Technical Note

Tips for using the Pulse Generator

Background and Purpose of this document

Many JAI cameras support a Pulse Generator function. Some have a single Pulse Generator, while other models support multiple Pulse Generators. By using the Pulse Generator function, you can generate/format/create signals which would be used for internally triggering the camera. The signals can also be output through a TTL/OPT out pin to be used for triggering other cameras.

For many users, however, setting up a Pulse Generator looks a bit difficult to understand. Therefore, this document will offer some guidance for how to effectively set up and use the Pulse Generator.

Pulse Generator Overview

It is helpful to understand the basic way a Pulse Generator operates (see Figure 1 below). A Pulse Generator is activated when a user-defined “Clear” signal exhibits a specific behavior (1), such as a rising or falling edge, high-level, low-level, etc. This causes the user-selected Pulse Generator to activate and run for a minimum of one “cycle” called the Pulse Generator Length (2). A user-specified “Start Point” and “End Point” (3) defines when the actual pulse will occur during the Pulse Generator cycle. Thus, each Pulse Generator cycle typically includes a portion of time when the signal is low, and a “pulse” period when the signal is high. Pulse Generator operation is extended by using a “Repeat Count” parameter, and/or by sending a new “Clear” signal to restart the Pulse Generator Length cycle. The restart can occur immediately (async mode) or at the end of the current Pulse Generator Length (sync mode).

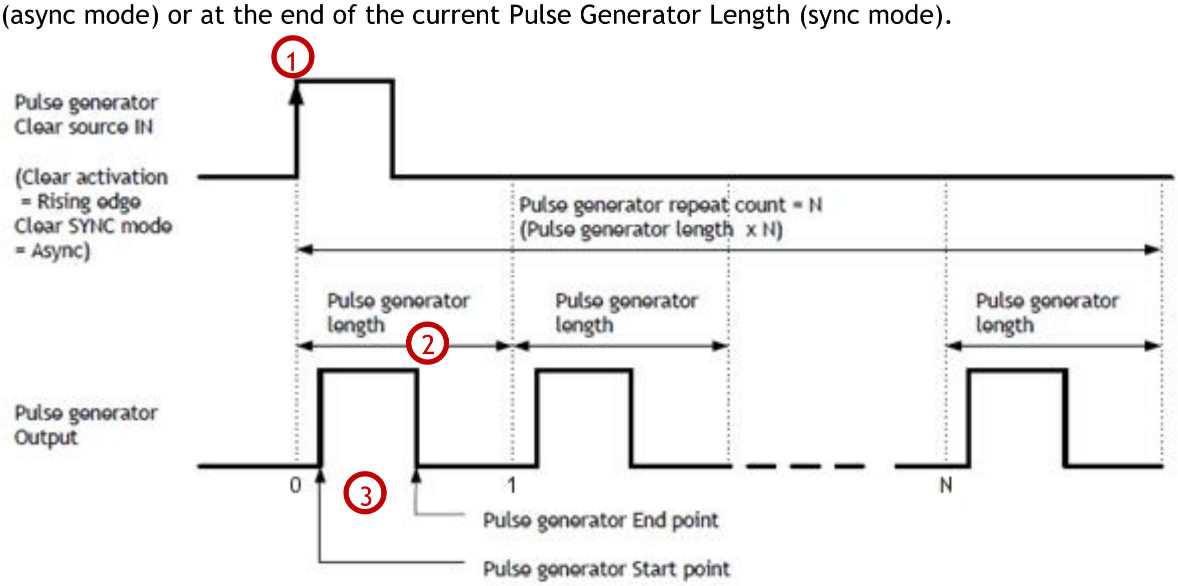

Figure 1 - Basic Pulse Generator operation

Pulse Generator Construction

As implied above, constructing a Pulse Generator consists of setting several parameters, including:

1) **Pulse Generator Clock:**
   The Pulse Generator Clock is a base clock to be used for setting the length of the cycle and the actual pulses. It is based on the camera’s pixel clock, but can be adjusted by the user either by using a dividing factor (the “pre-scaler”) or by directly setting a clock rate. The camera’s pixel clock can usually be found in the manual. Alternatively, it is the value that appears in the Pulse Generator Clock field when the Clock Pre-scaler is set to 1 (default). Once a Pulse Generator Clock has been defined, the length of one unit (clock cycle) can be determined, e.g., Pulse Generator Clock = 4 MHz -> length of one unit = 0.25 μsec.

See the possibilities

The following clock parameters are correlated. Changing one parameter is automatically reflected in the others.

i. Clock Pre-scaler:
This is the dividing value applied to the camera's pixel clock frequency.
Example: Pixel Clock = 48 MHz, Clock Pre-scaler = 2 -> Pulse Generator Clock = 24 MHz.

ii. Pulse Generator Clock:
Use this to directly specify a Pulse Generator Clock in MHz. The clock pre-scaler will be adjusted accordingly. This is often the easiest way to specify the base clock. Experienced pulse generator users often specify a 1 MHz clock to make pulse length calculations easier, while still being fast enough to support a 1 second pulse generator length cycle (see below). Actual value is rounded automatically.

Note: in many cases, particularly when using relatively short pulses (e.g., < 1 ms), the default pulse generator clock can be used without scaling. However, for long pulses, scaling the clock to create longer "base units" becomes necessary since these units are used as "counts" for the pulse generator cycle. If the units are too short, you may not be allowed to set a long pulse, since it would cause the counter to overflow/recycle before the pulse length is reached.

2) Length:

Total length of the pulse generator "cycle" including any "low" time and the pulse time:
The following parameters are correlated. Changing one parameter is automatically reflected in the others.

i. Pulse Generator Length:
The length of the pulse generator cycle as specified by a number of units.
Example: If Pulse Generator Length = 100 and length of one unit = 0.25 μsec
-> total length of one pulse generator cycle = 25 μsec.

ii. Pulse Generator Length (ms)
Use this to directly specify the length of the pulse generator cycle in milliseconds. Entries can be made in floating point numbers, so setting a length value of .025 = 25 μsec.

iii. Pulse Generator Frequency (Hz)
You can also define the pulse generator cycle by specifying a frequency. Many users find this to be an easy way to achieve a specific number of pulses per second.
Example: Pulse Generator Frequency (Hz) = 1000 -> total length of one pulse generator cycle = 1 msec.

Note: in practice, it is often easiest to define the Pulse Generator Length directly in milliseconds rather than calculating via clock units or frequency. Make sure you define a length that is greater than the size of your intended pulse plus any delay at the start of your pulse generator cycle. If a pulse is still active when the Pulse Generator Length is reached, it is automatically truncated at that point.

3) Start Point:

Start point of a pulse after the start of a pulse generator cycle. This can also be thought of as the "delay" time prior to the pulse:
The following parameters are correlated. Changing one parameter is automatically reflected in the others.

i. Pulse Generator Start Point:
The start point for the pulse as specified by a number of clock units.
Example: If Pulse Generator Start Point = 3 and length of one unit = 0.25 μsec
-> the pulse asserts at 0.75 μsec after the pulse generator is activated.

ii. Pulse Generator Start Point (ms)
Use this to directly specify the start point (delay) in milliseconds (decimal values allowed).

4) **End Point:**
End point of a pulse within a pulse generator cycle:
The following parameters are correlated. Changing one parameter is automatically reflected in the others.
  i. Pulse Generator End Point:
  The end point for the pulse as specified by a number of clock units.
  Example: Pulse Generator End Point = 10, length of one unit = 0.25 μsec
  -> the pulse negates at 2.5 μsec after the pulse generator cycle is activated
  ii. Pulse Generator End Point (ms)
  Use this to directly specify the end point in milliseconds (decimal values allowed).
  iii. Pulse Generator pulse-width (ms) (read only)
  This field is read only. The value is the result of the Start Point and End Point parameters.
  Example: Pulse Generator Start Point (ms) = 1 msec and Pulse Generator End Point (ms) = 5 msec,
  -> Pulse generator pulse-width (ms) becomes 4.

Note: as with Pulse Generator Length, the Start Point and End Point are usually easiest to define using direct millisecond entry (option ii). Decimals allow very precise setting points, provided they align with the clock unit size. In some cases, the Clock Pre-scaler may need to be adjusted in order to accommodate a specific Start or End Point.

5) **Pulse Generator Repeat Count:**
This defines the number of times to repeat the Pulse Generator cycle with the above parameters. After triggered (activated) by the Clear Source, the Pulse Generator cycle is generated repeatedly up to this Repeat Count number . If the Repeat Count is set to “0”, it works as a free-running generator with the cycle/pulses generated indefinitely. Sending a new “Clear” signal resets the Repeat Count and starts over (see below).

6) **Pulse Generator Clear Activation:**
Specifies the trigger condition (signal behavior) of the Pulse Generator Clear Source signal needed to activate or reset the Pulse Generator cycle.
Such as, High level, Low level, Rising edge, Falling edge.

7) **Pulse Generator Clear Source:**
Specifies which signal is used to trigger (activate) the Pulse Generator cycle. You can select it from the camera’s GPIO. Details of GPIO usage are explained in a separate Technical Note.

8) **Pulse Generator Clear Inverter:**
If set to “true,” this parameter causes the signal being input as the Pulse Generator Clear Source to have its polarity inverted.

9) **Pulse Generator Clear Sync Mode**
This parameter sets the start/restart method for the Pulse Generator cycle as follows:
  i. Async Mode:
  If the clear signal’s activation behavior is input mid-cycle (i.e., during a Pulse Generator cycle, including during a pulse), the current cycle is terminated immediately and the counter is reset to the Repeat Count value. A new Pulse Generator cycle then begins with the pulse timing starting as defined in parameters 1 – 5 above.

ii. Sync Mode:
In this mode, if the clear signal's activation behavior is input during a Pulse Generator cycle, the current working cycle continues until it is finished, including both high and low portions. Then, regardless of counts remaining on the repeat counter, the counter is reset to the Repeat Count value and a new Pulse Generator cycle begins with the pulse timing starting as defined in parameters 1 – 5 above.

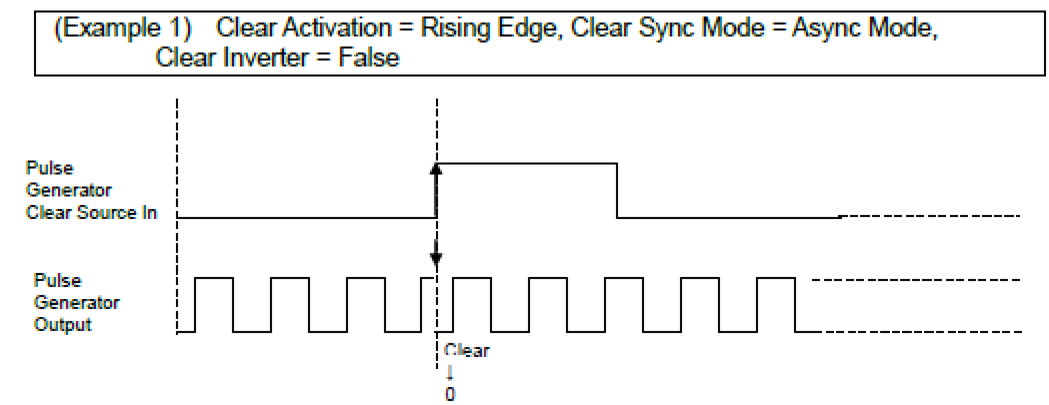

Figure 2: Async Mode

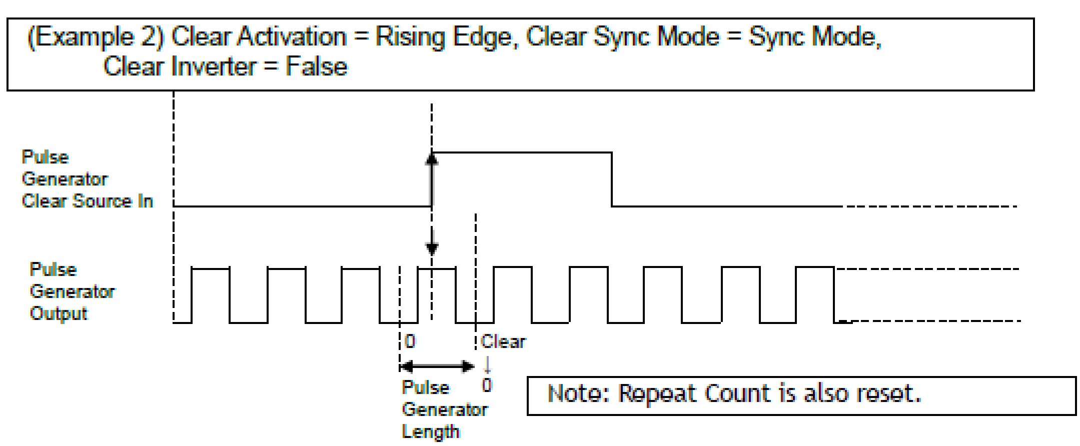

Figure 3: Sync Mode

Examples

To help further explain the setup and operation, we have provided a few Pulse Generator examples.

All samples below are for GO-5000M-USB (pixel clock = 48MHz). You can modify these samples to apply to other cameras from JAI.

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To monitor the generated pulse, it is useful to configure a line out of the GPIO.

Here is an example of how to use the GO-5000M-USB to monitor the output of Pulse Generator 0 (LineSource) through Line 2 - Opt Out1 (Line Selector).

d) Digital IO Control	
Line Selector	Line2 – Opt Out 1
Line Mode	Output
Line Inverter	False
Line Status	True
LineSource	Pulse Generator 0
Line Format	Opto Coupled
User Output Selector	User Output 1

Figure 4: Monitor Out

Example 1: Generate Repeating Clock
Example of generating the following pulse:

Cycle: 2 msec
Duty: 33%

Configure settings as shown in Figure 5 below, then you can generate the pulses seen in Figure 6.

JAI Gamma	0.45
f) Pulse Generators	
Clock Pre-scaler	1
Pulse Generator Clock (MHz)	48
Pulse Generator Selector	Pulse Generator 0
Pulse Generator Length	96000
Pulse Generator Length (ms)	2
Pulse Generator Frequency (Hz)	500
Pulse Generator Start Point	0
Pulse Generator Start Point (ms)	0
Pulse Generator End Point	32000
Pulse Generator End Point (ms)	0.666667
Pulse Generator pulse-width (ms)	0.666667
Pulse Generator Repeat Count	0
Pulse Generator Clear Activation	Off
Pulse Generator Clear Source	Low
Pulse Generator Clear Inverter	False
Pulse Generator Clear Sync Mode	Async Mode

Figure 5: Settings for 2 msec / duty cycle 33%

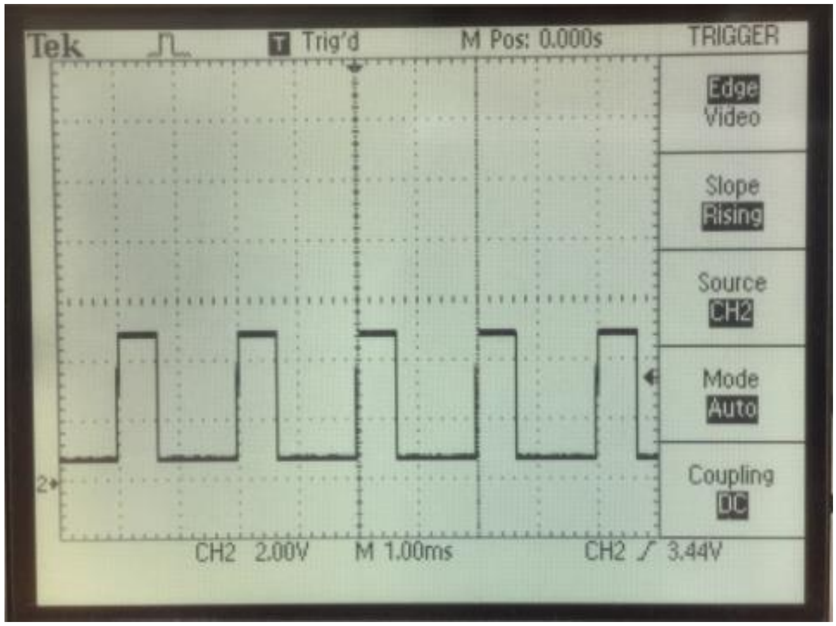


Figure 6: Generated Pulse as 2 msec / duty cycle 33%

Example 2: Generate repeating clock - changing pre-scaler

Take the setting from Example 1 and change the pre-scaler from ‘1’ to ‘2’. The other parameters are automatically changed as shown in Figure 7 and you can generate pulses as shown in Figure 8.

Cycle: 4 msec
Duty: 33%

f) Pulse Generators	
Clock Pre-scaler	2
Pulse Generator Clock (MHz)	24
Pulse Generator Selector	Pulse Generator 0
Pulse Generator Length	96000
Pulse Generator Length (ms)	4
Pulse Generator Frequency (Hz)	250
Pulse Generator Start Point	0
Pulse Generator Start Point (ms)	0
Pulse Generator End Point	32000
Pulse Generator End Point (ms)	1.33333
Pulse Generator pulse-width (ms)	1.33333
Pulse Generator Repeat Count	0
Pulse Generator Clear Activation	Off
Pulse Generator Clear Source	Low
Pulse Generator Clear Inverter	False
Pulse Generator Clear Sync Mode	Async Mode

Figure 7: Settings for 4 msec / duty cycle 33%

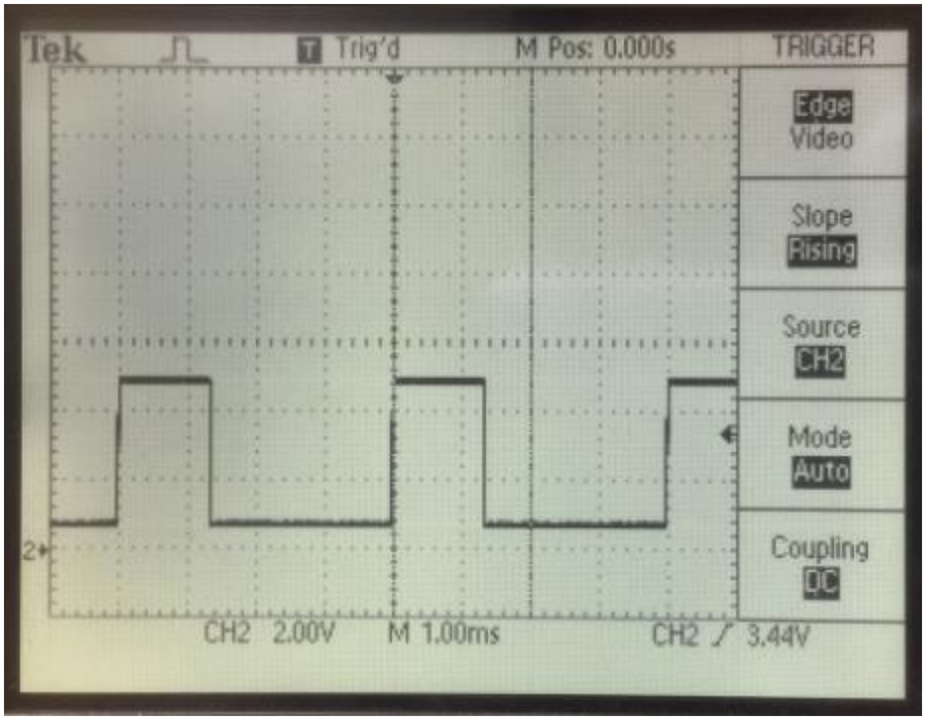


Figure 8: Generated Pulse as 4 msec / duty 33%

Example 3: Generating multiple pulses using Pulse Generator Clear Source
By using the Pulse Generator Clear Source, here is an example showing how to generate two pulses with 50 msec and 100 msec intervals, respectively.

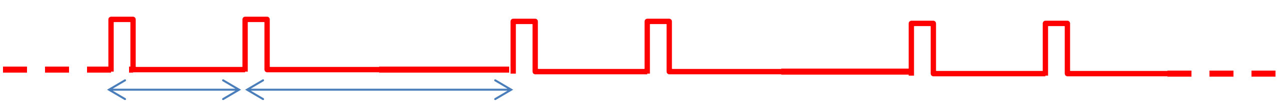


Figure 9: Two Pulses

First, you need to define a Clear Source which will cause the Pulse Generator cycle to re-activate every 150 msec. Looking at the bottom of Figure 10, you can see that we have set the Pulse Generator Clear Source to be the rising edge of a pulse that is input to Line 6 – Opt In 1. You will need an external device connected via the camera's 6-pin connector to provide the pulses as shown in Ch 1 of the scope image in Figure 11.

On JAI cameras equipped with multiple Pulse Generators, you could instead configure a second Pulse Generator to continuously output pulses at 150 msec intervals and designate it to be the first Pulse Generator's Clear Source (a Pulse Generator cannot be used as its own Clear Source, of course).

Clear Source Cycle: 150 msec

With the Clear Source defined, configure the rest of the Pulse Generator settings as shown in Figure 10. These settings apply a Clock Pre-scaler of 10 to the 48 MHz clock, and define a frequency of 20 Hz to produce a Pulse Generator cycle length of 50 msec.

The pulse, with a start point of 0 (no delay), has been defined as 50,000 clock units wide (roughly 10.4 msec) and a Repeat Count of 2 has been set. Thus, when a Clear Source activation is received from Line 6, the Pulse Generator immediately initiates a 10.4 msec pulse and repeats this for a second time at the conclusion of the 50 msec cycle.

When the second cycle ends, the Repeat Count has been fulfilled. Therefore, the Pulse Generator waits for a new Clear Source activation, which occurs 150 msec after the initial activation.

The combination of the Repeat Count and the Clear Source cycle results in the alternating 50 msec and 100 msec pulse intervals shown in Ch 2 of the scope image in Figure 11.

⊟ **d) Digital IO Control**	
⊟ Line Selector	Line2 - Opt Out 1
Line Mode	Output
Line Inverter	False
Line Status	True
LineSource	Pulse Generator 0
Line Format	Opto Coupled
⊞ User Output Selector	User Output 1
⊟ **e) Analog Control**	
⊞ Gain Selector	Digital All
Gain Auto	Off
⊞ Analog Base Gain Selector	All
⊞ Black Level Selector	Digital All
JAI LUT Mode	Off
JAI Gamma	0.45
⊟ **f) Pulse Generators**	
Clock Pre-scaler	10
Pulse Generator Clock (MHz)	4.8
⊟ Pulse Generator Selector	Pulse Generator 0
Pulse Generator Length	240000
Pulse Generator Length (ms)	50
Pulse Generator Frequency (Hz)	20
Pulse Generator Start Point	0
Pulse Generator Start Point (ms)	0
Pulse Generator End Point	50000
Pulse Generator End Point (ms)	10.4167
Pulse Generator pulse-width (ms)	10.4167
Pulse Generator Repeat Count	2
Pulse Generator Clear Activation	Rising Edge
Pulse Generator Clear Source	Line6 - Opt In 1
Pulse Generator Clear Inverter	False
Pulse Generator Clear Sync Mode	Async Mode
⊟ **g) LUT Control**	

Figure 10: Settings for two pulses

A script file for these settings is included in the appendix of this document.

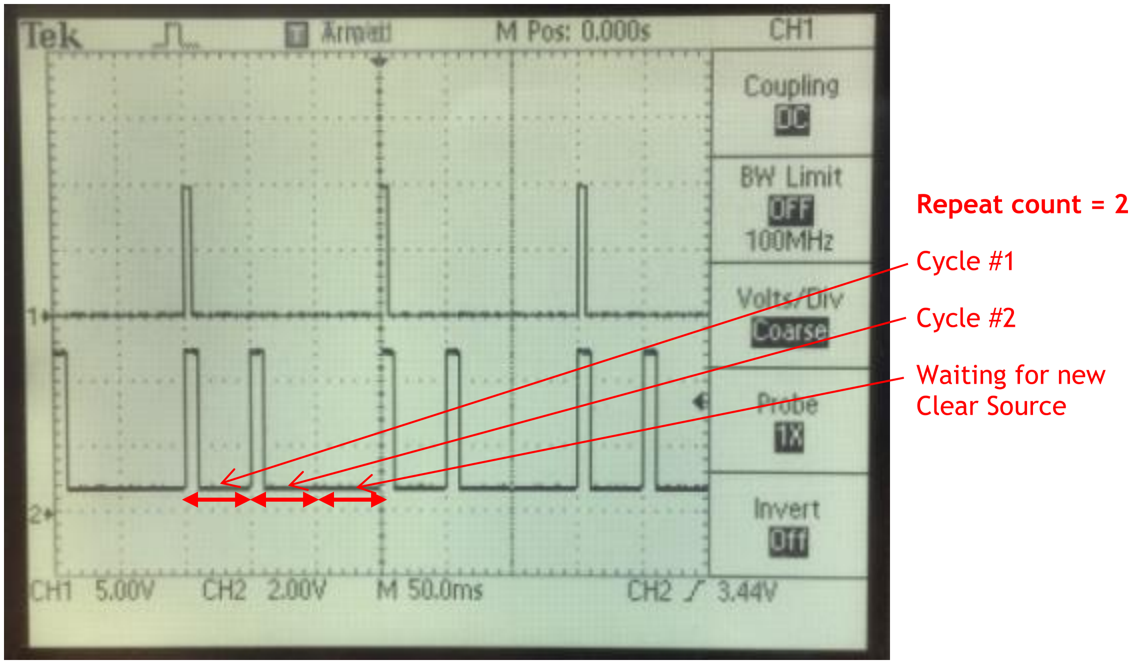
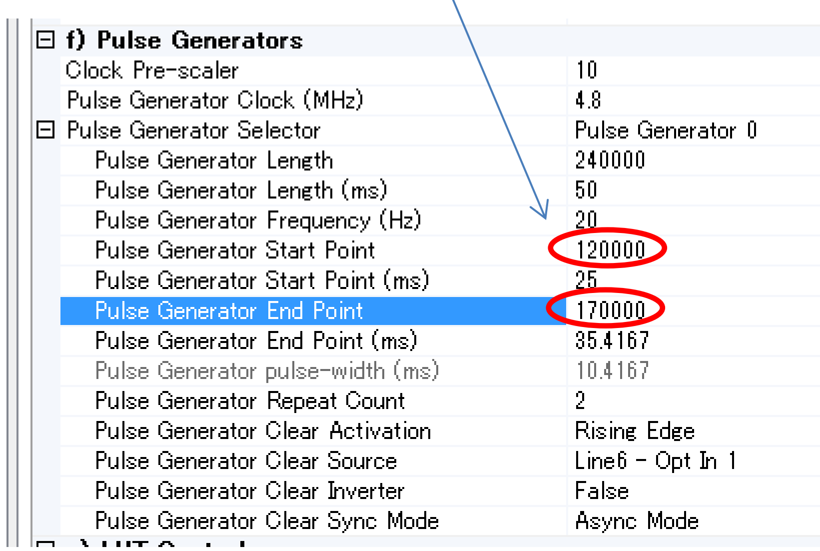


Figure 11: Generated output of two pulses

Example 4: Start delay after Pulse Generator Clear Source
Here is an example of a start delay after the Pulse Generator Clear Source is input.

Using the setup from Example 3, just change the Start Point and End Point as shown in Figure 12. This maintains the same width and spacing of the two pulses, but as can be seen in Figure 13, the pulses are now offset from the Clear Source activation points.



f) Pulse Generators	
Clock Pre-scaler	10
Pulse Generator Clock (MHz)	4.8
Pulse Generator Selector	Pulse Generator 0
Pulse Generator Length	240000
Pulse Generator Length (ms)	50
Pulse Generator Frequency (Hz)	20
Pulse Generator Start Point	120000
Pulse Generator Start Point (ms)	25
Pulse Generator End Point	170000
Pulse Generator End Point (ms)	35.4167
Pulse Generator pulse-width (ms)	10.4167
Pulse Generator Repeat Count	2
Pulse Generator Clear Activation	Rising Edge
Pulse Generator Clear Source	Line6 - Opt In 1
Pulse Generator Clear Inverter	False
Pulse Generator Clear Sync Mode	Async Mode

Figure 12: Settings for Start Delay

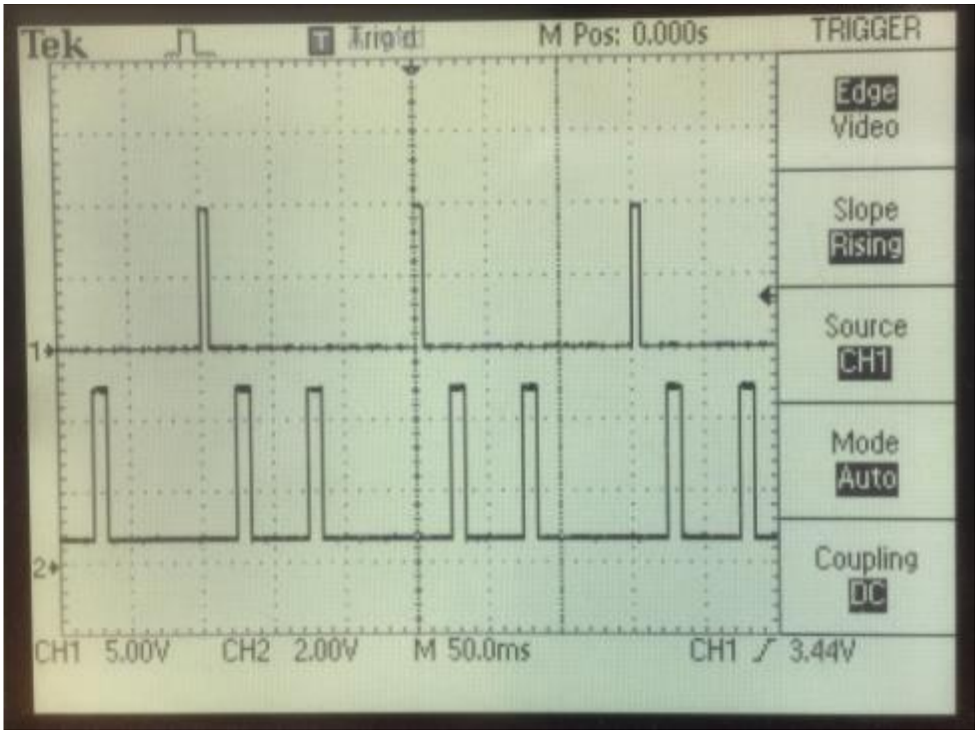


Figure 13: Generated Pulse of Start Delay

Example 5: Using a Pulse Generator to de-bounce a trigger line

A particularly effective use for a Pulse Generator function is to use it to avoid possible false triggering caused by a noisy trigger source. Depending on the type of trigger and what mechanical/electrical factors are generating the event, the trigger signal that is sent to the camera might exhibit a single “bounce” or even a very nasty series of bounces like those shown below.

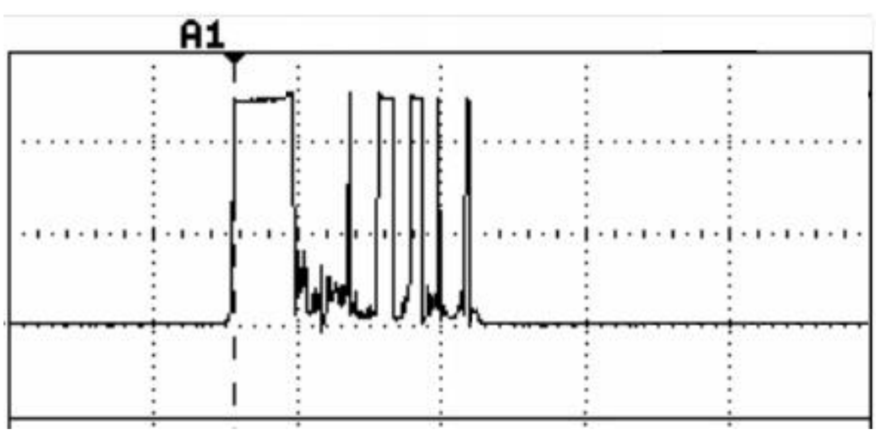


Figure 14: Bouncy trigger signal

If fed to a camera's trigger input, such a signal could result in very unpredictable results including many unwanted images. One option for dealing with this situation is included as an example in a separate Technical Note regarding GPIO use. It involves using two pulse generators. A second example is provided here, which can be used for cameras that only have a single pulse generator function available.

Start by reconfiguring the trigger circuit to use the "bouncy" trigger input line as a Pulse Generator Clear Source to the camera's Pulse Generator function. See the GPIO Technical Note for full configuration details, which would likely involve setting PulseGeneratorClearActivation to Rising Edge and PulseGeneratorClearSource to the external input line carrying the trigger input, for example, Line5 - Optical In 1.

Define a Pulse Generator Length long enough to handle your trigger pulse (a 100 µs pulse works well for most JAI cameras) PLUS a short delay of 10-50 µs. We will be using Async Mode, so the total length doesn't have to be exact; just longer than the minimum, for example 200 µs or 500 µs.

Now, set your Start Point and End Point. The Start Point should be slightly longer than the longest "bounce" in your trigger signal, but as short as possible to minimize jitter/delay. For example, try setting it to 0.050 (50 µs). If this eliminates the false triggers, you can try making the delay even shorter.

Set your End Point to 100 µs after the Start Point. In our example, that would be 0.150 ms.

Other settings include making sure the Pulse Generator Clear Sync Mode is set to "Async" so it will react instantly to any rising edges it receives; and setting the Pulse Generator Repeat Count to "1" so that it will wait for a new external trigger input after generating a single pulse.

With these parameters set, now configure your GPIO to use your Pulse Generator output as the input line for your camera's Frame Trigger (see the GPIO Technical Note for details).

The operation of your system should now work as explained below.

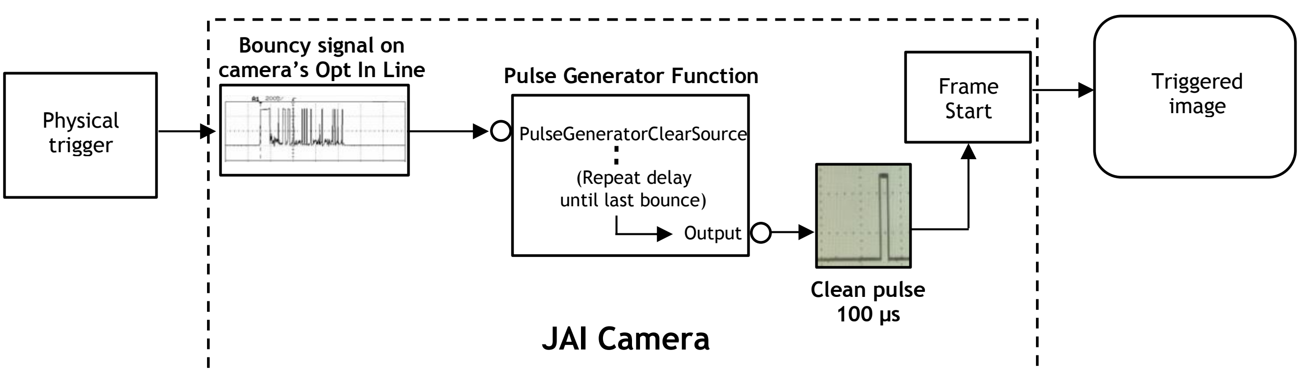


Figure 15. Trigger de-bouncing flow chart

When the input from the physical trigger is received by the camera, it is fed to the Pulse Generator Clear Source. The rising edge of the trigger causes the Pulse Generator to start its cycle. Because the Start Point has been set at 50 µs (0.050 ms), the Pulse Generator does nothing (delays) while waiting to reach this start point. But before it reaches the Start Point, it encounters the rising edge of the first “bounce.” Because it is in Async Mode, the Pulse Generator immediately restarts its cycle with another short delay. This process continues to repeat until the last “bounce” is received. This time, the Pulse Generator waits for the full 50 µs, and since it does not receive another bounce, it generates a 100 µs pulse. The Frame Start trigger, which has been set to receive its input from the Pulse Generator, reacts to this clean pulse by capturing a single image.

Since the Pulse Generator has now reached its repeat count (1), it simply resets and waits until the next physical trigger signal is received.

As noted, this method does introduce a small amount of latency, which might need to be considered when positioning the trigger and the camera. But it is typically much preferred over the alternative of dealing with numerous false triggers.

End.

Appendix

[Script file for Example 3. Generating multiple pulses with using Pulse Generator Clear Source:


```xml
<?xml version="1.0" encoding="utf-8"?>
<Script xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xmlns:xsd="http://www.w3.org/2001/XMLSchema">
  <CommandList>
    <Command>
      <FeatureName>LineSelector</FeatureName>
      <FeatureValue>Line2</FeatureValue>
    </Command>
    <Command>
      <FeatureName>LineInverter</FeatureName>
      <FeatureValue>False</FeatureValue>
    </Command>
    <Command>
      <FeatureName>LineSource</FeatureName>
      <FeatureValue>Pulse Generator 0</FeatureValue>
    </Command>
    <Command>
      <FeatureName>ClockPreScaler</FeatureName>
      <FeatureValue>10</FeatureValue>
    </Command>
    <Command>
      <FeatureName>PulseGeneratorSelector</FeatureName>
      <FeatureValue>Pulse Generator 0</FeatureValue>
    </Command>
    <Command>
      <FeatureName>PulseGeneratorLength</FeatureName>
      <FeatureValue>240000</FeatureValue>
    </Command>
    <Command>
      <FeatureName>PulseGeneratorStartPoint</FeatureName>
      <FeatureValue>0</FeatureValue>
    </Command>
    <Command>
      <FeatureName>PulseGeneratorEndPoint</FeatureName>
      <FeatureValue>50000</FeatureValue>
    </Command>
```

```
    <Command>
      <FeatureName>PulseGeneratorRepeatCount</FeatureName>
      <FeatureValue>2</FeatureValue>
    </Command>
    <Command>
      <FeatureName>PulseGeneratorClearActivation</FeatureName>
      <FeatureValue>Rising Edge</FeatureValue>
    </Command>
    <Command>
      <FeatureName>PulseGeneratorClearSource</FeatureName>
      <FeatureValue>Line6 - Opt In 1</FeatureValue>
    </Command>
    <Command>
      <FeatureName>PulseGeneratorClearInverter</FeatureName>
      <FeatureValue>False</FeatureValue>
    </Command>
    <Command>
      <FeatureName>PulseGeneratorClearSyncMode</FeatureName>
      <FeatureValue>Async Mode</FeatureValue>
    </Command>
  </CommandList>
</Script>
```