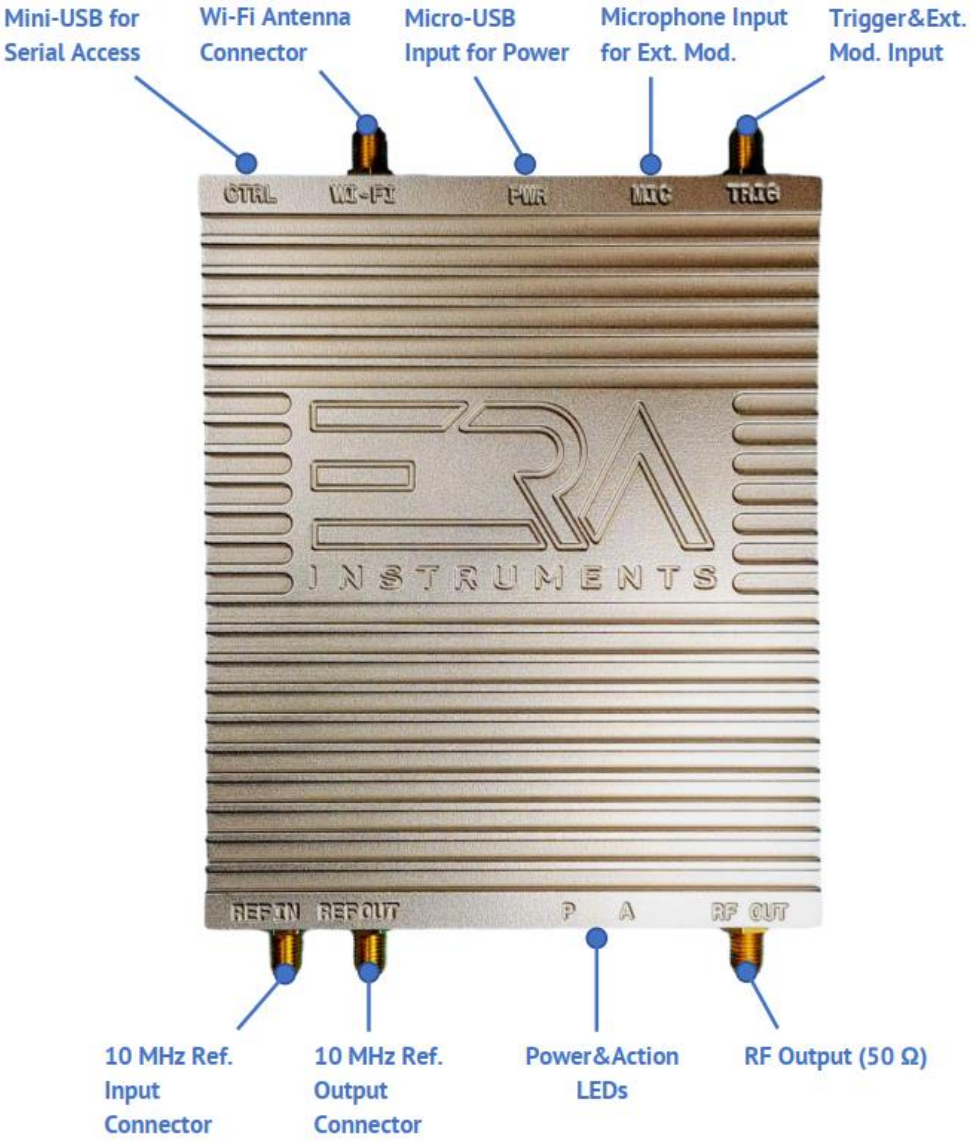
# ERASynth: An Open Source, Arduino-Compatible RF Signal Generator with Wi-Fi Connectivity

# DATASHEET

## GENERAL DESCRIPTION

ERASynth is an open source analog RF signal generator featuring an Arduino Due microcontroller and an ESP8266 powered web GUI. ERASynth uses advanced PLL/VCO technology, coupled with an internal ultra-low phase noise frequency reference to form a programmable analog signal generator capable of generating a low phase noise signals up to 20 GHz. ERASynth provides fast frequency switching and fine-tuning resolution using a multi-loop PLL architecture. ERASynth also offers frequency, amplitude and pulse modulation capabilities. The frequency tuning and control commands are loaded into the instrument via the serial interface or via the web GUI or Windows GUI.



## FEATURES

**Architecture**: Multiloop Integer-N PLL driven by a tunable reference.

**Frequency Range**:
- ERASynth: 250 kHz to 6 GHz
- ERASynth+: 250 kHz to 15 GHz
- ERASynth++: 250 kHz to 20 GHz

**Amplitude Range**: -60 to +15 dBm (typical)

**Phase Noise**: -120 dBc/Hz (typical phase noise @ 1 GHz output and 10 kHz offset)

**Frequency Switching Time**: 250 µs (typical)

**Reference**: Ultra-low noise 100 MHz VCXO locked to a
- ±0.5 ppm 10 MHz TCXO for ERASynth
- ±25 ppb 10 MHz OCXO for ERASynth+ and ERASynth++
- 10 MHz external reference

**MCU**: ATSAM3X8EA-CU (same as in the Arduino Due board with BGA package Atmel Microcontroller)

**Interfaces**:
- Wi-Fi interface for web-based GUI access
- Serial-USB (mini USB) for serial access
- Micro USB for power input
- Trigger Input (SMA) for triggered sweep
- REF In (SMA) for external reference input
- REF Out (SMA) for 10 MHz reference output
- RF Out

**Dimensions**: 10 cm x 14.5 cm x 2 cm

**Weight**: 400 g (14.1 oz)

**Power Input**: 4.5 to 12 V

**Power Consumption**:
- Typ < 6 W for ERASynth
- Typ < 7 W for ERASynth+ and ERASynth++

**Enclosure**: Precision-milled, nickel-plated aluminum case

**Open Source**: Schematics, embedded Arduino code, Web GUI source code, and RS-232 command set

**Modulation:** FM, AM, Pulse (Internal and external)

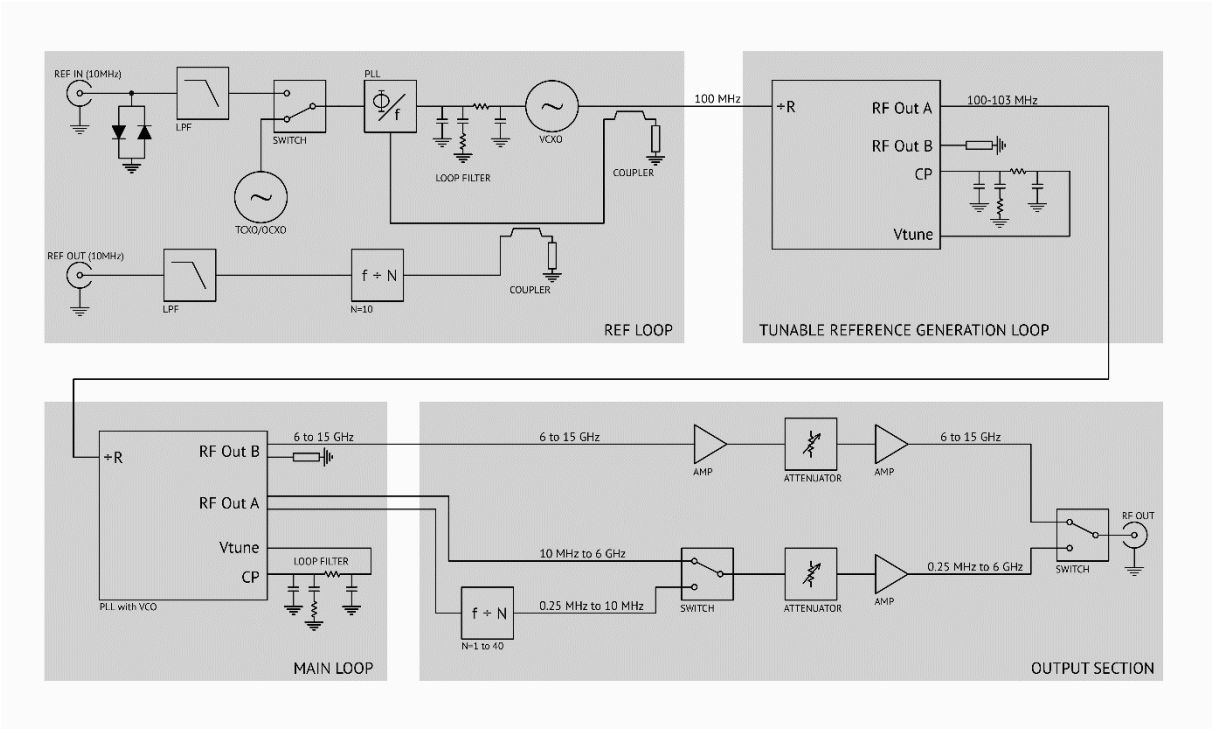



Figure 1: ERASynth general block diagram

## ORDER GUIDE

| | ERASynth | ERASynth+ | ERASynth++ |
|---|---|---|---|
| **Frequency Range** | 250 kHz to 6 GHz | 250 kHz to 15 GHz | 250 kHz to 20 GHz (*) |
| **Architecture** | LMX2594 driven by LMX2594 | LMX2594 driven by LMX2594 | LMX2595 driven by LMX2594 |
| **Reference** | ±0.5 ppm TCXO | ±0.5 ppm TCXO and ±25 ppb OCXO | ±0.5 ppm TCXO and ±25 ppb OCXO |
| * ERASynth++ comes with an external 15 to 20 GHz cavity filter for subharmonic rejection. | | | |

## ELECTRICAL CHARACTERISTICS

| | Minimum | Typical | | Maximum |
|---|---|---|---|---|
| **Supply Voltage** | 4.5 V | 5 V | | 12 V |
| **Supply Current** | | 1.1 A | | |
| **Supply Current, RF Out Muted** | | 300 mA | | |
| **Minimum Output Power** | | | | -60 dBm |
| **Maximum Output Power (*)** | | 250 kHz-15 GHz<br>15 GHz-16 GHz<br>16 GHz-19 GHz | 17 dBm<br>12 dBm<br>8 dBm | |
| **Output Level Accuracy** | | 250 kHz-15 GHz<br>15 GHz-20 GHz | ± 1.5 dB<br>± 3.5 dB | |
| **Output Power Resolution** | | 0.1 dB | | |
| **Frequency Resolution** | 1 Hz | | | |
| **Frequency Accuracy (using internal OCXO)** | | ±25 ppb | | |
| **Minimum Dwell Time**** | 1 ms | | | |
| **External Reference Input Level** | -10 dBm | 0 dBm | | +10 dBm |
| **External Reference Locking Range** | | 10 MHz ± 30 ppm | | |
| **External Trigger Low Level Input Voltage** | 0 V | | | 0.7 V |
| **External Trigger High Level Input Voltage** | 2 V | | | 3.3 V |
| **External Modulation Input Voltage Level** | | | | 0 ± 1.65 V |
| **RF Output Impedance** | | 50 Ohm | | |

* See Figure 2 for maximum unleveled output power up to 15 GHz.

** Dwell time: Duration of each signal point in a sweep sequence set by user.

## THERMAL CHARACTERISTICS

**Operating temperature range**: 0 to +50 °C

**Non-operating temperature range**: -40 to +85 °C

**Warm-up time**: 10 minutes

# TYPICAL PERFORMANCE

## 1. Max Unleveled Output Power

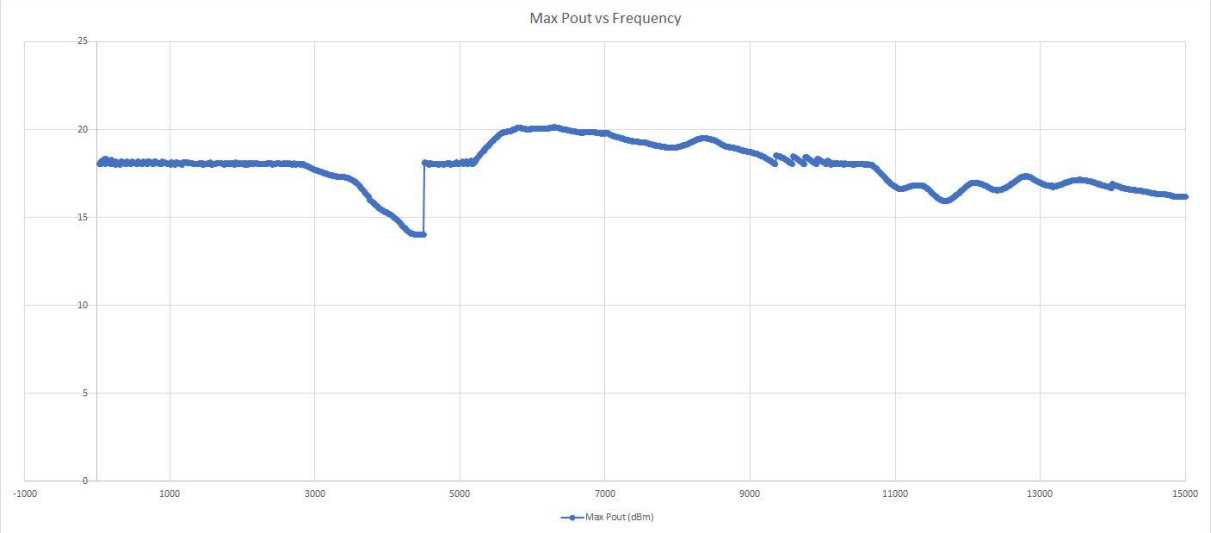



Figure 2: ERASynth+ Max Unleveled Power Output

## 2. Spectral Purity

ERASynth's multiloop architecture minimizes the spurious artifacts commonly encountered in fractional frequency synthesizers.

### Broadband Non-Harmonic Spurious Emissions

| Frequency | dBc (typical) at 0 dBm specified output power |
|---|---|
| 250 kHz-30 MHz | -67 dBc |
| 30 MHz-4500 MHz | -63 dBc |
| 4500 MHz-20000 MHz | -58 dBc |

### Harmonics (2nd or 3rd harmonics, whichever is worse)

| Frequency | dBc (typical) at 0 dBm specified output power |
|---|---|
| 1 MHz | -29 dBc |
| 3 MHz | -35 dBc |
| 10 MHz | -47 dBc |
| 20 MHz | -47 dBc |
| 30 MHz | -55 dBc |
| 100 MHz | -10 dBc |
| 300 MHz | -10 dBc |
| 1 GHz | -14 dBc |
| 2 GHz | -16 dBc |
| 3 GHz | -25 dBc |
| 6 GHz | -22 dBc |
| 10 GHz | -33 dBc |

## Sub-Harmonics (1/2 or 1/3 harmonics, whichever is worse)

| Frequency | dBc (typical) at 0 dBm specified output power |
|---|---|
| 3 MHz | -77 dBc |
| 9 MHz | -77 dBc |
| 30 MHz | -72 dBc |
| 100 MHz | <-90 dBc |
| 1 GHz | <-90 dBc |
| 3 GHz | -86 dBc |
| 6 GHz | <-90 dBc |
| 9 GHz | -55 dBc |
| 12 GHz | -52 dBc |
| 15 GHz | -30 dBc |
| 15 GHz-20 GHz | <-100 dBc (*) |
| * Sub-harmonics are rejected with external cavity filter. The cavity filter is included in the package with ERASynth++ | |

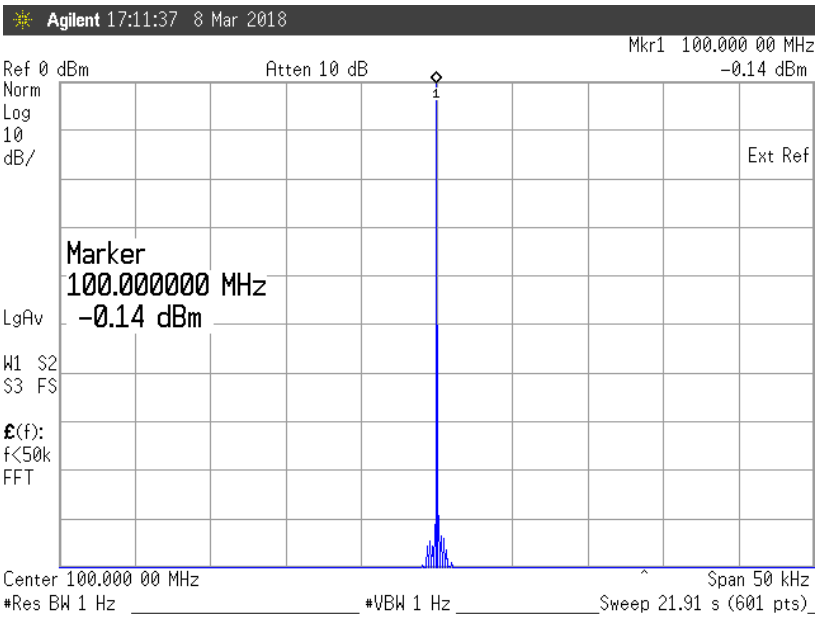



Figure 3: ERASynth+ Narrow-band Spurious Performance at 100 MHz

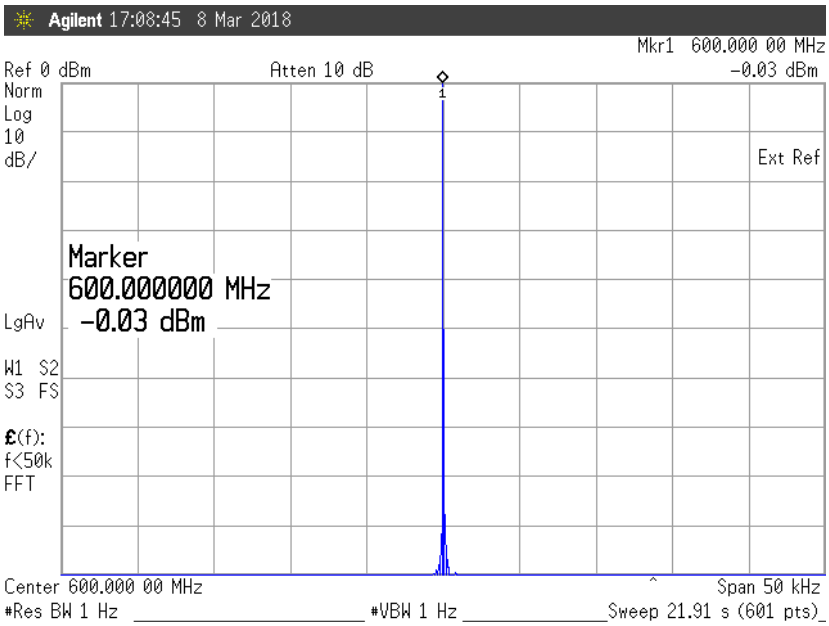



Figure 4: ERASynth+ Narrow-band Spurious Performance at 600 MHz

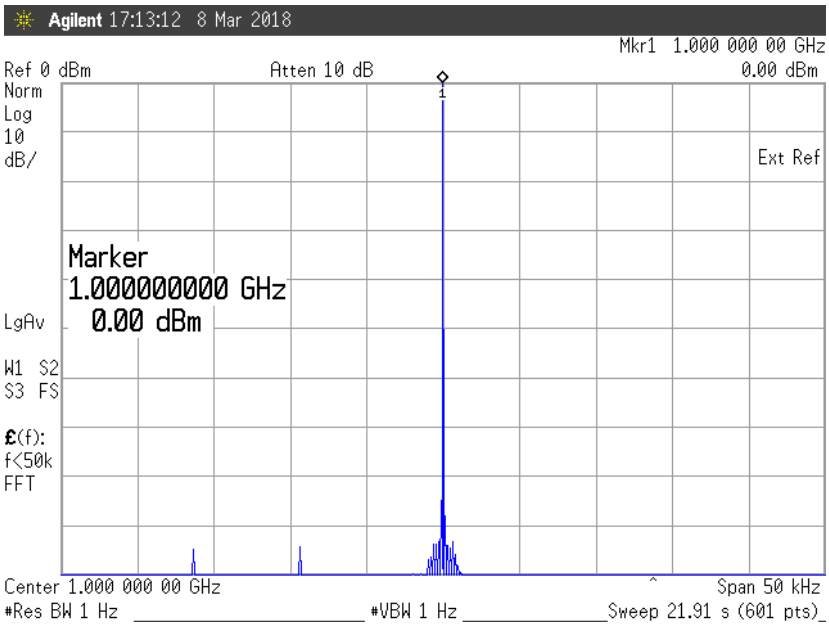



Figure 5: ERASynth+ Narrow-band Spurious Performance at 1 GHz

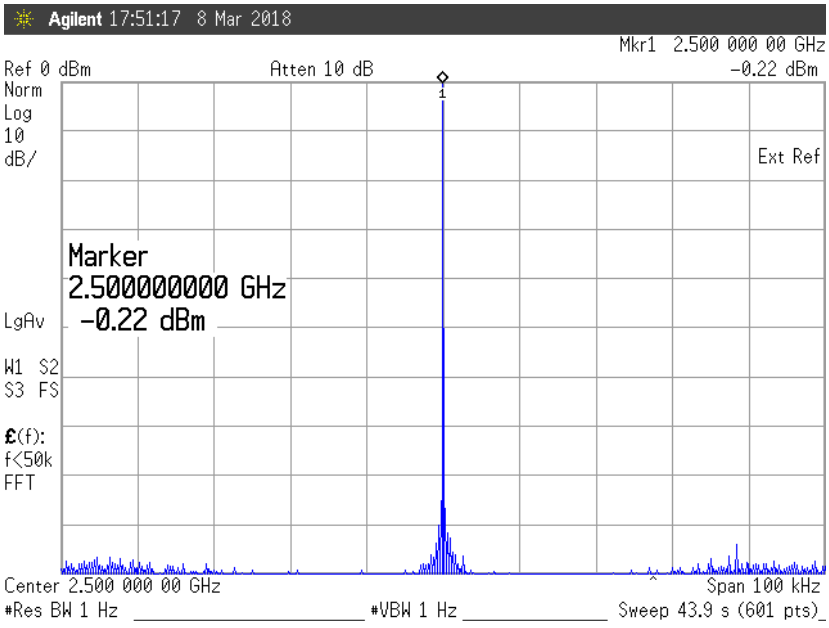



Figure 6: ERASynth+ Narrow-band Spurious Performance at 2.5 GHz

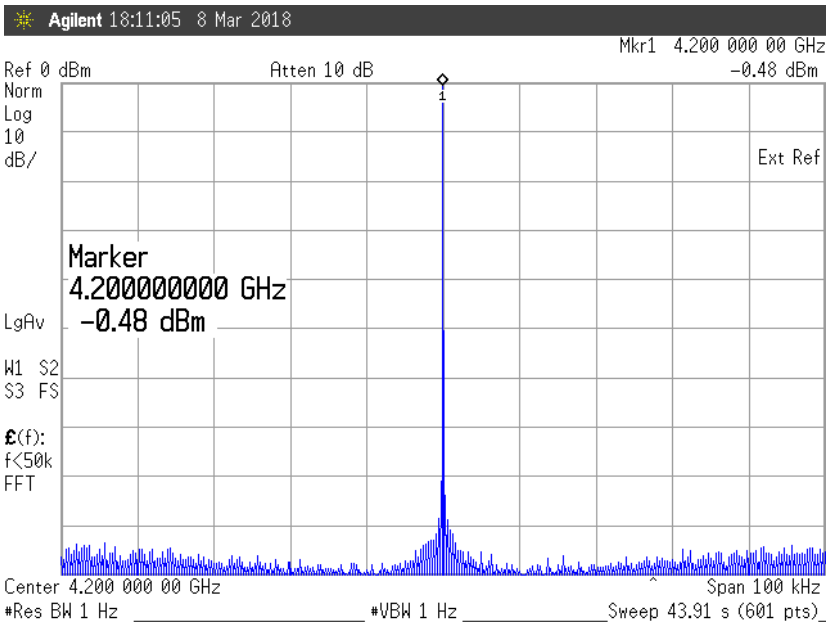



Figure 7: ERASynth+ Narrow-band Spurious Performance at 4.2 GHz

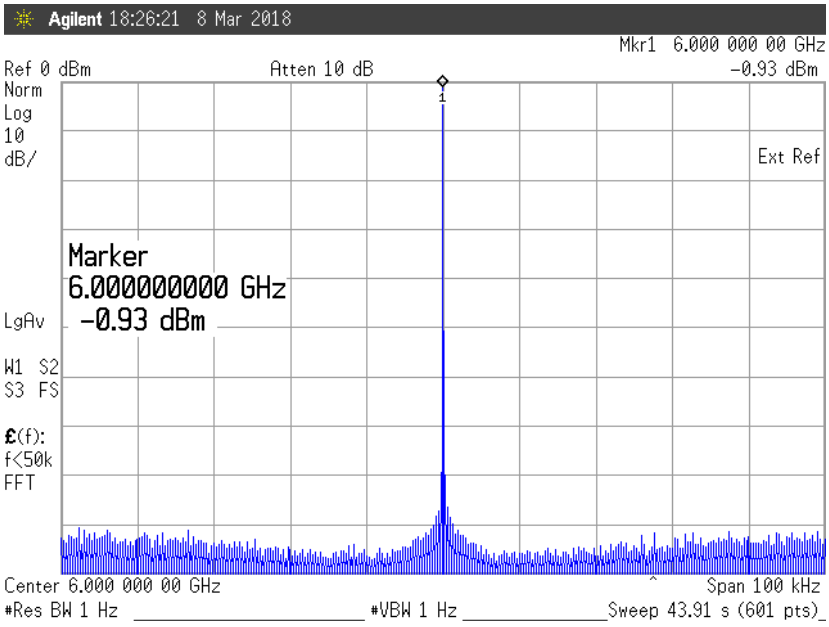



Figure 8: ERASynth+ Narrow-band Spurious Performance at 6 GHz

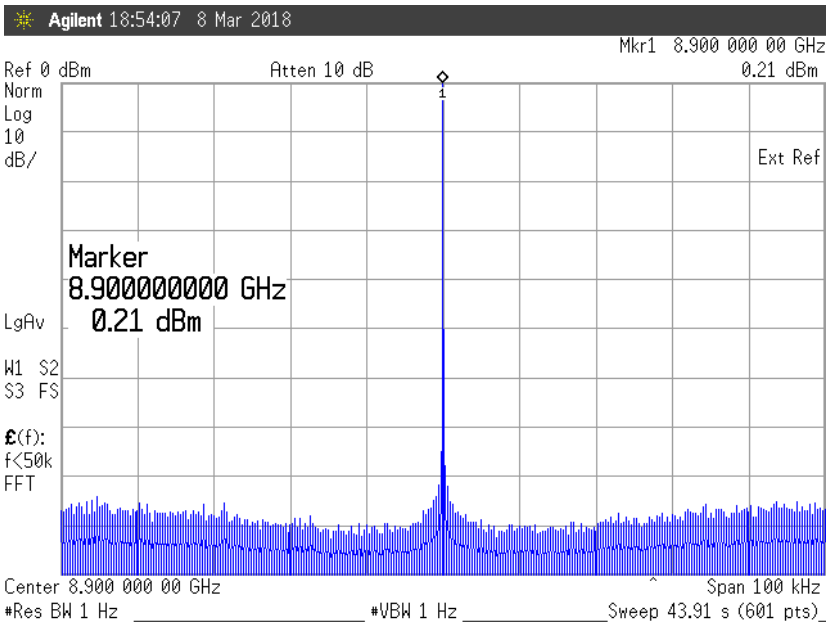



Figure 9: ERASynth+ Narrow-band Spurious Performance at 8.9 GHz

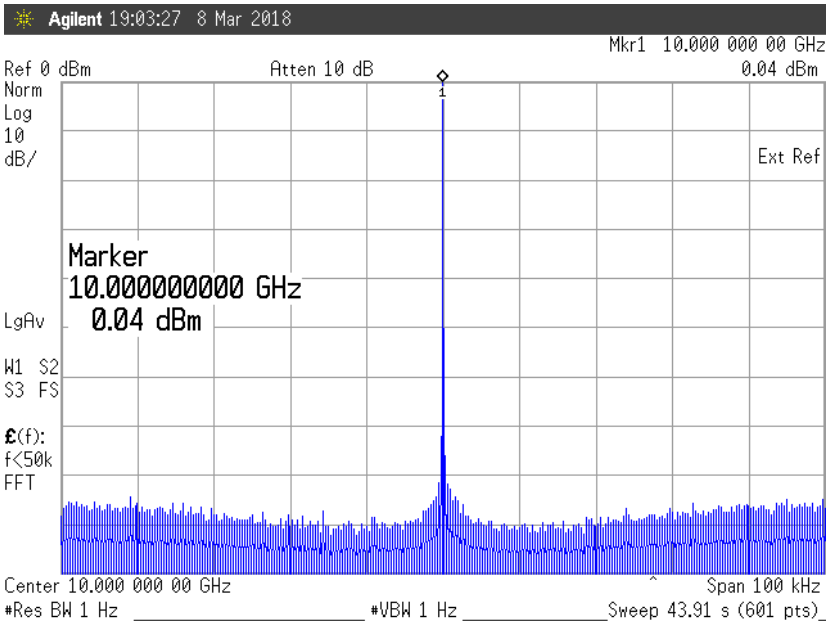



Figure 10: ERASynth+ Narrow-band Spurious Performance at 10 GHz

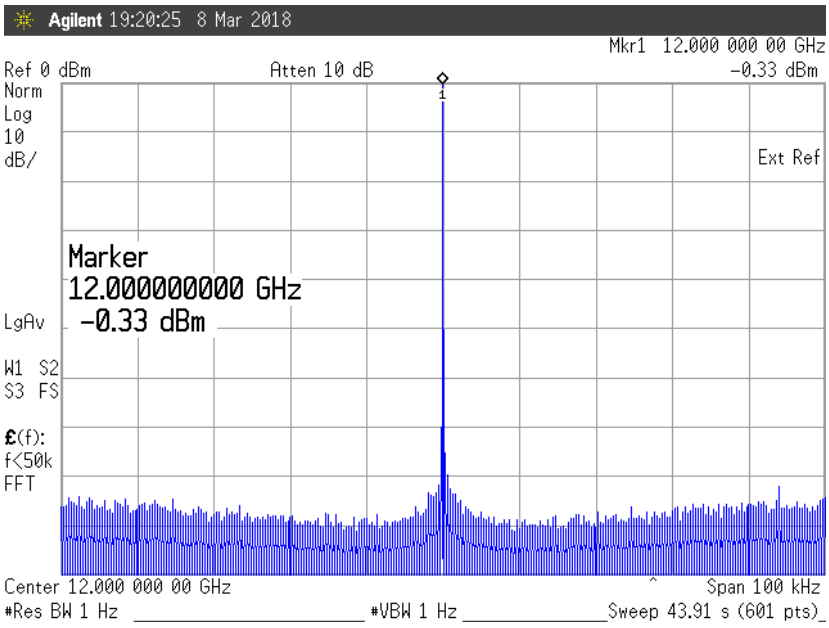



Figure 11: ERASynth+ Narrow-band Spurious Performance at 12 GHz

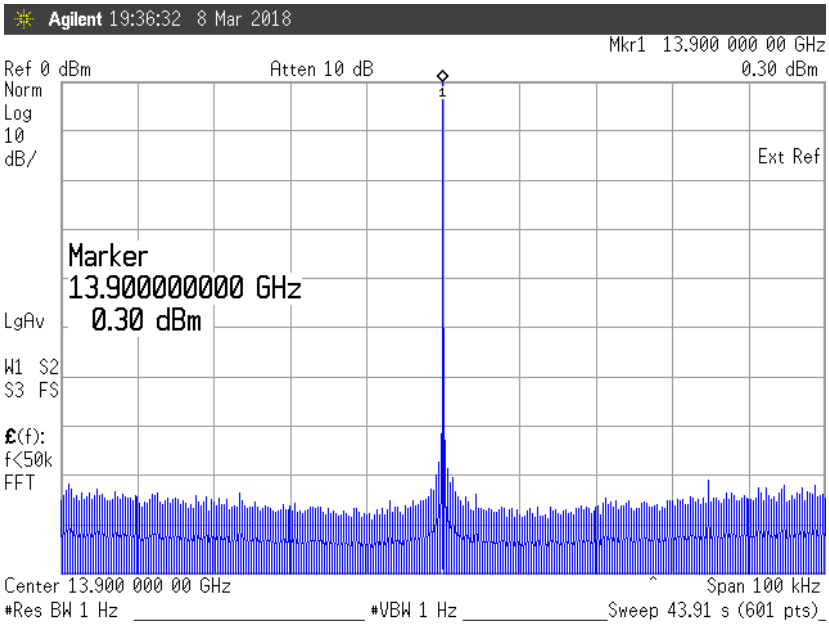



Figure 12: ERASynth+ Narrow-band Spurious Performance at 13.9 GHz

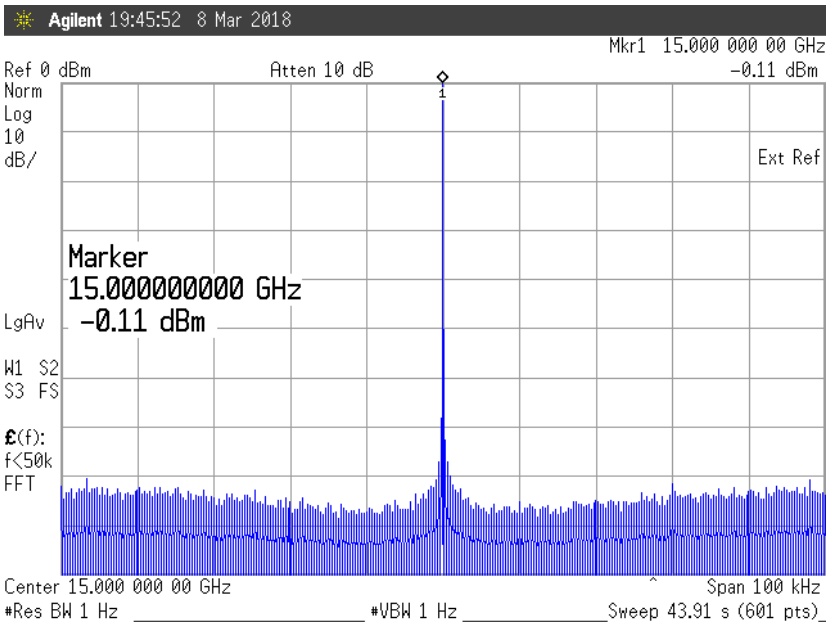



Figure 13: ERASynth+ Narrow-band Spurious Performance at 15 GHz

# 3. Phase Noise

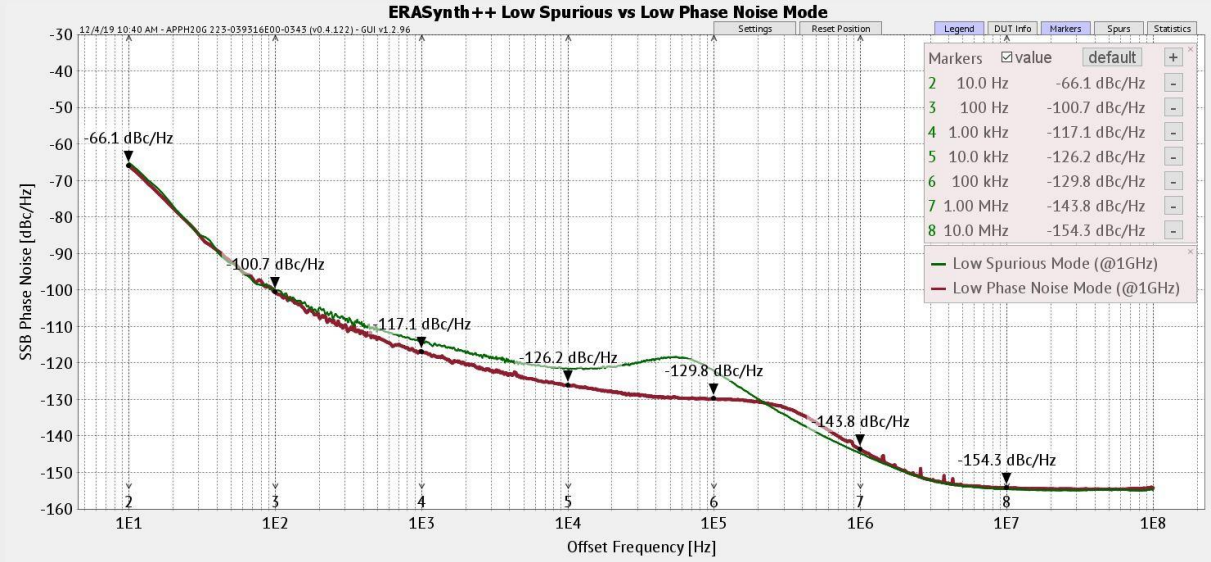



Figure 14: ERASynth++ Phase Noise Performance at 1 GHz RF Output (Low Spurious Mode vs Low Phase Noise Mode)

## 3.1. Low Spurious Mode

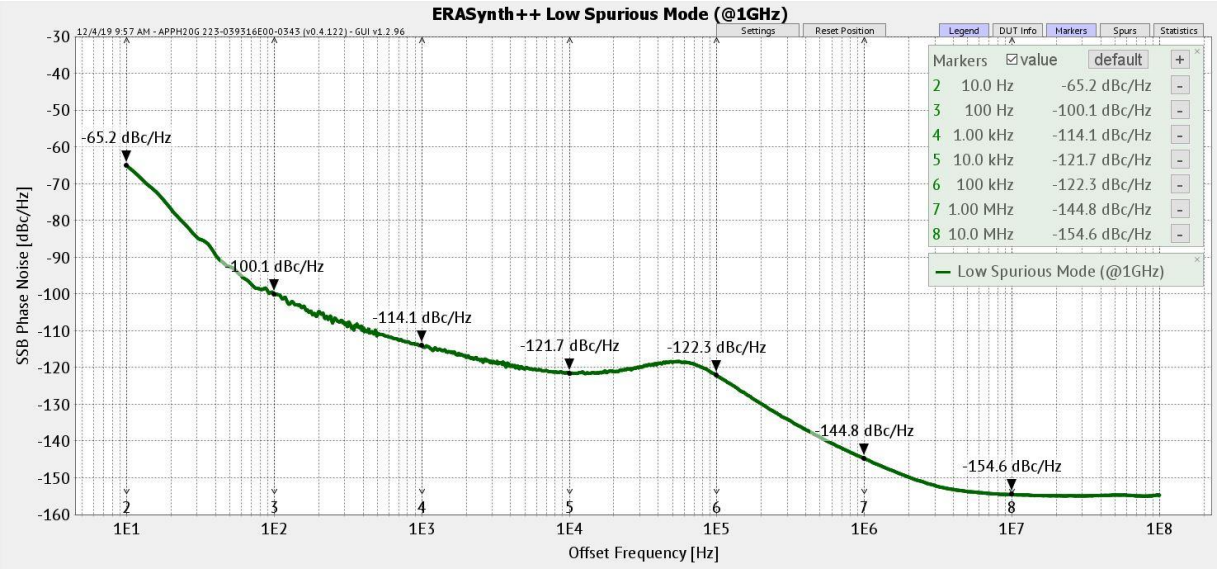



Figure 15: ERASynth++ Phase Noise Performance at 1 GHz RF Output

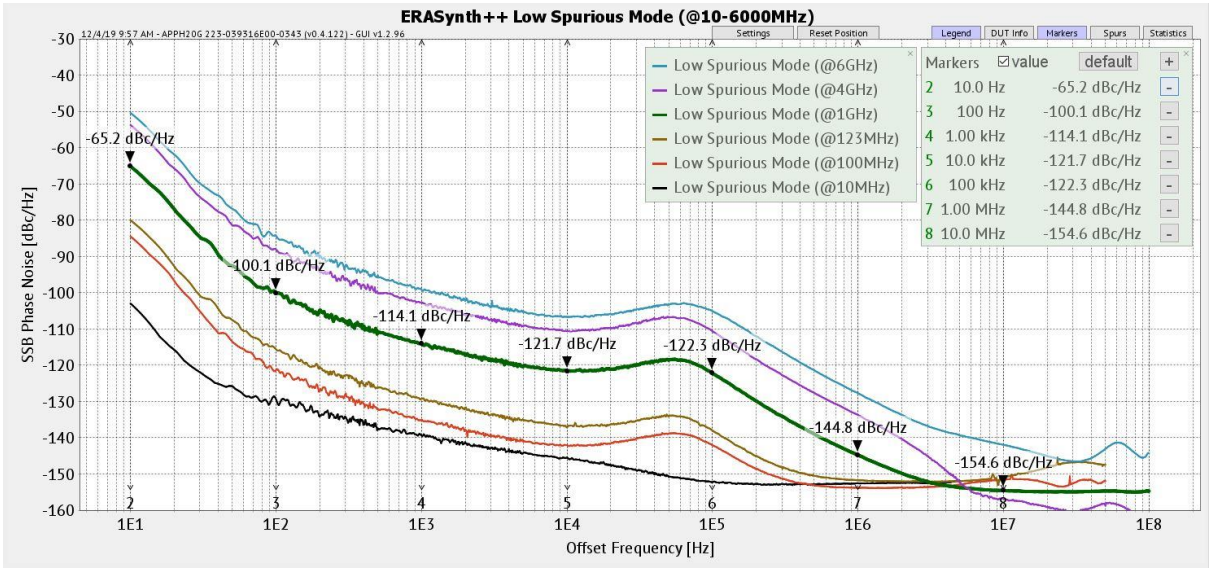



Figure 16: ERASynth++ Phase Noise Performance at Various RF Output (10 MHz to 6000 MHz)


Figure 17: ERASynth++ Phase Noise Performance at Various RF Output (10 GHz to 19 GHz)

## 3.2. Low Phase Noise Mode

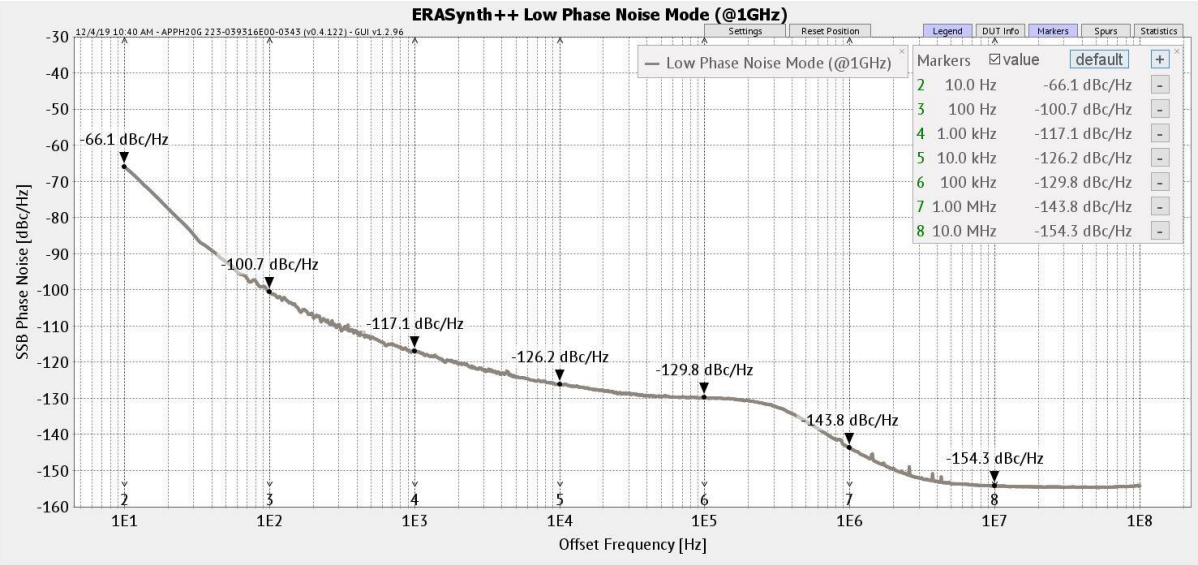



Figure 18: ERASynth++ Phase Noise Performance at 1 GHz RF Output

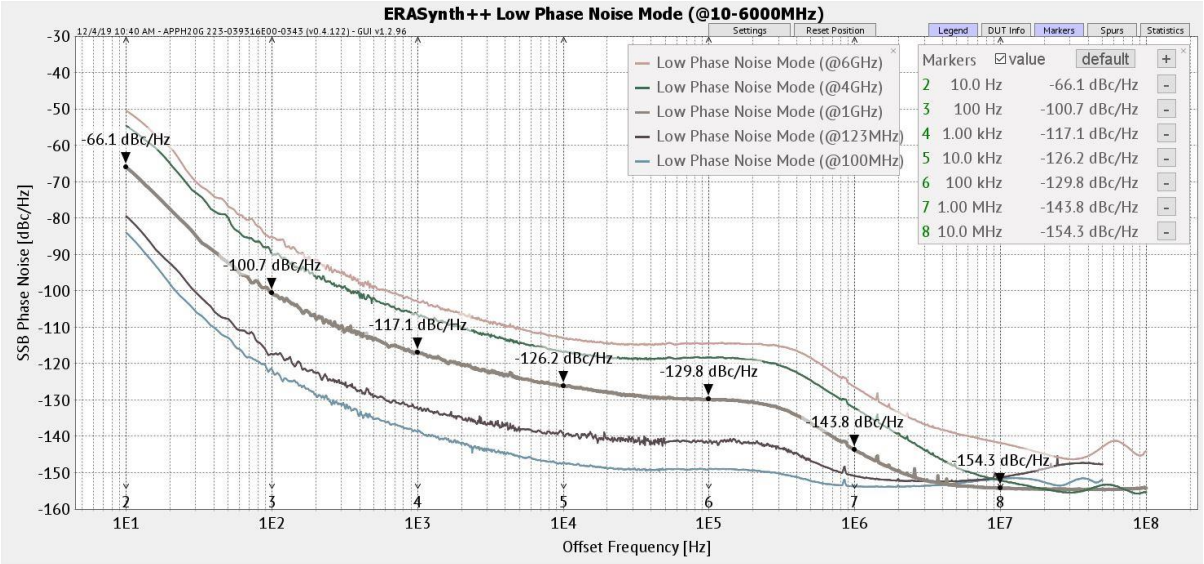



Figure 19: ERASynth++ Phase Noise Performance at Various RF Output (10 MHz to 6000 MHz)

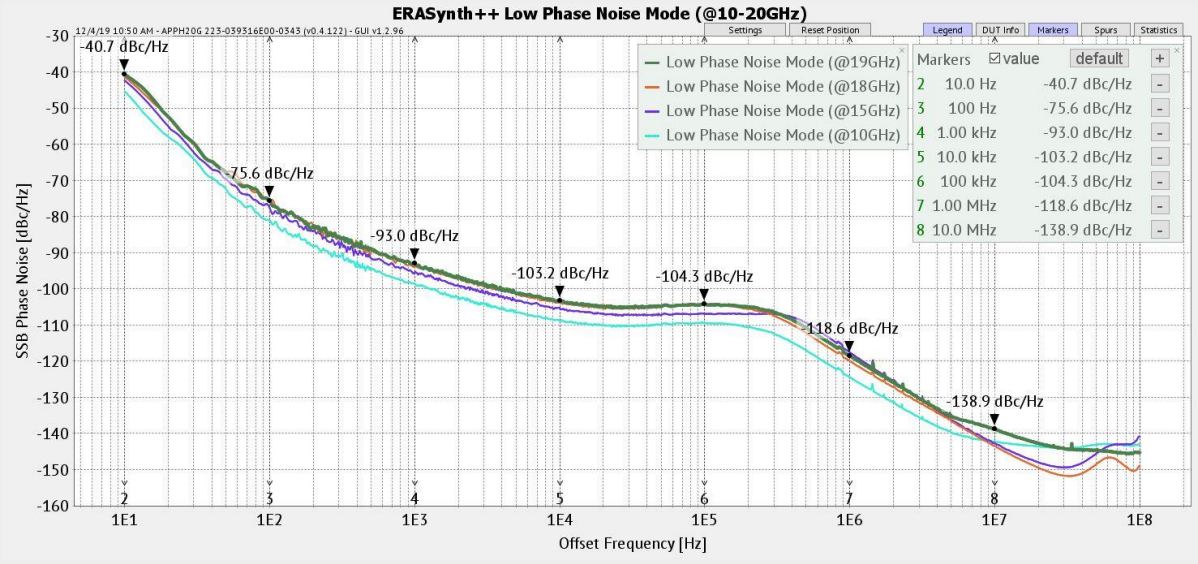



Figure 20: ERASynth++ Phase Noise Performance at Various RF Output (10 GHz to 19 GHz)

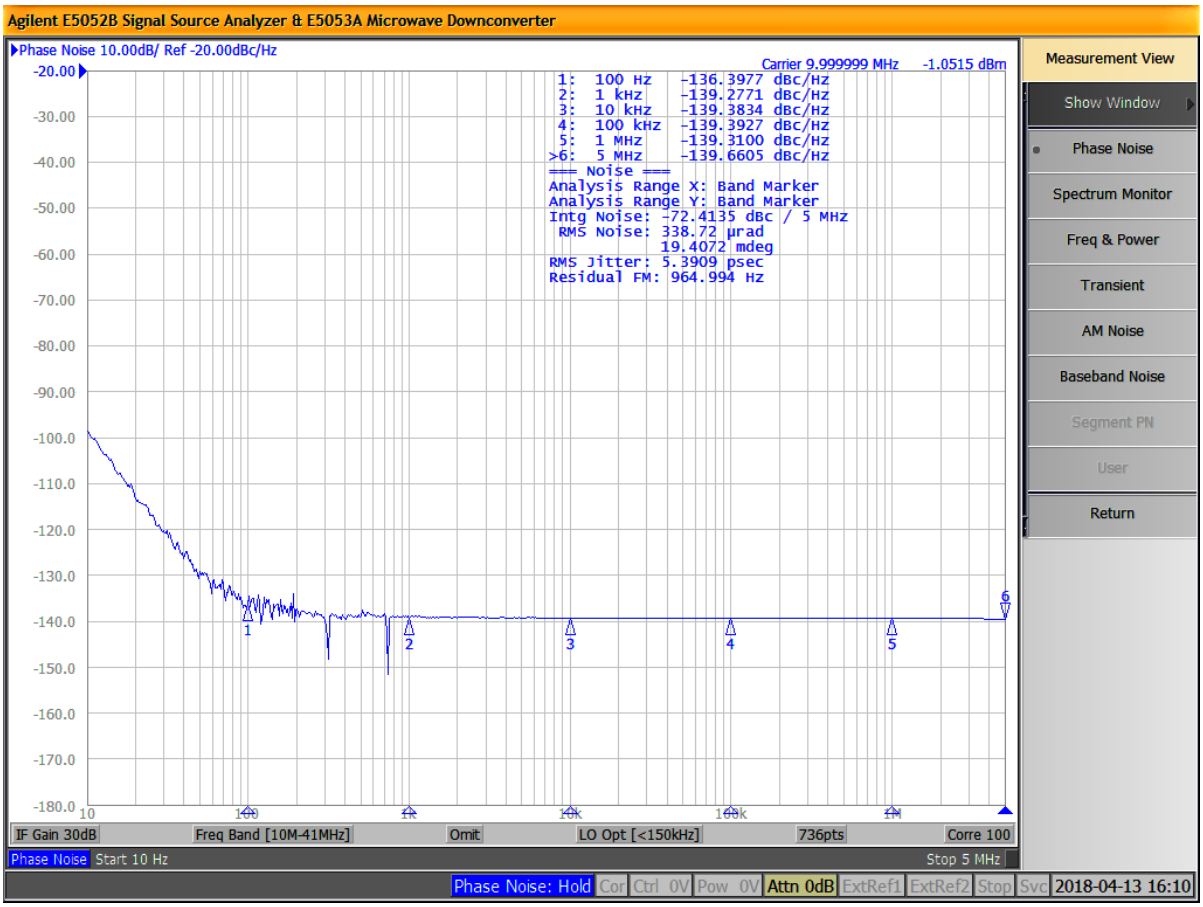



Figure 21: ERASynth+ 10 MHz REF OUT Phase Noise (Internal REF Source is selected as OCXO)

# 4. Operating Modes

ERASynth has two operating modes: Low Spurious Mode and Low Phase Noise mode.

The mode can be changed according to user application and requirements. There are some trade-offs that are explained as follow.

## 4.1. Low Spurious Mode

This mode is the default mode.

ERASynth uses multiloop Integer-N PLL driven by a tunable reference. Thanks to this multiloop architecture there is no fractional-N or integer boundary spurs at the output signal. However, this mode consumes more power and the phase noise increases slightly.

## 4.2. Low Phase Noise Mode

In Low Phase Noise mode one of the PLL IC is bypassed and powered down. In this way, ERASynth not only consumes about 2W less power but also the phase noise improves about 3dB. But the spur levels increase.

Note that this mode can be activated when the output frequency is above 30 MHz.

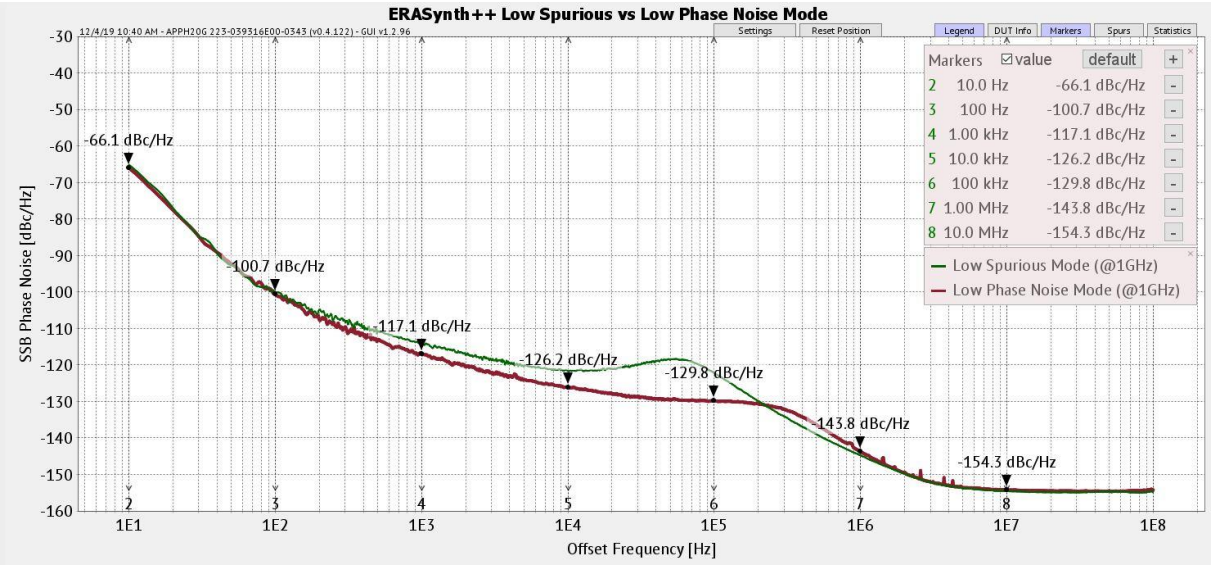



Figure 22: ERASynth++ Phase Noise Performance at 1 GHz RF Output (Low Spurious Mode vs Low Phase Noise Mode)

## 5. Phase Shift

Phase shift is only available in Low Phase Noise mode. Maximum shift amount that can be applied to the device at once is dependent on frequency. Nevertheless, multiple shift command can be applied one after another for getting desired amount of phase shift.

| | | |
|---|---|---|
| Maximum Phase Shift Amount at Once* | 30 MHz | 1 degree (typ) |
| | 100 MHZ | 3 degree (typ) |
| | 1 GHz | 44 degree (typ) |
| | 5 GHz | 179 degree (typ) |
| | 10 GHz | 359 degree (typ) |
| *Phase shift is available at frequencies higher than 30 MHz. | | |

# 6. Modulation

## Amplitude Modulation (AM)

| | |
|---|---|
| Modulation Depth | 30 dB (typ) (*) |
| Maximum Depth (Linear) | %95 |
| Internal Modulation Waveforms | Sine, Triangle, Ramp, Square |
| Maximum Internal Modulation Frequency | 30 kHz (typ) |
| Maximum External Modulation Frequency | 20 kHz (typ) |
| External Input | ± 1.65 V (typ) |
| External Input Impedance | 8 kΩ (typ) |
| *Measured with power set at max. amplitude range. AM is clipped when available power (min. or max.) is reached. | |

## Narrow Band Frequency Modulation (NBFM)

| | | |
|---|---|---|
| Maximum Deviation | 1 MHz<br>10 MHz<br>100 MHz<br>1 GHz<br>10 GHz | 45 Hz (typ)<br>450 Hz (typ)<br>4500 Hz (typ)<br>45 kHz (typ)<br>450 kHz (typ) |
| Frequency Shift (*) | 27.5 °C<br>40.0 °C<br>43.5 °C<br>45.3 °C | 5 ppm (typ)<br>1 ppm (typ)<br>400 ppb (typ)<br>170 ppb (typ) |
| Internal Modulation Waveforms | Sine, Triangle, Ramp, Square | |
| Maximum Internal Modulation Frequency | 30 kHz (typ) | |
| Maximum External Modulation Frequency | 20 kHz (typ) | |
| External Input | ± 1.65 V (typ) | |
| External Input Impedance | 8 kΩ (typ) | |
| *When NBFM modulation is enabled, voltage control input of VCXO is switched to an internal DAC. That causes a frequency shift. Temperature values are read from internal sensor | | |

### Wide Band Frequency Modulation (WBFM)

| | | |
|---|---|---|
| Minimum deviation | 100 MHz<br>1 GHz<br>3 GHz<br>10 GHz | 5 kHz (typ)<br>10 kHz (typ)<br>30 kHz (typ)<br>100 kHz (typ) |
| Maximum deviation | 100 MHz<br>1 GHz<br>3 GHz<br>10 GHz | 500 kHz (typ)<br>5 MHz (typ)<br>9.9 MHz<br>9.9 MHz |
| Internal Modulation Waveforms | Sine, Triangle, Ramp, Square | |
| Maximum Internal Modulation Frequency | 30 kHz (typ) | |
| Maximum External Modulation Frequency | 20 kHz (typ) | |
| External Input | ± 1.65 V (typ) | |
| External Input Impedance | 8 kΩ (typ) | |

## Pulse Modulation

| | | |
|---|---|---|
| On/Off Ratio | 250 kHz-100 MHz<br>1 GHz<br>3 GHz<br>6 GHz<br>10 GHz<br>15 GHz | >90 dB (typ)<br>88 dB (typ)<br>82 dB (typ)<br>76 dB (typ)<br>65 dB (typ)<br>75 dB (typ) |
| Minimum Pulse Width ([1]) | 30 us (typ) | |
| Minimum Pulse Period ([2]) | 60 us (typ) | |
| Maximum Pulse Period | 999 s | |
| Rise Time (10 to 90%) | 15 us (typ) | |
| Fall Time (10 to 90%) | 6 us (typ) | |
| External Input | +3.3 V = RF ON, 0 V = RF OFF | |
| External Input Impedance | 8 kΩ (typ) | |

[1] Minimum Pulse Width is 130us and Minimum Pulse Period is 260us if the embedded firmware version is older than v1.0.11

[2] Pulse period must be at least 30 us higher than the pulse width value.