching between different modulation types. The modulations supported with the PDW feature include pulses, frequency modulations, chirps, as well as waveform playback by selecting segment IDs.

Selecting segment IDs with PDWs for playback is only available for waveforms that are stored on the device's memory before PDWs are starting to be applied. Furthermore, restrictions such as parameter limits and constraints on control settings (e.g., availability of simultaneous modulations) naturally apply when deploying PDWs.

Timing

Each PDW contains Parameters with which its pulse width and start time are described. This allows full control of the output signal over an extended period of time.

Data Transfer

All PDW Parameters can be updated by sending them to the device. Upload options for PDWs are the following.

- Upload a PDW List from a file with the APVSG GUI.
- Configure and upload consecutive PDWs with the APVSG GUI.
- Set PDW Parameters individually through SCPI commands.
- Set multiple PDW Parameters (and Words) by using the SCPI command to send block data[1].
- Send PDW Parameters through the optional FCP interface. [PDW Stream mode only]

Section *SCPI Commands* gives an overview on the SCPI commands available for PDW control. The option to upload a file containing a PDW List with the GUI is only available in List mode. See section *PDW List File* for details and an example hereof.

PDW Mode

The PDW system can be operated in different modes which differ in their use-cases.

For each mode, the upload and playback of PDWs is different. The desired PDW mode must be set before enabling the PDW feature.

Mode Overview

PDW Mode	Input Interface	PDW upload	Device Storage	Simulation
List	APVSG GUI/ SCPI commands	before Simulation starts	PDW Memory	All PDWs in List, optionally repeat List
Stream	FCP / SCPI commands	before and during Simulation	PDW Buffer (FIFO)	PDWs in order of upload, only once.
Single	SCPI commands	during Simulation	single PDW register	each PDW triggered after upload

List Mode

This mode is suggested if there is a bulk of PDWs that are predetermined and require specific timing relations between each other. It is the default mode to simulate multiple PDWs.

The PDW-file upload is the recommended input form in this mode. Files containing lists of PDWs with their individual parameters can be uploaded to the device through the APVSG GUI. The list of PDWs is interpreted and preloaded to the PDW memory on the device. The PDWs in the memory all contain a start time at which the respective parameters are applied to the device's RF output. The timing concept for applying the PDWs saved in the memory is depicted in *Figure 2*.

A trigger signal is required to start the Simulation of the PDW List. Information on the PDW Trigger Subsystem can be found in section *PDW Timing*. The List mode also provides the option to repeat the PDW List in one Simulation by setting the List Count.

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[1] See the PDW:DATA SCPI command, explained in section *SCPI Commands*: *PDW Data.*
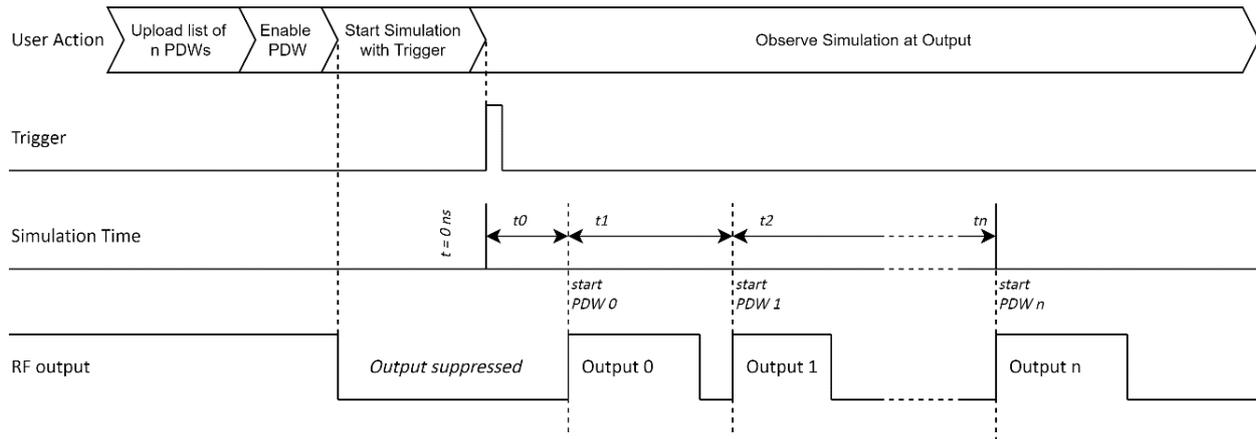
Figure 2: List mode timing concept with relative Time Mode. PDWs are applied at their dedicated start times. Figure not to scale.

Stream Mode (Real-Time)

This mode is ideal for sending PDWs to the device in bursts and obtain real-time streaming of the PDWs.

The PDW Stream mode is only available with the optional FCP Interface, as PDW Parameters are streamed through this external port. PDW Parameters are streamed consecutively and grouped into Words, using the CONFIG_END parameter. Each received PDW is buffered in a FIFO. Thus, PDWs are executed consecutively and applied at their respective START_TIME.

Additional PDWs can be streamed during Simulation and are then queued in the PDW FIFO buffer. Once applied, PDWs are no longer stored in the buffer.

The uploaded Words do not have to contain all possible PDW Parameters. Addresses that are not set will keep the previous value. This allows for fast PDW upload when few bytes of each Word are being set.

For further information on the FCP interface specifically, please consult the Application Note on FCP [3].
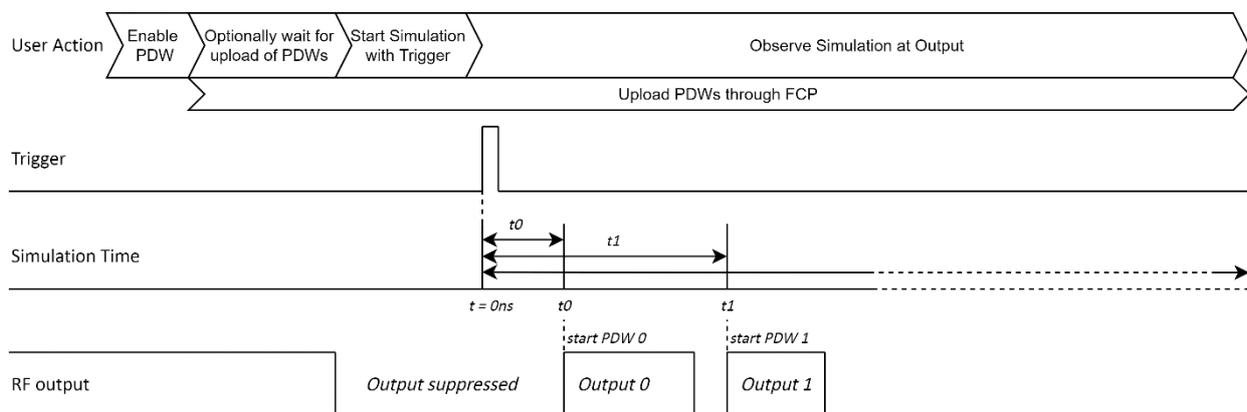

Figure 3: Stream mode timing concept with absolute Time Mode. Figure not to scale.

Single Mode

This mode does not take into account the START_TIME and PULSE_WIDTH parameters of the PDW, but rather starts pulses on a PDW trigger and keeps them enabled until the next pulse is triggered. Therefore, this mode is a good way for users to test their PDW settings and simulate scenarios that are not as time critical.

The PDW Single mode accepts PDW Parameters through SCPI. The parameters are grouped into Words and uploaded to the device's internal register using the CONFIG_END parameter. The uploaded Words do not have to contain all possible PDW Parameters. Parameters that are not set will keep the previous value, or the default value if they are never set at all. When triggered, the last uploaded PDW is activated and then applied to the RF output after a transient time (labeled t_t). The general concept of this mode is depicted in *Figure 4*.

An example for a SCPI command sequence in PDW Single Mode can be found in section *Examples*. Details on the transient time are described in section *Transient Blanking*.
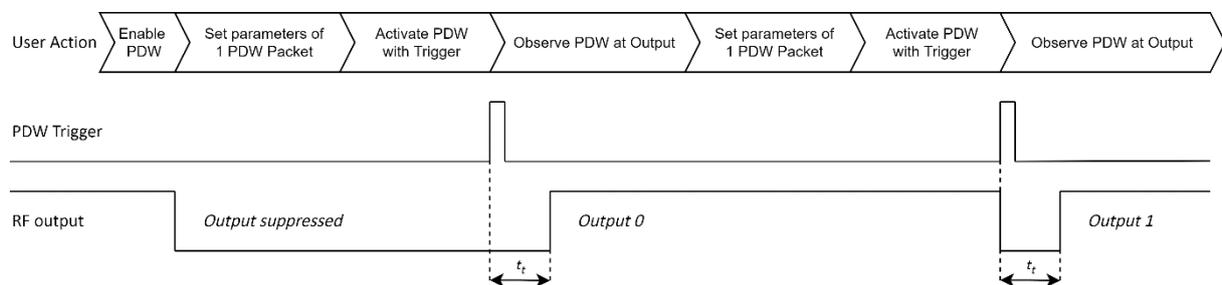

Figure 4: Single mode concept with trigger. Figure not to scale.

Application Details

Requirements and Restrictions

Device Options

- The PDW feature is an optional feature that can be equipped on each channel (separately) of an APVSG device at the time of ordering. The option PDW must be equipped for each channel of the device to support the PDW functionality described in this document.
- Fast PDW switching and short PDW pulses both require the option UFS (Ultra-Fast Switching). Otherwise, time parameters for PDWs are restricted. Parameter limitations and other PDW specifications for all available device options are listed in section PDW in the APVSG datasheet [1].
- Option PHS (Phase coherent switching) is available in combination with option PDW. PHS enables a well-defined deterministic relative phase between individual channels.
- The PDW Stream mode is only available with the option FCP.
- Synchronizing the simulations of multiple channels within the same APVSG device is inherently possible as soon as an APVSG device with at least two channels with options PDW are purchased. The PDW trigger source SYNC must be used to trigger the PDW Simulation of all desired channels simultaneously. More information can be found in section *PDW Trigger.*
- Synchronizing PDW Simulations of multiple devices will be available soon and is only available with option SYNC. Please ensure you mention any desire for multi-device synchronization when ordering your APVSG devices.
- Please make sure you select all desired options when buying your APVSG device.

Carrier Settings

- For one PDW there can only be a single carrier frequency, power and phase set. Detailed information about available parameters can be found in section *PDW Structure*. Information on parameter ranges can be found in the APVSG datasheet [1].

Waveform Modulation

- Segments (QI files for waveform modulation) must be uploaded to the device before the PDW is enabled.
- Only a playback rate of 500 MHz is supported for segments in use with PDW.
- There can only be one selected segment in each PDW.
- It is the user's responsibility to ensure the necessary segments are uploaded to the device before any PDW selects them. Selecting inexistent/not uploaded segments will result in suppressed RF output.
- If the pulse width of a PDW does not match the length of the enabled waveform segment, the waveform segment will be repeated or cut short. The PDW pulse width is the defining parameter for each PDW width.

Control Descriptor Word Option

The APVSG devices also provide the option to only control a subset of the parameters of the PDW. This subset is called Control Descriptor Word and allows the user to control only carrier parameters and waveform segment playback. The CDW (Control Descriptor Word) option does not include timing parameters and is limited to only support the upload of a single CDW at a time. Furthermore, it is only available in PDW Stream mode and requires the options UFS and FCP.

PDW Timing

PDW Activation

Multiple PDWs can be stored on the device. Depending on the PDW mode, the PDWs are either saved as a List on the device for replay or streamed to the device as subsequent PDWs to be replayed only once. Details on PDW storage limitations can be found in the APVSG datasheet [1].

Once saved on the device, the PDWs can be replayed in a Simulation that activates and applies each PDW at the RF output, according to its timing parameter specifications. A trigger starts the Simulation of the PDWs. For specific information on PDW Triggers, please see section *PDW Trigger.*

Transient Blanking

Naturally, when a PDW is activated, there is a transient period while the device transitions between different carrier and modulation settings, before the signal is applied at the RF output, as shown in *Figure 5*. With the PDW feature, these transition periods are blanked to prohibit unexpected behavior at the output.

The transient period is a fixed value of time and directly dictates the minimum switching time. Specific values can be found in the PDW section of the APSVSG Datasheet [1].
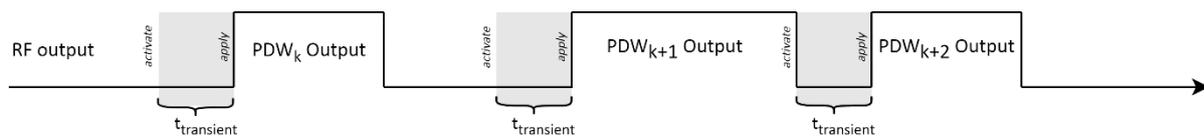
Figure 5: Depiction of transient periods between consecutive PDW pulses. Figure not to scale.

PDW Time Mode

The PDW Time Mode defines how the START_TIME parameter is interpreted by the device and when the simulation time is reset.

Absolute Time Mode:
Each PDW is activated at START_TIME after the Simulation trigger. The Simulation time starts with the Simulation trigger. PDWs are activated when their START_TIME equals the Simulation time. Thus, the START_TIME is interpreted as an absolute value.

Relative Time Mode:
The first PDW is activated at START_TIME after the Simulation trigger. Each consecutive PDW is then automatically activated at the START_TIME after the last activation. Thus, the START_TIME is interpreted relative to the start of the previous PDW. When getting the Simulation time of the device, the time since the last application of a PDW will be displayed.

Time Parameters

There are multiple parameters that describe the timing of each PDW. The most significant ones are described here and graphically represented in *Figure 6* and *Figure 7* which show the start of a PDW List simulation for each Time Mode.

- START_TIME
  The time at which a PDW is applied at the RF output. The START_TIME must be set such that it allows for the mandatory transient period after the previous pulse. If this PDW timing requirement is not met, the PDW with violating time parameters is discarded and not applied at the output. Timing Violations are explained in the next subsection.

- PULSE_WIDTH
  Defines the width of the PDW pulse at the RF output before it is suppressed again.

- Simulation Trigger Setup Time
  The time between the arrival of a trigger at the device and the start of the Simulation time. Specific values can be found in the PDW section of the APVSG Datasheet [1].

- FCP Activation Setup Time
  The time required to process a received PDW through FCP. This is the time between receiving a CONFIG_END parameter at the FCP interface and the first possible point in time a PDW can be activated. Specific values can be found in the FCP section of the APVSG Datasheet [1].
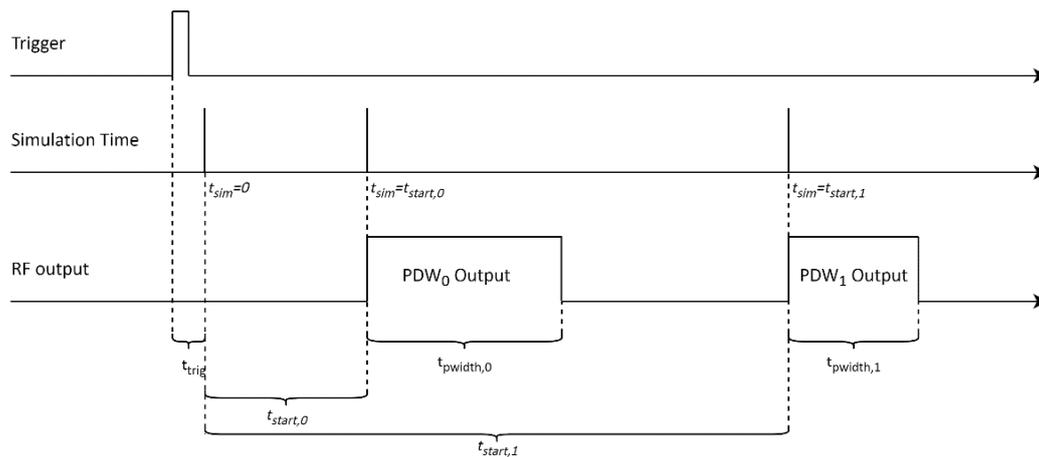
Figure 6: Trigger latency, start time and pulse width for a PDW List Simulation in absolute Time Mode. Figure not to scale.
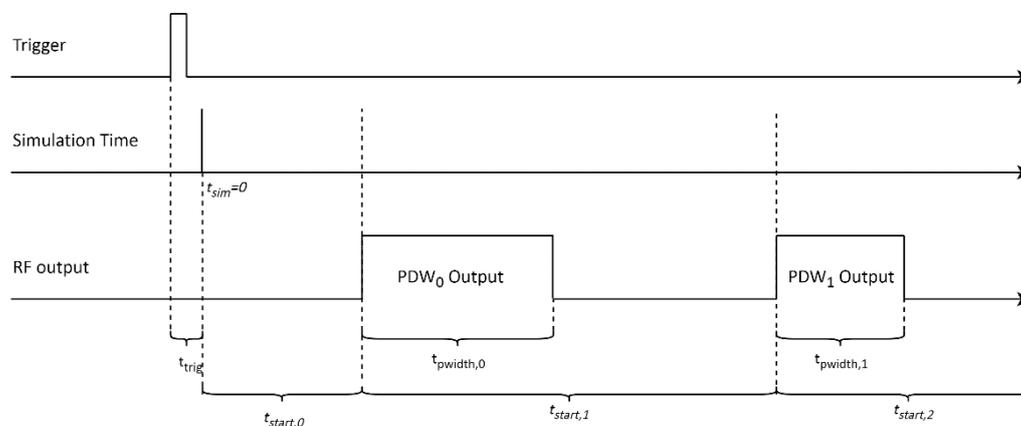
Figure 7: Trigger latency, start time and pulse width for a PDW List Simulation in relative Time Mode. Figure not to scale.

Timing Violations

For a PDW to meet the timing requirements, it must comply with the following rules:

- The START_TIME must arrive after the falling edge of the previous PDW pulse.
- The PDW must be uploaded, so that when read from the PDW memory or PDW buffer FIFO, the START_TIME can be met. As PDWs are read consecutively, they must be uploaded in the correct order, especially when using the absolute Time Mode. Also, when uploading PDWs through FCP, the FCP activation setup time must be met.

If any of these conditions are violated, the respective PDW is discarded at its activation. Figure 8 depicts a scenario with PDW k+2 being discarded during the pulse width of the previous PDW, as this happens to be its activation time. PDW k+2 thus clearly violates the first rule.
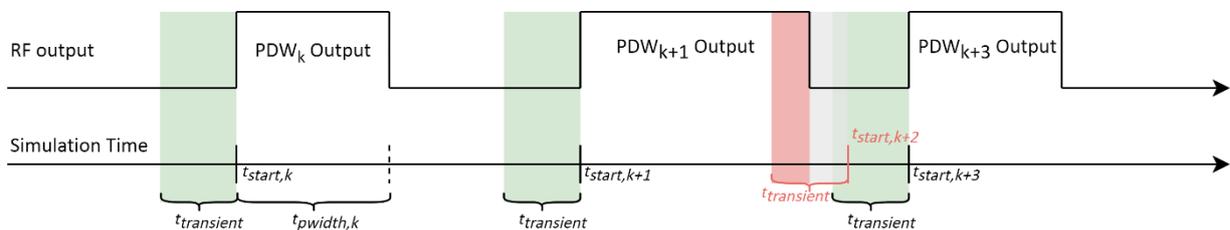
Figure 8: PDW timing violation due to overlap of PDW$_{k+1}$ output and PDW$_{k+2}$ transient. Overlap marked in red.

The APVSG device keeps track of the number of discarded PDWs. The respective SCPI command can be found in section *SCPI Commands*. The counter of discarded PDWs is reset when a new Simulation is triggered, or when the Simulation of one PDW List is restarted in case the List Count is bigger than 1 in a List mode Simulation.

PDW Linear Phase Sweep

The PDW Parameters support the option for a linear phase sweep (LPS) on pulse. This section gives an overview of the different PDW Parameters to control the phase sweep and gives a graphical example in *Figure 9*. The following parameters are required to define the phase sweep for one PDW.

- PHASE_MODE
  In the figure below, the nth PDW and the n+2nd PDW have the LPS enabled, which means the PHASE_MODE is set to sweep. The n+1st PDW has the LPS state disabled, which equals a fixed PHASE_MODE. Naturally, the PHASE_MODE must be set to either fixed or sweep to define if each PDW should contain a linear phase sweep.

- PHASE_STEP
  This parameter is utilized to define the difference in phase between two steps in the linear phase sweep. Please note that the sweep always starts at the PHASE (labeled Φ_n) value at the start of one PDW and the PHASE_STEP (labeled Φ_s) denotes the increment in phase with each LPS step inside of one PDW.

- SWEEP_DWELL
  The LPS dwell time, labeled $t_{LPS,dwell}$ in *Figure 9*, describes how long each phase step is active at the output. This time must be equal or less than the SWEEP_STEP.

- SWEEP_STEP
  During one sweep step, the set phase is constant. The sweep step time is set for one PDW. If the SWEEP_DWELL time is less than the SWEEP_STEP time, the LPS generates a pulse with an off time during which the output is blanked.
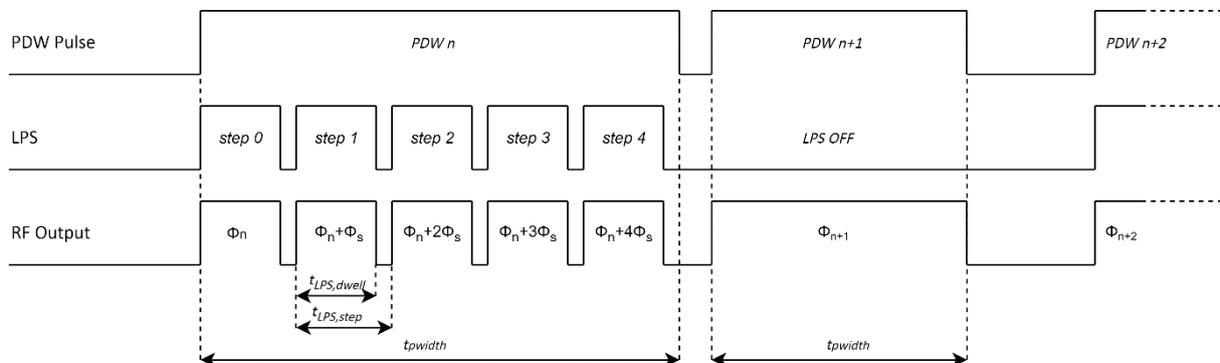

Figure 9: Graphical representation of pulse behavior with Linear Phase Sweep. Graph features PDW Pulse defined by START_TIME and PULSE_WIDTH, LPS pulse defined by SWEEP_DWELL and SWEEP_STEP and the resulting pulse and phase behavior at the RF output of the device. Figure not to scale.

PDW Trigger

There are several options for triggering a PDW simulation.

- Immediate trigger of the PDW Trigger subsystem as soon as the PDW state is turned on. Requires `PDW:TRIG:SOUR` to be set to immediate. The Simulation is automatically retriggered after it is finished, with a Simulation Trigger Setup Time delay.
- Internal trigger of the PDW Trigger subsystem, which can be sent with the SCPI command `PDW:TRIG`. Set the `PDW:TRIG:SOUR` to bus.
- External trigger signal sent through an MF input port. Check out the *External PDW Trigger* Example in the next section for details.
- Synchronous trigger to start Simulation of multiple channels simultaneously. Requires `PDW:TRIG:SOUR` to be set to synchronous and the trigger to be executed with an internal synch. trigger `TRIG:SYNC` or an external synch. trigger - see section *Synchronous Trigger* in *SCPI Commands* for useful commands and section *Synchronous PDW Trigger for multichannel devices* for an example.

Examples

Recommended PDW List upload with APVSG GUI

Section *PDW List File* describes the required file format and content for any PDW List file that is uploaded through the GUI.

For the upload process, open the APVSG GUI and select List mode in the PDW section. Simply load the content of the desired file for upload with "Add CSV", check the displayed list for correct interpretation and upload it to the device. The APVSG GUI informs the user in case of any incorrect or incomplete settings.

Be advised that there is a limited amount of PDWs that can be uploaded in one list.

Advanced PDW List upload with SCPI commands

The following passage explains how to upload a list of PDWs to the device. However, it is strongly suggested to upload PDW Lists by loading .csv files to the device with the GUI to avoid unsupported parameter combinations and timing violations.

The following sequence of commands is an example for setting the Parameters for one PDW element in a list of PDWs. The last command of this sequence tells the device that all desired Parameters are set and the PDW is complete.

Command	Description
`PDW:STAR:TIME 5ms`	Set start time of PDW to 5 milliseconds
`PDW:PWID 1ms`	Set the pulse width of the PDW to 1 millisecond
`PDW:MARK 1`	Set Marker of PDW to 1
`PDW:FREQ 2e9`	Set carrier frequency of PDW to 2 GHz
`PDW:POW -5`	Set fixed output power of PDW to -5 dBm
`PDW:PHAS 0`	Set fixed output phase of PDW to 0 rad
`PDW:OUTP:STAT ON`	Enable RF output of PDW
`PDW:WAV:STAT ON`	Enable the waveform modulation of the PDW
`PDW:WAV:WSEG 1`	Set the waveform segment ID of the PDW to 1
`PDW:CONF:END`	End setting Parameters for this PDW (1 PDW in List)

<u>Important</u>: The SCPI commands must be sent in the correct consecutive order, especially with the `PDW:CONF:END` command. Otherwise, Parameters might be assigned to incorrect Words which results in unexpected output behavior of the device.

<u>Alternative</u>: The PDWs can also be sent with the PDW:DATA SCPI command that supports block data. Be sure to place the Parameters containing configuration information like the CONF_END value after the descriptive Parameters for one PDW to group the PDWs together correctly.

PDW Simulation Start in List Mode

After uploading the PDW list to the device, the PDW Simulation can be started. Please make sure that the intended Time Mode is selected before the Simulation starts, as it dictates how the START_TIME values are interpreted during Simulation. The following set of SCPI commands is an example of how to start a PDW simulation with an internal trigger.

`PDW:STAR:TIME:MODE ABS`	Set the Time Mode to absolute.
`PDW:LIST:COUN 100`	Set the List Count to 100 (repeat PDW List 100 times).
`PDW:TRIG:SOUR BUS`	Set the trigger source to bus.
`PDW:MODE LIST`	Set the PDW mode to List.
`PDW:STAT ON`	Enable the PDW state.
`PDW:TRIG`	Set an internal trigger signal. Starts the Simulation.

PDW Simulation Start in Stream Mode

For the PDW Stream mode, the buffer FIFO does not necessarily need to be filled before the PDW Simulation can be started. Before enabling the PDW in Stream mode, please make sure that the intended Time Mode is selected as it dictates how the START_TIME values are interpreted during Simulation. The following set of SCPI commands is an example of how to start a PDW simulation with an internal trigger and when to start streaming PDWs.

`PDW:STAR:TIME:MODE ABS`	Set the Time Mode to absolute.
`PDW:TRIG:SOUR BUS`	Set the trigger source to bus.
`PDW:MODE STR`	Set the PDW mode to Stream.
`PDW:STAT ON`	Enable the PDW state.

The device can now receive streamed parameters and queue PDWs in the FIFO buffer. The simulation time has not started yet, so PDWs are not activated yet.

`PDW:TRIG`	Set an internal trigger signal. Starts the Simulation.

Once the simulation is started by trigger, PDWs can still be streamed to the device and will be queued in the FIFO buffer for activation. The Simulation in PDW Stream mode only ends once the PDW state is disabled.

PDW in Single Mode

This example shows a complete SCPI sequence for the PDW Single mode, with the following steps:

1. Set the device configuration and enable PDW in Single mode.
2. Set parameters for the first PDW with
   frequency 2 GHz, power 10.5 dBm, Waveform Modulation on Pulse with segment ID 3
3. Start simulating the first PDW with a Trigger.
4. Set parameters for the second PDW with
   frequency 2 GHz, power 3 dBm, CW only (no modulation on pulse)
5. Start simulating the second PDW with a Trigger.

In case you would like to utilize a different trigger source like the external trigger or synchronous trigger, please skip the first SCPI command and follow the instructions of example *External PDW Trigger* or *Synchronous PDW Trigger for multichannel devices* respectively, before proceeding with the following commands.

This example expects a waveform with segment ID 3 already being uploaded to the device. For further details on how to upload waveforms to APVSG devices, please consult [4].

First, the PDW trigger source is set to bus, which will allow for the SCPI command `PDW:TRIG` to initiate a PDW trigger event. Then, the correct PDW mode is selected and the PDW functionality enabled.

`PDW:TRIG:SOUR BUS`	Set the PDW Trigger source to Bus.
`PDW:MODE SING`	Set the PDW mode to Single.
`PDW:STAT ON`	Enable the PDW state.

Enabling the PDW results in the RF output being blanked until the first PDW is applied.

As soon as the PDW is enabled in Single mode, the first PDW can be set. Any parameters that are not set will keep their default values. In this example, the first PDW will keep the default phase value and phase sweep settings.

`PDW:FREQ 2e9`	Set the carrier frequency to 2 GHz.
`PDW:POW 10.5`	Set the carrier RF power level to 10.5 dBm.
`PDW:OUTP:STAT ON`	Enable the RF output.
`PDW:WAV:STAT ON`	Enable waveform modulation on pulse.
`PDW:WAV:WSEG 3`	Set the selected waveform segment ID to 3.
`PDW:CONF:END`	End this PDW and save it in the device for playback.

The `CONFIG_END` parameter is required at the end of each PDW. It tells the device that this (first) PDW configuration is finished and ready to be activated. The SCPI commands must be sent in the correct consecutive order, especially with the `PDW:CONF:END` command. Otherwise, Parameters might be assigned to incorrect Words which results in unexpected output behavior of the device. The PDW is then activated with a PDW trigger event. For the SCPI command, please be aware that there is a latency caused by the ethernet connection to the device as well as a processing latency of the device before the PDW is activated.

`PDW:TRIG`	Trigger the uploaded PDW.

The RF output first shows the blanked transient and then the set PDW.

Now, a second PDW can be set. Any parameters that are not set anew will keep their previous values like the carrier frequency of 2GHz in this example.

`PDW:POW 3`	Set the carrier RF power level to 3 dBm.
`PDW:WAV:STAT OFF`	Enable waveform modulation on pulse.
`PDW:CONF:END`	End this PDW and save it in the device for playback.

After the `PDW:CONF:END`, the second PDW can be activated with a trigger. Before the new PDW is triggered, the previously activated PDW is still applied at the RF output.

`PDW:TRIG`	Trigger the uploaded PDW.

The RF output again first shows the blanked transient and then the set (second) PDW.

Important: The SCPI commands must be sent in the correct consecutive order, especially with the `PDW:CONF:END` command. Otherwise, Parameters might be assigned to incorrect Words which results in unexpected output behavior of the device.

External PDW Trigger

The following set of SCPI commands is an example for configuring the device to detect and accept external PDW trigger signals.

`PDW:TRIG:SOUR EXT`	Set the PDW trigger source to external
`PDW:TRIG:EXT:SOUR MF1`	Set the external trigger source to MF1 port
`PDW:TRIG:EXT:SLOP POS`	Set the external trigger slope detection to positive

Now a positive edge can be sent on the MF1 port. This will trigger the PDW Simulation of the currently enabled PDW mode. The Simulation will not be triggered if:

- The `PDW:STATe` is disabled or
- The trigger source is not set correctly or
- List mode: The PDW List is empty (nothing saved in the memory)

Synchronous PDW Trigger for multichannel devices

The following set of SCPI commands is an example for configuring a two-channel device to use synchronous PDW trigger signals on both channels. This configuration is ideal to synchronously start the time base of PDW simulations on multiple channels.

With this setting, the PDW trigger subsystems on each individual channel are set to listen to a single global synchronous trigger event.

First, the source for the synchronous trigger signal should be set. The two main options are to start the synchronized PDW simulations with either a SCPI command or with an external trigger flank at one of the MF input ports.

Option 1:

`TRIG:SYNC:SOUR BUS`	Set the synchronous trigger source to bus, for SCPI.

Option 2:

`TRIG:SYNC:SOUR EXT`	Set the synchronous trigger source to external.
`TRIG:SYNC:EXT:SOUR MF1`	Set the external sync. trigger source to MF1 port.
`TRIG:SYNC:SLOP POS`	Set the MF1 input to trigger on positive edges

Next, each channel that must be told to start their PDW simulations synchronously by setting the synchronous trigger as the PDW trigger source.

`SOUR:SEL 1`	Select device channel 1.
`PDW:TRIG:SOUR SYNC`	Set the PDW trigger source to synchronous on CH 1.
`SOUR:SEL 2`	Select device channel 2.
`PDW:TRIG:SOUR SYNC`	Set the PDW trigger source to synchronous on CH 2.

Finally, the synchronous trigger can be activated to start the PDW simulations on all channels. Depending on the source of the synchronous trigger, use the following.

Option 1:

`TRIG:SYNC`	Triggers all subsystems listening to synchronous trigger sources.

Option 2: A positive edge must be sent on the MF1 port.

Important: The Simulation will not be triggered if:

- The `PDW:STATe` is disabled or
- The trigger source is not set correctly or
- List mode: The PDW List is empty (nothing saved in the memory)

SCPI Commands

PDW Settings

[SOURce<ch>:]PDW:STATe ON|OFF|0|1

Set the PDW State. Enabling the PDW state disables the control of RF output settings.

Example: PDW:STATE ON

[SOURce<ch>:]PDW:MODE LIST|STReam|SINGle

Set the PDW mode. See section *PDW Mode* for details on each mode. PDW:STAT must be turned off before mode is switched.

Example: PDW:MODE LIST

[SOURce<ch>:]PDW:STARt:TIME:MODE RELative|ABSolute

Set the Time Mode to interpret the START_TIME value either relative to the previous PDW or as an absolute value of Simulation time. For more information on the start time, see section *PDW Timing*. The start time mode is set to relative per default.

Example: PDW:STAR:TIME:MODE ABS

[SOURce<ch>:]PDW:CONDition:DISCarded?

Get the number of PDWs that were discarded due to timing violations.

Example: PDW:COND:DISC?

[SOURce<ch>:]PDW:SIMulation:TIME?

Get the Simulation time of the device. See section *PDW Timing: PDW Time Mode* for an explanation on the Simulation time.

Example: PDW:SIM:TIME?

[SOURce<ch>:]PDW:LIST:DELete

Delete all PDWs saved on the device in List mode.

Example: PDW:LIST:DEL

[SOURce<ch>:]PDW:LIST:COUNt <repeat>

Set the number of times the list of PDWs is to be repeated in one Simulation run. The repeat value must be an unsigned integer.

Example: PDW:LIST:COUN 2

[SOURce<ch>:]PDW:STReam:COUNt?

Get the number of saved PDW elements in the FIFO buffer. Returns zero if not in PDW Stream mode.

Example: PDW:STR:COUN?

PDW Data

[SOURce<ch>:]PDW:DATA <addr>,<param_data>

Set the value for one specific address in the PDW.

Example: PDW:DATA 4, 1   Enable the waveform state (Addr. 4)

[SOURce<ch>:]PDW:DATA <block data>

Set the value of multiple addresses with block data. Also allows values for addresses of multiple PDWs when each Word is terminated with a CONFIG_END of the PDW CONFIG_END Parameter.

> The block data has IEEE488.2 definite block data format:
>
>> #<num_digits><byte_count><data bytes>
>>
>>> <num_digits> specifies how many digits are contained in <byte_count>.
>>>
>>> <byte_count> specifies how many data bytes follow in <data_bytes>.
>
> <u>Example</u> of definite block data:
>
>> #18xxxxxxxx
>>
>>> **#18…**: byte count is one digit wide
>>>
>>> **#18**…: 8 data bytes will follow
>>>
>>> …**xxxxxxxx**: 8 bytes of data (4 address-parameter pairs)

The data itself consists of address-parameter pairs that are 16 bits wide per pair. Each of these pairs consists of one address and their respective Parameter value. The address is 8 bits wide and is followed by an 8 bit wide value for the Parameter. All bytes are two's complement values. The sent addresses do not have to be consecutive. **Addresses that are not set for a Word simply keep their default value**. The CONFIG_END Parameter may be utilized when a full list of PDWs is transmitted:

- CONFIG_END signals the end of a PDW. The subsequent address-parameter pairs are set to the next PDW in the List.

[SOURce<ch>:]PDW:DATA:FCP? <addr>

Get the most recently set value of one specific address in the PDW.

Example: PDW:DATA:FCP? 4   Returns 1 if the last sent waveform state is enabled.

[SOURce<ch>:]PDW:DATA:OUTPut? <addr>

Get the set value of one specific address of the active PDW.

Example: PDW:DATA:OUTP? 55   Returns 1 byte of carrier power of the active PDW.

For a list of all SCPI commands and detailed descriptions, please consult the Programmer's Manual [2].

PDW Parameters

Available SCPI commands for setting Parameters are listed here. For details on their functionality please consult the descriptions for each Parameter in section *Word Detail*.

<u>Configuration</u>

[SOURce<ch>:]PDW:CONFigure:END

[SOURce<ch>:]PDW:WAVeform:STATe ON|OFF|0|1

[SOURce<ch>:]PDW:MARKer <integer>

[SOURce<ch>:]PDW:STARt:TIME <float[s]>

[SOURce<ch>:]PDW:PWIDth <float[s]>

<u>Carrier & Output</u>

[SOURce<ch>:]PDW:OUTPut:STATe ON|OFF|0|1

[SOURce<ch>:]PDW:FREQuency <float[Hz]>

[SOURce<ch>:]PDW:POWer <float[dBm]>

[SOURce<ch>:]PDW:PHASe <float[rad]>

<u>Waveform Modulation</u>

[SOURce<ch>:]PDW:WAVeform:WSEGment <integer>

<u>Phase Sweep</u>

[SOURce<ch>:]PDW:PHASe:MODE FIXed|SWEep

[SOURce<ch>:]PDW:PHASe:STEP <float[rad]>

[SOURce<ch>:]PDW:SWEep:DWELl <float[s]>

[SOURce<ch>:]PDW:SWEep:STEP <float[s]>

PDW Trigger

[SOURce<ch>:]PDW:TRIGger[:SEQuence][:IMMediate]

Executes a PDW specific internal trigger event.

[SOURce<ch>:]PDW:TRIGger[:SEQuence]:SOURce IMMediate|BUS|EXTernal|SYNChronous

Sets the trigger source. Set to immediate per default.

IMM: No waiting for a trigger event occurs. Constantly, immediately triggered.

BUS: Trigger source is the command PDW:TRIG[:IMM].

EXT: Trigger source is an externally applied signal or the command PDW:TRIG[:IMM].

SYNC: Tigger source is the synchronous trigger subsystem, see next section for commands.

[SOURce<ch>:]PDW:TRIGger[:SEQuence]:EXTernal:DELay <float>

Sets the amount of time to delay the response to the trigger. Float value in seconds.

[SOURce<ch>:]PDW:TRIGger[:SEQuence]:EXTernal:SOURce[:PORT] MF1|MF2

Select which multi-function channel is used for the external trigger input.

[SOURce<ch>:]PDW:TRIGger[:SEQuence]:EXTernal:SLOPe POSitive|NEGative

Sets the polarity for an external trigger signal.

[SOURce<ch>:]PDW:TRIGger[:SEQuence]:ABORt

Inhibits the trigger signal.

[SOURce<ch>:]PDW:TRIGger[:SEQuence]:INITiate[:IMMediate]

Initiates the system: Trigger signals will be accepted by the trigger system.

[SOURce<ch>:]PDW:TRIGger[:SEQuence]:INITiate:CONTinuous ON|OFF|1|0

ON: Trigger signals will be accepted by the trigger system continuously.

OFF: Trigger signals will be accepted by the trigger until it's triggered once.

[SOURce<ch>:]PDW:TRIGger[:SEQuence]:OUTPut:POLarity NORMal|INVerted

Sets the trigger output signal polarity.

[SOURce<ch>:]PDW:TRIGger[:SEQuence]:OUTPut:DELay <float>

Sets the delay of the trigger output signal in seconds.

[SOURce<ch>:]PDW:TRIGger[:SEQuence]:OUTPut:PWIDth <float>

Sets the pulse width of the trigger output signal in seconds.

Synchronous Trigger

TRIGger:SYNChronous[:IMMediate]

Triggers all subsystems (e.g. PDW Trigger) listening to synchronous trigger sources.

TRIGger:SYNChronous:SOURce IMMediate|BUS|EXTernal

Sets the trigger source for the synchronous trigger subsystem. Set to immediate per default.

IMM: No waiting for a trigger event occurs. Constantly, immediately triggered.

BUS: Trigger source is the command TRIG:SYNC[:IMM].

EXT: Trigger source is an externally applied signal or the command TRIG:SYNC[:IMM].

TRIGger:SYNChronous:EXTernal:SOURce[:PORT] MF1|MF2

Select which multi-function channel is used for the external trigger input.

TRIGger:SYNChronous:SLOPe POSitive|NEGative

Sets the polarity for an external synchronous trigger signal.

PDW Structure

The following sections describe the structure of a Pulse Descriptor Word that consists of several parameters. Marked fields represent parameters that are intended for future implementation and not yet supported. Please note, that details for unsupported parameters are subject to change.

The list in section *Word Detail* does not entail limitations of the parameters, as these are device dependent. For more information about the parameter limits, please consult the PDW section in the Datasheet [1] of your APVSG device.

Frequency, power, phase and time parameters share a common fixed-point parameter definition, which is described in section

PDW Parameter Types at the very end of this document.

Table 1: Overview of the PDW structure

Address Range	Parameter Name	Parameter Group
1	PDW Configuration	PDW Setting
2 – 3	*Reserved*	
4	PDW Modulation	
5 – 6	*Reserved*	
7	PDW Marker	
8 – 15	*Reserved*	
16 – 23	Start Time	PDW Timing
24 – 31	Pulse Width	
32 – 33	Waveform Segment	Waveform Modulation
34 – 47	*Reserved*	
48	RF Output	Carrier Output
49 – 54	Frequency	
55 – 56	Power	
57 – 58	Fixed Phase	
60 – 69	*Reserved*	Offset
70 – 89	*Reserved*	FM/PM
90 – 97	*Reserved*	AM
98 – 105	*Reserved*	Chirp
106	Sweep On Pulse	Phase Sweep
107 – 108	Phase Step	
109 – 116	Sweep Dwell Time	
117 – 124	Sweep Step Time	
125 – 255	*Reserved*	*Reserved*

Word Detail

Add-ress	Parameter				
	Name	Bits	Bit Name	SCPI command	Description
0	*Reserved*	[7:0]	RESERVED		
1	PDW Configuration	0	CONFIG_END	PDW:CONF:END	Signal the end of one PDW, meaning all necessary parameters have been sent and the following parameters will pertain to the subsequent PDW. Default: 0
		1	PULSE_START_IMM		Decide whether the PDW is applied as soon as the previous PDW has ended. 0: Use the START_TIME value 1: Apply immediately after previous PDW.
		2	PULSE_WIDTH_INF		Decide whether the PDW pulse width is infinite. 0: Use the PULSE_WIDTH value 1: Pulse finishes at start of subsequent PDW.
		[7:3]	RESERVED		
2	*Reserved*	[7:0]	RESERVED		
3	*Reserved*	[7:0]	RESERVED		
4	PDW Modulation	0	WAVE_STATE	PDW:WAV:STAT	Enable/Disable Waveform Modulation Default: 0
		1	FM_STATE		Enable/Disable Frequency Modulation
		2	PM_STATE		Enable/Disable Phase Modulation
		3	AM_STATE		Enable/Disable Amplitude Modulation.
		4	CHIRP_STATE		Enable/Disable Chirp Modulation
		[7:5]	RESERVED		
5	*Reserved*	[7:0]	RESERVED		
6	*Reserved*	[7:0]	RESERVED		
7	PDW Marker	[7:0]	MARKER	PDW:MARK	8 bits of marker states that can be connected to the multi-function output ports. Default: Marker[7:0] = x00
8	*Reserved*	[7:0]	RESERVED		
9	*Reserved*	[7:0]	RESERVED		
10	*Reserved*	[7:0]	RESERVED		
11	*Reserved*	[7:0]	RESERVED		
12	*Reserved*	[7:0]	RESERVED		
13	*Reserved*	[7:0]	RESERVED		
14	*Reserved*	[7:0]	RESERVED		
15	*Reserved*	[7:0]	RESERVED		
16	Pulse Start Time 0	[7:0]	START_TIME[4] [7:0]	PDW:STAR:TIME	Start time of the PDW in seconds.
17	Pulse Start Time 1	[7:0]	START_TIME[4] [15:8]		Time at which PDW is applied to RF output. Consult section *PDW Time Mode* for details on interpreting this parameter. See *Figure 6* and *Figure 7* for graphical explanations. Minimum, maximum and resolution according to device limitations[5]. Default: 1ms
18	Pulse Start Time 2	[7:0]	START_TIME[4] [23:16]		
19	Pulse Start Time 3	[7:0]	START_TIME[4] [31:24]		
20	Pulse Start Time 4	[7:0]	START_TIME[4] [39:32]		
21	Pulse Start Time 5	[7:0]	START_TIME[4] [47:40]		
22	Pulse Start Time 6	[7:0]	START_TIME[4] [55:48]		
23	Pulse Start Time 7	[7:0]	START_TIME[4] [63:56]		
24	Pulse Width 0	[7:0]	PULSE_WIDTH[4] [7:0]	PDW:PWID	Width of PDW pulse. See *Figure 6* for a graphical explanation. Minimum, maximum and resolution according to device limitations[5]. Default: 1ms
25	Pulse Width 1	[7:0]	PULSE_WIDTH[4] [15:8]		
26	Pulse Width 2	[7:0]	PULSE_WIDTH[4] [23:16]		
27	Pulse Width 3	[7:0]	PULSE_WIDTH[4] [31:24]		
28	Pulse Width 4	[7:0]	PULSE_WIDTH[4] [39:32]		
29	Pulse Width 5	[7:0]	PULSE_WIDTH[4] [47:40]		
30	Pulse Width 6	[7:0]	PULSE_WIDTH[4] [55:48]		
31	Pulse Width 7	[7:0]	PULSE_WIDTH[4] [63:56]		
32	Waveform Segment 0	[7:0]	WAVE_WSEG [7:0]	PDW:WAV:WSEG	Waveform Segment ID. Unsigned integer It is the user's responsibility to ensure the selected segment IDs exist in the device's segment memory. Also see section *Requirements and Restrictions*. Default: 0
33	Waveform Segment 1	[7:0]	WAVE_WSEG [15:8]		

34	Waveform Sequence 0	[7:0]	WAVE_WSEQ [7:0]		Waveform Sequence ID. Unsigned integer
35	Waveform Sequence 1	[7:0]	WAVE_WSEQ [15:8]		
36	*Reserved*	[7:0]	RESERVED		
37	*Reserved*	[7:0]	RESERVED		
38	*Reserved*	[7:0]	RESERVED		
39	*Reserved*	[7:0]	RESERVED		
40	*Reserved*	[7:0]	RESERVED		
41	*Reserved*	[7:0]	RESERVED		
42	*Reserved*	[7:0]	RESERVED		
43	*Reserved*	[7:0]	RESERVED		
44	*Reserved*	[7:0]	RESERVED		
45	*Reserved*	[7:0]	RESERVED		
46	*Reserved*	[7:0]	RESERVED		
47	*Reserved*	[7:0]	RESERVED		
48	RF Output	0	OUTP_STATE	PDW:OUTP:STAT	RF output state for this PDW. 0: Disable the RF output 1: Enable the RF output Default: Device OUTP:STAT default.
		[7:1]	RESERVED		
49	Frequency 0	[7:0]	FREQ[1] [7:0]	PDW:FREQ	Carrier frequency value in Hz. Minimum and maximum determined by device limitations[5]. Resolution determined by device limitations[5] and PDW frequency format[1]. Default: Device frequency default.
50	Frequency 1	[7:0]	FREQ[1] [15:8]		
51	Frequency 2	[7:0]	FREQ[1] [23:16]		
52	Frequency 3	[7:0]	FREQ[1] [31:24]		
53	Frequency 4	[7:0]	FREQ[1] [39:32]		
54	Frequency 5	[7:0]	FREQ[1] [47:40]		
55	Power 0	[7:0]	POW[2] [7:0]	PDW:POW	Carrier power value (RMS) in dBm. Minimum and maximum determined by device limitations[5]. Resolution determined by device limitations[5] and PDW power format[2]. Default: Device power default.
56	Power 1	[7:0]	POW[2] [15:8]		
57	Phase 0	[7:0]	PHASE[3] [7:0]	PDW:PHAS	Carrier phase value, in PDW phase format[3]. Resolution determined by device limitations[5] and PDW phase format[3]. Default: Device phase default.
58	Phase 1	[7:0]	PHASE[3] [15:8]		
59	*Reserved*	[7:0]	RESERVED		
60	Frequency Offset 0	[7:0]	OFFSET_FREQ[1] [7:0]		Offset frequency [Hz] in respect to Carrier frequency. (signed value)
61	Frequency Offset 1	[7:0]	OFFSET_FREQ[1] [15:8]		
62	Frequency Offset 2	[7:0]	OFFSET_FREQ[1] [23:16]		
63	Frequency Offset 3	[7:0]	OFFSET_FREQ[1] [31:24]		
64	Frequency Offset 4	[7:0]	OFFSET_FREQ[1] [39:32]		
65	Frequency Offset 5	[7:0]	OFFSET_FREQ[1] [47:40]		
66	Amplitude Offset 0	[7:0]	OFFSET_AMP[2] [7:0]		Offset amplitude [dB] in respect to carrier amplitude. Must be negative. (signed value)
67	Amplitude Offset 1	[7:0]	OFFSET_AMP[2] [15:8]		
68	Phase Offset 0	[7:0]	OFFSET_PHASE[3] [7:0]		Offset phase in respect to carrier phase. (signed value)
69	Phase Offset 1	[7:0]	OFFSET_PHASE[3] [15:8]		
70	FM Frequency 0	[7:0]	FM_FREQ[1] [7:0]		Frequency modulation: frequency offset
71	FM Frequency 1	[7:0]	FM_FREQ[1] [15:8]		
72	FM Frequency 2	[7:0]	FM_FREQ[1] [23:16]		
73	FM Frequency 3	[7:0]	FM_FREQ[1] [31:24]		
74	FM Frequency 4	[7:0]	FM_FREQ[1] [39:32]		
75	FM Frequency 5	[7:0]	FM_FREQ[1] [47:40]		
76	FM Deviation 0	[7:0]	FM_DEV[1] [7:0]		Frequency modulation: frequency deviation
77	FM Deviation 1	[7:0]	FM_DEV[1] [15:8]		
78	FM Deviation 2	[7:0]	FM_DEV[1] [23:16]		
79	FM Deviation 3	[7:0]	FM_DEV[1] [31:24]		
80	FM Deviation 4	[7:0]	FM_DEV[1] [39:32]		

81	FM Deviation 5	[7:0]	FM_DEV[1] [47:40]		
82	ΦM Frequency 0	[7:0]	PM_FREQ[1] [7:0]		Phase modulation: frequency offset
83	ΦM Frequency 1	[7:0]	PM_FREQ[1] [15:8]		
84	ΦM Frequency 2	[7:0]	PM_FREQ[1] [23:16]		
85	ΦM Frequency 3	[7:0]	PM_FREQ[1] [31:24]		
86	ΦM Frequency 4	[7:0]	PM_FREQ[1] [39:32]		
87	ΦM Frequency 5	[7:0]	PM_FREQ[1] [47:40]		
88	ΦM Deviation 0	[7:0]	PM_DEV[3] [7:0]		Phase modulation: phase deviation
89	ΦM Deviation 1	[7:0]	PM_DEV[3] [15:8]		
90	AM Frequency 0	[7:0]	AM_FREQ[1] [7:0]		Amplitude modulation: frequency offset
91	AM Frequency 1	[7:0]	AM _FREQ[1] [15:8]		
92	AM Frequency 2	[7:0]	AM_FREQ[1] [23:16]		
93	AM Frequency 3	[7:0]	AM_FREQ[1] [31:24]		
94	AM Frequency 4	[7:0]	AM_FREQ[1] [39:32]		
95	AM Frequency 5	[7:0]	AM_FREQ[1] [47:40]		
96	AM Depth 0	[7:0]	AM_DEPTH [7:0]		Amplitude modulation: depth
97	AM Depth 1	[7:0]	AM_DEPTH [15:8]		
98	Chirp Rate 0	[7:0]	CHIRP_RATE [7:0]		Chirp rate in kHz/µs
99	Chirp Rate 1	[7:0]	CHIRP_RATE [15:8]		
100	Chirp Rate 2	[7:0]	CHIRP_RATE [23:16]		
101	Chirp Rate 3	[7:0]	CHIRP_RATE [31:24]		
102	Chirp Shape	0	CHIRP_SHAPE_SIN		Chirp shape is sine. One shape per PDW.
		1	CHIRP_SHAPE_RUP		Chirp shape is ramp up. One shape per PDW.
		2	CHIRP_SHAPE_RDOWN		Chirp shape is ramp down. One shape per PDW.
		3	CHIRP_SHAPE_TRIAN		Chirp shape is triangle. One shape per PDW.
		4	CHIRP_SHAPE_SQU		Chirp shape is square. One shape per PDW.
		[7:5]	RESERVED		
103	Reserved	[7:0]	RESERVED		
104	Reserved	[7:0]	RESERVED		
105	Reserved	[7:0]	RESERVED		
106	Sweep On Pulse	0	PHASE_MODE	PDW:PHAS:MODE	Enable/Disable linear Phase Sweep on Pulse. 0: fixed phase in PDW 1: sweep phase during PDW Default: 0 (fixed)
		[7:1]	RESERVED		
107	Phase Step 0	[7:0]	PHASE_STEP[3] [7:0]	PDW:PHAS:STEP	Phase increment for each step in the phase sweep on pulse. Ignored if PHASE_MODE is 0. Default: π
108	Phase Step 1	[7:0]	PHASE_STEP[3] [15:8]		
109	Sweep Dwell Time 0	[7:0]	SWEEP_DWELL[4] [7:0]	PDW:SWE:DWEL	Time for which each phase step is active for the Phase Sweep on Pulse. The RF out signal is then blanked until the end of SWEEP_STEP. Ignored if PHASE_MODE is 0. Default: 500µs
110	Sweep Dwell Time 1	[7:0]	SWEEP_DWELL[4] [15:8]		
111	Sweep Dwell Time 2	[7:0]	SWEEP_DWELL[4] [23:16]		
112	Sweep Dwell Time 3	[7:0]	SWEEP_DWELL[4] [31:24]		
113	Sweep Dwell Time 4	[7:0]	SWEEP_DWELL[4] [39:32]		
114	Sweep Dwell Time 5	[7:0]	RESERVED		
115	Sweep Dwell Time 6	[7:0]	RESERVED		
116	Sweep Dwell Time 7	[7:0]	RESERVED		
117	Sweep Step Time 0	[7:0]	SWEEP_STEP[4] [7:0]	PDW:SWE:STEP	Time for which each phase step is constant before being incremented for the Linear Phase Sweep on Pulse. Ignored if PHASE_MODE is 0. Default: 500µs
118	Sweep Step Time 1	[7:0]	SWEEP_STEP[4] [15:8]		
119	Sweep Step Time 2	[7:0]	SWEEP_STEP[4] [23:16]		
120	Sweep Step Time 3	[7:0]	SWEEP_STEP[4] [31:24]		
121	Sweep Step Time 4	[7:0]	SWEEP_STEP[4] [39:32]		
122	Sweep Step Time 5	[7:0]	RESERVED		
123	Sweep Step Time 6	[7:0]	RESERVED		
124	Sweep Step Time 7	[7:0]	RESERVED		
125	Reserved	[7:0]	RESERVED		
...	Reserved	[7:0]	RESERVED		
255	Reserved	[7:0]	RESERVED		

PDW Parameter Types

The following definitions are used for the respective fixed-point parameters of the PDW. All values are in 2's complement format. Maximum and minimum values may depend on device limitations, rather than the limits given by the bit widths.

[1]Frequency Value [Hz]

Addr.	5		4		3		2		1		0			
Bit	47	…	40	39	…	32	31	….	24	23	…	16	15	…	10	9	8	7	…	0
Data	integer bits (signed)												fractional bits		

[2]Power Value [dBm] or [dB]

Addr.	1		0	
Bit	15	8	7	6	0
Data	integer bits		fractional b.	

[3]Phase Value [rad]

Addr.	1		0	
Bit	15	…	8	7	…	0
Data	unsigned bits			

The 16-bit value represents a phase in the range $[0, 2\pi[$. One LSB is therefore equal to $\frac{2\pi}{2^{16}-1}$.

[4]Time Value [ns]

Addr.	7		6		5		4		3		2		1		0			
Bit	63	…	56	55	…	48	47	…	40	39	…	32	31	….	24	23	…	16	15	…	10	9	8	7	…	0
Data	integer of time in nanoseconds														fractional bits		

The time format supports a theoretical resolution of 1ps. The values will however be rounded to the actual PDW time resolution of the device.

[5]**Device Limitations** can be found in the APVSG Datasheet [1].

PDW Default

The default state of the PDW Parameters is given by the device default for each Parameter when not controlled by the PDW. Defaults for PDW specific parameters can be found in their respective descriptions of the *Word Detail*.

PDW List File

Each list file must be a .csv file that starts with a header row which indicates the parameters of each column. The following rows then contain one PDW each, with the parameters in the appropriate columns. The following list gives the strings required in the header row and a description of the value for the following PDW parameter rows.

Header String	Description	Value in Parameter Rows
OUTP_STATE	RF Output State	{1, 0} to either enable or disable
MARKER	8-bit Marker value	as an integer
START_TIME	Pulse Start Time	value in [s]
PULSE_WIDTH	Pulse Width of PDW	value in [s]
FREQ	Carrier Frequency	value in [Hz]
POW	Output Power	value in [dBm]
PHASE	Carrier Phase	value in [rad]
WAVE_STATE	Waveform Modulation State	{1, 0} to either enable or disable
WAVE_WSEG	Waveform Segment ID	value in $\mathbb{N}_0$
PHASE_MODE	Phase Mode	{1, 0} for enabled sweep or fixed phase
PHASE_STEP	Phase Increment per Step	value in [rad]
SWEEP_DWELL	Sweep Dwell Time	value in [s]
SWEEP_STEP	Sweep Step Time	value in [s]

The APVSG GUI interprets the csv list, respecting the following rules.
- Empty rows are ignored.
- Empty cells are interpreted as a value of zero.

Example List

The following table is an example of a PDW List with the mandatory header row and three words.

WAVE_STATE	START_TIME	MARKER	PULSE_WIDTH	WAVE_WSEG	OUTP_STATE	FREQ	POW	PHASE	PHASE_MODE	SWEEP_STEP	SWEEP_DWELL	PHASE_STEP
0	1.00E-03	1	1.00E-04	0	1	1.00E+08	5	0	0	5.00E-05	5.00E-05	0
0	2.00E-03	2	1.00E-04	0	1	1.00E+08	-5.5	3.14159265	1	2.50E-05	1.25E-05	3.14159265
1	3.00E-03	4	1.00E-04	5	1	1.00E+08	0	1.57079633	0	5.00E-05	5.00E-05	0

The APVSG GUI interprets the table as a list of 3 PDWs and displays the read values. The GUI also checks each input value against the minimum and maximum setting and adjusts the displayed values accordingly.

ID	RF State	Marker	Pulse		Carrier			Waveform Segment		Linear Phase Sweep			
			Start Time	Pulse Width	Frequency	Power	Phase	State	ID	State	Step Time	Dwell Time	Phase Step
0	ON	0000 0001	1.0 ms	100.0 µs	100.0 MHz	5.0 dBm	0.0 rad	OFF	0	OFF	50.0 µs	50.0 µs	0.0 rad
1	ON	0000 0010	2.0 ms	100.0 µs	100.0 MHz	-5.5 dBm	3.142 rad	OFF	0	ON	25.0 µs	12.5 µs	3.142 rad
2	ON	0000 0100	3.0 ms	100.0 µs	100.0 MHz	0.0 dBm	1.571 rad	ON	5	OFF	50.0 µs	50.0 µs	0.0 rad

Appendix

Further Related Documentation

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

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

[3] AN6002 – Fast Control Port
    https://www.anapico.com/downloads/application-notes-and-videos/
    Includes information about the FCP interface.

[4] AN6003 – Memory Segmentation
    https://www.anapico.com/downloads/application-notes-and-videos/
    Includes explanations on waveform segments.

AN6008 Changelog

AN version	FW version	Notes
v1_0	0.4.204	First Release. Parameters and options not supported by Firmware are marked throughout the document.
v1_1	0.4.205	Added Linear Phase Sweep Parameters.
v1_2	0.4.206	Included newly supported Stream mode, adapted sections where necessary. Added information about synchronous trigger subsystem for use in multi-channel synchronized simulation.
v1_3	0.4.208	Corrected frequency parameter type. Changed the `LPS_STATE` name to `PHASE_MODE` and adapted the respective SCPI command accordingly. (previous name still supported.) Added `PDW:DATA:FCP?` and `PDW:DATA:OUTP?`
v1_4	0.4.208	Corrected some typos.
v1_5	1.0.0	Fixed small formatting errors. Changed `START_TIME` and `PULSE_WIDTH` default to 1ms each. Added SCPI queries for easier user-side debugging. Added Single Mode and according Examples.