# Pulsing Unit

***Application Note 152***

This document describes the setup and usage of a *Pulsing Unit (PU)*. *PU* is a *Software Option* (see [2]), which enables encoder *Option Modules EN* or *EH*, to fire pulses up to 10 MHz in reference to the connected encoder or path planner position. The *Pulsing Unit works only with analog encoders.*

## Table of Contents




Document AN152_PulsingUnit_EP
Version 004, 2024-02-21
Source Q:\Doc\ApplicationNotes\
Destination T:\doc\ApplicationNotes
Owner lk

# 1 Purpose and Usage

A *Triamec Pulsing Unit* usually controls an external device by triggering a process with a digital electrical signal. The triggers are fired in reference to a position information of the motion system at up to 10MHz.

The *Pulsing Unit* is controlled via *Tama* program, *TAM API* or by main controllers via fieldbus. As it is fully controllable with drive registers, simple use cases can also be set up manually via *TAM System Explorer*.

For the explanations on the usage of the *Pulsing Unit*, *Triamec* uses the following terms (Figure 1).

| Term | Description |
|---|---|
| Pattern | Contains all pulses to form the target image or structure. |
| Row | A pulse pattern is configured by a set of rows. This is because the Pulsing Unit only has position information from one dimension. |
| Sequence | A row can have one or more sequences of equidistant pulses. |
| Pulse | The Pulsing Unit output |

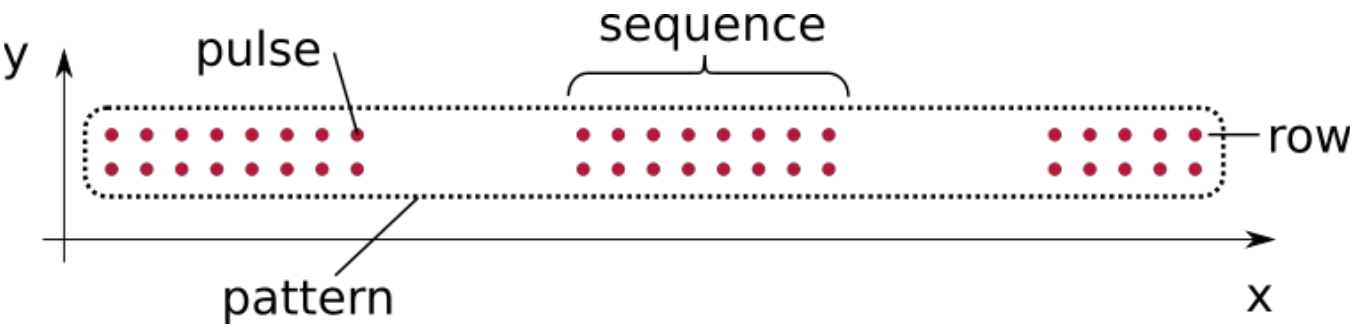



*Figure 1: Visualization of Pulsing Unit specific terms*

# 2 Preconditions

The following are mandatory for proper functionality.

- Only available on *Option Module Encoders EN* and *EH* (see [1])
- Only available in combination with analog sin/cos encoders, except using PU_Source = PathPlanner.
- Correct encoder settings must be configured, also in case of PU_Source = PathPlanner.
- Incompatible with EncoderTopology = Standard.

# 3 Pinout

The encoder pinout with enabled *Software Option PU*, is based on the analog encoder interface and adds the pulse output as *TTL* and *RS422* signals.

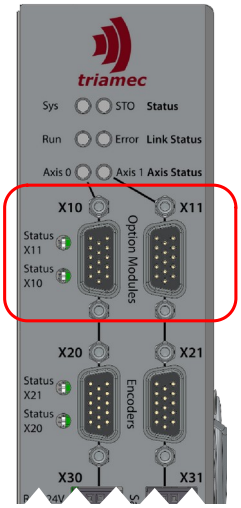
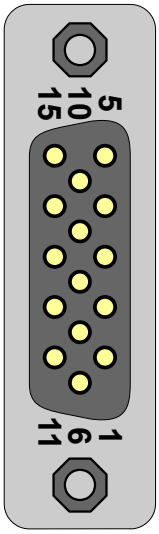



*Figure 2: Option Modules jack (X10,X11)*

| Pin Layout X10/X11 | Pin | Name | Encoder |
|---|---|---|---|
| 15-pin female D-Sub socket   | 1 | +5VDC | Encoder Supply |
| | 2 | ChA+ | Channel A positive, Cosine 1Vpp |
| | 3 | ChB+ | Channel B positive, Sine 1Vpp |
| | 4 | ChZ+ | Index channel positive, RS-422 input |
| | 5 | Pulse+ | **Pulse positive, RS-422 output** |
| | 6 | Gnd | Supply Ground |
| | 7 | ChA- | Channel A negative, Cosine 1Vpp |
| | 8 | ChB- | Channel B negative, Sine 1Vpp |
| | 9 | ChZ- | Index channel negative, RS-422 input |
| | 10 | Pulse- | **Pulse negative, RS-422 output** |
| | 11 | EncIn0 | TTL Level Input No. 0 (max 5VDC Input) |
| | 12 | EncIn1 | TTL Level Input No. 1 (max 5VDC Input) |
| | 13 | EncIn2 | TTL Level Input No. 2 (max 5VDC Input) |
| | 14 | PulseOut0 | **Pulse output, TTL single-ended 3.3V** |
| | 15 | Gnd | Signal Ground |

# 4 TAM Registers

The *Software Option PU* introduces new *TAM Registers* to control the *Pulsing Unit* functionality.

These registers appear in the Axes[] node, where the corresponding *Option Module EN* or *EH* is installed. If *Option Module* encoders are installed on both axes, the *Pulsing Unit* will be available on both modules.

## 4.1 Output

Generated pulses can be routed to either a differential output, or a single ended output (see chapter 3). The corresponding output is configured with the following register. This register can also be used to change the polarity of the desired output and thus also control the static state.

Axes[].Commands.OptionModule.PU_Output

| Value | Description |
|---|---|
| Disabled | The outputs are high impedance |
| RS422 | Output as RS-422 |
| RS422inverted | Output as inverted RS-422 |
| TTL | Output as TTL 3V3 |
| TTLinverted | Output as inverted TTL 3V3 |

## 4.2 Source

The position used for the pulse generator can be configured with the following register.

Axes[].Commands.OptionModule.PU_Source

The sources have different delay times, introduced by different signal paths with filters (Figure 3):

| Value | Description | Delay |
|---|---|---|
| EncoderFast | Encoder signals with the fast filter. | 5.2us* |
| EncoderSlow | Encoder signals as used by the position controller. | 49.3us* |
| PathplannerAx0 | Path planner position of axis 0. | 49.3us* |
| PathplannerAx1 | Path planner position of axis 1. | 49.3us* |

* Delays are perfectly repeatable. More precise values will be given here as more precise measurements of the actual delays become available.

It is recommended to start with EncoderFast and try other modes if the results are unsatisfactory. EncoderSlow and Pathplanner might provide an advantage at closely spaced pulses (e.g. 1nm) at very low speeds (e.g. 1 mm/s).

The delay may be compensated by adding it to the value in PU_DelayTime, see Chapter 4.4 Pulse Configuration. PU_DelayTime is used to calculate the correct firing time depending on current speed and acceleration, so that the actual position of the pulse is the desired one. If the speed changes during pulsing it is important to correctly configure PU_DelayTime, even if only the relative distance of the pulses matters.
If PathplannerAx0 or PathplannerAx1 is used as the source for the pulse generator, the parameter Encoder[].Pitch of the option module encoder must be configured, even if Encoder[].Type is set to None.

We recommend $Encoder[].Pitch > \frac{\sqrt{move\ range}}{5'000'000}$ as the value for Pitch in this use case.

**Note** The quality of the pulsing unit is strongly related to the quality of the encoder signals. Noisy and nonlinear encoder signals will directly affect the pulse firing position. Therefore the encoder input provides a slight signal filtering in order to reduce the effects of noise. Further the encoder auto calibration removes offset and gain errors from the sin/cos signals, but only if they are smoothly changing.

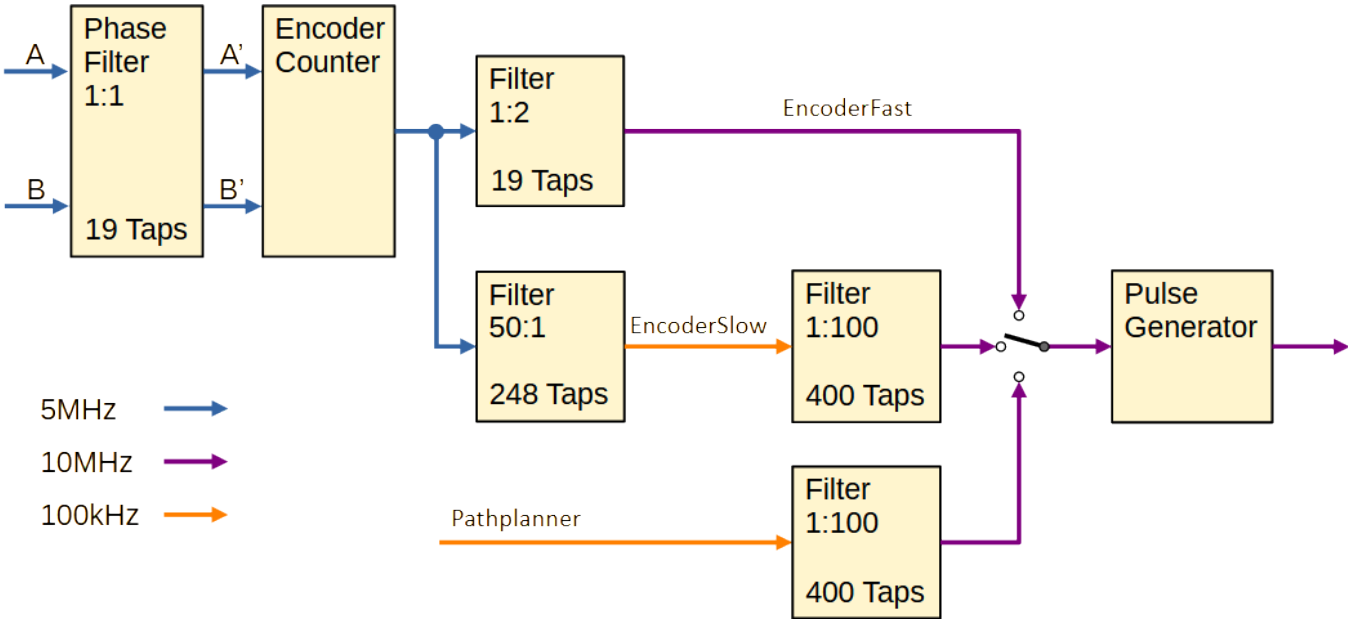



*Figure 3: Signal path of the pulse position source*

## 4.3 Mode

The Pulsing Unit can run in different modes. The main difference between modes is how the pulse configuration is applied.

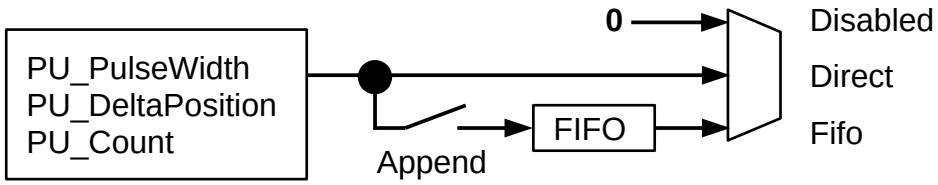



*Figure 4: Visualization of Pulsing Unit modes*

Axes[].Commands.OptionModule.PU_Mode

| Value | Description |
|---|---|
| Disabled | Disable the pulse generator. |
| Direct | Allows instant change of the pulse settings. |
| Fifo | Run sequences as stored in the FIFO. |

The two following register values are written once, when the a mode is activated. While the mode is active, all other configuration changes refer to these values and changes in these two registers have no effect.

- PU_ReferencePosition is the absolute position of the first pulse and thus the start of a pattern. Each subsequent pulse position is calculated internally by adding the PU_DeltaPosition to the last fired pulse position. See also chapter 4.4.
- PU_ActualPulseCount is reset when a mode is disabled. Accordingly, this value is 0 when activating a mode. From this point in time the value in PU_Count must be set larger than PU_ActualPulseCount to generate new pulses. See also chapter 4.5.

### 4.3.1 Direct

Use this mode to change the pulse configuration at any time (see Figure 4). Changing a register described in chapter 4.4 takes effect with each 10kHz cycle of the drive. There are two ways of usage:

- PU_Count = 0
  When activating the PU_Mode = Direct with PU_Count = 0, pulses will fire as long as the mode is active. The pulses start with crossing the PU_ReferencePosition once, and fire each time the PU_DeltaPosition is traveled. This is convenient if the pulse count is unknown or not calculated in advance.
  A typical use case is pulsing a spiral, where the pulse distance is recalculated for each 10kHz cycle.
- PU_Count > 0
  When activating the PU_Mode = Direct with PU_Count > 0, the configured amount of pulses fire while traveling across the positions. Further pulses only fire if the PU_Count is increased.
  Typical use cases are simple pulse rows, without gaps and equidistant pulse positions.

### 4.3.2 Fifo

The *Fifo* mode allows to buffer pulse sequences, where one entry represents an equidistant set of pulses as configured per chapter 4.4. Only one FIFO entry can be appended per 10kHz cycle. The register PU_FIFO is used for FIFO commands.

This mode is configured as follows:

- Configure a pulse sequence with the registers described in 4.4. Add up PU_Count for each sequence.
- Push the sequence to the FIFO, by setting PU_FIFO = Append.
- Repeat the above steps to join different sequences, i.e. to create a heterogeneous pulse pattern.

The next sequence will move into the active state as soon as the previous sequence has been fired. The previous sequence is deleted.

**Note** The FIFO has a size of 512 entries for sequences. The currently active sequence doesn't occupy a place in the FIFO. The amount of pulses within one sequence is not limited.

## 4.4 Pulse Configuration

The following registers in Axes[].Commands.OptionModule, define the pulses, as visualized in Figure 5. Also refer to chapter 5, for application examples.

| Register | Units | Resolution | Update Rate | Description |
|---|---|---|---|---|
| PU_PulseWidth | seconds | 10ns | 10kHz | Desired ON-time of the pulse. |
| PU_DeltaPosition | axis units | 64bit float | 10kHz | Distance between pulses. The sign indicates the crossing direction. |
| PU_Count | - | 32bit int | 10kHz | The accumulated number of pulses to fire. |
| PU_ReferencePosition | axis units | 64bit float | at mode activation | Position of the first pulse when a mode is activated. |
| PU_DelayTime | seconds | 10ns | at mode activation | Shift the pulse to compensate propagation delays. Fire early with negative values, or late with positive values. The delay is used to calculate the correct firing time depending on speed, acceleration and the desired position at the time of the pulse, see also Chapter 4.2 Source. |

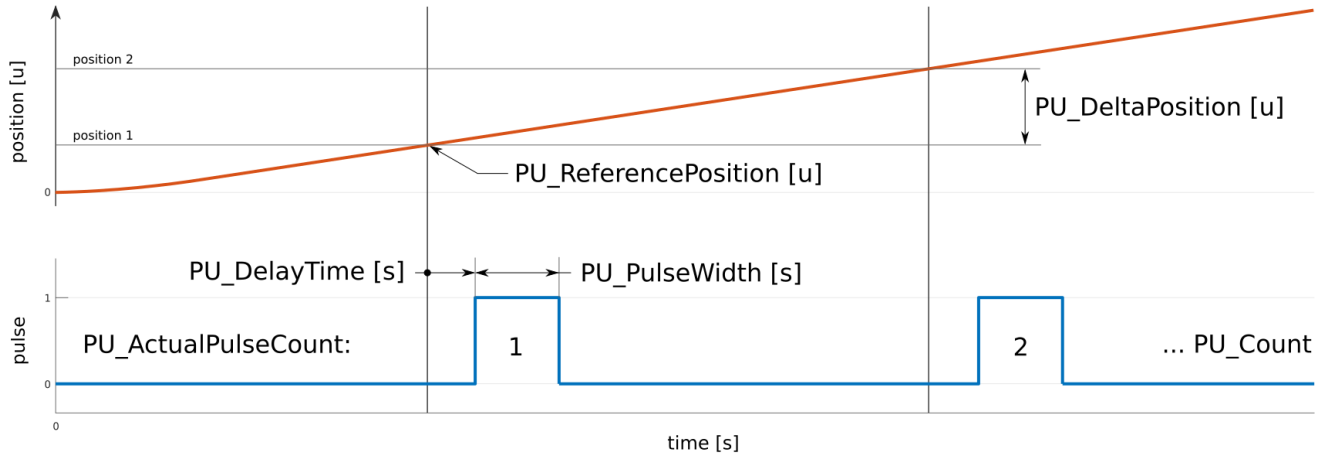



*Figure 5: Visualization of Pulsing Unit parameters*

**Note** The PU_ReferencePosition is only updated when the *Mode* is activated. To configure a sequence with a new reference position, set PU_Mode = Disabled, then configure the new sequence and lastly activate the *Mode*.

## 4.5 Signals

The following signals are available in Axes[].Signals.OptionModule and useful for debugging and programming.

- PU_ActualPulseCount indicates the last fired pulse index. If this value does not show the correct amount of pulses, it is usually an indicator for faulty configurations.
- PU_FreeFifoEntries indicates the currently available configuration slots. The first sequence pushed

into the FIFO is not reflected by this signal, as it is moved instantly into the active slot. While the value is 0, the FIFO is full and configurations are discarded. The following scenarios can lead to a full FIFO.

- A pulse configuration with PU_Count ≤ PU_ActualPulseCount has been pushed to the FIFO.
- A pulse configuration has been pushed to the FIFO with a PU_Count ≤ a previously pushed configuration. See also chapters 4.3 and 4.4.
- Continuously pushing to the FIFO, without actually consuming the pulse sequences.
  - The axis is not moving.
  - The axis is moving in the wrong direction, or
  - The pulses are configured for the wrong direction (negative PU_DeltaPosition).

**Note** The signals are delayed by 0.2ms (two cycles at 10kHz). In case of pushing sequences with *Tama*, consider to stop with a safety margin on PU_FreeFifoEntries, or count the entries with an own counter variable. Same applies to checks against PU_ActualPulseCount.

Using the *TAM System Explorer* Scope, the pulse output can be recorded with the register Axes[].Signals.General.DigitalInputBits.OptionEncIn3, if PU_Output is TTL or TTLinverted and the pulse duration PU_PulseWidth is larger than 20us.

# 5 Examples

Applications involving a *Pulsing Unit* are very flexible and therefore it is most probably commanded from *Tama* programs. To get started, *Triamec* provides examples on GitHub.

# Glossary

**FIFO** A FIFO is a data structure where the first item added is the first item to be removed.

# References


[1] “Option Modules Manual “, HWTO_OptionModulesManual_EP019.pdf, Triamec Motion AG, 2023.

[2] “Software Options Overview”, SWTO_SoftwareOptions_EP002.pdf, Triamec Motion AG, 2023.

## Revision History

| Version | Date | Editor | Comment |
|---|---|---|---|
| 001 | 2023-04-27 | sm | initial version |
| 002 | 2023-05-12 | Bl, lk | Clarification on pulse frequency and compensation of delays with PU_DelayTime |
| 003 | 2023-09-27 | sm | Add signals delay info, move example to GitHub |
| 004 | 2024-02-21 | ab | Added hints for the use case PathPlanner, Additional debug functionality added |



Triamec Motion AG
Lindenstrasse 16
6340 Baar / Switzerland

Phone +41 41 747 4040
Email info@triamec.com
Web www.triamec.com

## Disclaimer

This document is delivered subject to the following conditions and restrictions:

- This document contains proprietary information belonging to Triamec Motion AG. Such information is supplied solely for the purpose of assisting users of Triamec products.
- The text and graphics included in this manual are for the purpose of illustration and reference only. The specifications on which they are based are subject to change without notice.
- Information in this document is subject to change without notice.