

## *Application Note AN6009*

# Control Descriptor Word for APVSG

### **Important Note**

This document is an overview of the Control Descriptor Word (CDW) which is available for APVSG devices.

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## Control Descriptor Word

The APVSG supports Control Descriptor Words (CDW) that allow the user to control the carrier and active waveform segment remotely, through the fast control port (FCP) interface.

### Parameters

CDWs consist of several parameters, that describe and define different aspects of the RF output signal for the APVSG device. The following parameters are included in a CDW.

- Carrier frequency
- Carrier power
- Carrier phase
- RF output state
- Segment ID
- Modulation state

These CDW parameters all have a predefined bit-width, with a CDW address assigned to each individual byte. Each address is 8 bits wide and pertains to an 8-bit value. Hence, each CDW parameter consists of a predefined address range that covers the full bit-width of this specific parameter's value. A complete list of all CDW Parameters with their respective address ranges and descriptions of their values and properties can be found at the end of this document in section *CDW Parameters*.

### Relation to PDW

The CDW is technically a subset of the PDW (Pulse Descriptor Word) parameters. Timing Parameters that define the pulse and parameters for internally generated modulations are the main parameters missing in the CDW compared to PDW. The PDW option gives the user the best possible control of the timing at the RF output as pulses can be configured exactly and with a much higher time resolution. Furthermore, the PDW supports a PDW trigger subsystem functionality which is not available with the CDW feature. If you would like to upgrade to support PDW parameters, please talk to your representative about purchasing option PDW.

### RF Control with CDW

To control the RF output with CDW, the CDW state must be enabled on the device. Enabling it suppresses the RF output until the first CDW is applied and assigns all parameters a default value. The CDW parameters can be sent to the device through the FCP for a remote control of the RF output. The parameters are sent as sets of addresses and values consecutively. Hence, individual bytes of a single parameter can be changed if desired. Not sent addresses keep their previous value.

All parameters can optionally also be set with SCPI commands. However, there is no deterministic latency for setting CDWs with SCPI commands.

The end of a CDW is signaled with a specific flag in the CDW (CONF\_END). Setting it automatically applies the CDW setting at the RF output. Please note, that there will be a suppressed transient at the RF output.

Examples can be found in section *Application Examples*, the *Transient Blanking* is explained in section *Requirements and Restrictions* and there is a section detailing the use of the *Fast Control Port* with CDW.

## Requirements and Restrictions

### Option Requirements

- The CDW functionality is only available, if the APVSG device includes options FCP and UFS.

### CDW Limitations

- The CDW feature is not linked to any trigger system. Thus, applying CDW on multiple channels cannot be synchronized through the synchronous trigger and external triggers are not available with CDW.
- The CDW feature does not support any parameters to time the application of each CDW. All CDWs are directly applied after a fixed setup time (transient) on receiving the CONF\_END parameter.

### Carrier Settings

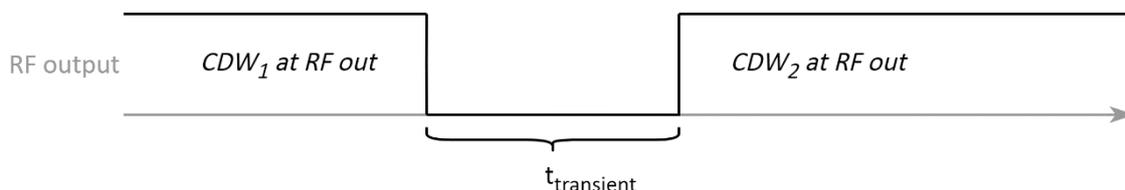
- For one CDW there can only be a single carrier frequency, power, and phase set. Detailed information about available parameters can be found in section *CDW Parameters*.
- Information on parameter ranges can be found in the APVSG datasheet [1].

### Waveform Modulation

- Only the maximum playback rate is supported for segments in use with CDW.
- There can only be one selected segment in each CDW.
- Segments (QI files for waveform modulation) must be uploaded to the device before the CDW state is enabled.
- It is the user's responsibility to ensure the only available and correct segment IDs are selected. Selecting inexistent/not uploaded segments will result in suppressed RF output without any further feedback.

### Transient Blanking

Naturally, when a CDW 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 1*. These transition periods are suppressed to prohibit unexpected behavior at the output. The transient period is a fixed value of time and directly dictates the switching time. For specific values, please consult the APVSG Datasheet [1].



*Figure 1: Depiction of transient period between CDW settings. Figure not to scale.*

### Fast Control Port Interface

For pin assignment, an overview of the FCP interface and similar FCP related information, please consult the FCP Application Note [3].

## SCPI Commands

### CDW Commands

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

Set the CDW State. Enabling the CDW state disables the control of RF output settings with other SCPI commands. If active, RF output can only be controlled with CDW parameter SCPI commands or CDW data streamed through the FCP.

*Example:* CDW:STAT ON

**[[:SOURce<ch>]:]CDW:<param\_name> <param\_data>**

Set one parameter in the CDW. This sets all addresses representing the referenced parameter.

*Example:* CDW:POW 2.0                      *Set the output power to 2.0 dBm.*

#### CDW Parameter Commands:

[SOURce<ch>:] CDW:FREQUency <float[Hz]>	Set carrier frequency
[SOURce<ch>:] CDW:PHASe <float[rad]>	Set carrier phase
[SOURce<ch>:] CDW:POWer <float[dBm]>	Set output power
[SOURce<ch>:] CDW:OUTPut:STATe ON OFF 0 1	Set RF output state
[SOURce<ch>:] CDW:WAVEform:WSEGment <integer>	Set segment ID
[SOURce<ch>:] CDW:WAVEform:STATe ON OFF 0 1	Set waveform modulation state
[SOURce<ch>:] CDW:CONFigure:END	Signal end of CDW configuration

**[[:SOURce<ch>]:]CDW:DATA <block\_data>|<address>,<parameter\_byte>**

This command writes CDWs (configuration pairs of addresses and parameter bytes) to the device. There are two options to choose from. Either send each pair of address and parameter with an individual SCPI command or send multiple address – parameter pairs as block data.

#### **Option 1:** SCPI with parameters <address>,<parameter\_byte>

Set the value for one specific address in the CDW. See chapter *Word Detail* for details on addresses and corresponding parameter bytes.

*Example:* CDW:DATA 48,1              Sets the RF output state to enabled.

#### **Option 2:** SCPI with parameter <block\_data>

Set the value of multiple addresses with block data.

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>.

Example of definite block data:

#18xxxxxxx

#18...: byte count is one digit wide

#18...: 8 data bytes will follow

...xxxxxxx: 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 byte 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 previous value. The CONFIG\_END parameter may be utilized and set at the end of the block data when a full CDW is transmitted:

- CONFIG\_END signals the end of a CDW. The CDW is then applied at the RF output after the transient period.

<u>Byte</u>	<u>Pair</u>	<u>Content</u>
0	1	An address of a CDW.
1	1	Parameter byte value of a CDW.
2	2	An address of a CDW.
3	2	Parameter byte value of a CDW.
4	3	An address of a CDW.
5...	3...	...

On little-endian systems this format is equivalent to an array of the following C type:

```
struct {
    int8_t address;
    int8_t parameter_byte;
} CDW_PAIR;
```

#### **[SOURCE<ch>:]CDW:DATA:FCP? <addr>**

Get the most recently set value (received but not yet applied at the output, awaiting the next CONFIG\_END) of one specific address in the CDW.

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

#### **[SOURCE<ch>:]CDW:DATA:OUTPut? <addr>**

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

*Example: CDW:DATA:OUTP? 55 Returns 1 byte of carrier power at the RF output.*

## FCP Commands

**[SOURce<ch>:] FCP:STReam:CDW ON|OFF|0|1**

Set the FCP into CDW mode. Cannot be set if any other FCP stream mode is active.

*Example: FCP:STR:CDW ON*

**[:SOURce<ch>]:FCPort:DIAGnostic**

Gets diagnostic information regarding the FCP. Available for FCP in all four stream modes (IQ, SEGment, CDW and PDW).

**[:SOURce<ch>]:FCPort:DIAGnostic?**

Prints the previously gathered diagnostic information of the FCP.

## Application Examples

### SCPI Example

This example shows how to setup the device for CDW operation and send desired parameters with SCPI commands. Please note that SCPI commands and FCP stream may be used concurrently. Nevertheless, it is the user's responsibility to ensure the parameters are sent in the proper consecutive order where necessary (especially with CONF\_END).

<p>CDW:STAT ON</p> <p>[D(P1)]</p> <p>CDW:WAV:STAT ON</p> <p>CDW:WAV:WSEG 10</p> <p>CDW:POW 5</p> <p>CDW:CONF:END</p> <p>CDW:WAV:STAT OFF</p> <p>CDW:CONF:END</p>	<p>Enable the CDW state. RF output is suppressed.</p> <p>Enable the waveform modulation with 1<sup>st</sup> CDW</p> <p>Set the waveform segment ID of 1<sup>st</sup> CDW to 10</p> <p>Set output power of 1<sup>st</sup> CDW to 5 dBm</p> <p>Signal the end of 1<sup>st</sup> CDW. Applied at RF output</p> <p>Disable the waveform modulation with 2<sup>nd</sup> CDW</p> <p>Signal the end of 2<sup>nd</sup> CDW. Applied at RF output.</p>
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### Signal Diagram for FCP with CDW

The following is an example on how to setup and stream CDW data through the FCP interface on an APVSG device. Please note, that this example only sets a handful of the CDW parameters. Parameters that are not set keep their previous value. If a parameter has not been set yet, it is set to its default value (see section *Word Detail*).

1. Connect the FCP interface to an external source from which the CDW data is streamed.
2. The following SCPI command sequence sets the device and its FCP interface to interpret CDW data.
 

FCP:STR:CDW ON	Enable FCP in CDW mode.
CDW:STAT ON	Enable CDW state on device.

3. Stream CDW data from the external source through the FCP interface.  
An example is given in *Figure 2*.

The first CDW in the example enables the waveform state, sets the segment ID and the power, but leaves all other parameters at their previous value. The fourth parameter CONF\_END signals the end of the first CDW here.

=> The RF out then automatically shows a suppressed transient, followed by the set configuration with the waveform of segment ID 10 being replayed.

The second CDW then only disables the wave state, with all carrier parameters left unchanged. The 6<sup>th</sup> parameter then signals the end of the second CDW.

=> The RF out then automatically shows a suppressed transient, followed by the set configuration with disabled waveform modulation.

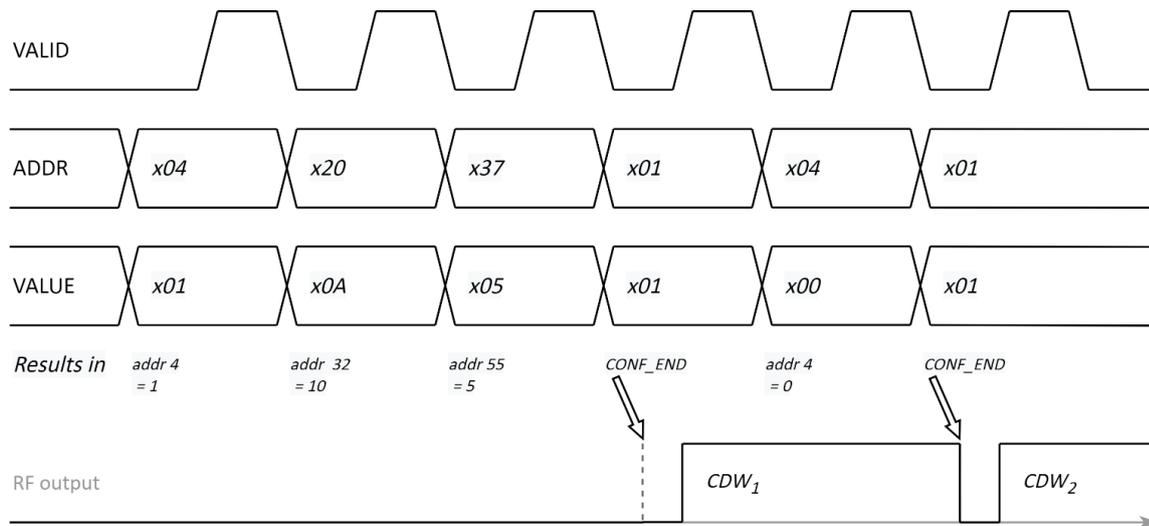


Figure 2: Example of CDW parameters at the FCP interface and their interpretation.  
Figure not to scale.

## CDW Parameters

### Word Detail

Address	Parameter				
	Name	Bits	Bit Name	SCPI command	Description
0	<i>Reserved</i>	[7:0]	RESERVED		
1	CDW Configuration	0	CONFIG_END	CDW:CONF:END	Signal the end of one CDW, meaning all necessary parameters have been sent. Directly initiates the parameters to be applied at the RF output. Default: 0
		[7:1]	RESERVED		
2	<i>Reserved</i>	[7:0]	RESERVED		
3	<i>Reserved</i>	[7:0]	RESERVED		
4	CDW Modulation	0	WAVE_STATE	CDW:WAV:STAT	Enable/Disable Waveform Modulation 0: Disable the Waveform State 1: Enable the Waveform State Default: 0
		[7:1]	RESERVED		
5-15	<i>Reserved</i>	[7:0]	RESERVED		
32	Waveform Segment 0	[7:0]	WAVE_WSEG [7:0]	CDW: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 <i>Requirements and Restrictions</i> .  Default: 0
33	Waveform Segment 1	[7:0]	WAVE_WSEG [15:8]		
34-47	<i>Reserved</i>	[7:0]	RESERVED		
48	RF Output	0	OUTP_STATE	CDW:OUTP:STAT	RF output state for this CDW.  0: Disable the RF output 1: Enable the RF output  Default: Device OUTP:STAT default.
		[7:1]	RESERVED		
49	Frequency 0	[7:0]	FREQ <sup>1</sup> [7:0]	CDW:FREQ	Carrier frequency value in Hz. Minimum and maximum determined by device limitations <sup>4</sup> . Resolution determined by device limitations <sup>4</sup> and CDW frequency format <sup>1</sup> . Default: Device frequency default.
50	Frequency 1	[7:0]	FREQ <sup>1</sup> [15:8]		
51	Frequency 2	[7:0]	FREQ <sup>1</sup> [23:16]		
52	Frequency 3	[7:0]	FREQ <sup>1</sup> [31:24]		
53	Frequency 4	[7:0]	FREQ <sup>1</sup> [39:32]		
54	Frequency 5	[7:0]	FREQ <sup>1</sup> [47:40]		
55	Power 0	[7:0]	POW <sup>2</sup> [7:0]	CDW:POW	Carrier power value (RMS) in dBm. Minimum and maximum determined by device limitations <sup>4</sup> . Resolution determined by device limitations <sup>4</sup> and CDW power format <sup>2</sup> . Default: Device power default.
56	Power 1	[7:0]	POW <sup>2</sup> [15:8]		
57	Phase 0	[7:0]	PHASE <sup>3</sup> [7:0]	CDW:PHAS	Carrier phase value, in CDW phase format <sup>3</sup> . Resolution determined by device limitations <sup>4</sup> and CDW phase format <sup>3</sup> . Default: Device phase default.
58	Phase 1	[7:0]	PHASE <sup>3</sup> [15:8]		
59-255	<i>Reserved</i>	[7:0]	RESERVED		

## Parameter Types

The following definitions are used for the respective fixed-point parameters of the packet. 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.

### <sup>1</sup>Frequency Value [Hz]

Addr.	5	4	3	2	1	0
Bit	47 ... 40	39 ... 32	31 ... 24	23 ... 16	15 ... 10	9 8 7 6 5 4 3 2 1 0
Data	integer bits (signed)					fractional bits

### <sup>2</sup>Power Value [dBm] or [dB]

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

### <sup>3</sup>Phase Value

Addr.	1	0
Bit	15 ... 8	7 ... 0
Data	uint bits	

The phase value must be in the range  $[0, 2\pi]$ . The largest value of the 16-bit phase (decimal 65535) represents the value  $2\pi$ .

<sup>4</sup>**Device Limitations** can be found in the APVSG Datasheet [1].

## Related Documentation

- [1] APVSG Datasheet  
[https://www.anapico.com/downloads/brochures-and-data-sheets/Specifications of APVSG devices](https://www.anapico.com/downloads/brochures-and-data-sheets/Specifications%20of%20APVSG%20devices)
- [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] AN6008 – PDW  
<https://www.anapico.com/downloads/application-notes-and-videos/>  
*Includes explanations of the PDW option.*