Application Note AN3003

# How to use the APSINXXG trigger system to perform extremely fast digital sweeps

## Purpose

This application note focuses on how to program and run fast frequency (or generalized list) sweeps using the APSINXXG signal generators with the fast switching option FS.

## Introduction

The APSINXXG (or the APMSXXG multi-channel) signal generators with option FS allow extremely fast sweeps that, in combination with the trigger system, can generate very accurate and fast frequency and power ramps.
In contrast to traditional analog sweeps, fast digital sweeps can be synchronized at any time during the sweep and yield precise frequencies throughout the sweep.

The APSINXXG and APMSXXG series of signal generators can be programmed to execute sweeps by either the APSIN graphical user interface (GUI) or by directly using the SCPI commands.

In this application note, we describe the configuration for a frequency sweep with the following parameters:

- Linear sweep from 1 to 12 GHz in total 10 steps
- Execute entire sweep once on every external trigger rising edge.
- Frequencies shall be switched every 50 us
- An output trigger shall provide a "signal valid" indication by changing to HIGH whenever the transient is completed and the signal becomes valid

To understand the timings for this sweep, we can look at the diagram shown in Figure 1. The "dwell time" $\tau_{step}$ is either programmed by the user or set by an external trigger signal (TRIG IN). In our example, $\boldsymbol{\tau_{step}}$ is 50 µs, and the rising

edge of an externally applied trigger starts the linear sweep with ten frequencies.

To obtain the "signal valid" digital signal, we need to enable the TRIG OUT on the rear multi-purpose BNC connector (named FUNC OUT). This signal indicates if the RF Signal at the output of the APSIN is stable. TRIG OUT is high , if a stable output is detected, and it goes low once a new frequency or power transition is started.
After the TRIG IN signal rising edge, the sweep is started and it takes $\tau_{de}$ (typically 5ns) until the TRIG OUT signal goes high for the first time.
TRIG OUT now remains high until t=50 µs is reached and switching to the next frequency is initiated. Within $\tau_{inv}$ the switching transient is completed and TRIG OUT goes high again. The new frequency / power pair remain stable until t=150 µs is reached. TRIG OUT goes low for a second time and the next frequency / power pair is programmed.
Note that the transient time $\tau_{invN}$ and the valid time $\tau_{valN}$ can vary from point to point, but the step time $\tau_{step}$ (=$\tau_{invN}$+$\tau_{valN}$)between frequencies is always 50 µs. In particular, for the first frequency of the sweep, $\tau_{inv1}$ is zero and the $\tau_{val1}$ is 50 µs.
TRIG OUT can be used to precisely synchronize sweeps to any external equipment.

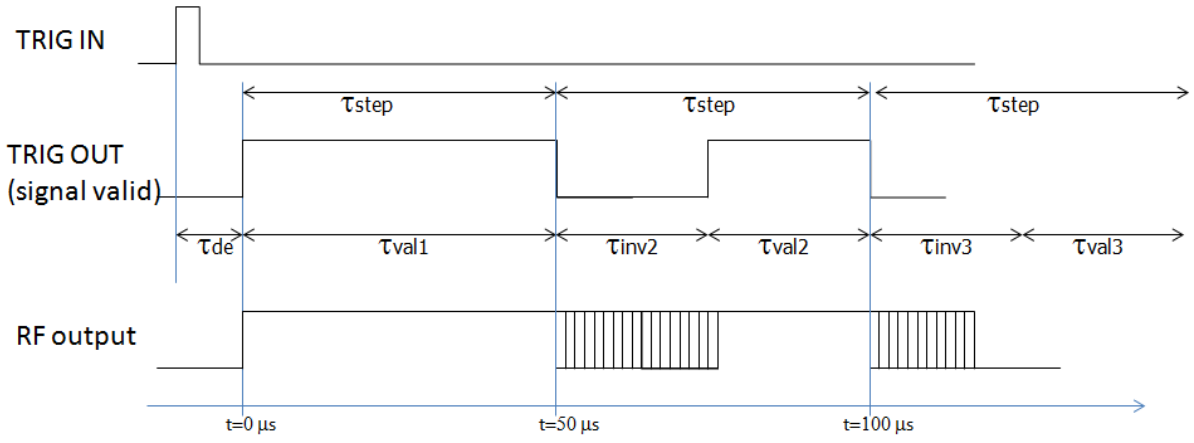


Figure 1: Timing diagram

## Sweep configuration

We configure this sweep in three steps

**1. Configure Trigger**

*Trigger input*

| | |
|---|---|
| TRIG:SEQ:TYPE | POIN |
| TRIG:SEQ:SOUR | EXT |
| TRIG:SEQ:DEL | 0 |
| TRIG:SEQ:SLOP | POS |
| TRIG:SEQ:ECO | 1 |

*Trigger output*

| | |
|---|---|
| TRIG:OUTP:MODE | VAL |

**2. Configure Sweep**

| | |
|---|---|
| SOUR:SWE:COUN | 1 |
| SOUR:SWE:DWEL | 50e-6 |
| SOUR:SWE:DEL | 0 |
| SOUR:SWE:SPAC | LIN |
| SOUR:SWE:POIN | 10 |
| SOUR:SWE:STAR | 1e9 |
| SOUR:SWE:STOP | 12e9 |
| SOUR:FREQ:MODE | SWE |

**3. Arm trigger**

| | |
|---|---|
| INIT:CONT | ON |

## The GUI setup

In the APPH GUI, the setup is straightforward. First, we configure the trigger system to wait for rising edge and run the entire sweep upon trigger.
We switch to the TRIGGER tab of the GUI as shown in Figure 2.. We set trigger mode to "Repeat", Trigger source to "External Trigger", Trigger Edge to "Rising", and Trigger Parameter to "Execute complete List" .
In the trigger output setting we set "Valid"

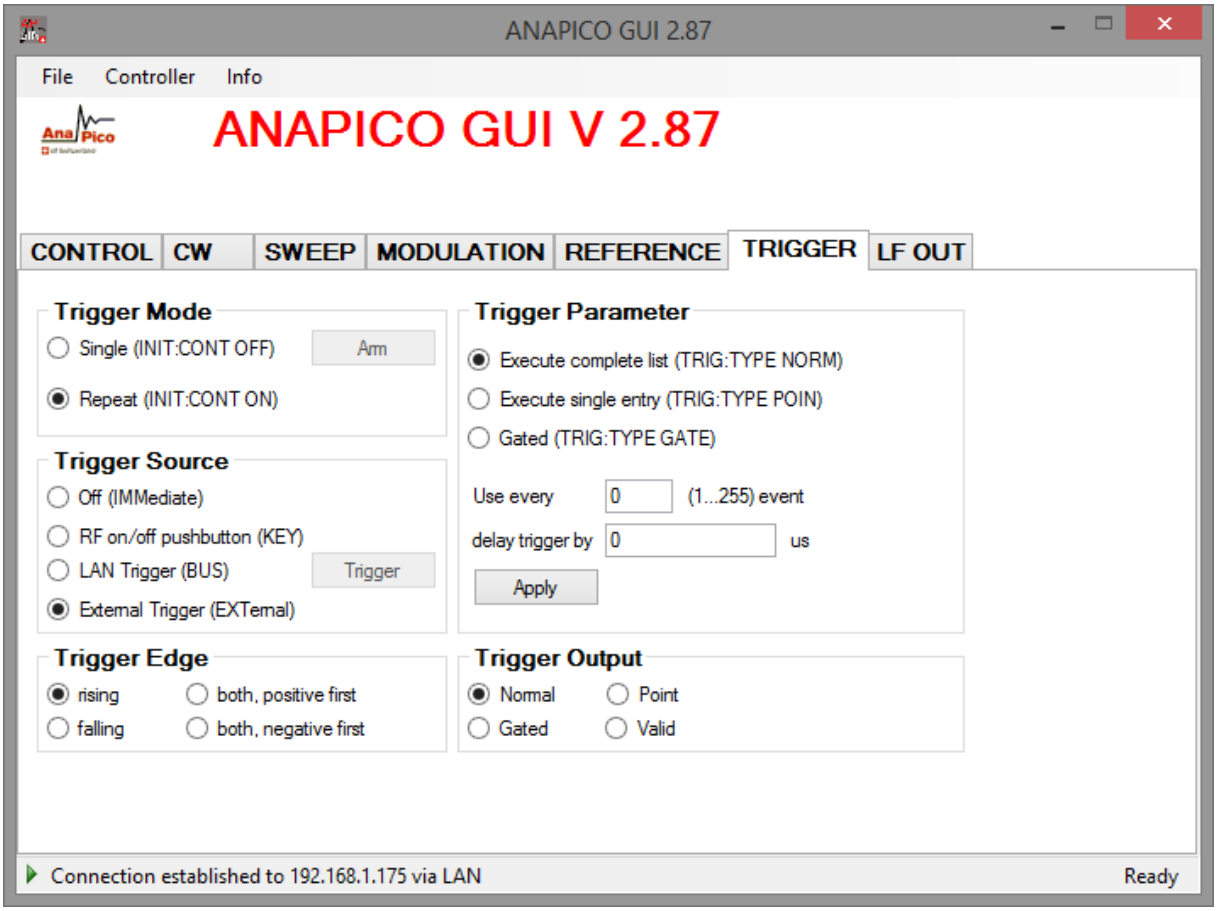

Figure 2: GUI trigger settings

Next, we switch to the SWEEP tab of the GUI as shown in Figure 3.
We set the start frequency to 1 GHz, and stop frequency to 12 GHz. The number of repetitions of the sweep we set to 1, number of points to 10, "Dwell time" to 0.05 ms, disable the "Auto" and set the "Off time" to 0 ms.
We can chose for the ALC (automatic level control) to operate in "on" or "hold" mode.
We can start the sweep with the "on/off" button on the left.

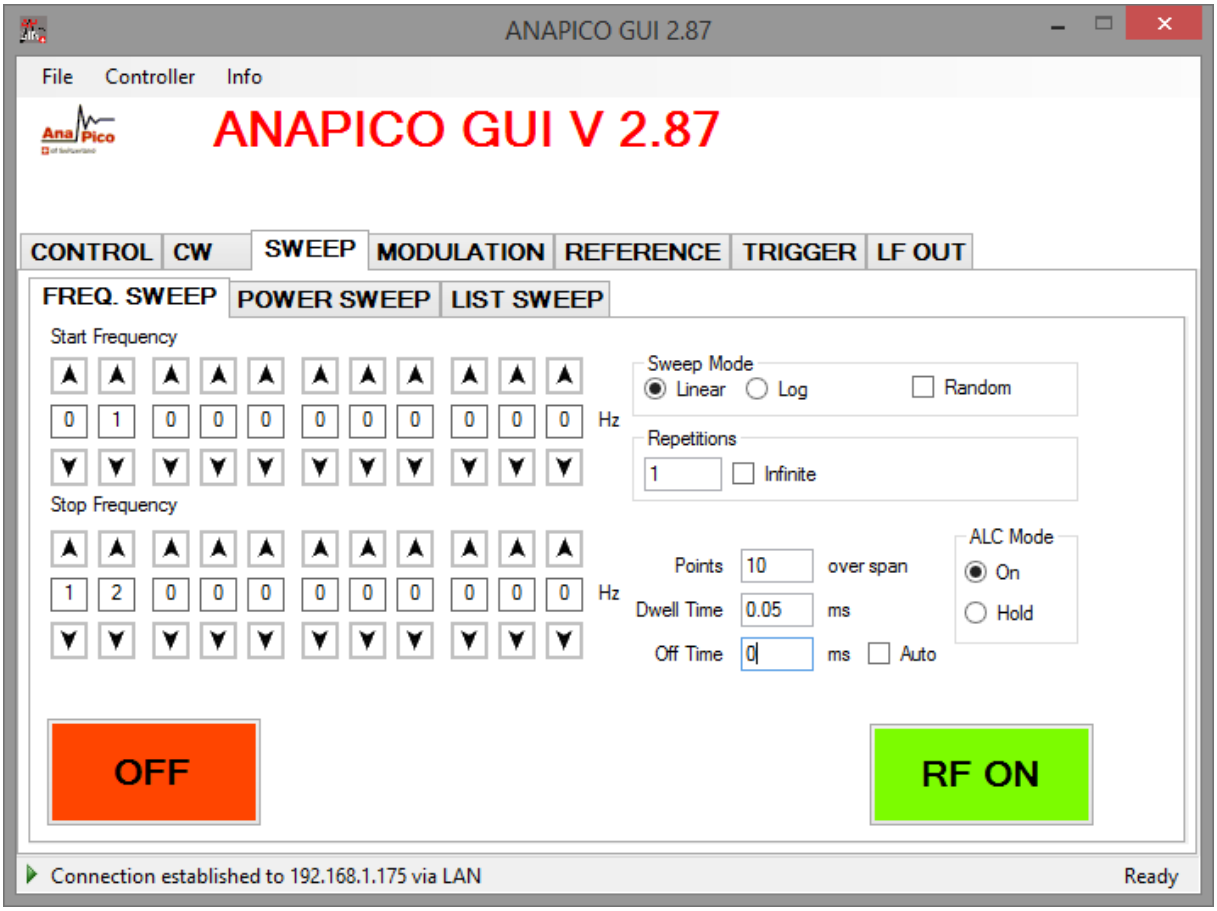

Figure 3: GUI sweep settings

## The measurement results

Figure 4 shows the time domain measurements of the sweep. TRIG IN is applied approx every 990 microseconds from an external source (red trace). Upon the rising edge, the "signal valid" (greed trace) goes high almost instantly, indicating that first frequency RF (blue trace) is stable. After the ten consecutive frequencies, "signal valid" does low a last time and remains low unit a new sweep starts upon new trigger rising edge.

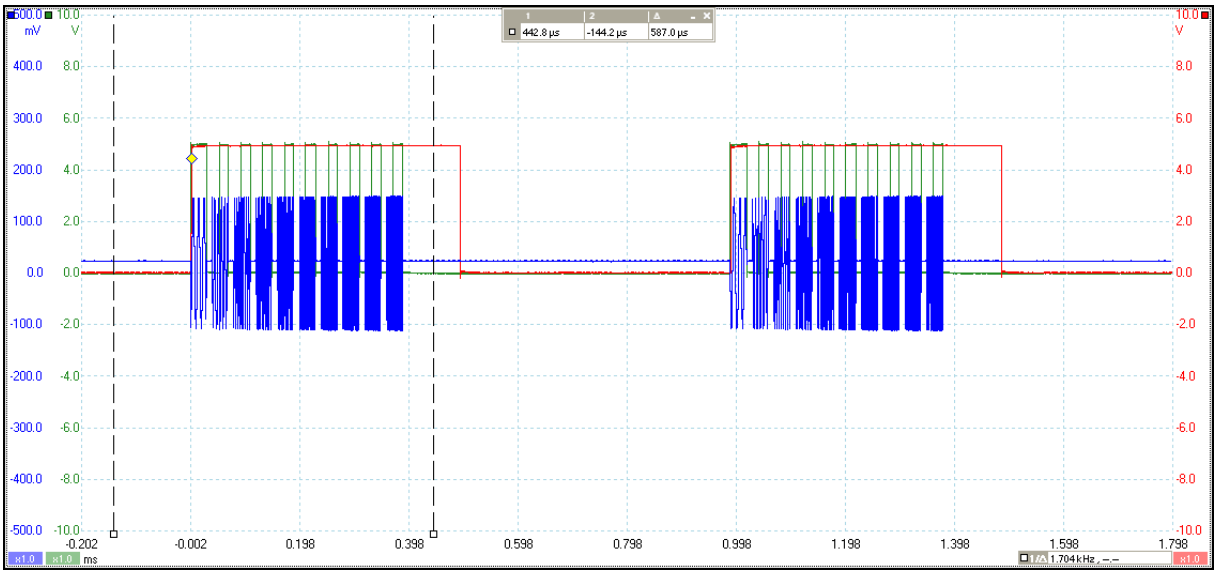


Figure 2: 10 point sweep with 50 µs step time.

The sweeping speed can be further enhanced. The specified minimum step time (time between two frequencies) is 30 µs. However, generally, even faster sweep are possible if some frequency bands are not crossed during the sweep. These band cross frequencies are 10 MHz, 3 GHz and 5.1GHz.
As shown in Figure 5, a faster sweep with a dwell time of 15 µs and a "off" time of 5 µs can be programmed within a band. In this example, a sweep is shown from 1 to 1.1 GHz as a 10 point sweep within 200 µs.

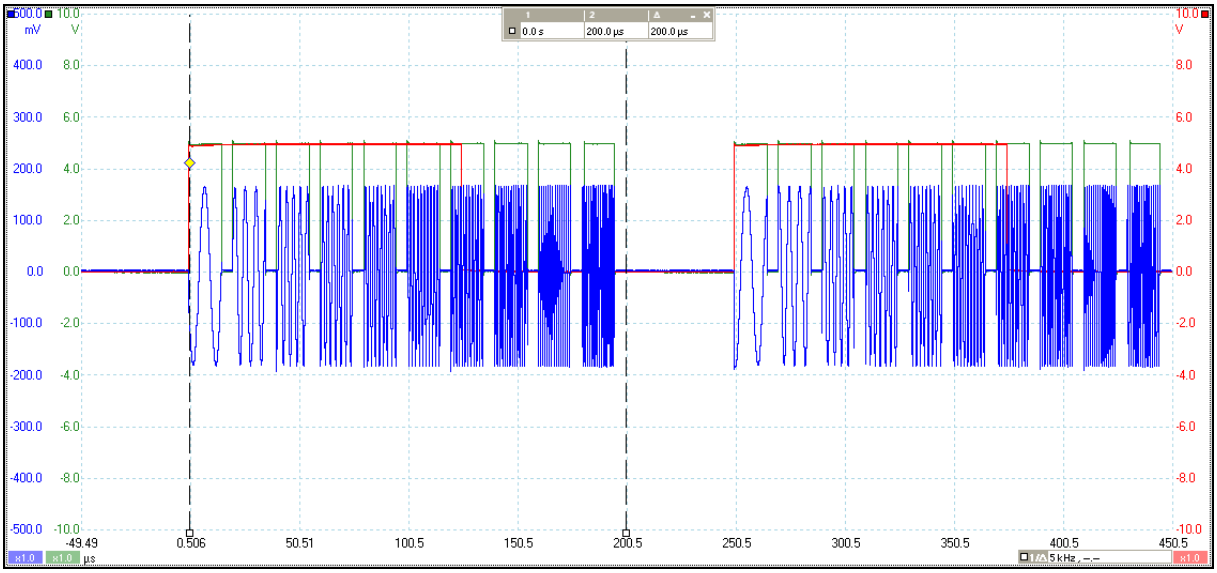


Figure 3

## Conclusion

The option FS for the APSINXXG allows extremely fast and precise digital sweeps that can be well synchronized to external equipment using input and output trigger.