# Pulse generators - overview

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## Introduction

- pulse generator according to CISPR 16-1-1
  - time-domain rectangular pulse
  - pulse-modulated RF signal
- rectangular pulses used for lower frequencies (bands A/B), RF signals for higher frequencies (bands C/D) because of high voltages and risk of receiver damage
- only the resulting spectrum amplitude and its uniformity is important, not the way how it is achieved

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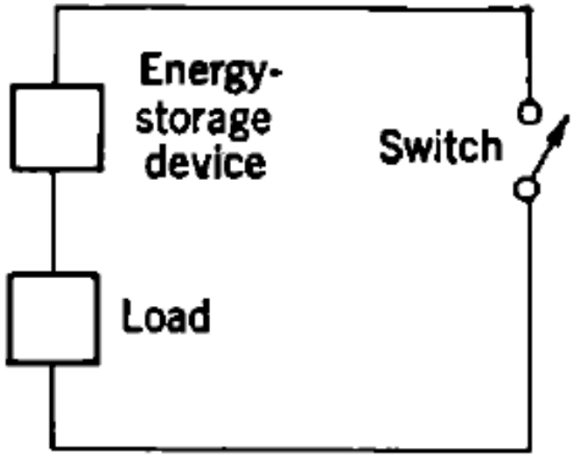
- generally an energy-storage device (electrostatic, magnetic field) and then discharge a fraction or all of the energy into a load




2,769,101

TRANSMISSION LINE PULSE GENERATOR

Ralph D. Drosd, Silver Spring, Md., assignor to the United States of America as represented by the Secretary of the Navy

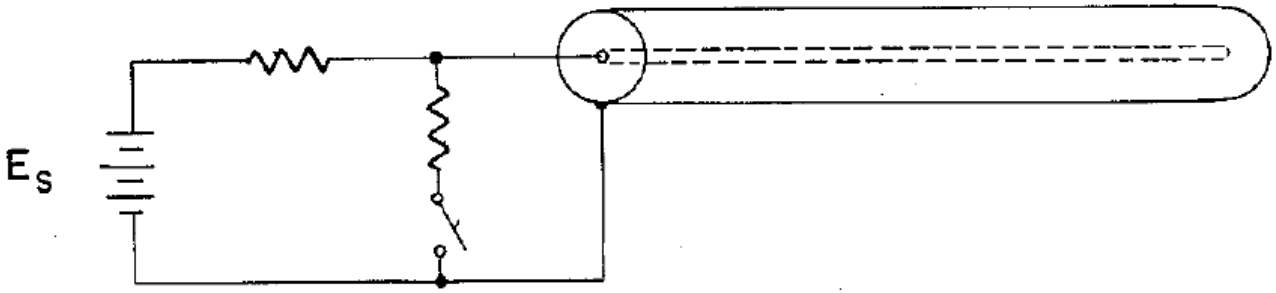
Application July 29, 1955, Serial No. 525,408

5 Claims. (Cl. 307—108)

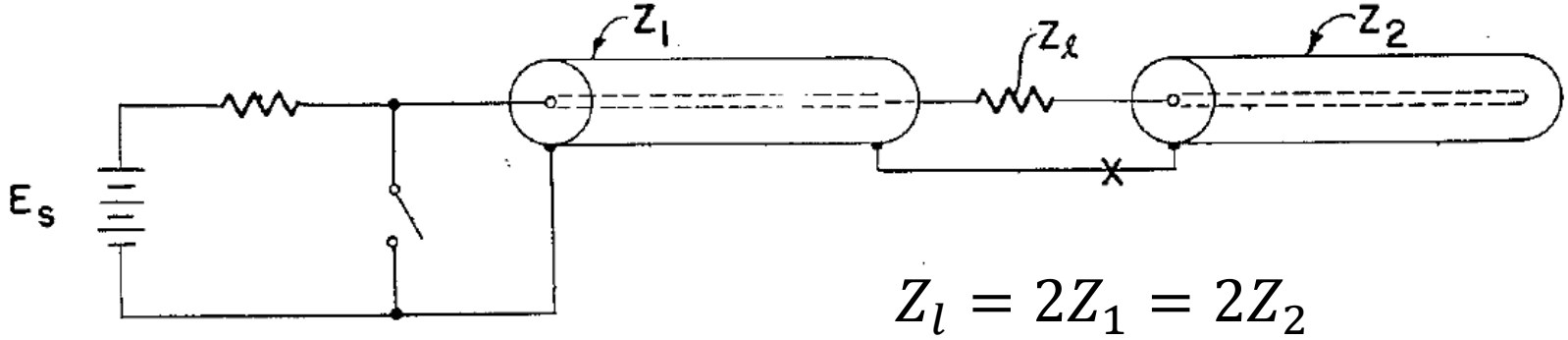
(Granted under Title 35, U. S. Code (1952), sec. 266)

- very often a charged coaxial line
- pulse duration ⇒ electrical length of the line
- impulse area ⇒ charge voltage
- other pulse shaping – TTL circuits

- transmission line generator (basic idea)

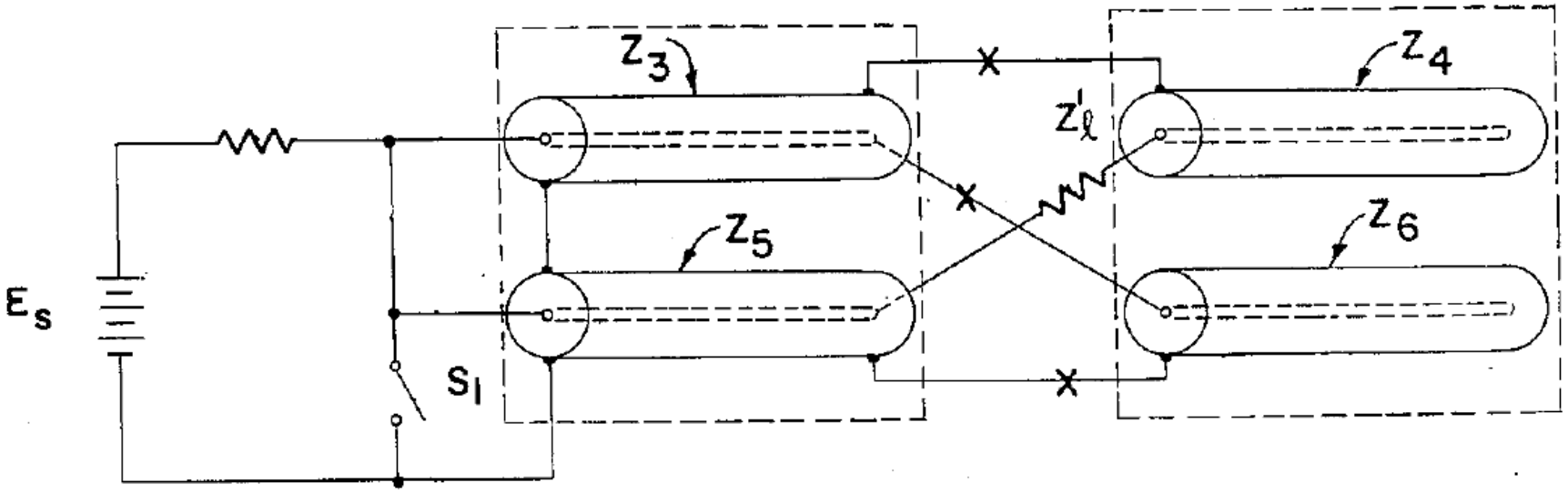



- pulse voltage only one half of the voltage to which the TL is charged, switch presents undesirable parasitic L, R, C, switch must resist twice the TL voltage ⇒ modifications




$$Z_l = 2Z_1 = 2Z_2$$

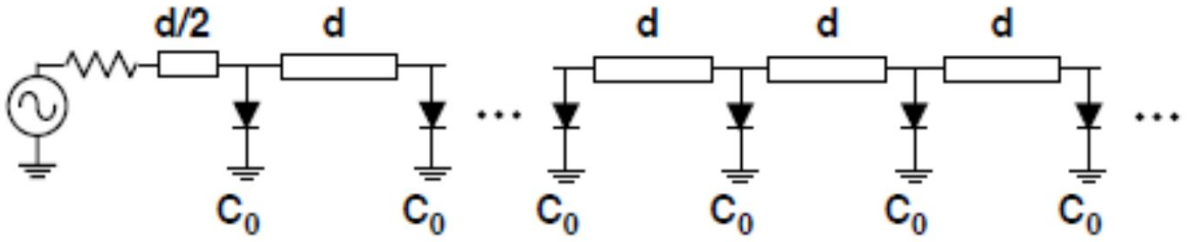
- pulse voltage doubler



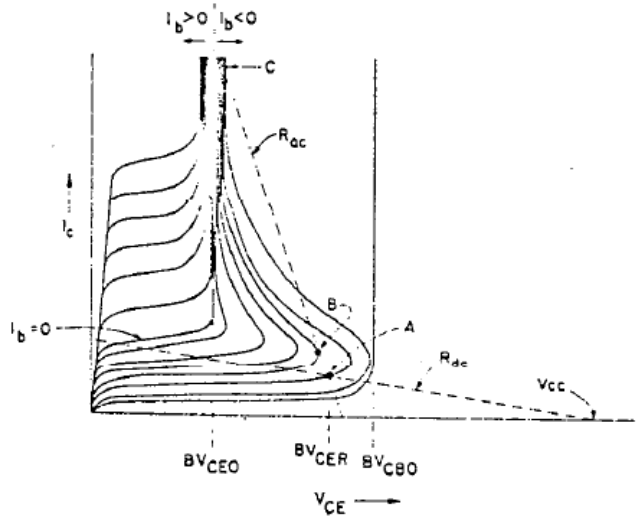

lines of equal characteristic impedances and electrical lengths

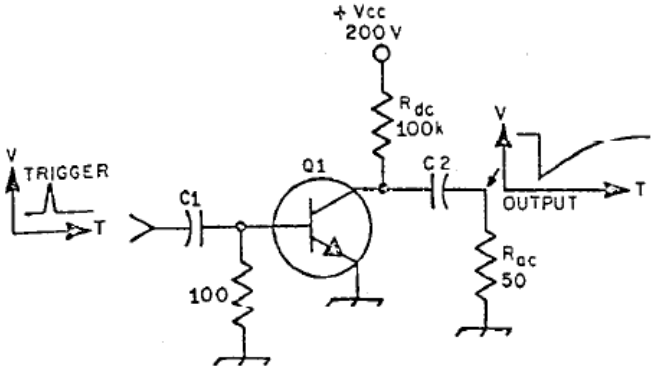
- also other principles used nowadays (nonlinear transmission line, step-recovery diode, avalanche transistor...)

- also other principles used nowadays
  - nonlinear transmission line




  - step-recovery diode
  - avalanche transistor



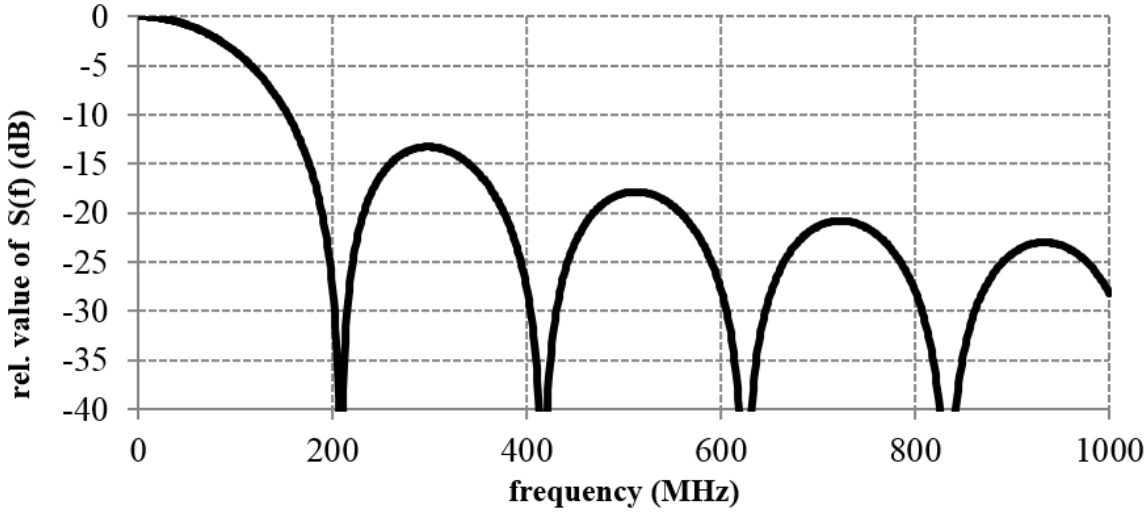



## Base-band pulse generators

- switch
  - mechanical mercury relay – obsolete, mercury (toxic) abandoned in many countries
  - semiconductor circuits (solid-state switches)

- example of rectangular pulse parameters

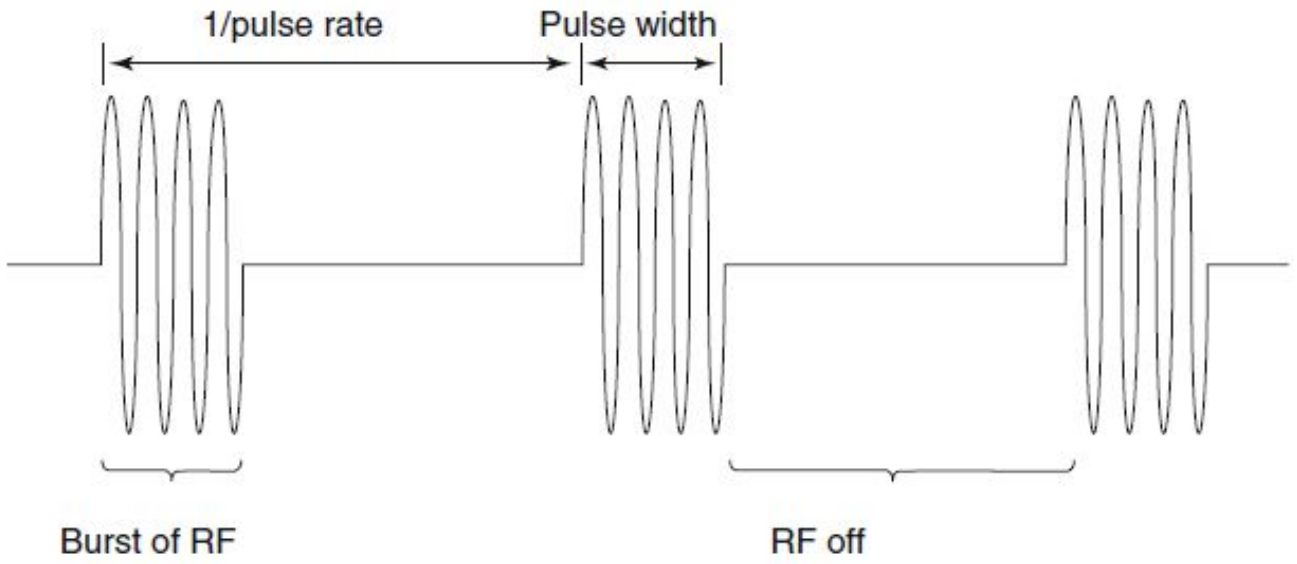
| band | A | B | C | D |
|---|---|---|---|---|
| frequency | 150 kHz | 30 MHz | 300 MHz | 1 GHz |
| rect-pulse duration for 0.3 dB S(f) decrease at given frequency | 960 ns | 4.8 ns | 0.481 ns | 0.144 ns |
| open-circuit amplitude for fulfilling the CISPR impulse area | 14.06 V | 65.8 V | 91.5 V | 305.6 V |




$$S(f) = 2AT\left|\frac{\sin(\pi T f)}{(\pi T f)}\right|$$

# Contents

- harmonic signal with a pulse envelope
- spectrum similar to a rectangular pulse (upconverted to the carrier frequency $f_c$), maximum of the spectrum at $f_c$




- uniform spectrum in a given bandwidth $\Rightarrow$ pulses with longer duration can be used with lower amplitudes compared to base-band pulse generators

- ideal rectangular pulse modulation

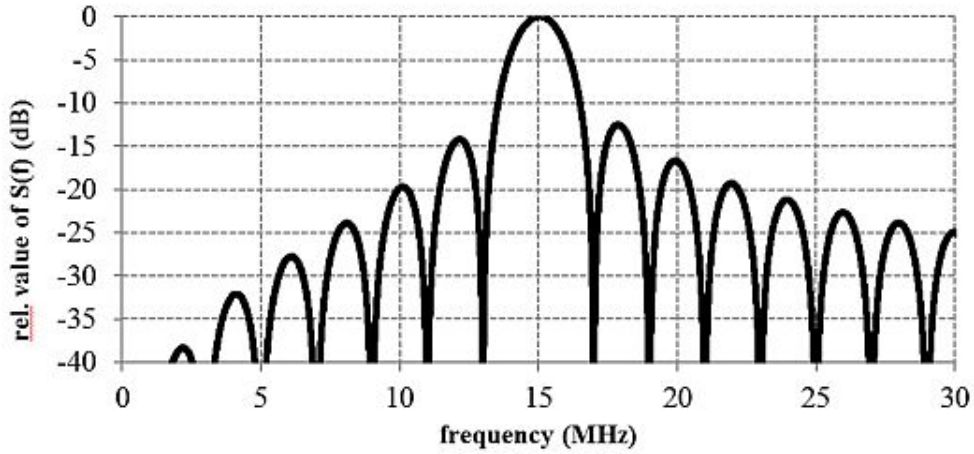
$$S(f) = AT\left|\frac{\sin(\pi\Delta fT)}{(\pi\Delta fT)} - \frac{\sin[\pi(2f_c + \Delta f)T]}{[\pi(2f_c + \Delta f)T]}\right|$$

$\Delta f = f - f_c$

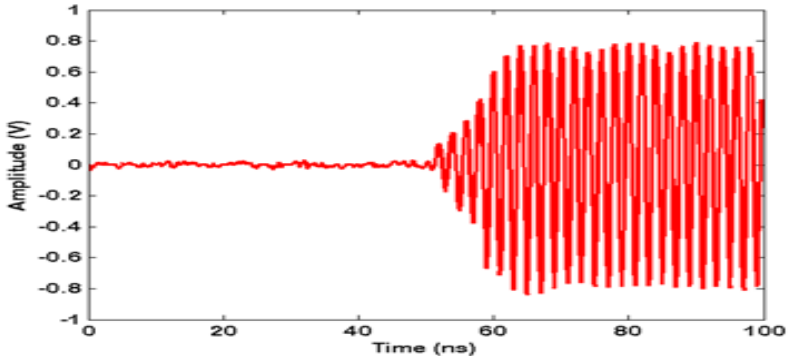
$A$ is the peak pulse amplitude

$T$ is the pulse duration

**spectrum of the signal not perfectly symmetric**



- in a narrow band around the carrier frequency and for >15 periods of the RF carrier in the pulse ⇒ spectral non-symmetry negligible
- spectrum amplitude @ $f_c$ calculable from the CW power and pulse duration
- proper choice of the pulse duration ⇒ uniform spectrum in the receiver selectivity bandwidth
- pulse-modulated RF signal recommended for calibration of EMI receivers (R&S, Keysight), mainly for C/D bands
- rect-pulse never ideal
  ⇒ deviation from ideal spectrum



- example of RF pulse parameters

| band | A | B | C | D |
|---|---|---|---|---|
| frequency | 150 kHz | 30 MHz | 300 MHz | 1 GHz |
| RF pulse duration for for 0.3 dB S(f) decrease at the boundaries of selectivity bandwidth | 1450 µs | 9.5 µs | 2.4 µs | 2.4 µs |
| peak CW voltage (open-circuit) for fulfilling the CISPR impulse area | 9.31 mV | 33.3 mV | 18.3 mV | 18.3 mV |

- energy of the pulse concentrated around the $f_c$ (freq. domain)
  $\Rightarrow$ the only usable solution for receivers without preselection

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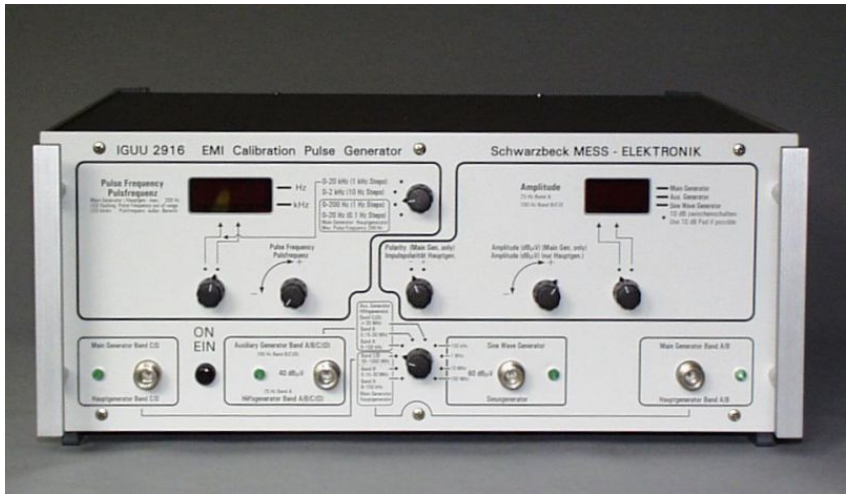
# base-band pulse generators

## Schwarzbeck IGUU 2916

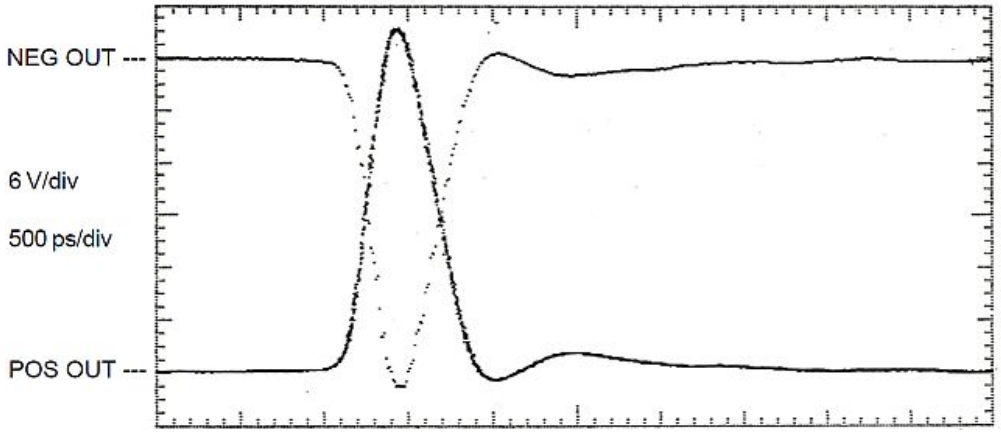



Universal Calibration Pulse Generator
acc. CISPR 16 for Bands A, B, C, D
(9 kHz - 1000 MHz)
especially for EMI Receiver Tests
(Pulse weighting, Overload)
Signal generator
100 kHz, 1 MHz, 10 MHz, 100 MHz (60 dBµV)
Pulse Repetition Frequency
0.1 Hz - 200 Hz (20 kHz)
Output Level adjustable in 1 dB steps
GPIB-Interface

# base-band pulse generators

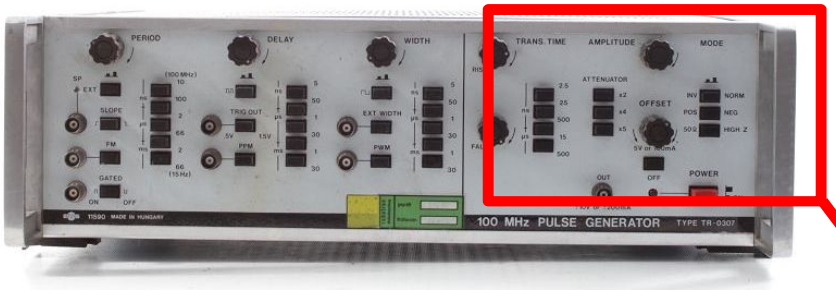
## Picosecond Pulse Labs 1000D


| | |
|---|---|
| Output Impedance | 50 Ω |
| Connector | SMA for impulse out, BNC for trig in |
| Rise Time | 250 picoseconds |
| Pulse Amplitude | 35 V |
| Output Pulse Width | 500 picoseconds |
| Typ. spectrum ampl. | 90 dBµV/MHz |

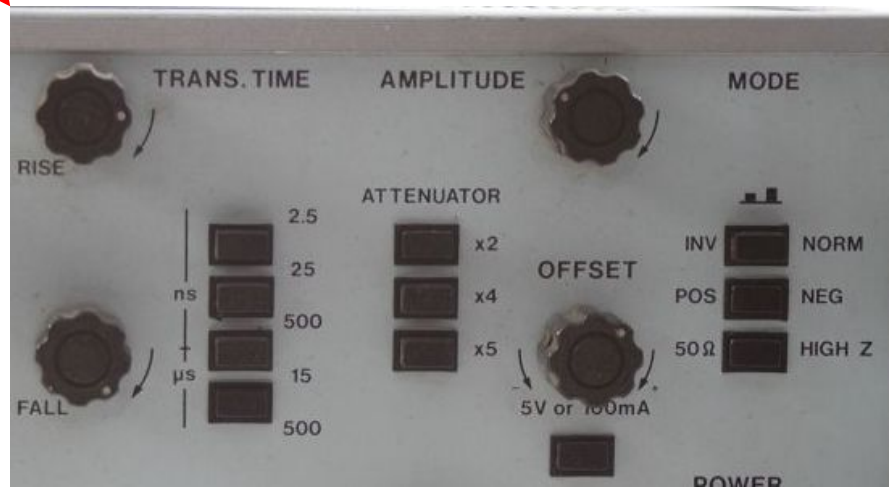


## base-band pulse generators

### EMG Type 11590 (TR-0307)




Repetition rate 15 Hz to 100 MHz
Pulse delay and width 5 ns to 30 ms
Rise time 2.5 ns to 0.5 ms
Amplitude 10 V (high-impedance)
5 V (50 ohms)
DC offset ±5 V



# base-band pulse generators

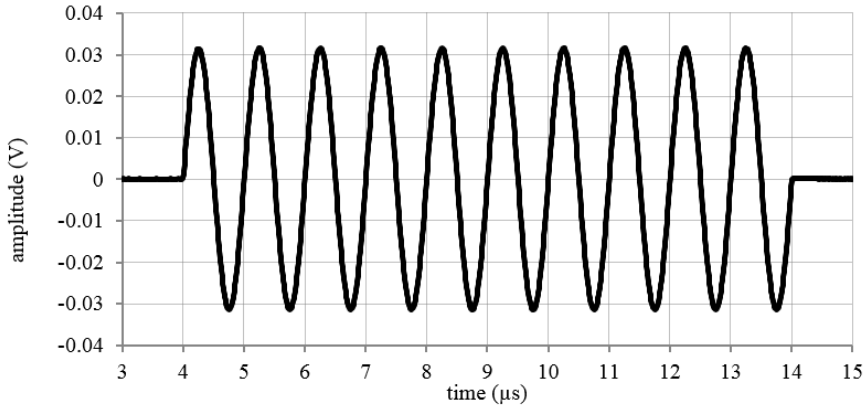
## Hewlett Packard 8008A

Repetition rate: 10 Hz to 200 MHz
Double pulse width: 100 MHz max.
DC offset ±2V across 50 ohms
Period jitter <0.1% + 50ps
Trigger output: amplitude 1 V or 200 mV (switchable) into 50 ohms load.
Width: 3 ns at 200 MHz (typ.), increasing to >0.5 ms at 10 Hz.
External input 50 ohms
GR874 output connectors

(newer version HP 8082A with BNC output connectors)

# pulse-modulated RF generators

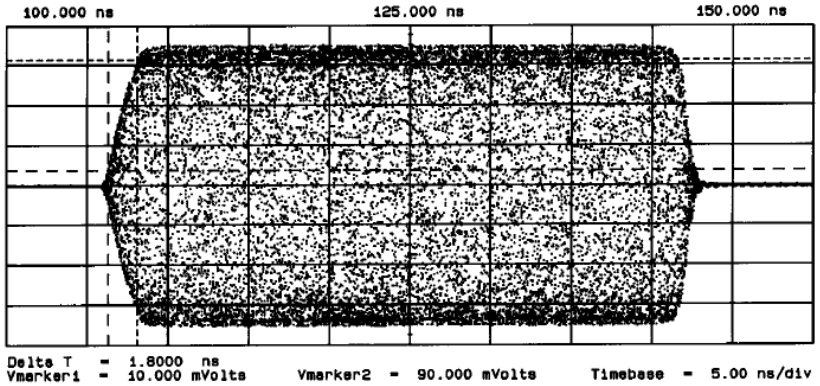
## Agilent 33120A


Band A only
Burst modulation of a sine wave
Max. 5 MHz
Repeatable pulse bursts

# pulse-modulated RF generators

## Hewlett Packard 83630B




On/off ratio 80 dB
Rise/fall times 25 ns
Minimum width 1 µs (INT leveled)
50 ns (search mode)
Minimum repetition frequency 10 Hz
Level accuracy ±0.3 dB (Widths ≥1 µs) 1%
Overshoot, ringing 15%
Compression ±10 ns, typical ±5 ns
Bands C/D

EMPIR project "15RPT01 Development of RF and microwave metrology capability"
http://rfmw.cmi.cz/

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# Thank you for attention