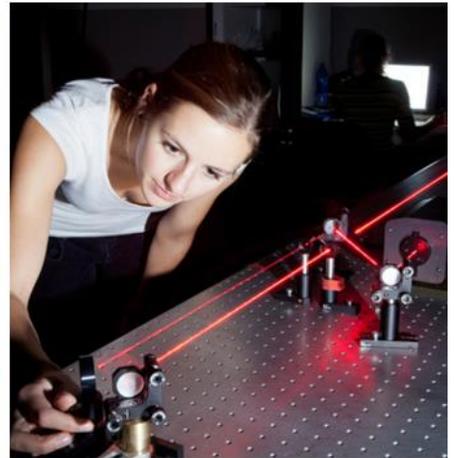# Model 765
Digital Delay / Pulse Generator

Features

- 70 ps Edge Time
- 5 Volts pk-pk
- Delay and Width Resolution of 10 ps
- Min Pulse Width less than 300 ps
- Jitter < 10 ps
- Easy to use touch GUI

Model 765

Fast Rise Time Pulse Generator

Applications

- Big Physics
- Experiments colliders
- Lasers modulations
- Radar and sonar systems
- Semiconductor tests

The Model 765 Pulse Generator is a feature-rich pulse and delay generator with 2 or 4 channels of completely programmable pulse and delay generation. The instrument offers many improvements over our previous design – faster transition times, narrow pulses, broader and more accurate amplitude control and a redesigned user interface. Take control of your time and amplitude domain!

Intuitive User Interface

The front panel controls for the Model 765 Pulse Generator include a 7" touchscreen and tactile controls for most operations. The touchscreen was designed to drive simplicity in operating and programming by giving users smartphone-like architecture complete with geesture control. The primary channel controls and programming options are easy to navigate, with a swipe gesture to move from channel to channel. Handy features like combining multiple pulses on one output can be graphically controlled and are easily identified on the screen. In addition, a rotary encoder and backlit pushbuttons provide an alternative yet familiar exerience to users needing front panel controls.

Rotary Encoder: The Model 765 front panel encoder is ideal for fine tuning pulse parameters on the fly. Dialing the encoder will change the value in continous, analog fashion. Pushing the encoder in will move the value adjustment from fine to coarse adjust, further simplifying setup and 'on-the-fly' adjustments.

Fast Rise Times and Plenty of Range

The Model 765 offers 70 ps Rise and Fall times (@ 5.0V pk-pk) over a large time domain. Our front end electronics circuit and new analog edge converter have been integrated into the pulse generator using a proprietary technology that virtually eliminates overshoot (< 5.0% typical) and ringing.

Figure 1: 70 ps Tr @ 5.0 V

Programming

The Model 765 offers several userful remote programming options. In addition, the networking feature allows users to use a VXI-11 LAN protocol to network the instrument for printing, file sharing, internet access and remote login. The remote programming uses common SCPI commands, ensuring compatibility with a wide range of development environments. Visual Studio, .NET, LabView, LabWindows/CVI, Microsoft Visual Studio and MatLab are all supported. Berkeley Nucleonics provides a comprehensive Software Development Kit (SDK) at no additional charge.

Inputs and Outputs

Pulse Out: The Model 765 offers inputs and outputs on the front and rear panel to accommodate users with rackmount or benchtop applications. The Pulse Out connectors are DC Coupled SMA connectors with 50 Ohm

impedance and with strain-relief panel mounts. The pulse out settings can be independently positive or negative (0V to +/-5V, adjustable). The following table shows the parameter limits for pulse outputs:

Parameter	Min	Max
Voltage	-5.0 V	+5.0 V
Amplitude	10 mVpp	5 Vpp
Offset	-2.5V	+2.5V
Width	300 ps	8 sec
Duty Cycle	< 1%	>99%
Period	5 ns	8 sec
Frequency	0.125 Hz	200 MHz
Delay	0 sec	8 sec
Burst N	1	4,294,967,295

Table 1: Pulse Out Limits

Trigger In / Out: The Model 765 Trigger Input is a SMA connector with a programmable impedance and threshold (50 Ohm / 1k Ohm, -10.0V to +10.0V). The programmable trigger threshold has a resolution of 4mV, ensuring precise triggering. The Model 765 can trigger on signals down to 50 mV and as narrow as 1ns, and a convenient 'Autosense' function will measure the current trigger input level. The Model 765 also measures the Trigger In frequency and displays the result in the Trigger Setup Window. The Trigger Out is a SMA connector with 50 Ohm impedance and an output voltage range of 1.8 V to 3.3 V (Adjustable).

USB: There are 2 handy USB 3.0 Ports on the front panel for auxiliary equipment such as a keyboard, additional storage or other system requirements.

Rear Panel: Additional input and output connectors on the rear panel include PS/2 Mouse and Keyboard connectors (HDMI, VGA), LAN and Audio.

Multi-pulse Mode: The Model 765 allows users to combine four digitally programmed pulses on each output. This allows complex timing sequences, and repetition rates to 800 MHz. The graphical user interface allows users an easy representation of the outputs on a given channel. Below is a simple example showing different delay and width settings from a common trigger:

Figure 2: Output 1 (PULSE1 + PULSE2)

Application Idea – Semiconductor Test

Characterization of Non-Volatile Memory Cells requires very precise pulse control, both in amplitude and time domains. The Model 765, with 10 ps time resolution and 10mV amplitude resolution allows just that. R&D in memory devices is leading to cell types which have the speed of RAM and the data retention of mass memory. Emerging R&D exits also in FeRAM (Ferroelectric RAM), ReRAM (Resistive RAM), MRAM (Magnetoresistive RAM), STT-MRAM (Spin-Transfer Torque Magnetoresistive RAM) and PCM (Phase Change Memory). This R&D is based on changing the

conductivity of a material using different stimuli principles. Examples include formation and destruction of a thin wire into a material stack, changing the material structure from amorphous to polycrystalline, alignment of magnetic fields, etc. Accurate front-end control in all these processes is critical for successful results. Let's look at testing STT-MRAM.

MRAM memory cells use Magnetic Tunnel Junctions (MTJ) that consist of two ferromagnets separated by a thin insulator. If the magnetic fields of the two ferromagnets are oriented in the same direction, electronics can tunnel from one ferromagnet to the other through the insulator. The first ferromagnet has a fixed magnetic field and the second can be changed by applying a current pulse. Inverting the magnetic field orientation changes the conductivity of the stack. To program or erase a bit, a current pulse is applied through the stack. The efficiency of the program/erase process depends on the duration and amplitude of the pulse, so R&D engineers are testing different combinations of pulse widths and amplitudes (and repetition rates). In the scope trace below, the 50 ns pulse @3.3 V is used to erase a single cell and the 100 ns pulse @3.3V is used to erase an array of cells.
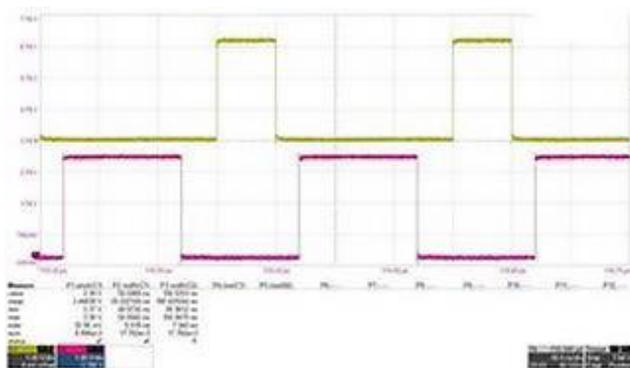

Figure 3: 50 ns @ 3.3 V, 100 ns @ 3.3 V

Application Idea – Radar

In radar testing, many situations make actual target measurements impractical. Simulating moving targets is a solution for expediting the R&D, Calibration and Test of Radar systems. The typical radar system measures the time of flight of the signal and calculates the distance from the target using the following equation:

Distance (km) = (DelayTime (sec) / 2) * 3x105 km/s, where 3x105 km/s is an approximation of the speed of light.

The delay between transmitted and received signals is dependent on distance. In complex systems, multiple targets are detected and the radar system is required to distinguish between various targets. A multi-channel pulse generator is used to test the detection ability of the radar without requiring actual field measurements of moving targets. The Model 765 is capable of multiple pulses per pulse period, allowing up to 4 pulses with different widths and delays to be generated on a single output. A repetition rate of 200 MHz allows testing the real time frequency capabilities of the radar system. With resolution of 10 ps and jitter < 10 ps RMS, the pulse generator can verify and calibrate a radar system with resolution under 1 centimeter. Shown below is an example of Quad-Pulse mode, 4 different narrow pulses with unique delays from the Trigger in, simulating the detection of multiple targets.
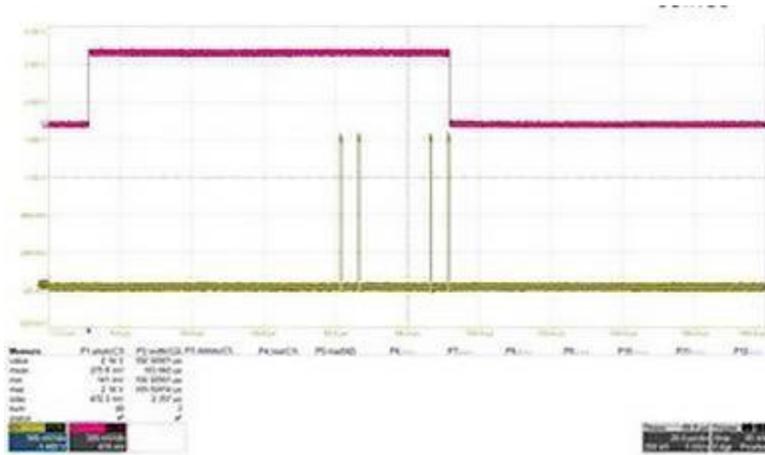
Figure 4: Quad-Pulse Mode

Ordering Information

Model 765-2C	2 Channel Pulse Generator
Model 765-4C	4 Channel Pulse Generator
P/N 765-RMKit	19: Rack Mount Kit for the 765-X
P/N 765 SSKit	1TB Solid State Storage Drive for 765-X

SPECIFICATIONS

Timing

Pulse Period	
Range (spec.)	5 ns to 8 sec.
Resolution (spec.)	10 ps
RMS Jitter[1] (Integration Range 100 Hz to 10 MHz, F_{out} = 200 MHz)	4 ps
Pulse Frequency	
Range (spec.)	0.125 Hz to 200 MHz (Single pulsemode)
	0.25 Hz to 400 MHz (Double pulsemode)
	0.375 Hz to 600 MHz (Triple pulsemode)
	0.5 Hz to 800 MHz (Quadruple pulse mode)
Accuracy	± 2 ppm max
Pulse Width	
Range (spec)	300 ps to (period–300 ps)
Resolution (spec.)	10 ps
Accuracy	± (0.1 % + 30 ps)
RMS Jitter[1]	< 10 ps
Pulse Delay	
Single/double/triple/quadruple	
Range (spec.)	0 ps to period
Resolution (spec.)	10 ps
Accuracy	± (0.1 % + 100 ps)

Output Specifications (50 Ohm load)

Impedance	50 Ohm nominal
Amplitude	
Range pk-pk (spec.)	10 mVpp to 5 Vpp
Resolution (spec.)	4 mV (250 mVpp to 5Vpp), 1 mV (10 mVpp to 250mVpp)

Absolute accuracy (spec.)	±(1% of amplitude p-p + 1% of |DCOffset|+20 mV)
DC Offset (HV only)	
Range (spec.)	0V or ± 25V adjustable
Resolution (spec.)	10 mV
Baseline Offset	
Range (spec.)	± 2.5V adjustable
Resolution (spec.)	2 mV
Rise/Fall Time (20% to 80%)	< 70 ps
Rise/Fall Time (10% to 90%)	< 95 ps (1Vpp amplitude), < 105 ps (5Vpp amplitude)
Overshoot	< 5%
Channel to Channel RMS Jitter[1]	< 10 ps
Initial Delay	0s to 8s (retriggerable delay off) 0s to 2.5us (retriggerable delay on)

[1] All channels at the same frequency in Single Pulse mode and Continuous mode
[2] With Offset ≠ 0V the width can deviate from this specification depending on the Offset voltage and other parameters

Trigger

Trigger Input	
Impedance	50 Ohm or 1K Ohm programmable
Range (spec.)	± 3.5 V (50 Ohm input impedance)
	± 10 V (1K Ohm input impedance)
Minimum detectable amplitude (spec.)	< 50 mVpp
Threshold	
Range (spec.)	± 8V
Resolution (spec.)	10 mV
Accuracy	± 100 mV
Max. Input frequency (spec.)	40 MHz
Min. pulse width (spec.)	1 ns
Max. external width mode input frequency (spec.)	1 GHz
Edge selection	Positive, negative, both
Prescaler (for every channel)	0 to 65535
Trigger output	
Impedance	50 Ohm nominal
Amplitude (open load)	
Range (spec.)	1.8V to 3.3V adjustable
Resolution (spec.)	1 mV
Accuracy	± 1%
Delay (trigger in to trigger out)	< 100 ns
RMS jitter (trigger in to trigger out)	< 30 ps (Trigger IN Frequency ≤ 15 MHz)
Width	10 ns (single, burst mode)
	Period/2 (continuous mode)
Initial delay	0s to 8s (continuous mode)
	0s to 2.5us (single, burst, gated mode)
Internal timer	
Time range (frequency range)	25 ns to 42.9 sec (40Mhz to 23.3 mHz)
Time resolution	1 ps
Frequency accuracy	± 2ppm max
External Clock IN	
Connector Type	SMA on rear panel
Input Impedance	50 Ω, AC Coupled
Input voltage range	-5 dBm to 4 dBm sine or square wave (rise time T10-90 <1 ns and duty cycle from 40% to 60%)
Damage level	+8 dBm or ±15 VDC Max
Frequency range	10 MHz to 100 MHz
External clock OUT	
Connector type	SMA on rear panel
Output Impedance	50 Ω, DC Coupled
Frequency	10 MHz or External Clock IN Frequency
Accuracy	± 2ppm max
Aging	± 1.0 ppm/year max
Amplitude	Square wave: 0V to 1.25 V into 50 Ω, 0V to 2.5 V into High Z

Programmability	
Trigger modes	Single, continuous, burst, gated
Multiple pulse modes	Single, double, triple, guadruple, external width

Power

Voltage range	100-240 VAC ±10%
Frequency range	47-63 Hz
Max. power consumption	120 W

Environmental Characteristics

Temperature (operating)	+5 °C to +40 °C (+41°F to 104 °F)
Temperature (non-operating)	-20 °C to +60 °C (-4 °F to 140 °F)
Humidity (operating)	5 % to 80 % relative humidity with a maximum wet bulb temperature of 29 °C at or below +40 °C, (upper limit de-rates to 20.6 % relative humidity at +40 °C . Non-condensing.
Humidity (non-operating)	5 % to 95 % relative humidity with a maximum wet bulb temperature of 40 °C at or below +60 °C, (upper limit de-rates to 29.8 % relative humidity at +60 °C. Non-condensing.
Altitude (operating)	3,000 meters (9,842 feet) maximum at or below 25°
Altutude (non-operating)	12,000 meters (39,370 feet) maximum

EMC and Safety

Safety	EN61010-1
Main Standards	EN 61326-1:2013 – Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 1: General requirements
Immunity	EN 61326-1:2013

General Characteristics

Display	7 inch, 1024x600, capacitive touch LCD
Operative system	Windows 10
External dimensions	EN W 445 mm – H 135 mm – D 320 mm (3U 19" rackmount)
Weight	21.4 lbs (9.7 Kg)
Front panel connectors	ALL OUTPUT (SMA) TRG.IN (SMA) TRG.OUT (SMA) 2 USB 3.0 ports
Rear panel connectors	External Monitor ports (HDMI, VGA) 2 USB 2.0 ports 2 USB 3.0 ports 3 COM ports 2 Ethernet ports (10/100/1000BaseT Ethernet, RJ45 port) Audio In/Out ports 2 PS/2 keyboard and mouse ports External Clock IN (SMA) External Clock OUT (SMA)
Hard disk	128 GB SSD
Processor	Intel® Celeron J1900, 2 GHz (or better)
Processor Memory	8 GB

DOCUMENT HISTORY

Version	Date	Author	Notes
V1.1	4/29/24	AT	New format
V1.2	12/19/24	AT	Data changes
V1.22	3/27/25	AT	Split datasheet

Berkeley Nucleonics Corporation

2955 Kerner Blvd.	*Phone:* (415) 453-9955	berkeleynucleonics.com
San Rafael, CA 94901	*Email:* info@berkeleynucleonics.com	berkeleynucleonics.com/downloads