# General Description

# The programmable filter is used to filter interference that negatively affects analog or digital signals, e.g. from sensors. It is possible to use low and high pass filter, while the cutoff frequency is adjustable.

# Functions and Benefits

* 1 channel
* Adjustable low-pass, high-pass, or band-pass mode
* Adjustable cutoff frequency
* Differential filter input and output
* Controllable via RS-485 communication
* Remote firmware update over Modbus

|  |  |  |  |
| --- | --- | --- | --- |
| Parameter | Value | | |
| **Minimum** | **Typical** | **Maximum** |
| Mounting | 35/7.5 (DIN 46277, EN 50022) | | |
| Size | 87 x 50.3 mm | | |
| Number of inputs | 1 RS-485 bus, 1 Filter input | | |
| Number of outputs | 1 Filter output | | |
| Ambient temperature | -30 °C |  | 200 °C |
| Power supply voltage | ± 11V | ± 12V | ± 25 V |
| Power supply consumption @ 12 V | ± 50 mA | ± 75 mA | ± 200 mA |
| Cutoff frequency range for low pass filter | **20 kHz** | 100 kHz | **320 kHz** |
| Cutoff frequency range for high pass filter | **300 Hz** | 500 Hz | **10 kHz** |
| Input and output mode | Differential | | |
| Maximum filter input voltage (IN+, IN-) to GND |  |  | ± 10V (20V pk-pk) |
| Maximum filter output voltage (OUT+, OUT-) to GND |  |  | ± 8V (16V pk-pk) |
| Modbus communication | 19200 baud/s, 8 data bits, Even parity, 1 stop bit | | |
| Modbus address | 32 + DIP value | | |

# Parameters

Obsah obrázku obvod, elektronika, Elektronické inženýrství, Elektronická součástka

Popis byl vytvořen automaticky

ProgFilter

# Pin Description - TBD

RS-485 bus termination selection

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RS-485 bus address selection

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User push button

## Pin Placing

Obsah obrázku obvod, Elektronické inženýrství, Elektronická součástka, Pasivní součástka

Popis byl vytvořen automaticky

Filter differential output

GND   
OUT+

OUT-

Filter differential input

GND

IN+

IN-

RS-485 bus connector

GND

RS485+ A  
RS485- B

Power connector

-12 V

GND

+12V

## Pinout Table

|  |  |  |
| --- | --- | --- |
| **PIN** | **Type** | **Description** |
| +12V | Power supply pin | Positive power supply pin for external power supply |
| -12V | Power supply pin | Negative power supply pin for external power supply |
| GND | Power supply pin | Power pin for supply ground |
| RS485-A | RS-485 bus | Positive RS-485 bus differential input/output |
| RS485-B | RS-485 bus | Negative RS-485 bus differential input/output |
| IN+ | Filter pin | Positive pin of the differential filter input |
| IN- | Filter pin | Negative pin of differential filter input |
| OUT+ | Filter pin | Positive pin of the differential filter output |
| OUT- | Filter pin | Negative pin of differential filter output |
| GND | Filter pin | Filter common GND |
| ADDRESS 0  –  ADDRESS 4 | Switch | Set Modbus RTU protocol address that will be added to **base value 32**. Individual address switches represent numerical values:  ADDRESS 0: 1  ADDRESS 1: 2  ADDRESS 2: 4  ADDRESS 3: 8  ADDRESS 4: 16  If given switch is turned on, related numerical value is effective. RS-485 Modbus protocol address is determined as sum of all numerical values enabled by switches. If all switches are ON, address is equal to 31 (1 + 2 + 4 + 8 + 16) + **32** = **63**. |

# Modbus RTU Protocol

The device implements Modbus RTU slave.

## Modbus Registers Mapping – Input Registers

|  |  |  |  |
| --- | --- | --- | --- |
| **Address** | **Name** | **Format** | **Description** |
| 0, 1 | Uptime | INT | Elapsed seconds from device startup Unit: s. |
| 2, 3 | Register map version | INT | Version of register map in format xxxyyy. Xxx - major version of register map. Yyy - minor version of register map. Major version defines compatibility of different register maps. If major version of register map changes, the values previously stored in the flash memory are discarded and factory values are used *Minimum: 1001. Maximum: 5050.* |
| 4, 5 | Status register | BIN | Binary map of different status flags Meaning of respective bits:  Bit 0 - Generic error - Error in the device. Bit 1 - Testing mode - Testing mode is enabled. Bit 2 - Calibrated successfully - Calibration data read successfully. Bit 3 - Modbus timeout - No modbus communication for timeout period. Bit 16 - Configuration flash error - Error when working with configuration memory. Bit 17 - Reset by IWDG - Last reset was caused by Independent watchdog. |
| 6 | Input signals | INT | Set of input signals.  Bits 0-4 - Modbus address offset Bits 5-8 - Bootstrap Bit 9 - Pushbutton *Minimum: 0. Maximum: 1023.* |
| 7, 8 | Serial number | INT | Serial number of product with common device ID in format xxyyzzzz. Xx - year of production Yy - month of production zzzz - serial incremental number of the product |
| 9, 10 | Product number | INT | Unique device ID *Minimum: 8753. Maximum: 8743.* |
| 11, 12 | Hardware version | INT | Hardware revision of the device defined as xxxyyy: xxx - major revision (letter) yyy - minor revision (number) *Minimum: 1001. Maximum: 5099.* |
| 13, 14 | Bootloader version | INT | Firmware revision of the bootloader as number xxxyyy: xxx - major version of bootloader yyy - minor version of bootloader *Minimum: 1001. Maximum: 5099.* |
| 15, 16 | Firmware revision | INT | Firmware revision of the current application image as an incremental number. See list of FW revision or release notes for respective features. *Minimum: 1. Maximum: 999.* |
| 17, 18 | Assembly date | INT | Assembly information of the current application in format xxxxyyzz: xxxx - year of FW build yy - month of FW build zz - day of FW build *Minimum: 20240810. Maximum: 20240810.* |
| 19, 20 | Configuration writes | INT | Number of writes into internal configuration flash memory (size 4kB, entry 128 B, total endurance 10000 \* 4096 / 128 = 320000) *Minimum: 0. Maximum: 1000000.* Unit: writes. |

## Modbus Registers Mapping – Holding Registers

The table below contains a description of all Holding registers and its function description.

|  |  |  |  |
| --- | --- | --- | --- |
| **Address** | **Name** | **Format** | **Description** |
| 0, 1 | Command | INT | Following commands are supported: Value 9901 - Reset Value 8801 - Factory reset Value 7701 - Testing mode Value 66xx - Invoke error Value 5501 - Invoke watchdog reset **Default: 0.** *Minimum: 0. Maximum: 9901.* |
| 2, 3 | Testing register | INT | Generic system testing register |
| 4 | Modbus baud rate | ENUM | Modbus RTU serial port baud rate Allowed values:  Value 0 - 9600 - 9600 baud/s. Value 1 - 19200 - 19200 baud/s. Value 2 - 38400 - 38400 baud/s. Value 3 - 57600 - 57600 baud/s. Value 4 - 115200 - 115200 baud/s. **Non-volatile, default: 1.** *Minimum: 0. Maximum: 4.* |
| 5 | Modbus parity | ENUM | Modbus RTU serial port parity Allowed values:  Value 0 - NONE - NONE parity. Value 1 - EVEN - EVEN parity. Value 2 - ODD - ODD parity. **Non-volatile, default: 1.** *Minimum: 0. Maximum: 2.* |
| 6 | Modbus stop bits | ENUM | Modbus RTU serial port - number of stop bits Allowed values:  Value 0 - 1 stop bit - 1 stop bit. Value 1 - 2 stop bits - 2 stop bits. **Non-volatile, default: 0.** *Minimum: 0. Maximum: 1.* |
| 7 | Apply modbus parameters | INT | Apply new modbus communication parameters. Value 1 - Apply new settings **Default: 0.** *Minimum: 0. Maximum: 1.* |
| 8 | Modbus timeout | INT | Longer silent period implies connection lost. Zero value disables timeout indication. **Non-volatile, default: 10.** *Minimum: 0. Maximum: 7200.* Unit: s. |
| 9, 10 | LP cutoff frequency | INT | Set cutoff frequency of low pass filter **Default: 100.** *Minimum: 10. Maximum: 320.* Unit: **kHz**. |
| 11, 12 | HP cutoff frequency | INT | Set cutoff frequency of high pass filter **Default: 1000.** *Minimum: 1000. Maximum: 10000.* Unit: **Hz**. |
| 13 | Filters mode | ENUM | Modbus RTU serial port - number of stop bits Allowed values:  Value 0 - **lowpass** - active only low pass filter. Value 1 - **highpass** - active high pass filter and 100 kHz LP. Value 2 - **bandpass** - active high and low pass filter - recommended to set LP below or equal to 100kHz. Value 3 - **without filter** - bypass both filters. **Default: 0.** *Minimum: 0. Maximum: 3.* |
| 14 | Reset filters | INT | Write 0 for reset. Switches off the power supply to the filters for 100ms. **Default: 1.** *Minimum: 0. Maximum: 1.* |

## RS-485 Communication Settings

RS-485 settings can be changed through Modbus Holding registers. The new settings are applied **only** after writing the “Apply modbus parameters” register. The default configuration is as follows.

|  |  |
| --- | --- |
| Parameter | Value |
| Baud rate | 19200 Baud/s |
| Word length | 8 bits |
| Parity | Even |
| Stop bits | 1 |

# Led Indication

For simple behavior indication, the device is equipped with Red and Green LED diode inside the housing (**LED1**, **LED2**).

|  |  |
| --- | --- |
| LED state | Meaning |
| Green – blinking | Operational state with active communication. |
| Red – solid | Malfunction, device is not operating. |
| Red – blinking | Warning state. Some internal error, requested resistance is out of range or undervoltage. |
| Red + Green concurrent blinking | Modbus communication timeout. |
| Red + Green alternate blinking | Bootloader is working. Either at power on or after remote firmware upgrade. |

# Functional Description

Obsah obrázku text, diagram, snímek obrazovky, Písmo

Popis byl vytvořen automaticky

The programmable filter consists of two parts: a control section and an analog section. The analog section contains high-pass and low-pass filters, which are connected through analog switches. This allows selecting whether one of the filters will be bypassed or if the signal will pass through without any filtering. The filters use switched capacitor (SC) technology, and their cutoff frequency is controlled by an external clock generated by a microcontroller via PWM. This ensures the ability to independently control each filter.

The differential input of the filter is routed to a differential instrumentation amplifier, and the filtered signal at the output is converted back to differential.

# Wiring and Power Up

Recommended powering-up sequence is as follows:

1. Power up Programmable filter

2. Connect Programmable filter to RS485 bus

3. Set filter mode and frequency

4. Connect differential input

# Bandpass Use Case

1. Write “Value 2 - bandpass” to register “PF\_MODE”.
2. Enter the desired cutoff frequency for the high-pass filter in the "PF\_CUTOFF\_HP" register and for the low-pass filter in the "PF\_CUTOFF\_LP" register.

# Device Limitations

**Filter input and output**

The differential input of the filter can accommodate a maximum voltage of +10V (IN+) and -10V (IN-), corresponding to a 20V peak-to-peak range. Higher voltages may lead to distortion or damage the device.

If using a **single-ended** input signal, connect it to one of the differential inputs (IN+ or IN-) relative to ground (GND). **Maximum input voltage in this mode is 4V**. In this mode, **the other input must be externally connected to ground to ensure proper filter operation**.

Obsah obrázku text, Písmo, snímek obrazovky, řada/pruh

Popis byl vytvořen automaticky

**High-pass mode**

**In the** **high-pass mode** (register "PF\_MODE = 1"), the **low-pass filter with a fixed value of 100 kHz is also activated**. This is necessary to avoid distortion of the passing signal.

**Band-pass mode**

**In the** **bandpass mode** (register “PF\_MODE = 2”), it is **recommended to set the cutoff frequency of the low-pass filter to a value less than or equal to 100 kHz**. A higher value may lead to distortion of the filtered signal.

**Cutoff frequency**

**The cutoff frequency of the low-pass filter for higher frequencies** (above 100 kHz) **is restricted to discrete values**. Based on the set cutoff frequency, the closest available discrete value is automatically selected.

Here is a list of discrete cutoff frequencies above 100 kHz in kHz:

{375.0, 300.0, 250.0, 214.3, 187.5, 166.7, 150.0, 136.4, 125.0, 115.4, 107.1, 100.0}

This limitation is due to the constraints of the microcontroller's timer prescaler.

**Device start up**

It is first necessary to provide power to the device before the differential signal can be connected to the filter input. Otherwise, there is a risk of damage to the device.

# Document revisions

|  |  |  |
| --- | --- | --- |
| Revision number | Date | Remarks |
| Rev 01.0 |  | Document release |
|  |  |  |