

# Model 845-HP Datasheet

Portable 20+ GHz Microwave Signal Generator  
High Power +23dBm Power Output



**Berkeley Nucleonics**  
Test, Measurement and Nuclear Instrumentation since 1963

## Introduction

The Model 845-HP is a low-noise and fast-switching microwave signal generator covering a continuous frequency range from as low as 100 kHz up to 20.4 GHz with a 0.001 Hz resolution.

The Model 845-HP is a wide and accurately levelled output power range (up to +23 dBm) and high spurious suppression. Advanced frequency synthesis with fractional-N divider makes for low SSB phase noise and micro-Hz resolution. Power Level extension is available to accurately level below -100 dBm.

The Model 845-HP includes amplitude modulation (AM), DC-coupled, low distortion wideband frequency modulation (FM), PM, FSK and PSK, frequency chirp, and fast pulse modulation with internal pulse train generator. Three internal modulations sources are available. All modulation modes of the Model 845-HP can be combined. This allows the generation of complex modulation signals for modern communication and location systems. The combination of FM and AM can be used to check fading effects of FM receivers. The combination of pulse modulation and FM simulates Doppler effects or chirp signals.

Simultaneous AM and pulse modulation provides the types of signal occurring in pulse radar applications with rotating antenna.

Both Model 845-HP models allow fast analog and digital sweeps including flexible list sweeps, where frequency, power and dwell times can be set individually. A flexible triggering capability simplifies synchronization within test environments.

The Model 845-HP's operate with an ultra-stable temperature compensated 100 MHz reference (OCXO) to ensure minimal drift, and can be phase-locked to any stable external reference in a range from 1 to 200 MHz. Additionally, optimum phase synchronous signals can be achieved by bypassing internal and feeding a 100 MHz signal directly as reference.

The Model 845-HP's support various standard interfaces such as USB-TMC, LAN, and GPIB.

It is targeted for applications where a high-quality CW microwave source with versatile modulation is required. It offers an alternative to expensive high-end microwave signal generators, where small size and excellent microwave performance at an attractive cost is required.

Applications for the Model 845-HP include:

- R&D low noise microwave source
- Production testing (industry-leading switching times; high dynamic range)
- Service and maintenance (battery operation)
- Signal simulation (Radar, WiMax, UWB)
- Aerospace & Defence (Pulse modulator, Chirps)

## Signal Specification

The specifications in the following pages describe the warranted performance of the signal generator for  $23 \pm 10$  °C after a 30 minute warm-up period and for all configurations (options 7096 if not explicitly stated). Typical specifications describe expected, but not warranted performance. Min and Max specifications are warranted.

Parameter	Min.	Typ.	Max.	Note
CW mode				
Frequency range	100 kHz		20 GHz	
resolution		0.001 Hz		
Phase resolution		0.1 deg		
Frequency update rate		400 μs		time from receipt of SCPI command
List/Sweep mode		400 μs		
SSB Phase noise at 10 GHz				
at 1 kHz from carrier		-100 dBc/Hz		
at 20 kHz from carrier		-108 dBc/Hz		
Wideband noise		-150 dBc/ Hz		
Amplitude Noise at 10 GHz		-130 dBc/Hz -140 dBm		Pout=+10 dBm, 100 kHz offset noise floor

## Signal Specification continuing

Parameter	Min.	Typ.	Max.	Note
<b>Output power</b>				
Range without option 7096				
< 18 GHz	-20 dBm		+24 dBm	
> 18 GHz	-20 dBm		+21 dBm	
Range WITH option 7096				
< 18 GHz	-90 dBm		+21 dBm	
> 16 GHz, see plot	-90 dBm		+17 dBm	
Level resolution		0.01 dB		
Level uncertainty, ALC on		0.3 dB	< 1 dB	> -15 dBm
User flatness correction		up to 2000 points	< 1.5 dB	< -15 dBm
Output impedance		50 $\Omega$		
VSWR		2.0		
<b>Reverse Power Protection</b>				
DC Voltage			$\pm 15$ V	
RF power			30 dBm	
Spectral purity at + 5 dBm				
Output harmonics		-40 dBc	-35 dBc	0.1 to 5.0 GHz
		-35 dBc	-25 dBc	5.0 to 10.0 GHz
		-40 dBc	-30 dBc	> 10.0 GHz
Sub -harmonics				
		-75 dBc	-65 dBc	
Non -harmonic spurious				
		-75 dBc	-60 dBc	
Residual FM @ 10 GHz		15 Hz		0.3 kHz to 3 kHz, weighted (ITU-T), RMS
Residual AM @ 10 GHz		0.02 %		RMS value (0.01 kHz to 15 kHz)

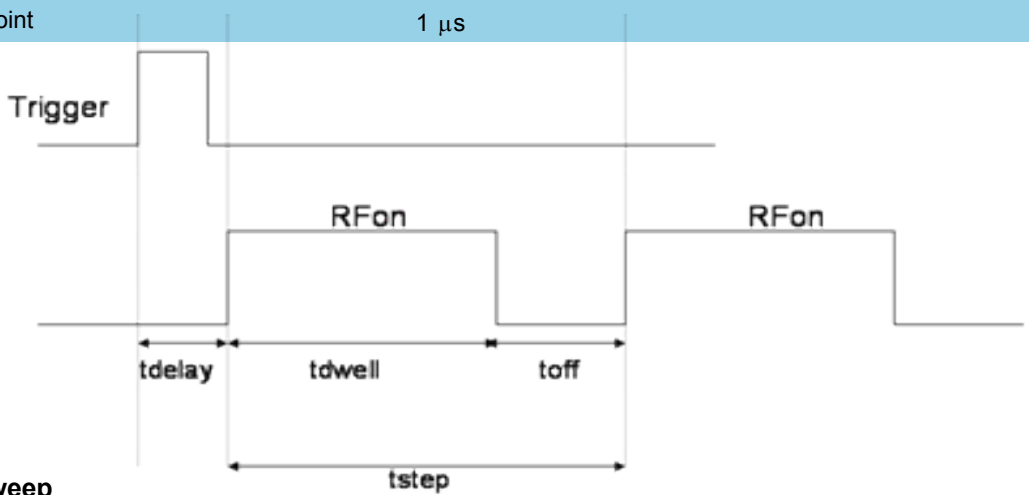
## Sweeping Capability

Sweeps can be performed with combined internal or external AM/FM/PM/pulse modulation running. With modulation enabled, the minimum step time increases to 2 ms.

Parameter	Min.	Typ.	Max.	Note
<b>Digital frequency sweep</b>				
Sweep type: linear, logarithmic, random				
Step time ( $t_{step}$ )	500 $\mu$ s		19998 s	

## Sweeping Capability continued

Parameter	Min.	Typ.	Max.	Note
Dwell time ( $t_{dwell}$ )	10 $\mu$ s		9999 s	
Off-time (incl. transient time) ( $t_{off}$ )	0 / 50 $\mu$ s		9999 s	
Timing accuracy per point		1 $\mu$ s		



The diagram shows a Trigger pulse that initiates a sweep. Following the trigger, there is a delay interval ( $t_{delay}$ ) before the RF signal (RFon) begins. The RF signal is active for a dwell time ( $t_{dwell}$ ), then turns off for an off-time ( $t_{off}$ ). The total time for one step is  $t_{step}$ , which is the sum of  $t_{delay}$ ,  $t_{dwell}$ , and  $t_{off}$ . The diagram also indicates a typical timing accuracy of 1  $\mu$ s.

**Generalized list sweep**  
allows individual setting of frequency, power, dwell-time, and off-time for each point

List size	2	65'000	
Step time ( $t_{step}$ )	500 $\mu$ s	19998 s	mechanical attenuator not used
Dwell time ( $t_{dwell}$ )	50 $\mu$ s	9999 s	
Off-time (incl. transient time) ( $t_{off}$ )	0 / 50 $\mu$ s	9999 s	
Time resolution		0.1 $\mu$ s	
Timing accuracy per point		1 $\mu$ s	

**Ramp (analog) sweep**

Sweep span		20 %	of carrier frequency
Sweep rate	tbd	N · 5 GHz / ms	
Sweep time	0.1 ms	100 ms	

**Frequency Chirps**  
(linear ramp, up/down)

Bandwidth	10%		of carrier frequency
Dwell time ( $t_{dwell}$ )	10 ns	100 $\mu$ s	
Number of frequencies		65'000	

## Reference Frequency

REF IN input and REF OUT output are at rear panel

Parameter	Min.	Typ.	Max.	Note
<b>Internal reference frequency</b>		100 MHz		
Initial accuracy			±40 ppb	calibrated at 23 ± 3 °C at time of calibration
Temperature stability (0 to 50 degC)			±100 ppb	
Aging 1 <sup>st</sup> year		0.5 ppm		
Aging per day (after 30 days operations)			5 ppb	
Warm-Up time		5 min		
Output of internal reference		10 MHz 10/100 MHz		
Output power		0 dBm		
Output impedance		50 Ohms		
Bypass Internal reference Input		100 MHz, -5 to +10 dBm		High phase synchronus mode
Phase Lock to External Reference				
External Input Range	1 MHz		250 MHz	User programmable
Reference input level	-5 dBm	0 dBm	+13 dBm	
Lock Range			±1.5 ppm	
Reference input impedance		50 Ohms		

## Multi Purpose Output (FUNC OUT)

Output is FUNC OUT at rear panel

Parameter	Min.	Typ.	Max.	Note
<b>MULTIFUNCTION GENERATOR</b>		sine, triangle, square wave		
Frequency range	1 Hz		3 MHz	sine
	1 Hz		1 MHz	triangle
			50 kHz	square
Frequency resolution		0.1 Hz		
Output voltage amplitude peak-peak	10 mV	5V	2 V	Sine, triangle, Square (CMOS output)
Harmonic Distortion		1 %		< 100 kHz, 1 Vpp
Output impedance		50 Ohms CMOS		Sine, triangle square wave
<b>VIDEO OUTPUT (of internal pulse modulator)</b>				
Output		CMOS		
Period	30 ns		50 s	

## Multi Purpose Output (FUNC OUT) continued

Parameter	Min.	Typ.	Max.	Note
Pulse Width	15 ns		50 s	
RF delay		10 ns		
<b>TRIGGER OUT</b>	<b>Synchronization mode for multiple sources</b>			
Modes		Trigger on sweep start Trigger on each point		
Trigger waveform pulse width		100 ns		

## Trigger (TRIG IN)

Input is TRIG IN at rear panel

Parameter	Min.	Typ.	Max.	Note
<b>Trigger Types</b>	<b>Continuous, single, gated, gated direction</b>			
Trigger Source	<b>RF key, external, bus (GPIB, LAN, USB)</b>			
Trigger Modes	<b>Continuous free run, trigger and run, reset and run</b>			
Trigger latency		tbd		
Trigger uncertainty		5 $\mu$ s		
External Trigger delay	50 $\mu$ s		40 s	
External Delay Resolution		15 ns		
Trigger Modulo	1		255	Execute only on Nth trigger event
Trigger Polarity		Rising, falling		

## Modulation Capabilities

Combined AM/PM/FM/PULSE possible (see user manual)

Parameter	Min.	Typ.	Max.	Note
Multifunction Generator	sine, triangle, square wave			
Output is FUNC OUT at rear panel				
Frequency range	1 Hz		3 MHz	sine
	1 Hz		1 MHz	triangle
			50 kHz	square
Frequency resolution	0.1 Hz			
Output voltage amplitude peak-peak	10 mV		2 V	Sine, triangle

## Modulation Capabilities continued

Parameter	Min.	Typ.	Max.	Note
Output voltage amplitude peak-peak		5V		Square (CMOS output)
Harmonic Distortion		1 %		< 100 kHz, 1 Vpp
Output impedance		50 Ohms CMOS		Sine, triangle square wave
<b>Pulse Modulation</b>				
On/off ratio		70 dB		<b>at +10 dBm</b>
Repetition frequency	DC		10 MHz	
Pulse width	30 ns 500 ns			ALC hold ALC on
Pulse rise/fall time		7 ns		
Pulse trains length (pulses)	2		4192	
Pulse width	30 ns		100 $\mu$ s	
Pulse resolution		15 ns		
Polarity		selectable		
External input amplitude		1 V TTL		AC DC
<b>Frequency Modulation</b>				
Maximum Frequency deviation (peak)		$> 0.05 \cdot f$ $N \cdot 200 \text{ MHz}$		$< 1.25 \text{ GHz}$ $1.25 \text{ GHz to } 2.5 \text{ GHz } (N=0.125)$ $2.5 \text{ GHz to } 5 \text{ GHz } (N=0.25)$ $5 \text{ GHz to } 10 \text{ GHz } (N=0.5)$ $> 10 \text{ GHz to } 20 \text{ GHz } (N=1)$
Modulation rate	DC		800 kHz	$> -3\text{dB}$ frequency response
Modulation waveforms		Sine, triangle, FSK		
External input sensitivity				
AC		0 to $N \cdot 200 \text{ MHz} / \text{V}$		adjustable for $\pm 1 \text{ V}$ range
DC		0 to $N \cdot 100 \text{ MHz} / \text{V}$		discr. values ; $\pm 5 \text{ V}$ range
Total harmonic distortion		$< 1\%$		1 kHz rate & $N \cdot 1 \text{ MHz}$ deviation
<b>Phase Modulation</b>				
Phase deviation (peak)	0		$N \cdot 300 \text{ rad}$	$< 1.25 \text{ GHz}$ $> 1.25 \text{ GHz}$
Modulation rate	DC		800 kHz	$> -3\text{dB}$ frequency response Max. phase deviation degrades above 20 kHz modulation rate
Modulation waveforms		Sine, triangle, FSK		
External Input sensitivity		Settable 0.1 rad/V to 360 rad/V		
Total harmonic distortion		$< 1\%$		1 kHz rate & $N \times 100 \text{ rad}$ deviation

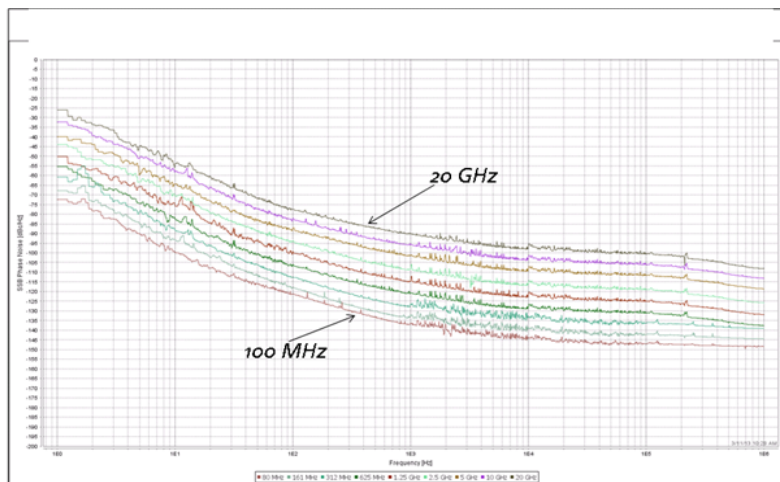


## Modulation Capabilities continued

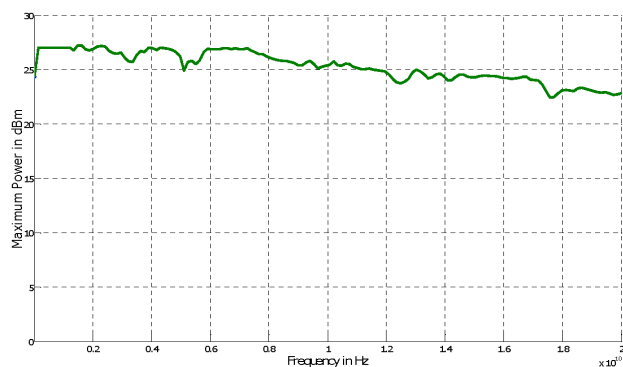
Parameter	Min.	Typ.	Max.	Note
<b>Amplitude Modulation</b>				
Modulation rate	0.1 Hz		20 kHz	
Modulation waveforms	Sine, triangle, square			
Modulation depth	0 %		90 %	
Distortion (sine wave)		2 %		at 60% modulation depth
Accuracy		4 %		

## Typical performance curves

Phase Noise Performance (1 Hz to 50 MHz offset)

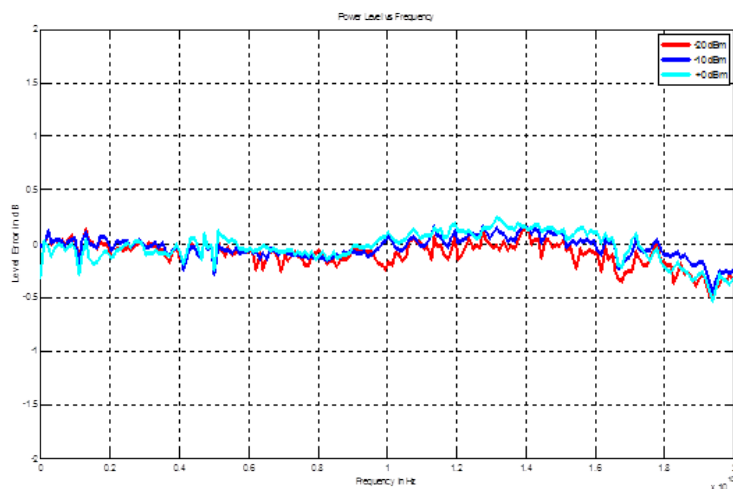


Typical Maximum Output Power (option HP)

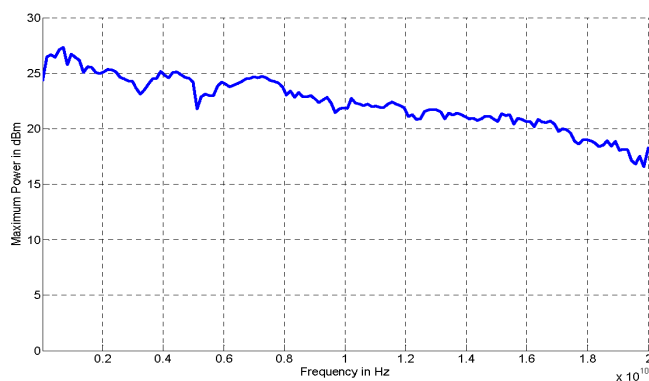


Typical Maximum Output Power (without option 7096)

Typical Frequency Response 0 to 20 GHz at -10, 0, and +10 dBm



Typical Maximum Output Power

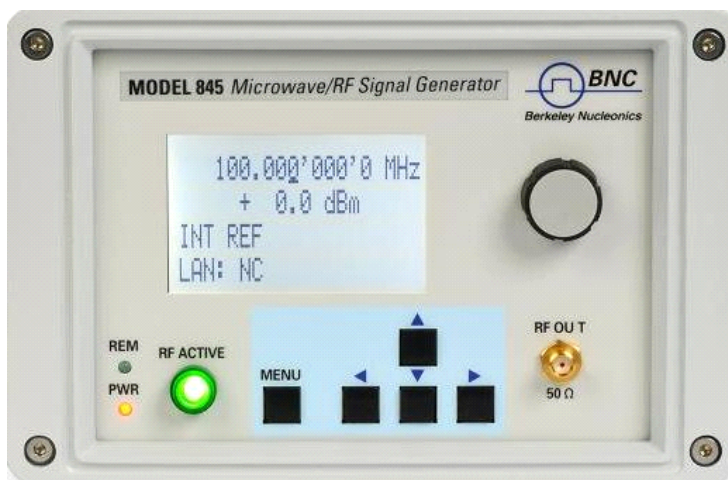


Typical Maximum Output Power (WITH option 7096)



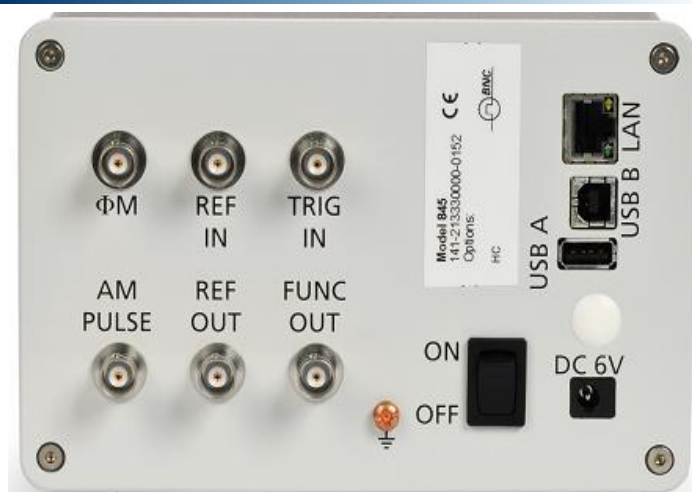
## Connectors

845 Series Front Panel



1. RF output: SMA female
2. RF on/off button
3. Rotary knob
4. Menu and arrow keys

845 Series Rear Panel



1. Trigger input: BNC female
2. Function output: BNC female
3. External reference input: BNC female
4. Internal reference output: BNC female
5. FM/PM modulation input: BNC female
6. AM and Pulse modulation: BNC female
7. LAN connection: RJ-45
8. USB 2.0 host and device
9. GPIB: IEEE-488.2, 1987 with listen and talk (optional)
10. DC Power plug (6V, 2.5A)
11. DC power switch

## General Characteristics

### Options

- 7096: Extended power range down to <-90 dBm) step attenuator module
- 7088: battery module
- 7094: IEEE-488.2,1987 programming interface
- 7091: 19" rackmount enclosure: good for one or two adjacent units.



Figure 1

GPIB: IEEE-488.2,1987 programming interface.

**Weight** = 2.5 kg (6 lbs) net, = 4 kg (8 lb.) shipping

**Dimensions** 106 mm H x 172 mm W x 220 mm L  
[4.21 in H x 6.77 in W x 8.66 in L]

**Recommended calibration cycle** 24 months

#### Remote programming interfaces

Ethernet 100BaseT LAN interface,  
USB 2.0 host & device  
GPIB (IEEE-488.2,1987) with listen and talk (optional)  
Control language SCPI Version 1999.0

#### Power requirements: 6 VDC; 20 W maximum

Mains adapter supplied: 100-240 VAC in/ 6V, 3.3A DC out  
Operating temperature range: 0 to 40 °C  
Storage temperature range: -40 to 70 °C  
Operating and storage altitude up to 15,000 feet

#### CE notice

Safety/EMC Complies  
with applicable Safety and EMC  
regulations and directives.