HRP Job Aid

Pulse Generators and Signal Generators

Description	ECCN
Frequency synthesized signal generators	3A002.d
Signal generators, frequency synthesizer based	3A002.d
Generators, high-speed pulse	3A230
High-speed pulse generators	3A230

Key Terms

Pulse generators are electronic test equipment used to generate electrical signals (i.e., pulses).

Pulse transition time is the time it takes for the pulse to "rise" from a minimum to a maximum value, specifically from 10% to 90% voltage amplitude.

Signal generators are an analog or digital device that generates electronic signals with set properties of amplitude, frequency, and wave shape (waveform).

Pulse Generators

Key Points

Model 6040 pulse generator from Berkeley Nucleonics Corp. Pulse generators are generally used in scientific experimentation and optics. The Model 6040 has +4 V pulse into 50 Ω and 700 ps rise time. Note: Model 6040 does not meet the ECCN 3A230 specifications.

- Electronic test equipment used to generate electrical signals is very common, and most will not be export controlled
- Very high speeds make certain pulse generators export controlled
- Look for the following technical specifications to determine control:
  - Output voltage: >6 V into a resistive load <55 Ω
  - Pulse transition time: <500 ps
  - Associated pulse heads (also known as *impulse forming networks*) are also controlled
  - The pulse head can be an integral part of the pulse generator, a plug-in module to the device, or an externally connected device

Appearance

- Pulse generators look like generic laboratory equipment
- Usually they are stand-alone units containing their own power supplies and supporting circuits
- Pulse generators include a shielded metal outer case with electrical connectors for coaxial cables and push buttons or knob controls
- Typical dimensions: 3–6 in. high × 10–19 in. wide × 8–15 in. deep
- The presence of these controls during inspection can assist with determining if the equipment is a pulse generator:
  - o Voltage amplitude (volts)
  - o Pulse width (seconds)
  - o Pulse delay or pulse transition time (seconds)
  - o Repetition rate (hertz)
  - o Waveform selector
- Pulse heads, if not an integral part of the pulse generator, resemble a small plug-in module

Applications

- Development of high-speed recording systems
- Simulation of electromagnetic pulses, used in response testing of instrumentation and networks
- Driving laser diodes
- Electronic component manufacture (e.g., telecommunications, research labs)
- Nuclear weapons development and testing, specifically to characterize the performance of high-speed recording equipment

Examples

Features
- Repeat rate: to 10 MHz
- Output: ±5 V into 50 Ω
- Rise time: 5 ns
- Variable width
- $375 US

Features
- Sine, triangle, square, Haverfunctions, and DC
- 1–50 MHz, 32 Volts peak-to-peak for all waveforms
- Variable (10 ns/min) pulse width, 6 ns transitions
- Wide range of operating capability
- $2,500 US

Remember: The key control parameter is a pulse transition time <500 ps or 0.5 ns. The rise time of both these pulse generators units is too slow to be controlled under ECCN 3A230.

Signal Generators

Signal generators produce electronic signals with set properties of amplitude, frequency, and wave shape (waveform). These signals are used as a stimulus for electronic measurements, typically in designing, testing, troubleshooting, and repairing electronic devices and circuits.

Types and Applications

Waveform or Function Generators

- Produce electrical waveforms (patterns or shapes) over a wide range of signals
- Outputs include sine wave, square wave, ramp or triangular wave, pulse wave, etc.
- "Function" is used when the instrument is limited to simple repetitive waveforms

Arbitrary Function Generator (AFG)

- Uses a preset list of waveforms
- Unlike function generators, AFGs can also generate arbitrary waveforms
- AFG is the prevailing signal generator architecture in the industry today
- Excellent stability and fast response to frequency changes; routinely used in power electronics testing

Arbitrary Waveform Generator (AWG)

- A more complex and versatile instrument used to produce custom compiled waveforms—rather than preset common waveforms
- Sophisticated playback system delivers waveforms based on stored digital data
- Applications include optical modulation, quantum computing, automotive antilock brake system simulation, and wireless network stress testing

Radio Frequency (RF) and Microwave Signal Generators

- RF and microwave signal generators have similar features and capabilities but are differentiated by frequency range
  - o RF signal generators range from a few kilohertz to 6 GHz
  - o Microwave signal generators cover a much wider frequency range, (up to 70 GHz)
- Used for testing components, receivers and test systems including cellular communications, WiFi, WiMAX, GPS, audio and video broadcasting, satellite communications, radar, and electronic warfare

Vector Signal Generator

- Also known as digital signal generators, vector signal generators are used for digital communication applications

Technical Parameters

Note: Look for these on available paperwork, manufacturer's nameplate, internet search

Controlled

Signal generators having any of the following are controlled under 3A002.d.1

- **Frequency range:** Between 31.8 and 37 GHz
- **Pulse duration:** <25 ns
- **On/off ratio:** ≥65 dB

Signal generators with the following are controlled under 3A002.d.2

- **Output power:** >100 mW (20 dBm)
- **Frequency range:** Between 43.5 and 90 GHz

Signal generators with the following are controlled under 3A002.d.3

- **Frequency switching time:**
  - o <100 μs for any frequency change >2.2 GHz within the frequency range between 4.8 and 31.8 GHz
  - o <500 μs for any frequency change >550 MHz within the frequency range between 31.8 and 37 GHz
  - o <100 μs for any frequency change >2.2 GHz between 37 and 90 GHz

Signal generators with the following are controlled under 3A002.d.4

- **Single sideband phase noise:**
  - o Less (better) than $-(126 + 20 \log_{10}F - 20\log_{10}f)$ for anywhere within the range of 10 Hz ≤ F ≤ 10 kHz anywhere within the frequency range exceeding 3.2 GHz but not exceeding 90 GHz
  - o Less (better) than $-(206 - 20\log_{10}f)$ for anywhere within the range of 10 kHz < F ≤ 100 kHz anywhere within the frequency range exceeding 3.2 GHz but not exceeding 90 GHz

Note: In 3A002.d.4, F is the offset from the operating frequency in Hz and f is the operating frequency in MHz

Signal generators with any of the following are controlled under 3A002.d.5

- **RF modulation bandwidth:**
  - o >2.2 GHz within the frequency range between 4.8 and 31.8 GHz
  - o >550 MHz within the frequency range between 31.8 and 37 GHz
  - o >2.2 GHz within the frequency range between 37 and 90 GHz

Signal generators having the following are controlled under 3A002.d.6

- **Maximum frequency:** >90 GHz

Examples

A simple analog signal generator, circa 1990. Not controlled.

The LATNEX® RF signal generator is pocket size and lightweight. It measures 4.5 in. × 2.75 in. × 1 in. and weighs 0.55 lb. It offers wide band support in the frequency range 24–6,000 MHz. It is fully programmable when connected to a PC. Controlled under ECCN 3A002.d.

The Hittite Microwave Corporation HMC-T2270 signal generator operates at 10–70 GHz. Applications include automated test equipment and measurements.Controlled under ECCN 3A002.d.

The Tektronix AWG70000B Series AWG is used for leading-edge research in communications, defense electronics, physics, and chemistry. The MSRP is $83,600 US. Controlled under ECCN 3A002.d.

Appearance

- Signal generators are very similar in size and appearance to pulse generators, but they can be much smaller (e.g., pocket size RF signal generator)
- Available as benchtop instruments or rackmount instruments
- May be controlled using a microprocessor or an attached PC with software
- The front panel includes an LCD screen, numeric keypad, function keys to adjust waveform parameters, which are labeled *frequency*, *amplitude*, *offset*, *phase*, *harmonic*, *waveform*, and *sweep*
- Test leads are used to channel outputs to the device under test (LAN, USB, and VGA interfaces)

DOE/NNSA High Risk Property

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