EnOcean

RAIL-TO-RAIL SENSOR APPLICATIONS

ADC RANGE OF STM 300 AND STM 3XY
HOW TO MEASURE RAIL-TO-RAIL

31 August 2026

Observe precautions! Electrostatic sensitive devices!

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WO98/36395, DE 100 25 561, DE 101 50 128,
WO 2004/051591, DE 103 01 678 A1, DE 10309334,
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The following major modifications and improvements have been made to this document:

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1.1	CB		2020.01	STM31x to STM300 and STM3xy. No EVA330
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Published by EnOcean GmbH, St.-Martin-Straße 76, 81541 Munich, Germany
www.enocean.com, info@enocean.com, phone +49 (89) 6734 689-0

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Packing: Please use the recycling operators known to you.

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1 Introduction

The STM 300 is a universal, customer-configurable EnOcean device platform for many kinds of sensor applications. The STM 33x is calibrated and configured as a temperature sensor and set point control, and the STM 32x as a magnetic contact sensor. The STM 300 is more flexible and can be used with other sensors, for example a light sensor. Like the ready-to-use sensor modules, STM 300 devices can be programmed and configured for a specific customer application. The analog-to-digital converter of the Dolphin chip inside the STM 3xy modules cannot measure a true Rail-to-Rail signal, that is, the full range from GND to SWPWR. Two elements are therefore needed:

- Special firmware called STMSEN must be built. The source code is part of the DolphinAPI examples, see [2]. This firmware reads the two external references REFN and REFP on ADIO3 and ADIO4 before it reads the sensor signal, and it refers every measurement result to these two references. Compile the source code and flash the result into the module.
- An external hardware adaptation circuit. This document describes the circuit and how to use it.

Details on the analog input range of the Dolphin chip are given in the Dolphin Core Description [1] and in the user manuals of the individual STM 3xy modules, which you find on the product pages [4], [5].

2 References

[1] Dolphin Core Description https://www.enocean.com/en/support/faq-knowledge-base/
[2] EnOcean software tools https://www.enocean.com/en/product/dolphinapi/
[3] EnOcean support (support@enocean.com), https://www.enocean.com/en/support/
[4] STM 300 product page https://www.enocean.com/en/product/stm-300/
[5] STM 330 product page https://www.enocean.com/en/product/stm-330/

3 Measurement principle

A Rail-to-Rail measurement needs two offset references, REFN and REFP, that lie inside the measurement range of the Dolphin chip. A simple voltage divider generates both references. Two voltage followers can buffer them, which improves the accuracy. This external circuit shifts the supply voltage rails of the device into the measurement range of the internal ADC.

The divider resistors R1, R2 and R3 define the two offset voltages. Their values are chosen so that both references stay inside the analog input range of the Dolphin chip:

- REFN, the zero scale reference, is about 4.2% of SWPWR.
- REFP, the full scale reference, is about 92.67% of SWPWR.

The sensor adapter circuit must operate between these two rails and deliver its full-scale output within REFN and REFP. In the reference designs of this document, a 10 kΩ potentiometer replaces the sensor and simulates its output signal. Two additional analog inputs, ADIO3 and ADIO4, read the two external references first. All measurement results are then referred to these two references.

For the divider we recommend resistors with a tolerance of 1 % or better. A tighter tolerance directly improves the accuracy of the two references.

4 Rail-to-Rail sensor application with STM 3xy modules

Figure 1 shows the reference design for the STM 3xy platform. SWPWR supplies the divider and the two voltage followers. REFP is connected to ADIO4, REFN to ADIO3, and the output of the sensor circuit to ADIO0.

Note: the default firmware of the STM 3xy modules does not use the analog inputs ADIO3 and ADIO4 and performs no measurement on them. The module must therefore be reprogrammed with the STMSEN firmware through its 20-pin connector, before the external REFP and REFN circuit is put into operation.

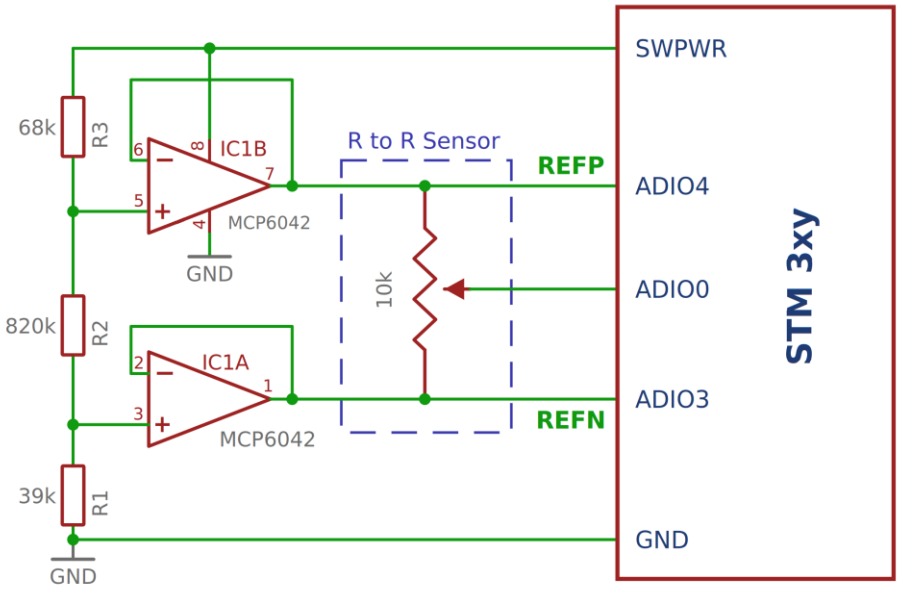

Figure 1 Reference design for STM 3xy, Rail-to-Rail measurement on ADIO0

5 Rail-to-Rail sensor application with STM 300 modules

In an STM 300 application that needs a Rail-to-Rail measurement, DVDD normally supplies the sensor voltage. The SCO control pin (WXIDIO) switches this supply through the transistor Q1, and it does so only during the measurement. R5 pulls the gate of Q1 up to DVDD, so Q1 stays off while the SCO pin is inactive. Figure 2 shows the reference design. The potentiometer R4, connected to ADIO0, simulates the output of the external sensor. The STMSEN firmware is used in this application as well.

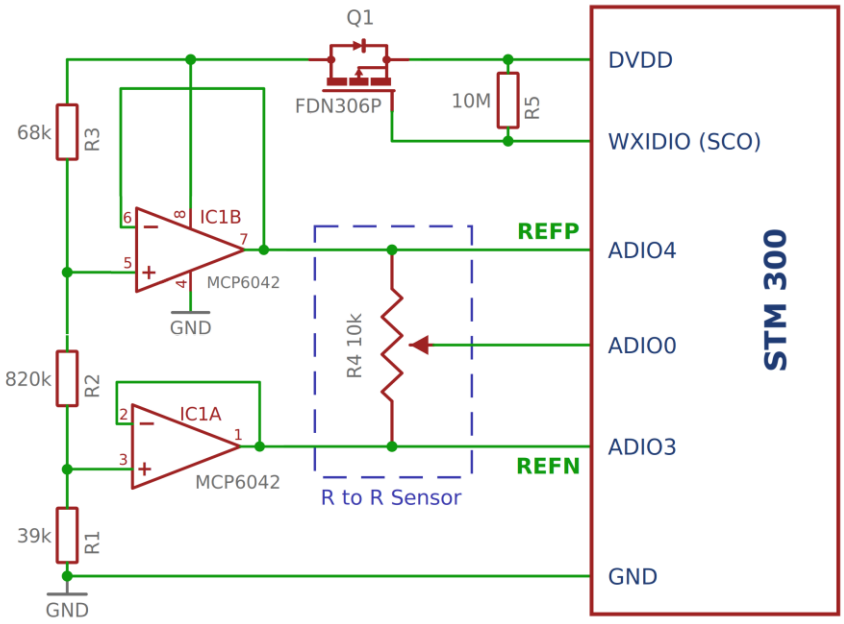

Figure 2 Reference design for STM 300, Rail-to-Rail measurement on ADIO0

The default STM 300 firmware does not support Rail-to-Rail measurements [4]. It uses the following internal references:

- RVDD - output of the RF supply voltage regulator (1.8 V)
- RVSS - ground connection of the RF part (0 V)

To come close to a Rail-to-Rail measurement, the firmware must measure the new references REFN and REFP on two ADIO pins first, in the same way as the STMSEN firmware does.

In the default STM 300 firmware no ADIO pin is left free for this task. A suitable pin pair must be selected and freed in the firmware. Only the ADIO pins listed in Table 1 are available as analog inputs. ADIO0, ADIO1 and ADIO2 are already used as analog input channels 0, 1 and 2 in the default firmware. ADIO3 and ADIO4 are used as digital input channels 0 and 1. ADIO3 and ADIO4 are recommended for REFN and REFP. They are then no longer available as digital input channels 0 and 1. The resulting pin assignment is shown in Table 1.

Table 1 ADIO pin assignment in the STM 300

ADIO pin	Default firmware	Rail-to-Rail firmware
ADIO0	Analog input channel 0	Analog input channel 0, sensor signal
ADIO1	Analog input channel 1	Analog input channel 1
ADIO2	Analog input channel 2	Analog input channel 2
ADIO3	Digital input channel 0	Analog input, negative reference REFN
ADIO4	Digital input channel 1	Analog input, positive reference REFP

ADIO3 and ADIO4 are also hardware configuration pins. Whenever you change their function, set the configuration values in DolphinStudio and write them into the configuration area. These values then overwrite the hardware settings. If the configuration area holds no values, the module reads the hardware configuration pins instead, which can lead to undefined states. As an option, you can change the default STM 300 firmware so that it uses a different default value when the configuration area is empty.

5.1 Step-by-step procedure for the STM 300

To enable Rail-to-Rail measurements on an STM 300 platform, perform the following steps.

1. Use the reference design shown in Figure 2.
2. Change the source code of the STM 300 firmware so that ADIO3 and ADIO4 are used as references during the analog measurement. Change the function `void MeasureAnalog()` in the file `measurement.c`. Figure 3 shows the two lines that change.

C:\Program Files (x86)\EnOcean\DolphinAPI\EO3000I_API\Examples\STM300\measurement.c

Original File

```
23 void MeasureAnalog()
24 {
25     sint16 s16adio0value;
26     sint16 s16adio1value;
27     sint16 s16adio2value;
28     uint16 u16Value;
29
30     // do the measurement of the 3 analog ports
31     io_enableAnalog(1); // configuring hardware for analog measurement no VGA, increase current to Analog current
32     //lint -save -e534
33     io_ulpMeasAnalog(GPIO1_ADIO_0, &s16adio0value); // measure ADIO_0 against internal voltage
34     io_ulpMeasAnalog(GPIO1_ADIO_1, &s16adio1value); // measure ADIO_1 against internal voltage
35     if (unigcfg.cfg.stm300_cfg.u8AD_2_Mode == FLASH_ERASED_8)
36         io_ulpMeasAnalog(GPIO1_ADIO_2, &s16adio2value); // measure ADIO_2 against internal voltage
37     else
38         io_ulpMeasAnalog(VDD_4, &s16adio2value); // measure VDD_4 against internal voltage and put this in AD_2 value
39     io_ulpMeasAnalog(RVSS, &s16gnegref); // measure negative reference against internal voltage
40     io_ulpMeasAnalog(RVDD, &s16gposref); // measure positive reference against internal voltage
41     //lint -restore
42     io_enableAnalog(0); // restoring previous configuration
```

C:\Program Files (x86)\EnOcean\DolphinAPI\EO3000I_API\Examples\STM300\measurement_new.c

Modified File

```
23 void MeasureAnalog()
24 {
25     sint16 s16adio0value;
26     sint16 s16adio1value;
27     sint16 s16adio2value;
28     uint16 u16Value;
29
30     // do the measurement of the 3 analog ports
31     io_enableAnalog(1); // configuring hardware for analog measurement no VGA, increase current to Analog current
32     //lint -save -e534
33     io_ulpMeasAnalog(GPIO1_ADIO_0, &s16adio0value); // measure ADIO_0 against internal voltage
34     io_ulpMeasAnalog(GPIO1_ADIO_1, &s16adio1value); // measure ADIO_1 against internal voltage
35     if (unigcfg.cfg.stm300_cfg.u8AD_2_Mode == FLASH_ERASED_8)
36         io_ulpMeasAnalog(GPIO1_ADIO_2, &s16adio2value); // measure ADIO_2 against internal voltage
37     else
38         io_ulpMeasAnalog(VDD_4, &s16adio2value); // measure VDD_4 against internal voltage and put this in AD_2 value
39     io_ulpMeasAnalog(ADIO_3, &s16gnegref); // measure negative reference against internal voltage
40     io_ulpMeasAnalog(ADIO_4, &s16gposref); // measure positive reference against internal voltage
41     //lint -restore
42     io_enableAnalog(0); // restoring previous configuration for
```

Figure 3 Original and changed version of MeasureAnalog() in measurement.c

```
// default firmware: the internal rails are used as references
io_ulpMeasAnalog(RVSS, &s16gnegref); // measure negative reference
io_ulpMeasAnalog(RVDD, &s16gposref); // measure positive reference

// changed firmware: the external references are measured
io_ulpMeasAnalog(ADIO_3, &s16gnegref); // measure negative reference
io_ulpMeasAnalog(ADIO_4, &s16gposref); // measure positive reference
```

3. Change the pin configuration of ADIO3 and ADIO4 in DolphinStudio from digital inputs to analog inputs.

   Open the profile file STM300.dat in DolphinStudio, for example \SourceCode\Profiles\STM300.dat, and set ADIO3 and ADIO4 as shown in Figure 4.

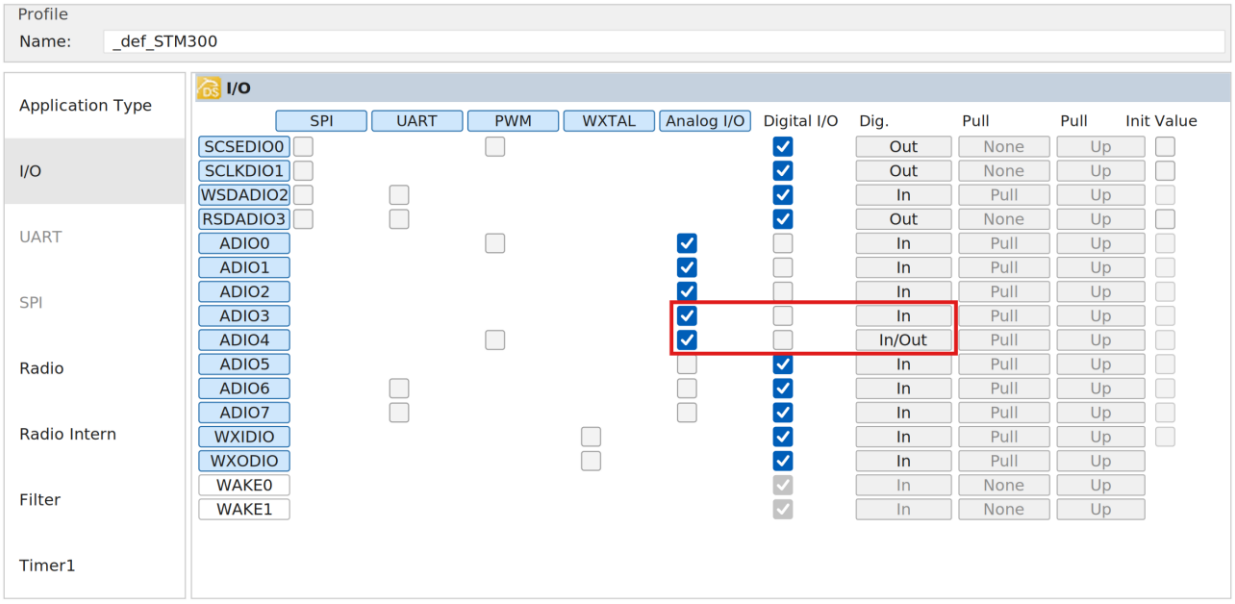

Figure 4 Pin configuration of ADIO3 and ADIO4 in the STM300.dat profile

Save the profile file STM300.dat and generate the configuration files.

4. Compile the new firmware and flash it into the STM 300 device.
5. Configure the STM 300 with DolphinStudio. Set the SCO pin to active low as shown in Figure 5. If you prefer an active high signal, invert the polarity of the SCO signal in the reference design.

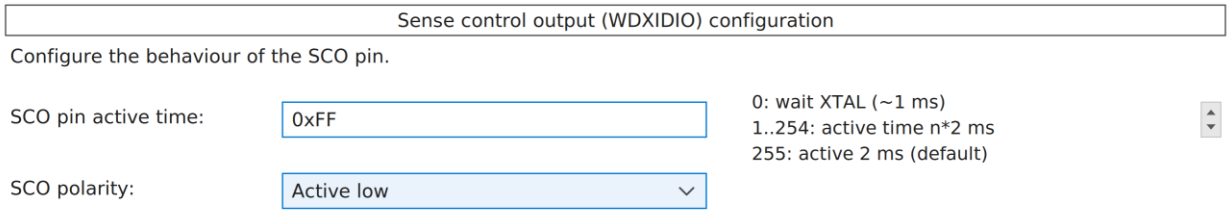

Figure 5 SCO pin set to active low

6. Set the digital input mask so that DI0 and DI1 are not considered. Figure 6 shows one example. Other combinations are also possible.

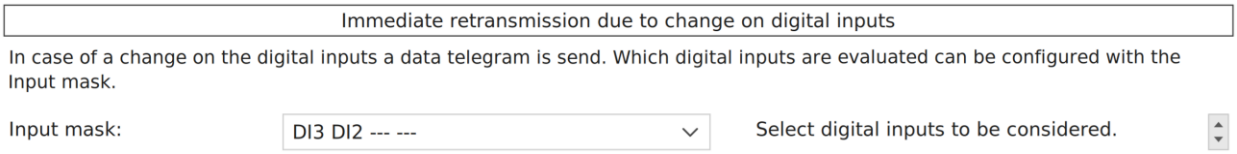

Figure 6 Digital input mask without DI0 and DI1

7. Write the configuration to the module.

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