MODEL 12010 AND MODEL 12020
PULSE/PATTERN GENERATORS

PRODUCT SPECIFICATION

Features:

- **1.6GHz or 800MHz Models**
- **Full Pulse and Pattern Generator Capabilities**
- **Programmable Patterns**
  - User Defined
  - 16Mbit per channel
  - PRBS
- **Built-in Jitter Insertion Option**
  - Random
  - Multi-UI Sinusoidal
  - Deterministic
- **Built-in Spread Spectrum Clocking**

Model 12010 800MHz
Model 12020 1.6GHz
Pulse/Pattern Generators

- **1 or 2 Differential Output Channels**
- **50mV to 2.5V Programmable Amplitude**
- **Programmable Offset**
  (–2.0V to +3.3V Window)
- **Adjustable Trigger Output**

The **Models 12010 and 12020 pulse/pattern generators** are effectively two instruments in one, a programmable pulse generator and a programmable pattern generator. Both models also feature the option for ***built-in jitter insertion***, an unprecedented capability for pulse/pattern generators at this price performance point. These generators may be set to operate in one of four modes, Pulse, Pattern, Burst, or External Width.

- **Pulse Mode** delivers a single pulse per trigger event. The pulse timing is programmable in repetition rate, duration, and delay.
- **Pattern Mode** delivers a defined pattern per trigger event. The pattern may be presented in either NRZ, RZ, or R1 formats. In NRZ mode the crossing point is programmable. In RZ and R1 mode the duration of the pattern pulse is programmable.
- **Burst Mode** delivers a 'burst' of *n* pulses per trigger event.
- **External Width Mode** delivers pulse levels that follow the edges of the "Ext In" input. A rising edge causes the output to go high, while a falling edge causes the output to go low.

Fully Programmable Pulse Generator with Burst and External Width Modes

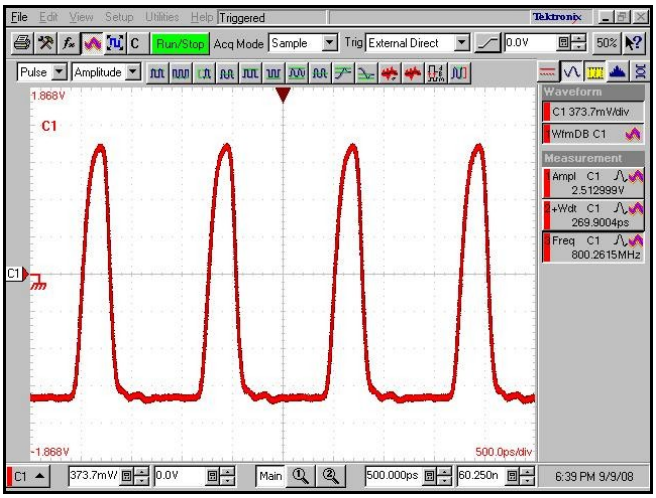


Figure 1. Pulse Output of Model 12020 Pulse/Pattern Generator at 800MHz Repetition Rate and $2.5V_{pp}$

High Quality Pattern Generator with Option for Jitter Insertion

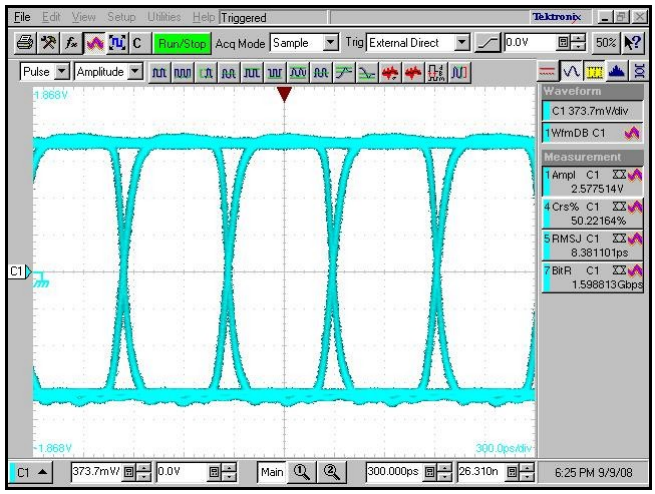


Figure 2. 1.6GHz, 2^7-1 PRBS, NRZ Pattern Output of Model 12020 Pulse/Pattern Generator at $2.5V_{pp}$

Output Signal Characteristics *[also see notes below]*

Parameter	Specification	Notes
Amplitude		
Range	50 mV to 2.5 V	Within level window
Resolution	3 digits (1 mV best case)	
Accuracy	± (50 mV + 1%)	50Ω to 0V termination
Level Window		
Range	-2.0 V to +3.3 V	
Resolution	3 digits (1 mV best case)	
Offset		
Range	-1.975 V to +3.275 V	Within level window
Resolution	3 digits (1 mV best case)	
Accuracy	± (50 mV +2%)	50Ω to 0V termination
Termination Voltage		
Range	-2.0 V to +3.3 V	
Resolution	3 digits (1 mV best case)	
Baseline Noise	1 mV rms typical	
Overshoot/Preshoot/Ringing	± (5% + 50 mV)	At 25 C
Signal Rise/Fall Time	150 ps typ, TBD maximum	10 - 90 %
Width/Duration		
Range	250 ps to (period-250 ps)	May be set as duration or duty cycle
Resolution	4 digits, 1 ps best case	
Accuracy	± (100 ps + 1%)	
Jitter RMS (trigger out to trailing edge)	< 10 ps	Pulse Mode, jitter insertion disabled, delay = 0
Delay		
Range	0 ps to period	
Resolution	4 digits, 1 ps best case	
Accuracy	+/- (50ps + 1%)	Relative to 0 delay setting
Jitter RMS (trigger out to leading edge)	< 10 ps	Pulse Mode, jitter insertion disabled
Output Impedance	50Ω typical	

Notes:
[1] The "Output Characteristics" table applies to the Ch1 and Ch2 outputs.
[2] Ch1 and Ch2 are independent.
[3] True and complement outputs share the same settings. Differential values (true minus complement) are double those stated.
[4] The output is designed to drive into a 50 Ohm load terminated to a user-provided voltage. The termination voltage must be in the range specified. For the generator to display accurate levels, the user must enter the actual termination voltage.
[5] Each channel has independent delay and duration settings.

Internal Clock Characteristics *[1]*

Parameter	Specification	Notes
Frequency		
Range for Model 12010	15 MHz - 800 MHz	May be set as frequency or period
Range for Model 12020 *[2]*	15 MHz - 1.6 GHz	May be set as frequency or period
Resolution	1 Hz	
Accuracy	± 100 ppm	
RMS Jitter (int ref, int clock, cycle-to-cycle)	< 10 ps	With jitter insertion disabled
Pulse/Pattern Clock Source	Internal Clock or "Clk In"	
Spread Spectrum Clocking *[3]*	1KHz – 100KHz 0% to 2%	Triangular wave frequency modulation of the clock at a specified frequency and % amplitude below nominal selected clock frequency

Notes:
[1] The clock source is shared between both channels.
[2] For the Model 12020, some modes of operation (burst, pulse with external trigger, RZ/R1 patterns) are only specified to 800MHz. However, over-programming is allowed for these modes, and some will work to frequencies higher than 800MHz.
[3] Spread spectrum clocking and internal clock modulation sinusoidal jitter may not be used at the same time.

Pattern Mode Characteristics

Parameter	Specification	Notes
Pattern		
Types	Data, PRBS	
PRBS length	2^n-1 with n = 5, 6…15, 23, 31	
Pattern length resolution	8 bits	
Memory depth	16 Mbit	Per channel
Data Formats		
NRZ	Yes	Programmable crossing point
RZ, R1	Yes	Programmable duration/duty cycle
RZ, R1 max repetition rate	800 MHz	The Model 12020 operates up to 1.6GHz for NRZ data and 800MHz for RZ, R1 data
Crossing Point Adjustment		For NRZ format only. Calibrated for 50% duty cycle data signals
Range	30 - 70 % typ	
Resolution	1%	

Burst Mode Characteristics *[1]*

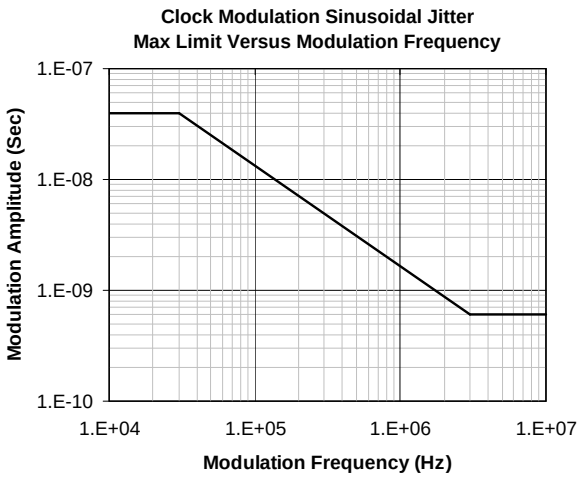
Parameter	Specification	Notes
Burst Count	2 - 1,048,576 pulses	Number of pulses in burst
Burst Period		
Range	8- 1,048,576 clocks	Number of clock cycles in a burst. Must be ≥ number of pulses.
Resolution	8 clocks	Clock cycles.
Max Rep Rate in Burst Mode	800 MHz	Applies to both the Model 12010 and 12020

Notes:
[1] Each channel has independent number of pulses, and common burst period.
[2] See Figure 5 for example.

Jitter Insertion Characteristics *[also see notes below]*

Parameter	Specification	Notes
Internal Clock Modulation Sinusoidal Jitter	10kHz: 40ns$_{pk-pk}$ 30kHz: 40ns$_{pk-pk}$ 3MHz: 0.6ns$_{pk-pk}$ 10MHz: 0.6ns$_{pk-pk}$	Jitter amplitude range is from 0ns to these values at the specified frequencies. Between these frequencies, the limit points are interpolated linearly on log-log scale plot *(see Note 9 and plot).*
Delay Modulation Jitter		See bandwidth note below.
Deterministic Waveforms		
Square	1Hz - 20MHz: 0 - 0.4UI$_{pk-pk}$	
Triangle	1Hz - 4MHz: 0 - 0.5UI$_{pk-pk}$	
Sine	1Hz - 20MHz: 0 - 0.5UI$_{pk-pk}$	See Figure 8 for example.
Random Jitter [Gaussian Noise]	80 MHz BW: 0 - 0.08 UI$_{rms}$	See Figure 7 for example.
External Input	80 MHz BW: 0 - 0.5 UI$_{pk-pk}$	±1 V max useable input with 2 V p-p input corresponding to 0.5 UI$_{pk-pk}$. See bandwidth note below.

Notes:
[1] The Model 12020 is capable of generating jitter from 2 different mechanisms, modulation of the internal clock source or output channel delay modulation.
[2] Delay modulation sources can be either internal or external. External delay modulation is applied via an analog signal on the delay inputs (separate for each channel).
[3] Modulation of the internal clock is applied to both channels of a two-channel instrument.
[4] Delay modulation jitter may be applied to each channel independently with the ability to apply different jitter functions to each channel.
[5] Internal clock and delay modulation jitter can be applied in any combination. The combined amplitude of delay modulation jitter (deterministic waveforms, random, and external) is limited to 0.5 UI$_{pk-pk}$ max.
[6] The trigger output is also subject to the internal clock modulation jitter but not delay modulation jitter.
[7] The bandwidth of the delay modulation jitter depends on the clock frequency. Below 300 MHz clock frequency, the delay modulation jitter insertion bandwidth will be reduced. Jitter insertion signal frequencies approaching ½ the clock frequency or higher are not recommended and may result in unexpected behavior (due to in-band mix products / undersampling).
[8] Spread spectrum clocking and internal clock modulation sinusoidal jitter may not be used at the same time.
[9] Plot of limit points (linearly interpolated on a log-log scale between stated frequency points) for internal clock modulation sinusoidal jitter:



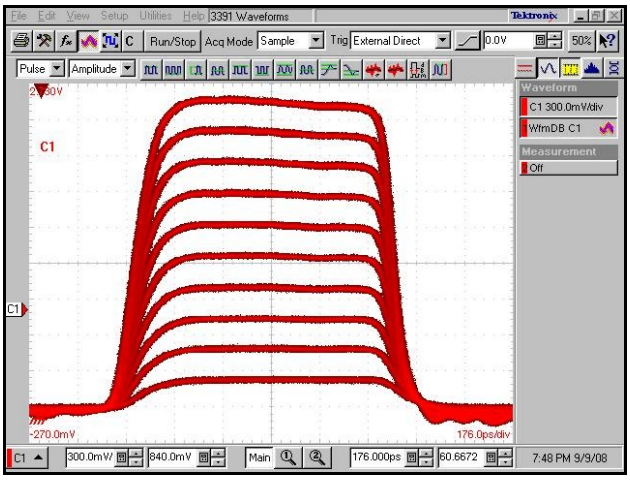


Figure 3. Programmable Pulse Amplitude (250mV to 2.5V) at 500MHz Rate and 900ps Width

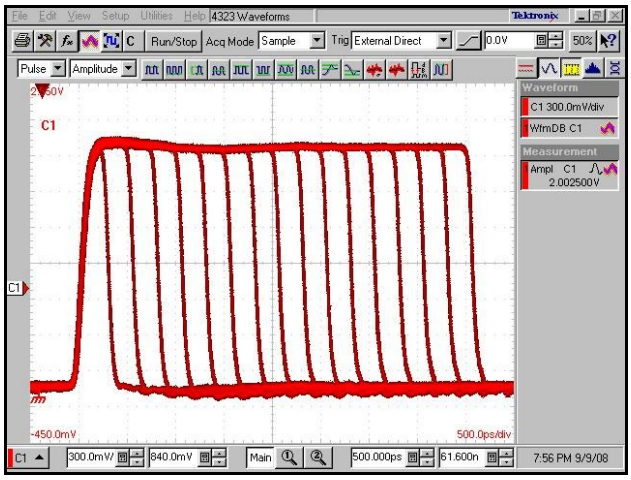


Figure 4. Programmable Pulse Width/Duration at 200MHz Repetition Rate and 2.0V_{pp}

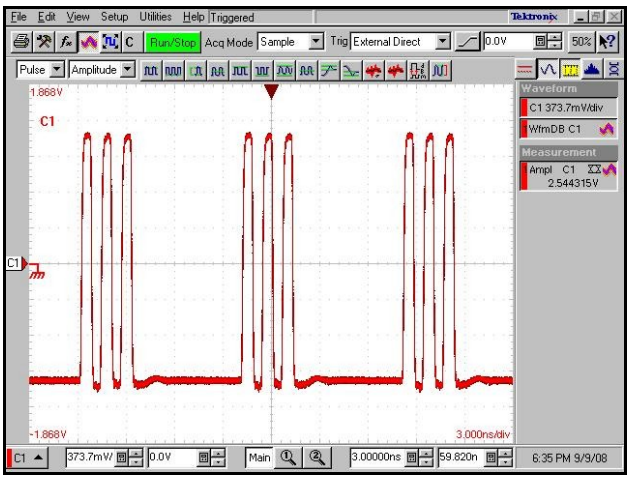


Figure 5. Pulse Burst Mode (3 Pulses with a Burst Period of 8 Pulses) at 800MHz Rate and 600ps Width

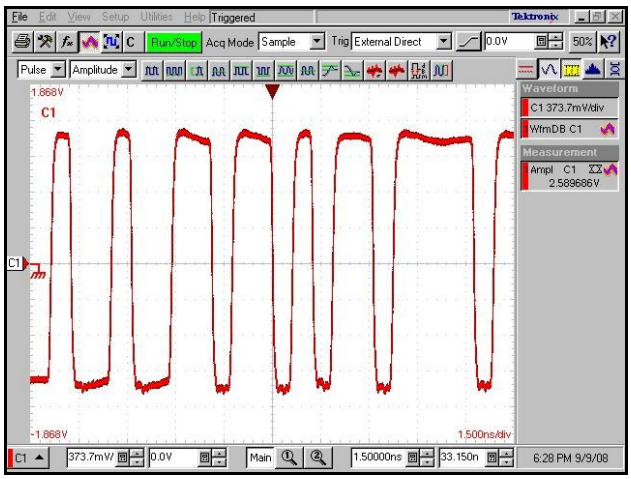


Figure 6. 1.6Gbps, 2^7-1 PRBS, NRZ Pattern Captured with Pattern Trigger (One per Pattern)

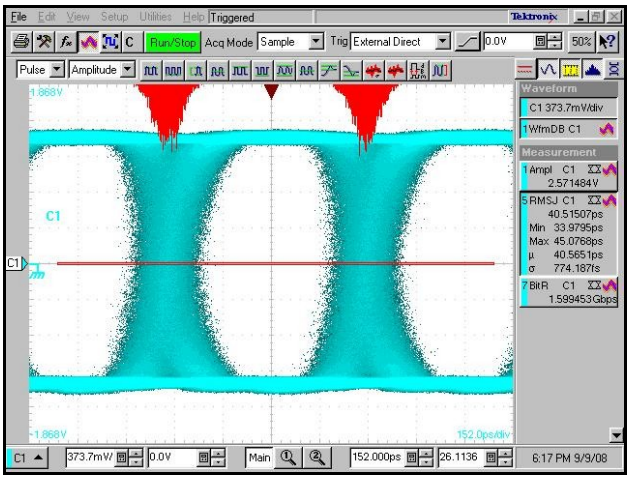


Figure 7. 1.6Gbps, 2^7-1 PRBS, NRZ Pattern with Built-in Random Delay Modulation Jitter Insertion

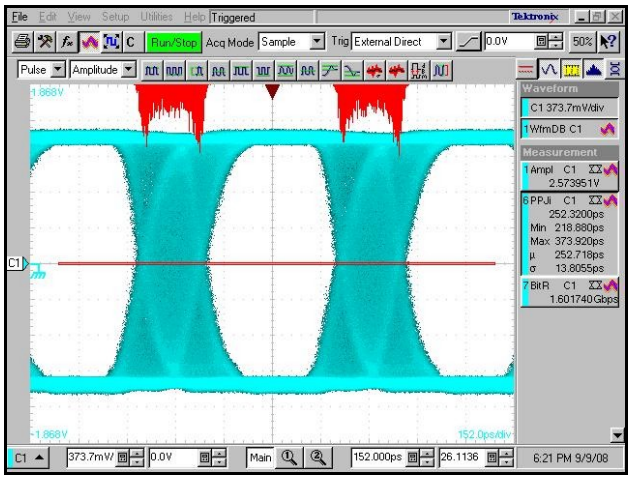


Figure 8. 1.6Gbps, 2^7-1 PRBS, NRZ Pattern with Built-in Sine Delay Modulation Jitter Insertion

Trigger Types

When in Pulse Mode:

- **Continuous:** One pulse per period of the internal clock or Clk In.
- **Ext In, Edge:** One pulse per valid edge on the Ext In input. Latency between the Ext In signal and the output signal is repeatable (deterministic) and is adjustable with the delay control. Ext In signal may vary from single shot to 800 MHz. Clk In is not used.
- **Ext In, Level:** The active Ext In level enables continuous pulses. Pulse period set by internal clock or Clk In. Clock frequency is limited to 800MHz. Latency between trigger source and signal output is not fixed or deterministic.
- **Remote/Manual:** A trigger command from the remote interface or front panel generates a single pulse. Clk In is not used.

When in Burst or Pattern Mode:

- **Continuous:** Trigger Circuitry is always armed. Clock may be internal or Clk In. Bursts or Patterns are continuously generated.
- **Ext In, Edge:** The active transition on Ext In generates one burst or pattern. Burst or Pattern pulse period set by internal clock or Clk In. No fixed latency between trigger source and signal output.
- **Ext In, Level:** The active Ext In level enables continuous bursts or patterns. On an inactive input level, a burst or pattern in progress will finish before halting. Burst or Pattern pulse period set by internal clock or Clk In. Latency between trigger source and signal output is not fixed or determinant.
- **Remote/Manual:** A trigger command from the remote interface or front panel generates a single burst or pattern. Burst or Pattern pulse period set by internal clock or Clk In.

When in External Width Mode:

- No triggering, outputs follow Ext In signal. Trigger output not active.

Inputs

Front Panel Inputs use SMA jacks, 50Ω impedance.

Rear Panel Input uses BNC jack, 50Ω impedance.

Clk In – Accepts external clock to set pulse period. AC coupled signal with selectable AC or DC coupling of the termination.
Termination Voltage: -2 V to +3 V (active only for DC coupled termination)
Input Absolute Limits: 2.6Vpp max AC, -2V to +3V DC
Input Frequency: 15 MHz – 800 MHz except for NRZ Pattern, then 15 MHz – 1.6 GHz

Ext In – Accepts external signal to start or gate burst/pattern or trigger pulses. DC coupled.
Termination Voltage: -2 V to +3 V
Input Threshold: -2 V to +3 V
Input Absolute Limits: -3V to +4V
Input Frequency: DC to 800MHz

Delay In (1 and 2) – Accepts external signal for jitter insertion on channels 1 & 2. 50Ω, DC coupled.
Voltage Range: -1 V to +1 V typical
Input Absolute Limits: ±5 V

Ref Osc In (rear panel) – Accepts external 10 MHz signal for Timebase reference.
Termination Voltage: AC Coupled. 50Ω typ.
Input Amplitude: 0 dBm typ.
Input Absolute Limits: 4 Vpp max AC, ±10 V DC

Outputs

Front Panel Outputs use SMA jacks, 50Ω impedance.

Rear Panel Output uses BNC jack, 50Ω impedance.

Output 1 – Channel 1 signal output
/Output 1 – Channel 1 complement signal output
Output 2 – Channel 2 signal output
/Output 2 – Channel 2 complement signal output

Trig Out – Generates trigger pulse corresponding to each output pulse or start of burst or pattern, DC coupled.
Adjustable amplitude range: 50mV to 2.5V
Adjustable offset range:-2V to +3.3V window

Outputs (continued)

Ref Osc Out (rear panel) – Generates 10 MHz signal phase locked to instrument Timebase.
Signal Amplitude: 1.4 V_{pp} typ.
Ref Osc Output Impedance: AC coupled. 50Ω typ.

Interfaces

The Model 12010 and 12020 generators may be controlled via either the front panel GUI interface, a GPIB interface, or a USB interface. IEEE 488.2, SCPI compliant.

General Mechanical Characteristics

Size: 439 mm (17.3 in) wide x 87 mm (3.4 in) high x 329mm (15.5 in) deep

Temperature

Operating Ambient Temperature: 0 to 50 C
Specifications apply from 0 to 50 C unless otherwise noted.
All ventilation openings must allow unobstructed flow of ambient air.

Ordering Information

Model Number	Description/Configuration:
12010-1	800MHz pulse/pattern generator, 1 differential output channel
12010-2	800MHz pulse/pattern generator, 2 differential output channels
12010-1-J	800MHz pulse/pattern generator, 1 differential output channel with jitter insertion option
12010-2-J	800MHz pulse/pattern generator, 2 differential output channels with jitter insertion option
12020-1	1.6GHz pulse/pattern generator, 1 differential output channel
12020-2	1.6GHz pulse/pattern generator, 2 differential output channels
12020-1-J	1.6GHz pulse/pattern generator, 1 differential output channel with jitter insertion option
12020-2-J	1.6GHz pulse/pattern generator, 2 differential output channels with jitter insertion option

Warranty: One year standard. Extended 3-year warranty and calibration services are available. See Terms and Conditions of Sale for details.