Synthesized Function Generators

DS345 — 30 MHz function and arbitrary waveform generator

DS345 Function/Arb Generator

- **1 μHz to 30.2 MHz frequency range**
- **1 μHz frequency resolution**
- **Sine, square, ramp, triangle & noise**
- **Phase-continuous frequency sweeps**
- **AM, FM, burst and phase modulation**
- **16,300 point arbitrary waveforms**
- **10 MHz reference input**
- **RS-232 and GPIB interfaces (opt.)**

- **DS345 ... $1595** *(U.S. list)*

The DS345 is a full-featured 30 MHz synthesized function generator that uses an innovative Direct Digital Synthesis (DDS) architecture. It generates many standard waveforms with excellent frequency resolution (1 μHz), and has versatile modulation capabilities including AM, FM, Burst, PM and frequency sweeps. It also generates arbitrary waveforms with a fast 40 Msample/s update rate.

Functions and Outputs

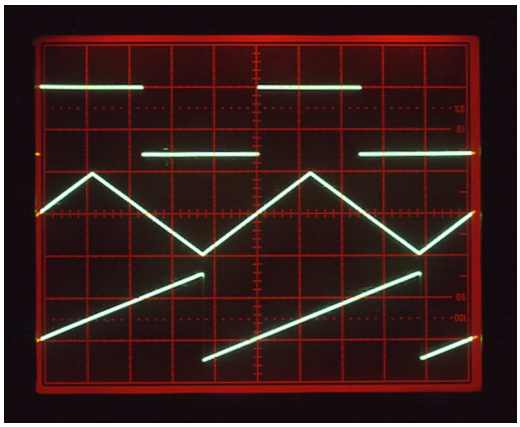
The DS345 generates sine waves and square waves at frequencies up to 30.2 MHz, and triangle and ramp waveforms up to 100 kHz. The frequency resolution for all functions is 1 μHz. In addition to the standard waveforms, the unit also provides a wideband (10 MHz) white noise source.

Both the function output and a TTL SYNC output are available through floating, front-panel BNC connectors. Both outputs have 50 Ω output impedances and may be floated up to ±40 V relative to earth ground. The amplitude of all function outputs is adjustable from 10 mVpp to 10 Vpp with 3-digit resolution, and can be displayed in Vp, Vpp, Vrms or dBm. In addition, standard TTL and ECL output levels can be selected.

Additional useful connectors are provided on the rear panel. A trigger input is used to trigger arbitrary waveforms, modulation patterns, sweeps and bursts, while a TTL trigger output is provided to allow synchronization of external

devices to sweeps and bursts. A sweep output generates a 0 to 10 V ramp synchronous with frequency sweeps. The sweep marker outputs allow specified portions of a frequency sweep to be highlighted on an oscilloscope.

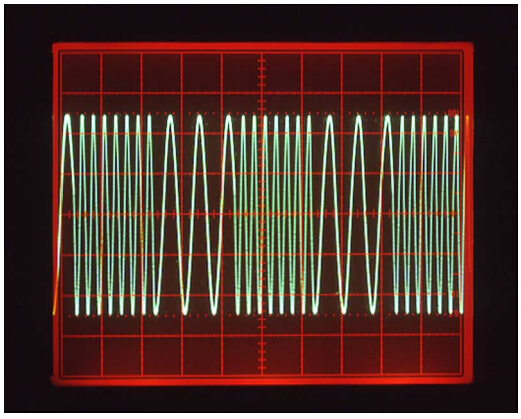
A 10 MHz rear-panel input allows the DS345 to be synchronized to an external timebase. A 10 MHz rear-panel output allows multiple DS345s to be phase locked together.



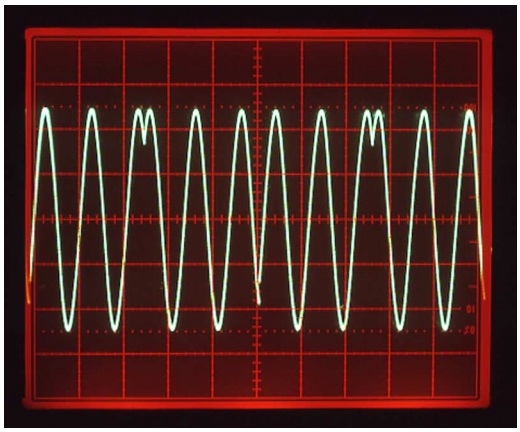
Square, triangle and ramp waveforms

Modulation

The DS345 offers a wide variety of modulation options. It contains an internal modulation generator which can modulate any of its standard waveforms except noise. The modulation waveform can be a sine, square, triangle, ramp, or an arbitrary waveform. Modulation rates from 1 mHz to 10 kHz can be selected.



Frequency modulation

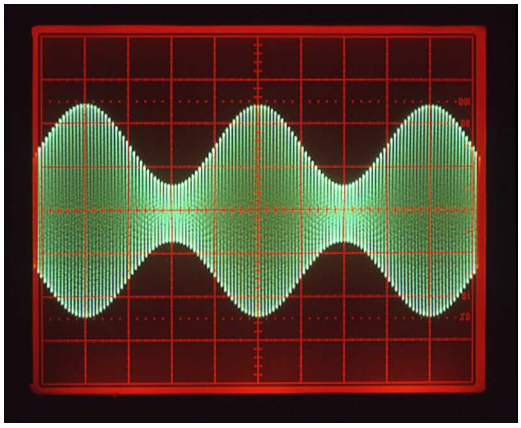


Phase modulation

The modulation generator can provide amplitude modulation (AM), frequency modulation (FM), and phase modulation (PM). When using AM, modulation depths of ±100 % can be selected with 1 % resolution. Negative values of modulation correspond to Double Sideband Suppressed Carrier (DSBSC) modulation. FM spans can be selected with 1 µHz resolution, and phase modulation can be set between 0° and 7200° with 0.001° resolution.

External Amplitude Modulation

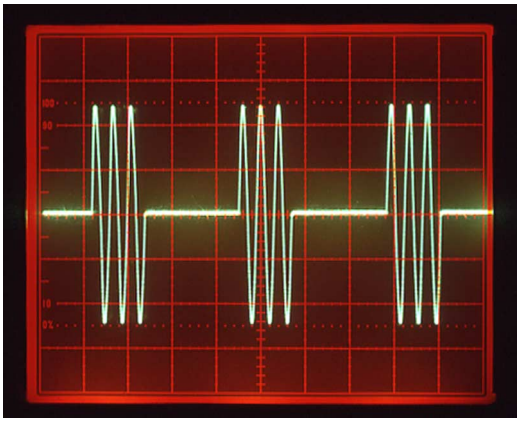
In addition to the internal modulation generator, the output waveform can be amplitude modulated by an external signal applied to the rear-panel AM input. This input is always active—even when other modulation types are turned on.



Amplitude modulation

Burst Modulation

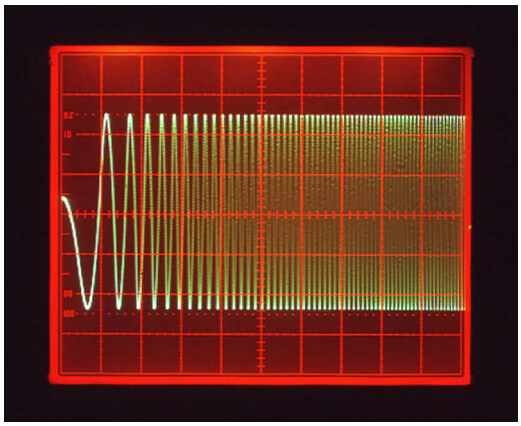
You can generate tone bursts of any output function except noise. In the burst mode, the DS345 will output an exact number of complete waveform cycles after receiving a trigger. By adjusting the phase, you can control where in the waveform the burst begins. While using the burst mode, the maximum frequency for sine waves and square waves is 1 MHz, while triangles and ramps are limited to 100 kHz. Burst mode may be used with arbitrary waveforms at any frequency.



Burst modulation

Frequency Sweeps

The DS345 can frequency sweep any of its function outputs (except noise). You can sweep up or down in frequency using linear or log sweeps. Unlike conventional function generators, there are no annoying discontinuities or band-switching artifacts when sweeping through certain frequencies. The DS345's DDS architecture inherently allows it to perform smooth, phase-continuous sweeps over it's entire frequency range.

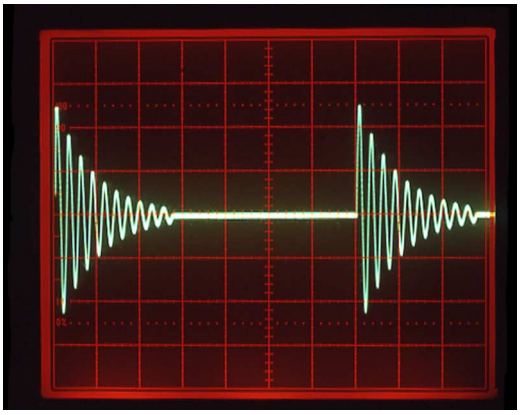


Frequency sweep

Two sweep marker frequencies can be specified. When the sweep crosses either of the marker frequencies, a TTL transition is generated at the rear-panel MARKER output to allow synchronization of external devices.

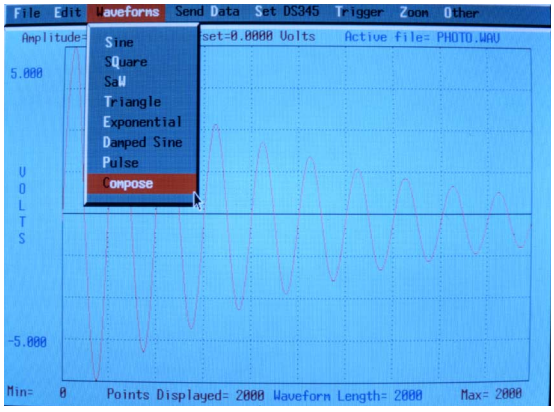
Arbitrary Waveform Capability

The DS345 isn't just a function generator. It's also a full-featured arbitrary waveform generator. Output waveforms have 12-bit vertical resolution, and can be played back at rates up to 40 Msamples/s.



Arbitrary waveform

Since composing complex arbitrary waveforms at the keyboard can be a tedious task, Arbitrary Waveform Composer (AWC) software is provided at no charge. AWC is a menu-based program which lets you create and edit arbitrary waveforms on the screen, store them, and download them to the DS345.



AWC software

Frequency Range

	Max. Freq.	*Resolution*
Sine	30.2 MHz	1 µHz
Square	30.2 MHz	1 µHz
Ramp	100 kHz	1 µHz
Triangle	100 kHz	1 µHz
Noise	10 MHz	(Gaussian weighting)
Arbitrary	10 MHz	40 MHz/N (sample rate)

Output

Source impedance	50 Ω
Grounding	Output may float up to ±40 V (AC + DC) relative to earth ground.

Amplitude

Range	0.01 to 10 Vpp (50 Ω), 20 Vpp (Hi-Z)
Resolution	3 digits (DC offset: 0 V)
Sine wave accuracy	(0 VDC offset)
5 to 10 Vpp	±0.2 dB (1 µHz to 20 MHz) ±0.3 dB (20 MHz to 30.2 MHz)
0.01 to 5 Vpp	±0.4 dB (1 µHz to 20 MHz) ±0.5 dB (20 MHz to 30.2 MHz)
Square wave accuracy	
5 to 10 Vpp	±3 % (1 µHz to 100 kHz) ±6 % (100 kHz to 20 MHz) ±15 % (20 MHz to 30.2 MHz)
0.01 to 5 Vpp	±5 % (1 µHz to 100 kHz) ±8 % (100 kHz to 20 MHz) ±18 % (20 MHz to 30.2 MHz)
Triangle, ramp and arbitrary accuracy	±3 % (>5 Vpp) ±5 % (<5 Vpp)

DC Offset

Range	±5 V (limited such that |VAC peak| + |VDC| < 5 V)
Resolution	3 digits (VAC = 0)
Accuracy	1.5 % of setting + 0.2 mV (DC only) ±0.8 mV to ±80 mV, depending on AC and DC settings

Sine Wave

Spurious components	< –55 dBc (non-harmonic)
Phase noise	< –50 dBc in a 30 kHz band centered on the carrier, exclusive of discrete spurious signals
Sub-harmonic	< –50 dBc
Harmonic distortion	*Level* / *Frequency Range* < –55 dBc / DC to 100 kHz < –45 dBc / 0.1 to 1 MHz < –35 dBc / 1 to 10 MHz < –25 dBc / 10 to 30 MHz

Square Wave

Rise/fall time	<15 ns (10 to 90 %), at full output
Asymmetry	<1 % of period + 4 ns
Overshoot	<5 % of peak to peak amplitude at full output

Ramps, Triangle and Arbitrary Waveforms

Rise/fall time	45 ns (10 MHz Bessel filter)
Linearity	±0.5 % of full-scale output
Settling time	<1 µs to settle within 0.1 % of final value at full output

Arbitrary Waveforms

Sample rate	40 MHz/N, N = 1 to 2^{34}–1
Memory length	8 to 16,300 points
Resolution	12 bits (0.025 % of full scale)

Phase

Range	±7199.999° with respect to arbitrary starting phase
Resolution	0.001°

Amplitude Modulation

Source	Internal (sine, square, triangle or ramp) or External
Depth	0 to 100 % AM or DSBSC
Rate	0.001 Hz to 10 kHz (internal), 15 kHz max. (external)
Distortion	< –35 dB at 1 kHz, 80 % depth
DSB carrier	< –35 dB (typ.) at 1 kHz modulation rate (DSBSC)
External input	±5 V for 100 % modulation, 100 kΩ impedance, 15 kHz BW

Frequency Modulation

Source	Internal (sine, square, triangle, ramp or arbitrary)
Rate	0.001 Hz to 10 kHz
Span	1 µHz to 30.2 MHz (100 kHz for triangle, ramp)

Phase Modulation

Source	Internal (sine, square, triangle, ramp)
Rate	0.001 Hz to 10 kHz
Span	±7199.999°

Frequency Sweep

Type	Linear or log, phase continuous
Waveform	Up, down, up-down, single sweep
Time	0.001 s to 1000 s
Span	1 µHz to 30.2 MHz (to 100 kHz for triangle, ramp)
Markers	Two markers may be set at any sweep point (TTL output)
Sweep output	0 to 10 V linear ramp signal, synchronized to sweep

Burst Modulation

Waveform	Any waveform except noise may be burst modulated.
Frequency	Sine and square to 1 MHz Triangle and ramp to 100 kHz Arbitrary to 40 MHz sample rate
Count	1 to 30,000 cycles/burst (1 µs to 500 s burst time limits)

Trigger Generator

Source	Single, Internal, External, Line
Rate (internal)	0.001 Hz to 10 kHz (2-digit resolution)
External trigger	Positive or negative edge, TTL
Output	TTL level

Standard Timebase

Accuracy	±5 ppm (20 °C to 30 °C)
Aging	5 ppm/year
Input	10 MHz/N ± 2 ppm (N = 1 to 8), 1 Vpp minimum input level
Output	10 MHz, >1 Vpp sine into 50 Ω

Optional Timebase

Type	Ovenized AT-cut oscillator
Stability	<0.01 ppm, 20 °C to 60 °C
Aging	<0.001 ppm/day
Allan variance (1 s)	$<5 \times 10^{-11}$

General

Interfaces	Optional RS-232 (300 to 19.2 kbaud, DCE) and GPIB with DOS based arbitrary waveform software (AWC). All instrument functions are controllable over the interfaces.
Non-volatile memory	Nine sets of instrument settings can be saved and recalled.
Dimensions	8.5" × 3.5" × 13" (WHD)
Weight	10 lbs.
Power	50 W, 100/120/220/240 VAC, 50/60 Hz
Warranty	One year parts and labor on defects in materials and workmanship

DS345 rear panel (with opt. 01)

Ordering Information

DS345	30 MHz function/arb. generator	$1595
Option 01	GPIB, RS-232 and arb. software	$495
Option 02	10 ppb OCXO timebase	$650
O345RMD	Double rack mount kit	$85
O345RMS	Single rack mount kit	$85

SRS Tech Note

What is Direct Digital Synthesis (DDS)?

Direct digital synthesis (DDS) has had a dramatic impact on the best approach to bench-top function generators. Over the last few years, improvements in LSI logic, fast random access memories (RAM), and digital-to-analog converters (DACs) have made DDS the technology of choice for this application.

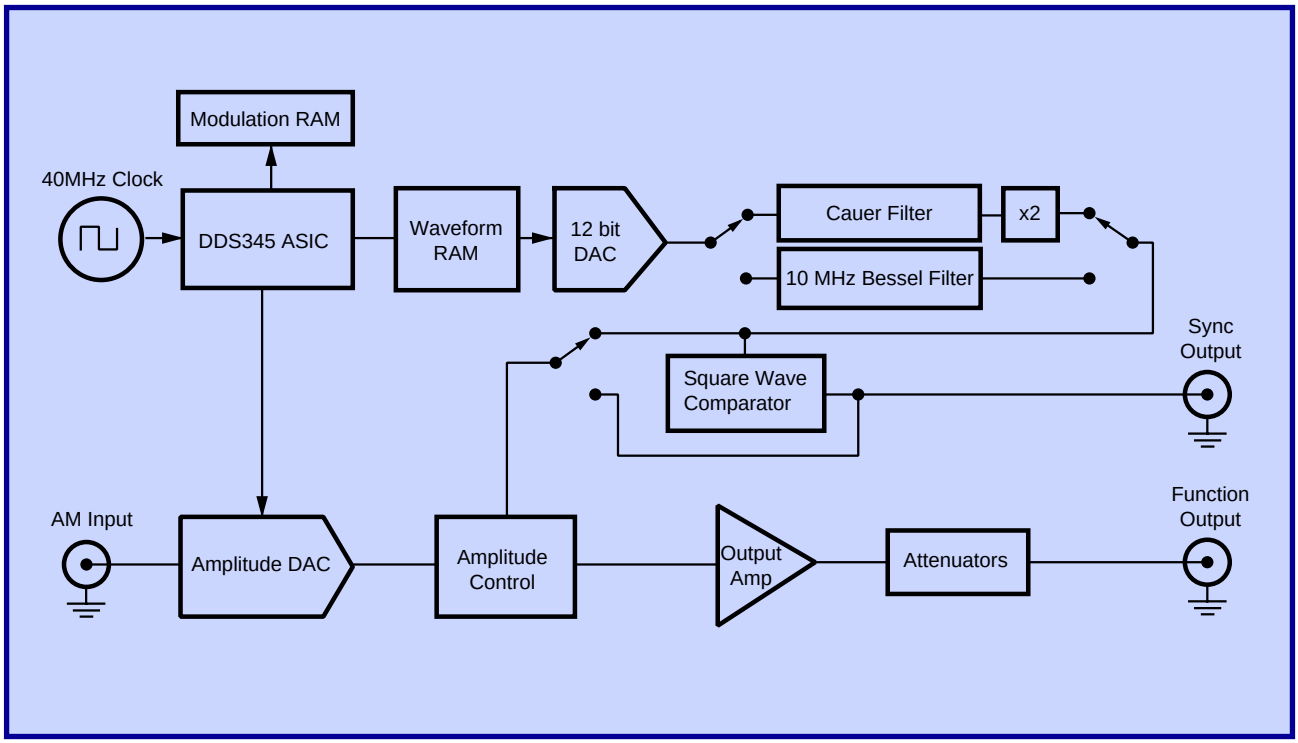
There are three major components to DDS: a phase accumulator, a sine look-up table, and a DAC. The phase accumulator computes an address for the sine table (which is stored in RAM). The sine value is converted to an analog value by the DAC. To generate a fixed-frequency sine wave, a constant value (called the Phase Increment) is added to the phase accumulator with each clock. If the phase increment is large, the phase accumulator will step quickly through the sine look-up table, and so generate a high-frequency sine wave.

One might think that to generate a clean sine wave you would need hundreds or thousands of points in each cycle of the sine wave. In fact, you need about three. Of course, a three step approximation to a sine wave hardly looks like a sine wave, but if you follow the DAC with a very good low-pass filter, all the high-frequency components are removed, leaving a very clean sine wave.

The frequency resolution of the DDS is given by the number of bits in the phase increment and phase accumulator. manybits provide very high frequency resolution. The DS345 uses a 48-bit phase accumulator for a frequency resolution of one part in 10^{14}. This provides 1 µHz resolution at all frequencies from 1 µHz to 30 MHz.

The maximum frequency depends on how fast you can add the 48-bit phase increment to the phase accumulator. Using a highly pipe-lined architecture, these additions can be performed at 40 MHz. This allows direct digital synthesis to 15 MHz. A frequency doubler is used to reach 30 MHz.

For agile frequency and phase modulation, it is necessary to change the phase increment values quickly. To do this, the phase accumulator may switch between two 48-bit phase increment values in 25 ns, and each of these 48-bit registers may be loaded in less than 1 µs. During frequency modulation one register is used while loading the other.



DDS block diagram