BNC
Berkeley Nucleonics Corp

MODEL 670C

Arbitrary Waveform Generator

TAIL PULSE OPTION

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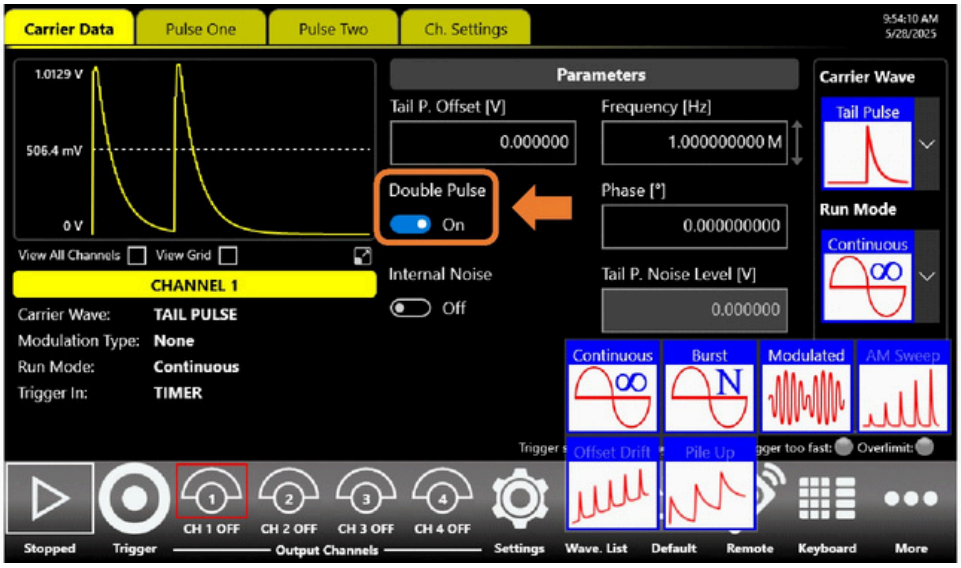
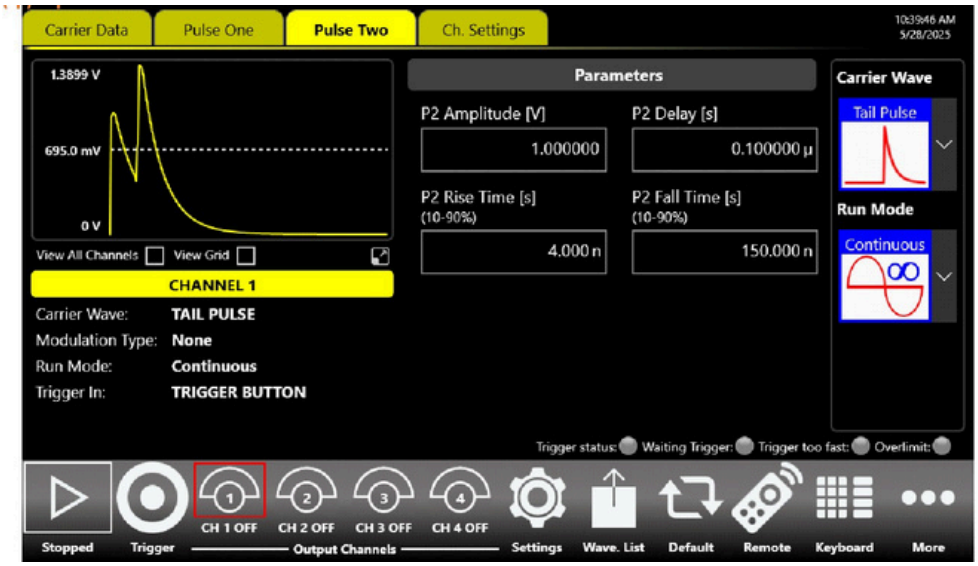
Overview: Tail Pulse (option for 670C)

This section introduces the *Tail Pulse* waveform, which is available as an optional feature exclusively on 670C models. In the main "Carrier Data" tab, users will find all the standard parameters common to other waveform types, including **Offset**, **Frequency**, **Phase** and **Noise**.

A **Double Pulse** toggle is available, enabling the *Double Tail Pulse* mode. When activated, this mode adds a second pulse within the generation period. Enabling this mode will also activate the dedicated **Pulse Two** tab, where users can configure the second pulse. All parameters available for *Pulse One*—such as **Amplitude**, **Rise/Fall Time**, and **Delay**—are replicated for *Pulse Two*.

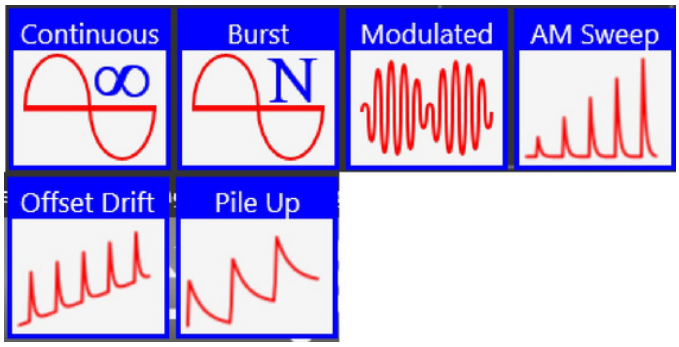


Unlike the *Double Square Pulse*, the *Double Tail Pulse* mode does not impose overlap constraints between the two pulses. This means the two pulses can be freely overlapped and the result is a Pile-up (see image below).



Tail Pulse Run modes

When the *Tail Pulse* waveform is selected for generation, the **Run Mode** section in the main tab displays all available run modes. As expected, some of these run modes correspond to the standard modes previously described for other generic waveforms, including **Continuous**, **Burst**, and **Modulated**. This section focuses specifically on the three operational modes dedicated to the *Tail Pulse*: **AM Sweep**, **Offset Drift**, and **Pile-Up Mode**.

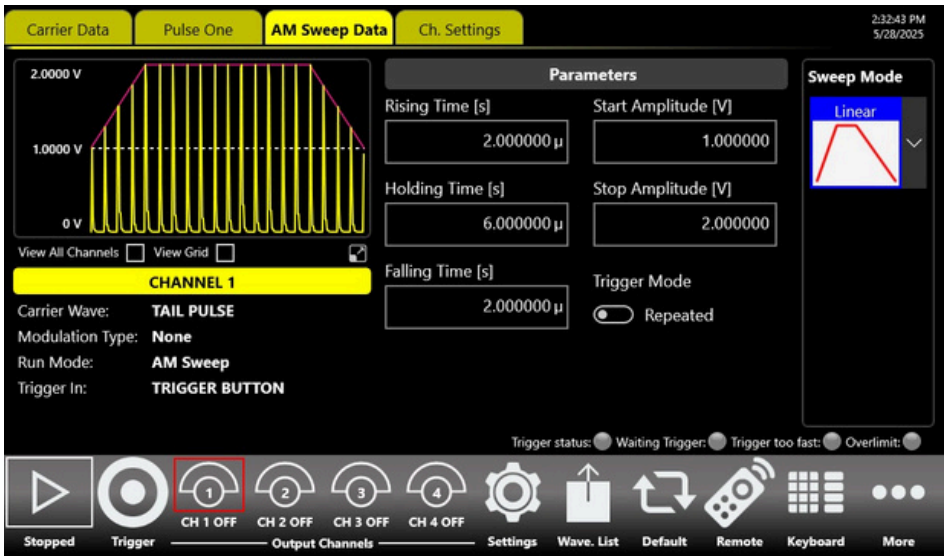


(specific Run modes only for Tail Pulse - optional)

Note: When *Double Tail Pulse* mode is enabled, these additional modes are not available. They are supported only in *Single Tail Pulse* mode.

AM-Sweep

The AM-Sweep mode varies the Amplitude pulse following a law that can be **Linear, Logarithm, Upstair** or **User Defined.** The **User Defined** selection gives the possibility to load the sweep profile from a file. AM Sweep mode is available only for the Tail Pulse waveform, and cannot be used when Double Tail Pulse is enabled.

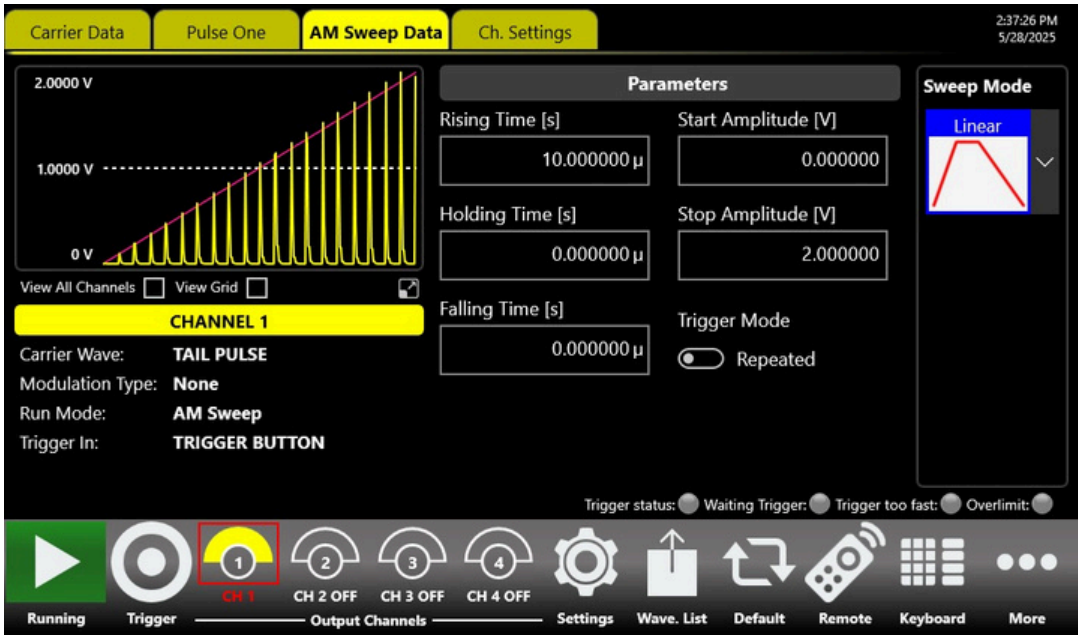


In *AM Sweep* mode, most of the parameters are the same as those described for the standard *Sweep* mode (Frequency) covered in previous sections. The only differences concern the **Start** and **Stop** parameters.

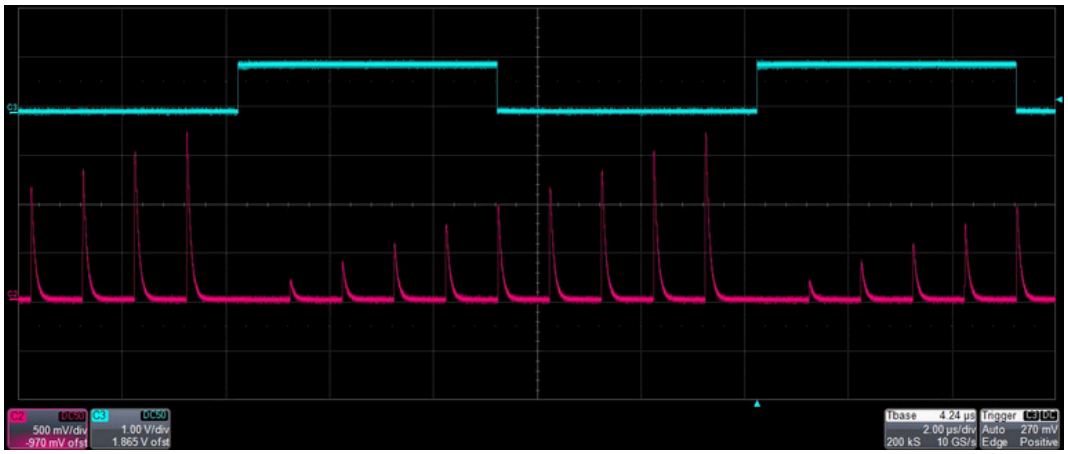
Parameters

- **Start Amplitude [V]:** it selects the initial sweep Amplitude.
- **Stop Amplitude [V]:** it selects the final sweep Amplitude.

AM-Sweep example For example, to perform 1 MHz Tail pulse modulated with AM Sweep with a rising time of **10 µs** (holding time and falling time at 0 s), setting the Start amplitude to **0 V** and the Stop amplitude to **2 V** (see parameter settings in the image below), the resulting output waveform is shown in the figure further down.



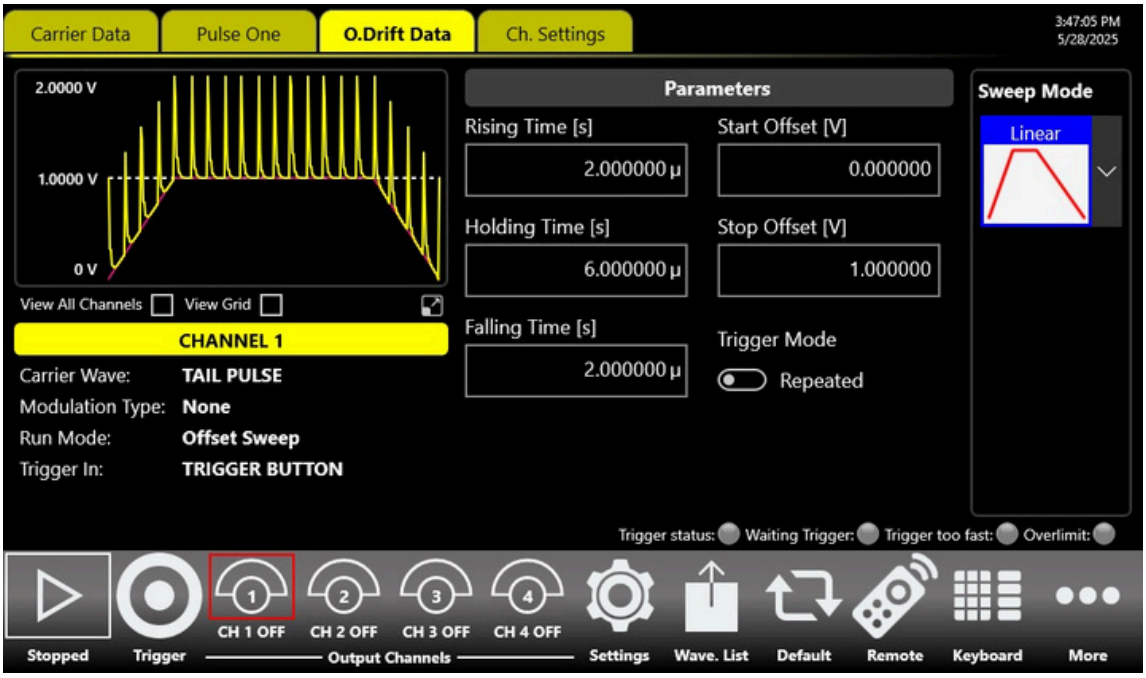
AM-Sweep tail pulse – Example Settings



Marker out (blue, top) synchronous with the sweep (red, bottom)

Offset Drift (Baseline Drift)

The Offset Drift mode varies the offset pulse following a law that can be **Linear, Logarithm, Upstair** or **User Defined.** The **User Defined** selection gives the possibility to load the sweep profile from a file. Offset Sweep mode is available only for the Tail Pulse waveform, and cannot be used when Double Tail Pulse is enabled.



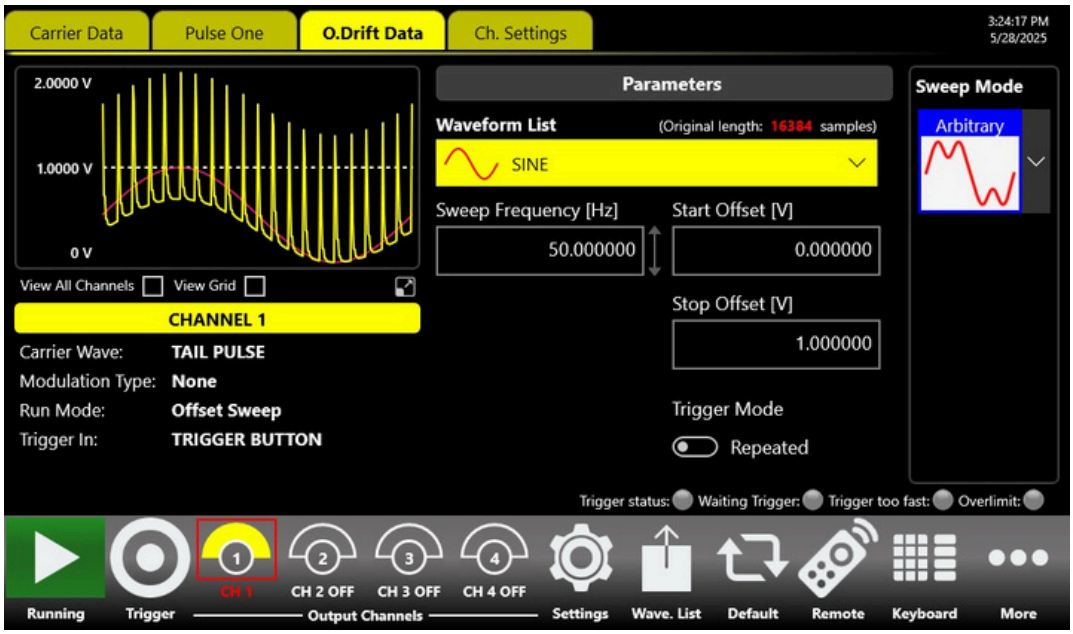
In *Offset Drift* mode, most of the parameters are the same as those described for the standard *Sweep* mode (Frequency) covered in previous sections. The only differences concern the **Start** and **Stop** parameters.

Parameters

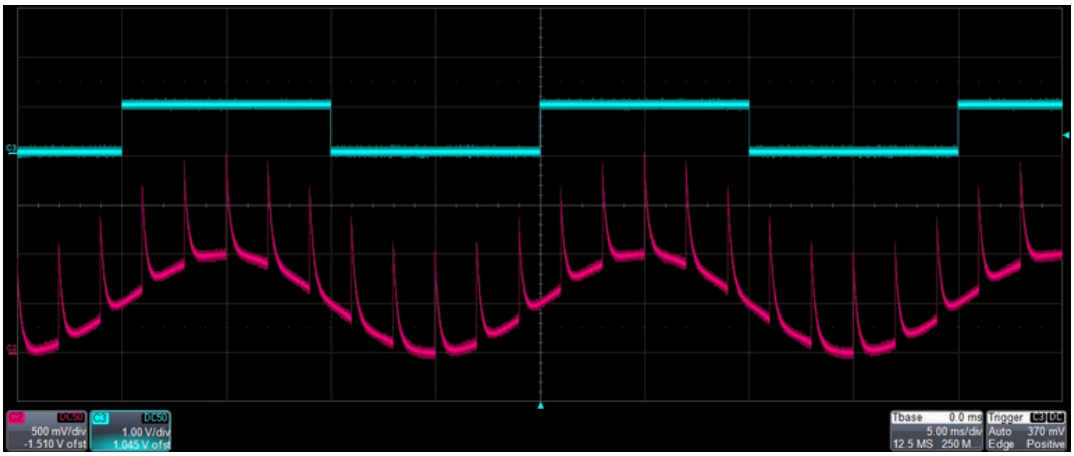
- **Start Offset [V]:** it selects the initial sweep Offset.
- **Stop Offset [V]:** it selects the final sweep Offset.

OffsetDrift example

For example, to simulate a 50 Hz AC sine wave noise in the test setup, the desired condition can be reproduced using the *Offset Drift Sweep* mode with an arbitrary law and a sine wave selected as the modulation waveform. Once configured, it is sufficient to set a Sweep Frequency of 50 Hz and adjust the offset variation dynamics using the Start and Stop Offset parameters. The resulting output waveform is shown in the figure below (Tail pulse frequency = 0.5 KHz and maximum fall time).



Offset Drift tail pulse – Example Settings

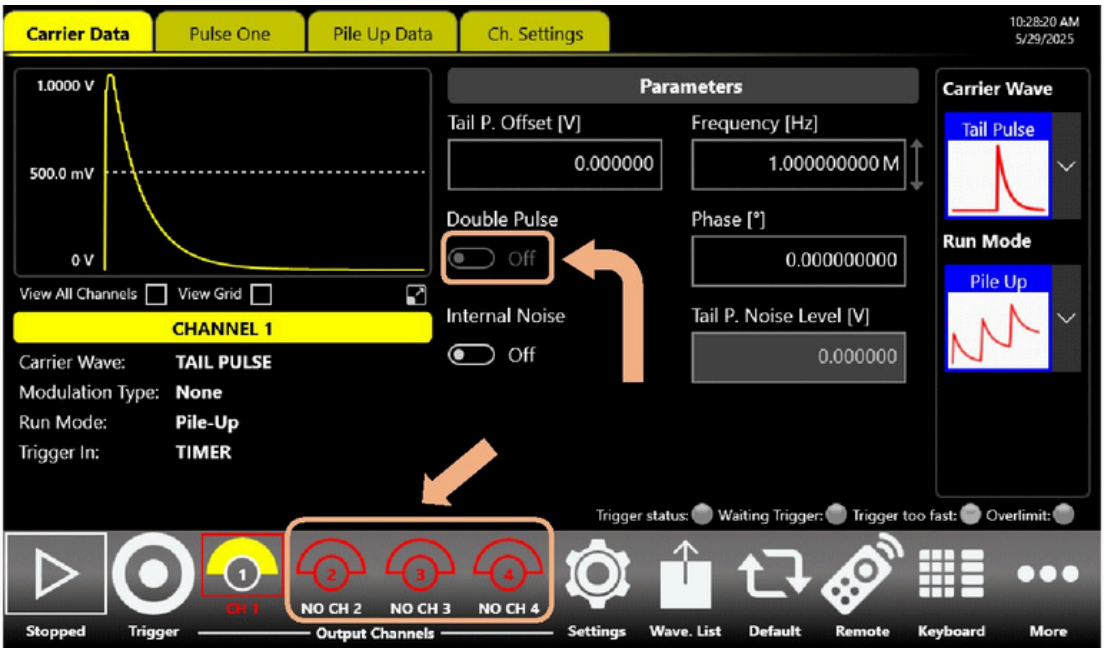


Marker out (blue, top) synchronous with the sweep (red, bottom)

Pile Up mode

This operating mode for the *Tail Pulse* waveform allows the User to generate pulses periodically, with no constraints between the configurable parameters. By appropriately combining values for **Amplitude**, **Rise/Fall Time**, and **Frequency**, it is possible to create a condition where pulses overlap with each other—this phenomenon is referred to as **pile-up**.

Pile-up mode is available only on **Channel 1**. When it is selected on Channel 1, Channels 2, 3, and 4 will be automatically disabled and made unavailable. Additionally, *Double Pulse* mode is not supported in this configuration. As a result, the corresponding activation control will be disabled.

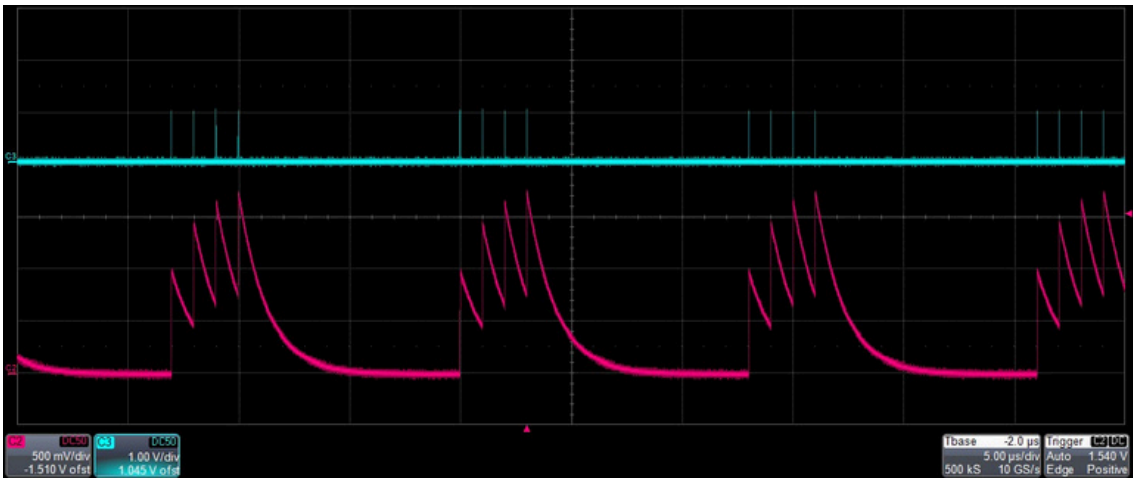


Pile-Up example 1: generating Pile up using rise/fall time variation only Starting from default parameters, generating an initial *Pile-Up* condition is quite straightforward.

By using a pulse repetition frequency of 1 MHz, it is sufficient to increase the **Fall Time** from the default value of 150 ns to, for example, 2800 ns.

As a result, the elongated "tail" of each pulse does not return to the low level before the arrival of the subsequent pulses (as determined by the configured frequency), thus creating a *Pile-Up* condition.

It is important to note that the **maximum number of overlapping pulses** (i.e., the maximum pile-up depth) is **4**. Once this limit is reached, no additional pulses will be generated until a new valid condition is met (See figure below.)



Marker out (blue, top) ,ch 1 (red, bottom)

PILE UP example 1: generating Pile UP using Fall time variation only

Pile-Up Data Tab

When using the *Pile-Up Run Mode*, the software provides additional features to generate and customize pile-up behaviour. These features are primarily located within the dedicated Pile-Up Data tab. The available parameters are as follows.

PILE UP Data tab parameters:

- **RND Distribution [UNIFORM/POISSON]:** Defines the type of distribution used to vary the time interval between consecutive Tail Pulses.
  In *Pile-Up Mode*, it is possible to specify an average pulse arrival frequency (frequency parameter) and introduce random variations in the pulse period based on either a **Uniform** or **Poisson** distribution.

- **Distribution Depth[%]:** This parameter defines the maximum percentage variation allowed with respect to the average frequency set in the **Frequency** parameter.
  For example, if the Frequency is set to 1 MHz and the Distribution Depth is 0%, the output frequency will remain exactly 1 MHz.

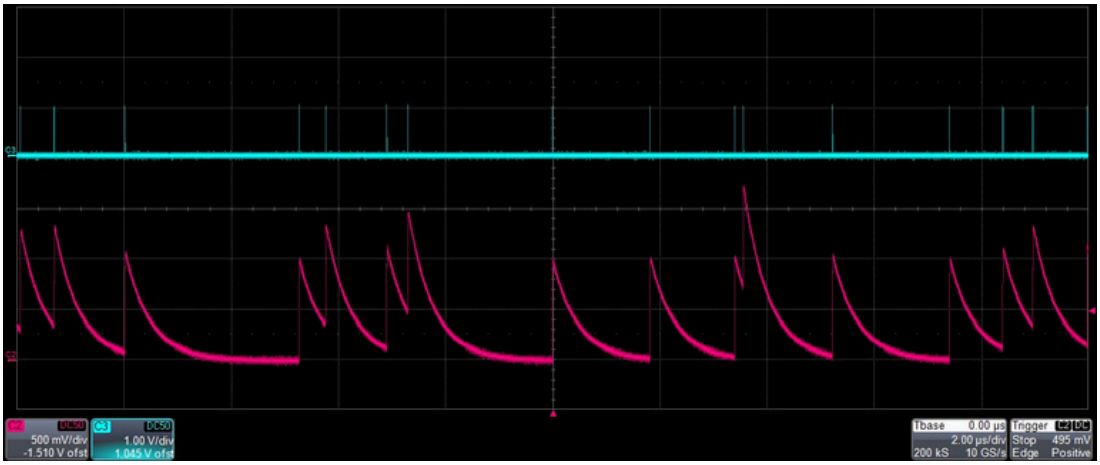
However, if the value is different from 0%—for instance, 10%—the random variations between periods (based on the selected distribution type) may deviate by up to ±100 kHz.

- **Amplitude Reference [NONE/RANDOM/ARBITRARY]:** This parameter allows modulation of the pulse amplitude during pile-up generation. If set to **NONE**, all pulses are generated with the same amplitude defined in the **P1 Amplitude [V]** parameter. When set to **RANDOM**, the amplitude of each pulse is randomly varied, and the variation range can be adjusted using the **AMP. Reference Depth [%]** parameter. Alternatively, selecting **ARBITRARY** enables amplitude variation according to a user-defined arbitrary waveform. In ARBITRARY mode, the user can customize the waveform shape, modulation frequency, and both Start and Stop Amplitude values.

- **Offset Drift [ON/OFF]:** This switch enables or disables modulation of the **Tail Pulse offset** (baseline). When enabled, the offset can be customized arbitrarily by selecting the modulation law from the **Waveform List**, setting the **Offset Frequency**, and defining the **Start** and **Stop Offset** values during modulation period.

Pile-Up example 2: generating Pile up using RND distribution

Starting from periodic pulse generation with an average frequency of 1 MHz (Frequency), a Rise Time of 4 ns, and a Fall Time of 1000 ns, a random variation is introduced using a uniform distribution and a Distribution Depth of 86%. The resulting waveform is shown in the figure below.



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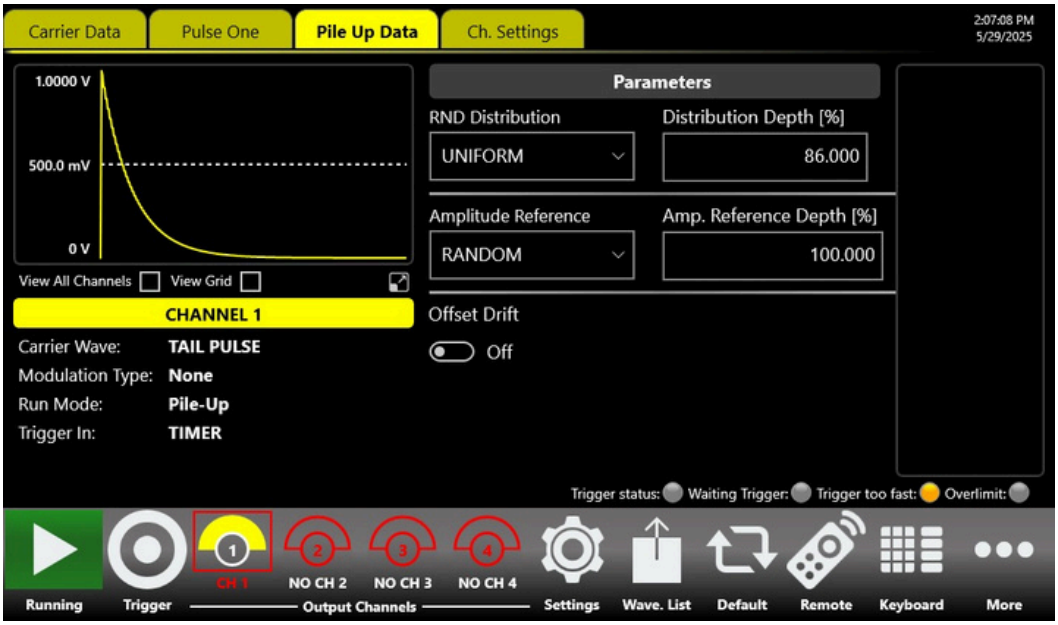
PILE UP example 2: generating Pile UP using RND distribution.

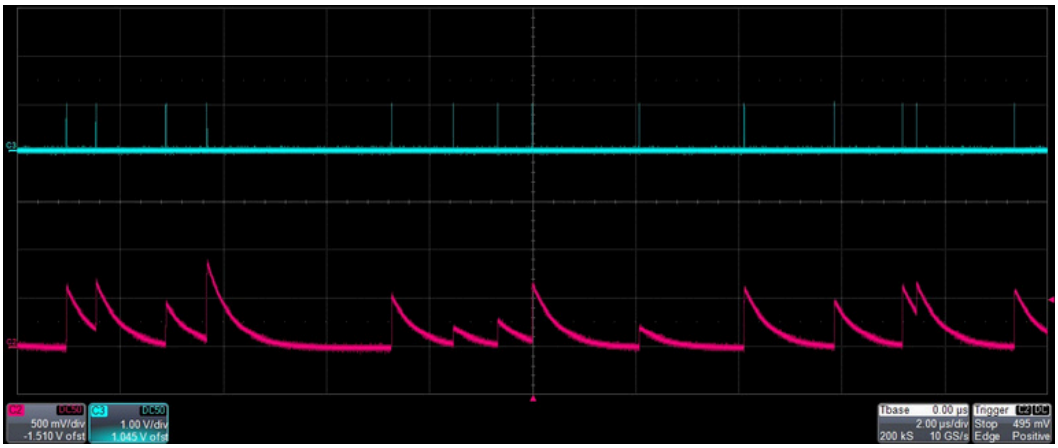
Naturally, the pile-up effect can be further increased by raising the **Rise/Fall Time** values, increasing the repetition **Frequency**, or by enlarging the **Distribution Depth** percentage.

Pile-Up example 3: Adding Amplitude Reference and Offset Drift to Pile-Up

Assuming the **Uniform** random distribution remains active with a **Distribution Depth** of 86%, a random amplitude variation can now be introduced by setting the **Amplitude Reference** parameter to **RANDOM**.

In this configuration, each generated pulse will have a varying amplitude, with the maximum variation percentage defined by the **Amp. Reference Depth [%]** parameter.





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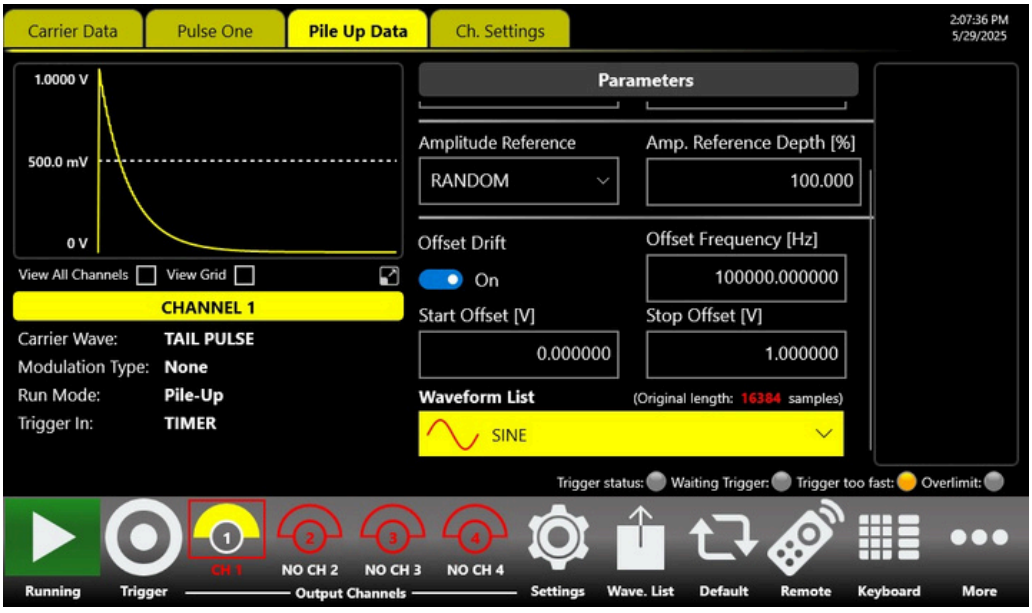
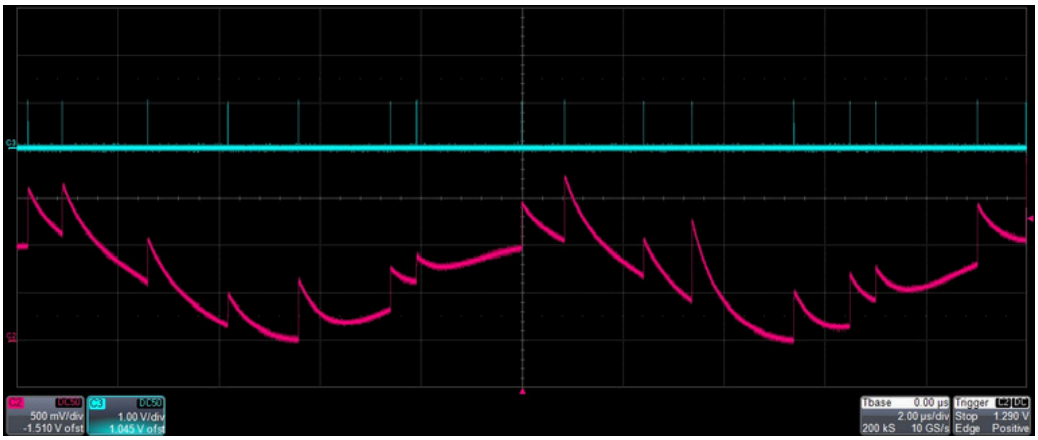
PILE UP example 3.1: adding Random amplitude reference to Pile Up.

If we now want to introduce a baseline variation to the pile-up—such as a sinusoidal variation with a frequency of 100 kHz and an amplitude range from 0 V to 1 V—it is sufficient to enable **Offset Drift** and configure the corresponding parameters (see figure) to achieve the desired offset modulation.





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PILE UP example 3.2: adding Offset drift to Pile Up.