Application Note AN6oo6

RF Output Modes of APVSGs

Purpose

This application note describes the RF output modes provided by APVSG devices. It provides information about how different RF output modes affect transients and modulations, including blanked transitions.

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Introduction

AnaPico signal generators use multiple methods that control the behavior of the RF output signal during transients and when modulations are active.

The most significant methods are:

- An automatic leveling correction (ALC) system that provides maximum output power accuracy. The ALC compensates effects of ambient conditions like temperature on output power. The ALC monitors the output power, compares it to the programmed setting and corrects the power level if needed.
- An output blanking switch that can turn off the signal at the RF output. It is utilized to blank transitions between different settings and suppress the RF output signal during transients. Thereby the output power will not overshoot while the hardware settles after switching between different power or frequency settings.
- A crest factor correction that compensates power level differences at the output caused by active modulations.

The ALC loop and the output blanking switch are both depicted in *Figure 1.*

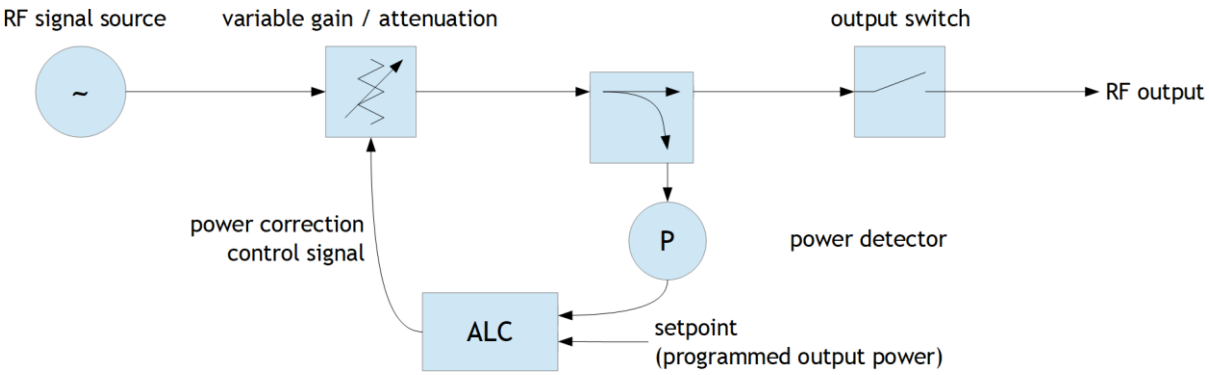

Figure 1: RF output overview

Automatic Levelling Control

For APVSG devices, the automatic levelling control (ALC) is activated whenever the RF output is changed and an output transition occurs. These output transitions are mainly caused by frequency and power setting changes. A list of settings that cause such a transition can be found in section *Output Transition Causes*. The ALC process is described in-depth in section *ALC Process* to give a detailed understanding of the behavior at the RF output of the APVSG device during transients.

ALC Modes

In the following, the operating modes available for ALC in APVSG devices are described. The corresponding commands can be found at the end of this document in section *SCPI Commands*.

ALC sample & hold enables automatic output power correction for power or frequency changes.

When changing output power or frequency in this mode, the signal generator activates the ALC to sample the new power correction control signal. This ALC process is explained in more detail in section *ALC Process*.

The effects of ambient conditions on output power are not corrected. Output power typically still meets specifications, but this is not guaranteed as conditions like internal temperature may vary.

This mode can be set with the following SCPI commands.

- POW:ALC ON
- POW:ALC:SEAR ON

ALC off disables the complete ALC system.

The internal automatic level control loop is deactivated. The output level is set with values from an internal calibration table. Modulations are not temporarily turned off while the output level is being set.

Output power range and resolution degrade. Specified accuracy is not guaranteed.

This mode may be used in applications where lowest amplitude noise is important or when constant active modulations are essential. Limited power range and accuracy are the drawbacks of this mode.

This mode can be set with either one of the following SCPI commands.

- POW:ALC OFF
- POW:ALC:SEAR OFF

ALC once readjusts the output level by executing the ALC process one time.

The user can initiate this behavior with the POW:ALC:SEAR ONCE command.

The corresponding SCPI command is

- POW:ALC:SEAR ONCE

ALC Process

The ALC system provides maximum output power level accuracy for a specific carrier frequency without modulation. The ALC compensates effects of ambient conditions like temperature on output power. Offsets caused by IQ modulations must be cancelled out with a crest factor correction, depending on the active modulation. In the following, the steps the APVSG takes to adjust the output power are described.

1. Start Blanking the output
   This is only the case if blanking is enabled.
   Blanking is deactivated by default. See section *Transition Blanking for ALC* for details.
2. All modulations turned off
   This includes AWGN modulations as well as streamed modulations (e.g. FCP, AIQ).
   Modulations are not turned off if the device is in ALC off mode.
3. Crest factor correction applied to the output power
   See section *Crest Factor Correction* for more information.
4. ALC for accurate power output.
   The ALC monitors output power, compares it to the programmed setting and corrects the output power if needed. For disabled blanking, drastic power level changes may occur during this step.
5. Modulation turned back on
   This only applies if any modulation has been active before the process started.
   Please note, that the actual output power might deviate from the set power value for modulations that do not support crest factor correction.
6. Finish output blanking
   This step only applies for enabled blanking. Blanking is deactivated by default.

The described steps are done automatically whenever the ALC is executed. For details on the different available modes and settings that provoke an ALC process, consult *ALC Modes* and *Transition Blanking for ALC* respectively.

Output Transition Causes

The ALC is activated whenever the power or the carrier frequency is changed. This is the case if any of the following settings change.

- Power
- Carrier frequency
- Crest factor correction (see section *Crest Factor Correction* for details)
- AWGN configurations with AWGN active

Selecting a new segment in the device's memory or otherwise switching between modulations on APVSG devices does not cause the ALC to execute unless a new crest factor correction is set with the new modulation. Section *Crest Factor Correction* contains explanations and a list of modulations that crest factors.

For more information on selecting and/or sequencing segments, please consult [3].

RF Output

Crest Factor Correction

The output power set for the device relates to the RMS value of the power. Each modulation has its own RMS value that may deviate from the RMS value of a single frequency carrier. The ALC process always adjusts output power in reference to the carrier frequency. Therefore, modulating the carrier frequency at a fixed power would usually result in an actual output power that deviates from the power level chosen by the user.

$$P_{out,uncorrected} = P_{carr} - P_{RMS,offset} = P_{RMS,mod}$$

To compensate this effect, the crest factor for the active modulation is added[1].

$$P_{out} = P_{mod} = P_{carr} + P_{crest}$$

As mentioned in section *ALC Process*, the crest factor is applied before the respective modulation is enabled. Hence, the output power of the device may overshoot the set power during transients, if output blanking is disabled.

The total applied crest factor correction is a sum of the following individual crest factors.

- Automatic crest factor
- Manual crest factor
- AWGN crest factor

$$P_{crest} = P_{cF,autoORmanual} + P_{cF,AWGN}$$

Automatic Crest Factor

This crest factor is calculated and set automatically for the following modulations.

- Analog Modulation (AM, FM, PM)
- [option] AVIO (DME, ILS, VOR)

AWGN Crest Factor

The crest factor for the additive noise is calculated automatically and added to any other applying crest factor.

Manual Crest Factor

For modulations that are streamed or created by the user, a manual crest factor is applied to correct the power level. The manual crest factor must be set correctly by the user according to the applied modulation, for all of the following modulations.

- Waveform segments saved in the memory of the device. (See [3] for segment details.)
- [option] FCP IQ Streaming
- [option] AIQ streaming

For all other modulations, there is currently no crest factor correction available.

The SCPI commands related to crest factor correction are listed and explained in section *SCPI Commands*.

[1] Available only for selected modulations that support crest factor correction.

Transition Blanking for ALC

Blanking of the RF output during transitions can be enabled or disabled.

Output blanking disabled

may be beneficial in applications where best switching speed is required or when disabling the RF output momentarily is not admissible.

Please beware**:** For disabled output blanking, the power during transitions may exceed the set power value. The offset is the crest factor plus an undershoot/overshoot uncertainty. The output can therefore overshoot or undershoot the set power value even if there is no crest factor present.

$$P_{out,trans} = P_{carr} + P_{crest} + P_{uncertainty}, \quad P_{carr} = P_{set}$$

See [2] for specifications on the Power Level Uncertainty.

Output blanking enabled

implies that the RF output power is reduced during the transient phase (e.g. while the frequency changes until it reaches the new setting). Output power will then rise and reach the programmed setting. Thus, the output power will never exceed the programmed setting (except for a specified uncertainty, see [2]).

SCPI Commands

***RST**

Resets the device to factory default settings. This enables the ALC system and automatic ALC mode with output blanking.

[:SOURce<ch>]:OUTPut:STATe?

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

Enable/Disable the RF output.

*RST: OFF

ALC Mode

[:SOURce<ch>]:POWer:ALC?

[:SOURce<ch>]:POWer:ALC 0|OFF|1|ON

Enables or disables the ALC system.

ON: Utilize the internal automatic level control loop.

OFF: Utilize the internal calibration table values to set the output power.

*RST: ON

[:SOURce<ch>]:POWer:ALC:SEARch?

[:SOURce<ch>]:POWer:ALC:SEARch 0|OFF|1|ON|ONCE

Sets the ALC search mode.

OFF: Sets the device into ALC off mode.

ON: Sets the device into ALC sample & hold mode.

ONCE: Readjusts the power level once, executing the ALC process.

*RST: ON

Blanking

[:SOURce<ch>]:OUTPut:BLANking?

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

Enable/Disable blanking of the RF output during ALC execution.

*RST: ON

Crest Factor Correction

[:SOURce<ch>]:IQ:CRESt:TOTal?

Returns the active crest factor correction applied at the RF output, or 0.0 dB if no modulation is enabled.

*RST: 0.0 dB

[:SOURce<ch>]:IQ:CRESt:AUTOmatic?

Returns the automatic crest factor applied at the RF output, or 0.0 dB if inactive. Applies for AVIO, DM(IVM) and analog Modulation.

*RST: 0.0 dB

[:SOURce<ch>]:IQ:CRESt:AWGN?

Returns the AWGN crest factor applied at the RF output, or 0.0 dB if AWGN is disabled. Available only if the AWGN option is included in the device.
*RST: 0.0 dB

[:SOURce<ch>]:IQ:CRESt:MANual?

Returns the set manual crest factor.

[:SOURce<ch>]:IQ:CRESt:MANual <float>

Set the manual crest factor in dB. It will be applied at the RF output when a modulation with manual crest factor correction is enabled.
Applies for WAVe, FCP[option] and AIQ[option]
*RST: 0.0 dB

Further Related Documentation:

- [1] Programmer's Manual
  with a description of all SCPI commands
- [2] APVSG Datasheet
  with specifications for APVSG devices
- [3] AN6003 – Memory Segmentation
  with explanations on storing and playing segments and sequences to/from the memory.
- [4] AN6005 – Additive White Gaussian Noise
  with details and examples of the AWGN option