IS4413-M1: I2C 4-20 mA Current Loop Transmitter

3-Wire Configuration

General Description

The IS4413 is a 4–20 mA current loop transmitter module controlled via I2C. The current output pad (COUT) outputs the programmed current at the Data (Hi) and Data (Lo) register.

The IS4413 reduces engineering effort by providing a ready-to-use module that shortens your product's time-to-market.

The module has a small footprint of 15.24 × 17.78 mm, making it compatible with 2.54mm breadboards and protoboards and easy to integrate into other designs.

Applications

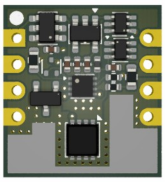
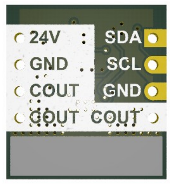
- Development of Process Control Systems
- Development of Sensors and Transmitters:
    - Pressure
    - Temperature
    - Flow
    - Level
    - pH
    - Conductivity
    - Position or Displacement
    - Vibration
    - Gas Concentration
    - Weight/Load
- Actuators Controllers
- Custom Application-Specific Solutions
- PLC

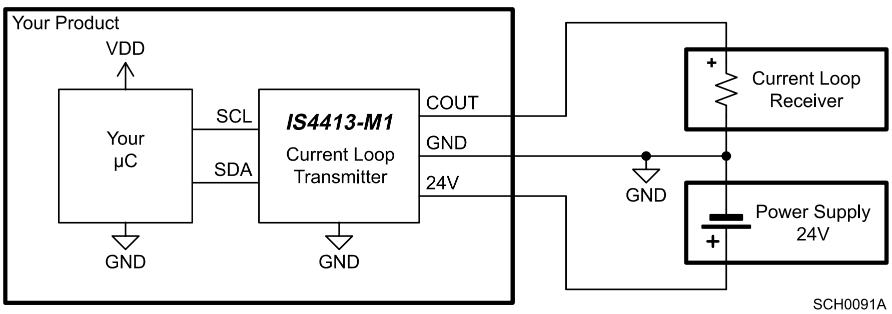
Main Advantages

- Reduces engineering time and cost associated with analog design.
- Uses standard I2C-serial interface; no dedicated libraries required, making firmware easy to maintain and port.
- Easy-to-use solution.
- Shortens product time to market.
- Provides a cost-effective solution.

Characteristics

- Current Loop Connection Type: 3-Wire Configuration
- Current Loop Output Current: 0 mA to 22 mA
- Resolution: 12-bit (~5.6 µA/bit)
- Current Loop Input Voltage: 24 V
- Current Loop Load: 250 Ω
- Configurable Safe Power-Up Current
- I2C Voltage: 5 V
- I2C Speeds: 100 kbps, 400 kbps, and 3.4 Mbps
- I2C Slave Address: 96 (7-bit address)

Part Number	Format	Op. Temperature
IS4413-M1-I	Module	-40°C to +85°C
		



1 Revision History

This datasheet and the IS4413 may be revised without notice. Users are responsible for obtaining and reviewing the latest version of this document before purchasing the product or designing it into any application. The most recent datasheet revision available on the company's website (www.inacks.com) shall be considered the only valid and authoritative source of product information.

1.1 Document Revision

Date	Revision Code	Description
September 2026	ISDOC150**A**	- Initial Release
April 2026	ISDOC150**Z**	- Preliminary document; not valid for design.

1.2 Hardware Revision

Date	Revision Code	Description
September 2026	**J**	- Initial Release

2 Specification

Operation Conditions

Parameter			Symbol	Min	Nom	Max	Unit
Supply Voltage			V_{24V}	—	24	—	V
Input Voltage at SCL and SDA			$V_{I/O-IN}$	—	0 and 5	—	
Current Loop Receiver Resistance			R_{LOOP}	—	250	—	Ω
Operating Temperature[1]	IS4413-M1-I	Industrial	T_{OP}	-40	25	85	ºC

Exceeding the Min/Max specifications could potentially lead to irreversible harm to the device. It's important to note that these ratings solely indicate stress limits and don't guarantee the device's functionality under such conditions, or any others not specified in the Recommended Operating Conditions. Prolonged exposure to conditions at or beyond the Absolute Maximum Ratings might compromise the reliability of the device.

Electrical Characteristics

Parameter		Symbol	Min	Typ	Max	Unit
Current Consumption (T_A = 25ºC, R_{LOOP} = Open)	I2C Data=0	$I_{OP(I2C=0)}$	—	0.764	—	mA
	I2C Data=4095	$I_{OP(I2C=4095)}$	—	5.795	—	
Input Voltage Levels at SCL and SDA pads	Logical High-Level	V_{IH}	3.5	—	—	V
	Logical Low-Level	V_{IL}	—	—	1.5	
Current Loop Output Current (T_A = 25ºC, R_{LOOP} = 252.1Ω)	I2C Data=0	$I_{LOOP(I2C=0)}$	—	0.015	—	mA
	I2C Data=4095	$I_{LOOP(I2C=4095)}$	—	22.680	—	
Current Loop Output Voltage (T_A = 25ºC, R_{LOOP} = 252.1Ω)	I2C Data=0	$V_{LOOP(I2C=0)}$	—	0.017	—	V
	I2C Data=4095	$V_{LOOP(I2C=4095)}$	—	5.77	—	

EEPROM

Parameter	Symbol	Min	Nom	Max	Unit
Write Time	T_{WRITE}	—	25	50	ms
Data retention1	—	—	200	—	Years
Endurance1	—	1	—	—	Million Cycles

1 Evaluated by characterization. Not tested in production.

3 Description

What is it, and what it does

The IS4413 is a module that generates a 4–20 mA current loop signal (3-wire configuration), controlled via I2C-serial interface from your microcontroller.

Utility

The module allows you to design process control systems such as sensors or transmitters that send process control data to a PLC, or to design actuator controllers.

For example, you may design a custom sensor that needs to report data via 4–20 mA; the module can be used to send the current. Or you may need to control a current loop actuator without implementing a PLC system, in which case the module can be used.

Benefits

The module saves all the time required to engineer the analog circuitry of a current loop transmitter, allowing you to finish your product sooner.

The product integrates very easily through the standard I2C-serial interface, which is present in any microcontroller or microprocessor. The product does not require specific libraries; only one register is needed to control the output current.

Configurable Safe Power-Up Current

The module incorporates a safe power-up system, which allows you to set the current that will be generated before any I2C command is received. This is especially useful to prevent the module from sending an invalid current during the few milliseconds before the microcontroller has completely initialized and sent the I2C command that configures the current. This safe power-up current can be set to 0 mA, which will be interpreted by the current loop receiver as invalid data and therefore discarded.

The safe power-up current is saved in the internal EEPROM by issuing the `Set Default Value` command (writing value `96` to the `Command` register) instead of `Set Current Value` (writing value `64` to the `Command` register).

Self-Power Higher Than 4 mA

3-wire current loop transmitters have a major benefit over 2-wire transmitters: the amount of current the transmitter can draw to power itself.

2-wire current loop transmitters can be self-powered, but they cannot use more than 4 mA, as they use the same loop for power and for the current loop value; if they used more than 4 mA they would generate a wrong 4–20 mA reading. This makes 2-wire current loop transmitters suitable only for very simple sensors.

On the other hand, 3-wire current loop transmitters have the power and the current loop value split independently into two circuits, making the self-powered consumption independent from the generated current loop. This allows the transmitter to consume more than 4 mA and therefore allows much more complex self-powered current loop transmitters to be built.

Extended Current-Loop Current Margins

Current loop signals range from 4 to 20 mA. This module allows you to work with the extended current loop margins, both at the bottom (0 to 4 mA) and at the top (20 to 22 mA). While working from 4 mA to 20 mA represents the measured magnitude from 0% to 100%, working below 4 mA and above 20 mA can indicate extra information, such as signal saturation (e.g. 3.6 mA to 4 mA; 20 mA to 20.4 mA) and fault conditions (e.g. <3.3 mA or >20.7 mA), while keeping the current loop signal alive.

Calibration

The module is supplied ready to use, and no specific calibration is required for general use. However, if a highly accurate output is required, a calibration procedure may be implemented.

Unit-to-unit variation is minimal: for a given I2C value, different IS4413 modules deliver current levels that differ only slightly. Where maximum accuracy matters, each module should be calibrated individually, since the small offset is specific to each unit.

Temperature Drift

A temperature increase may produce a small variation in the output current. Therefore, keeping the module temperature stable increases measurement accuracy. The same applies to module self-heating, which is proportional to the generated loop current: at higher loop currents the drift increases slightly; at lower loop currents it decreases.

4 Performance Curves

The graphs and tables included below are derived from statistical data obtained from a limited sample set and are intended solely as reference information. The characteristics and performance values shown are neither verified for every device nor guaranteed. Some data points presented in the figures or tables may correspond to conditions outside the specified operating limits (for example, beyond the recommended supply voltage range) and therefore should not be considered covered by warranty or guaranteed specifications.

Unless otherwise indicated, $T_A = 25$ ºC, $V_{24} = 24$ V, $R_{LOOP} = 252.1\ \Omega$

Figure 1: Output Current vs. I2C Value

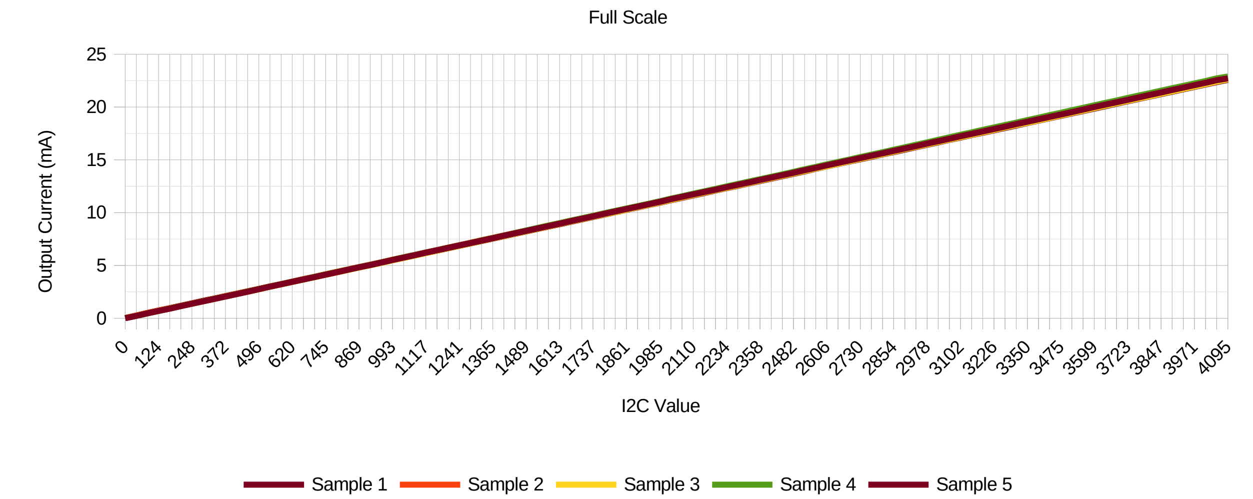


Figure 2: Output Current vs. I2C Value

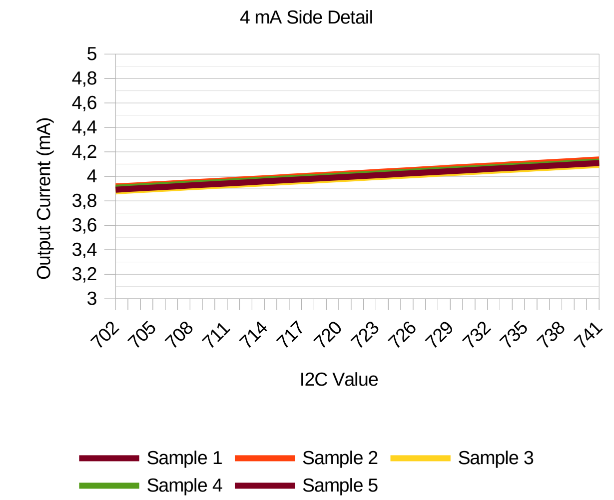
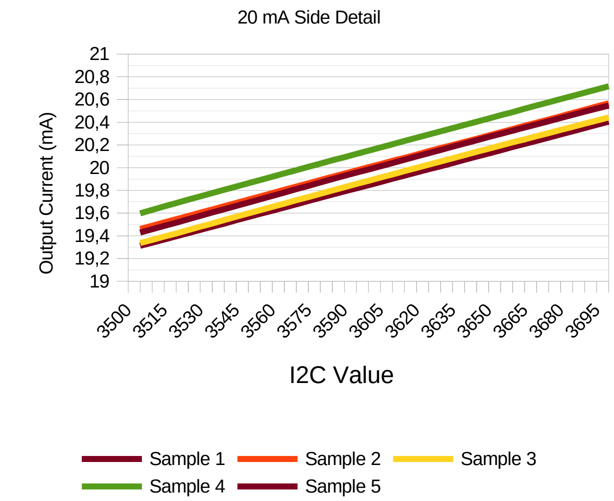


Figure 3: Output Current vs. I2C Value



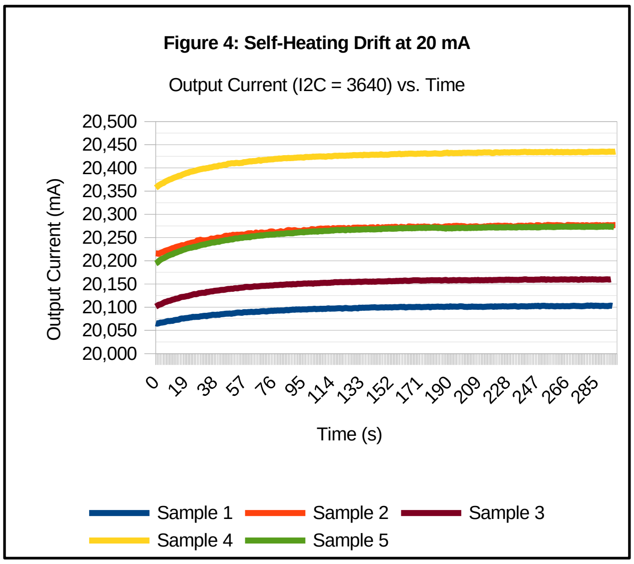


Figure 4: Self-Heating Drift at 20 mA
Output Current (I2C = 3640) vs. Time
Output Current (mA)
20,500
20,450
20,400
20,350
20,300
20,250
20,200
20,150
20,100
20,050
20,000
0 19 38 57 76 95 114 133 152 171 190 209 228 247 266 285
Time (s)
Sample 1
Sample 2
Sample 3
Sample 4
Sample 5

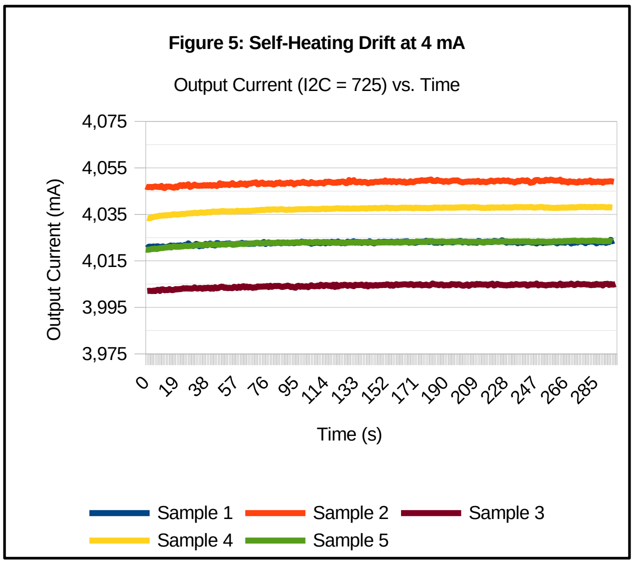


Figure 5: Self-Heating Drift at 4 mA
Output Current (I2C = 725) vs. Time
Output Current (mA)
4,075
4,055
4,035
4,015
3,995
3,975
0 19 38 57 76 95 114 133 152 171 190 209 228 247 266 285
Time (s)
Sample 1
Sample 2
Sample 3
Sample 4
Sample 5

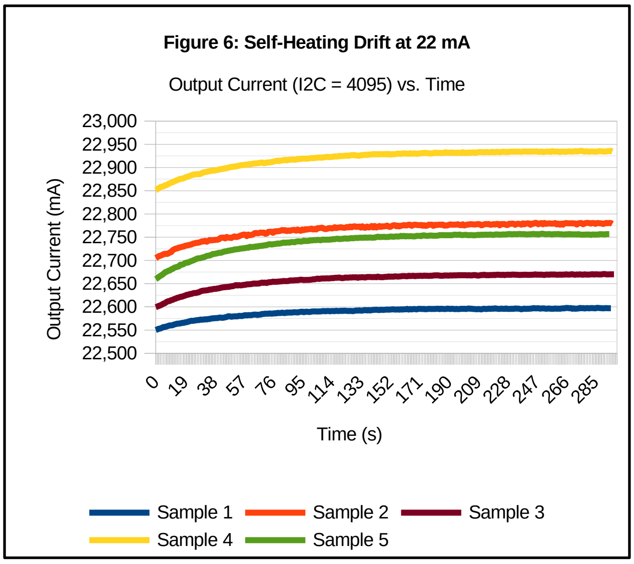


Figure 6: Self-Heating Drift at 22 mA
Output Current (I2C = 4095) vs. Time
Output Current (mA)
23,000
22,950
22,900
22,850
22,800
22,750
22,700
22,650
22,600
22,550
22,500
0 19 38 57 76 95 114 133 152 171 190 209 228 247 266 285
Time (s)
Sample 1
Sample 2
Sample 3
Sample 4
Sample 5

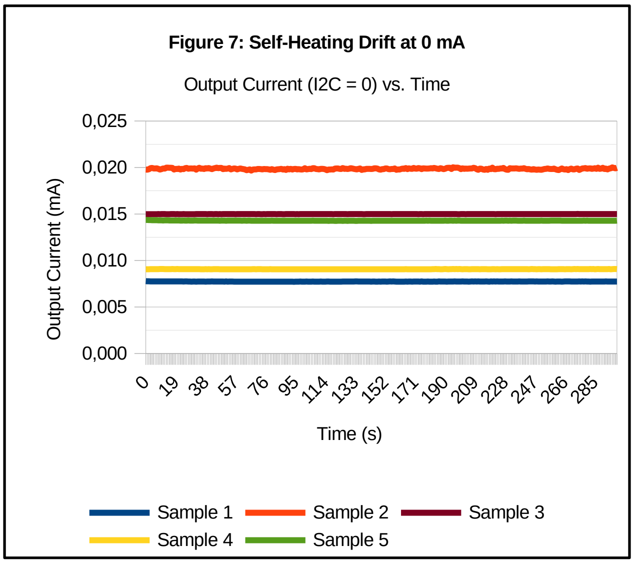


Figure 7: Self-Heating Drift at 0 mA
Output Current (I2C = 0) vs. Time
Output Current (mA)
0,025
0,020
0,015
0,010
0,005
0,000
0 19 38 57 76 95 114 133 152 171 190 209 228 247 266 285
Time (s)
Sample 1
Sample 2
Sample 3
Sample 4
Sample 5

5 Usage

To set the module output current, your microcontroller (I2C-master) must perform a four-byte write operation to the IS4413 (I2C-slave). The four bytes are transmitted in the following order:

- `I2C-Slave Address` byte
- `Command` byte
- `Data (Hi)` byte
- `Data (Lo)` byte

The `I2C-Slave Address` byte is always `96` (7-bit address). This is the value that identifies the module on the I2C-serial interface.

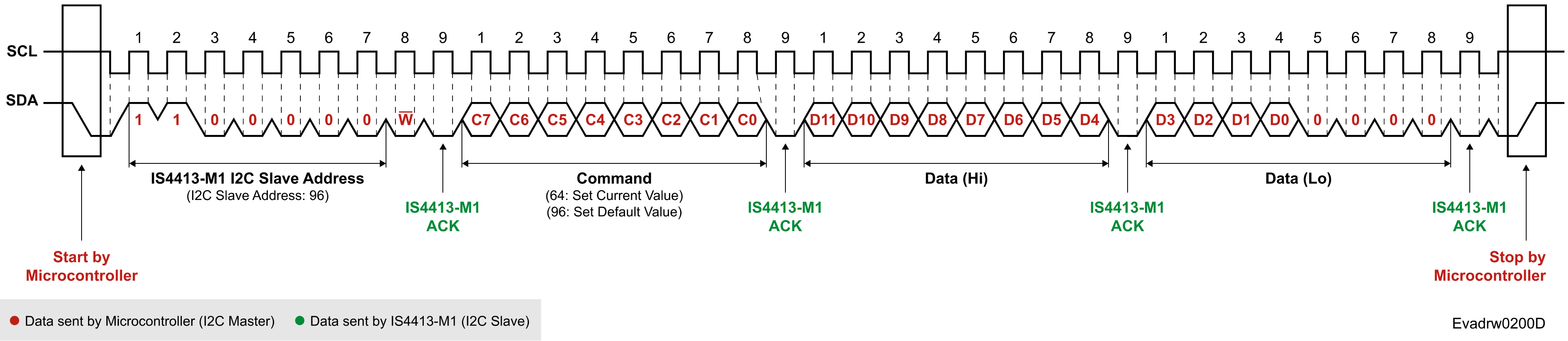
The `Command` byte can be set to `64` for Set Current Value operation, which updates the module output current (this is the normal operation), or to `96` for the Set Default Value operation (Safe Power-Up), which stores the default output value in the internal EEPROM. This stored value is applied after power-up, before the microcontroller updates the output.

After issuing the `Set Default Value` command, a delay of at least 50 ms shall be observed to allow the EEPROM write operation to complete.

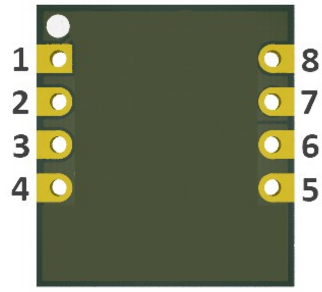
Setting the default value to `0` ensures a safe power-up condition by forcing the output current to 0 mA, which is below the valid 4–20 mA range. This prevents the current-loop receiver from interpreting an uninitialized value as a valid measurement until the microcontroller sends the desired value.

The `Data (Hi)` and `Data (Lo)` bytes contain the 12-bit value that sets the module output current. The `Data (Hi)` byte contains bits `D11–D4`. The `Data (Lo)` byte contains bits `D3–D0`; the lower four bits are unused and shall be set to `0`.

Setting `D11–D0` to `0` forces the module output current to its minimum value (0 mA), while setting `D11–D0` to `4095` forces the output current to its maximum value (approximately 22 mA).



6 Pads



(Top View)

Pad 1 Location:

To locate pad 1, look for the fully square pad. All other pads have one square end and one semicircular end, whereas pad 1 is square on all sides. A white dot is also printed next to it.

Pad	Name	Type	Description
1	SDA	Open Drain	I2C serial interface. These pads connect to your microcontroller. Two external pull-up resistors to 5 V are required.
2	SCL		
4, 5, 6	COUT	Current Loop Output	Current loop output pad. Connect this pad to the current loop receiver, typically a PLC.
3 & 7	GND	Module Power Supply	GND reference pads. These pads provide the 0 V reference voltage for the module, your microcontroller, and the current loop receiver return path.
8	24V		24 V power supply for the current loop and the module.

6.1 COUT Pad

Current Output Pad.

The COUT pad is the current output that sources the 4–20 mA loop current. This pad must be connected to the current-loop receiver, typically a PLC input, or to a 250 Ω resistor. When using a 250 Ω resistor, the 4–20 mA current generates a proportional voltage across the resistor, which can be measured by an ADC.

The COUT return path is shared with the receiver and the power supply GND.

6.2 24V & GND Pads

Power Supply Pads.

The IS4413 module is powered through the 24V and GND pads. The power voltage is 24 V.

The current drawn through these pads is the sum of the module's supply current and the 4–20 mA loop current. Ensure that the power supply can provide at least 30 mA.

The GND pad provides the common ground reference for the power supply and the current-loop receiver.

6.3 SCL & SDA Pads

I2C-Serial Interface Pads.

SCL (Serial Clock Line): This pad is used to synchronize data transfer between the IS4413 module and your microcontroller.

SDA (Serial Data Line): This bidirectional pad is used for both sending and receiving data between the IS4413 module and your microcontroller.

Both pads are open-drain and must be pulled up to 5 V. The pull-up resistor value should be chosen based on the bus speed and capacitance. Typical values are 4.7 kΩ for Standard Mode (100 kbps) and 2 kΩ for Fast Mode and High-Speed (400 kbps and 3.4 Mbps).

7 I2C Description

The IS4413 operates as a slave in the I2C-serial interface. It supports Standard Mode (100 kbps), Fast Mode (400 kbps) and High-Speed Mode (3.4 Mbps). The I2C-master device, typically a microcontroller or a microprocessor, initiates and manages all operations to the slave.

The IS4413 is represented on the bus by the I2C device address `96` (7-bit address).

Pull-up resistors to 5 V are required on the SCL and SDA lines for proper operation. The resistor values depend on the bus capacitance and operating speed. Typical values are 4.7 kΩ for Standard Mode (100 kbps) and 2 kΩ for both Fast Mode (400 kbps) and High-Speed Mode (3.4 Mbps).

The high state of the IS4413 I2C pads is 5 V. A logical `0` is transmitted by pulling the line low, while a logical `1` is transmitted by releasing the line, allowing it to be pulled high by the pull-up resistor. The I2C master device controls the Serial Clock (SCL) line, which generates the synchronous clock used by the Serial Data (SDA) line to transmit data.

To send data from your microcontroller to the IS4413 via I2C, the following sequence must be executed: your microcontroller begins by pulling SDA low while SCL is high, generating a Start Condition. It then sends the IS4413 slave address (`96`) in write mode (`W=0`), which is acknowledged by the module. Your microcontroller then sends the `Command` (`64` or `96`), which is also acknowledged.

Next, your microcontroller sends the `Data (Hi)` byte of the current loop value, followed by the `Data (Lo)` byte; both are acknowledged by the IS4413.

Finally, your microcontroller generates a Stop Condition by releasing SDA while the SCL is high.

7.1 Highlights

I2C Voltage: 5 V

I2C Device Address: `96` (7-bit address)

I2C Register Size: 8-bit

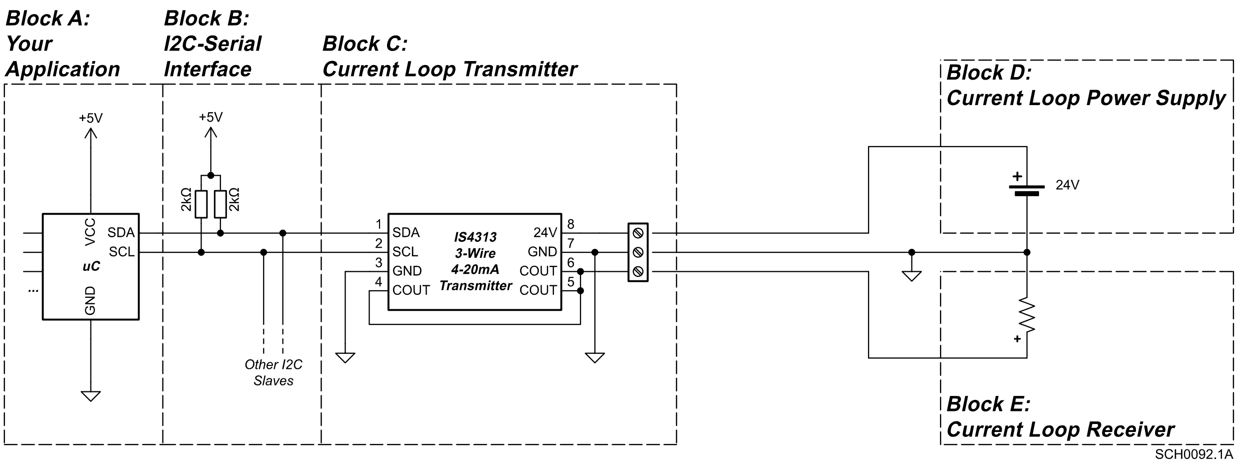
Byte and Bit Order: Most Significant Bit First and Most Significant Byte First

Compatible I2C Speeds:
- Standard Mode (100 kbps), recommended SCL and SDA pull-up value: 4.7 kΩ
- Fast Mode (400 kbps), recommended SCL and SDA pull-up value: 2 kΩ
- High-Speed Mode (3.4 Mbps), recommended SCL and SDA pull-up value: 2 kΩ

8 Hardware Examples

The following chapter represents an application design example for explanation purposes and is not part of the product standard. The customer must design his own solution, choose the most appropriate components and validate the final product according to the legislation and the current loop standard specifications.

8.1 Basic Current Loop Transmitter



Block A: Your Application

This is usually the main part of your product, where you read sensors, or acquire data that needs to be sent via current loop.

Typically, a microcontroller interfaces with the IS4413, but a microprocessor or a single-board computer can also be used as long as they are equipped with an I2C-serial interface.

Block B: I2C-Serial Interface

For proper operation of the I2C-serial interface, pull-up resistors to 5 V are necessary. Typical resistor values are 4.7 kΩ for Standard Mode (100 kbps) and 2 kΩ for both Fast Mode (400 kbps) and High-Speed Mode (3.4 Mbps).

Block C: IS4413

The IS4413 is very simple to integrate into your design.

Provide power to both the module and the current loop by supplying 24 V to the 24V pad and 0 V to the GND pad.

Connect the current output pad (COUT) to your current loop receiver, typically a PLC.

As the IS4413 is a 3-wire current loop transmitter, the voltage reference and return path of the current loop receiver must be connected.

GND pads 3 and 7 are internally connected. Connect both pads to your PCB ground to ensure good return paths and thermal dissipation.

COUT pads 4, 5, and 6 are internally connected. Connect all three pads on your PCB to provide an additional thermal dissipation path. A lower operating temperature improves output current precision.

Block D & E: Power Supply and Receiver

The current loop power supply is nominally 24 V and provides power to the IS4413 module.

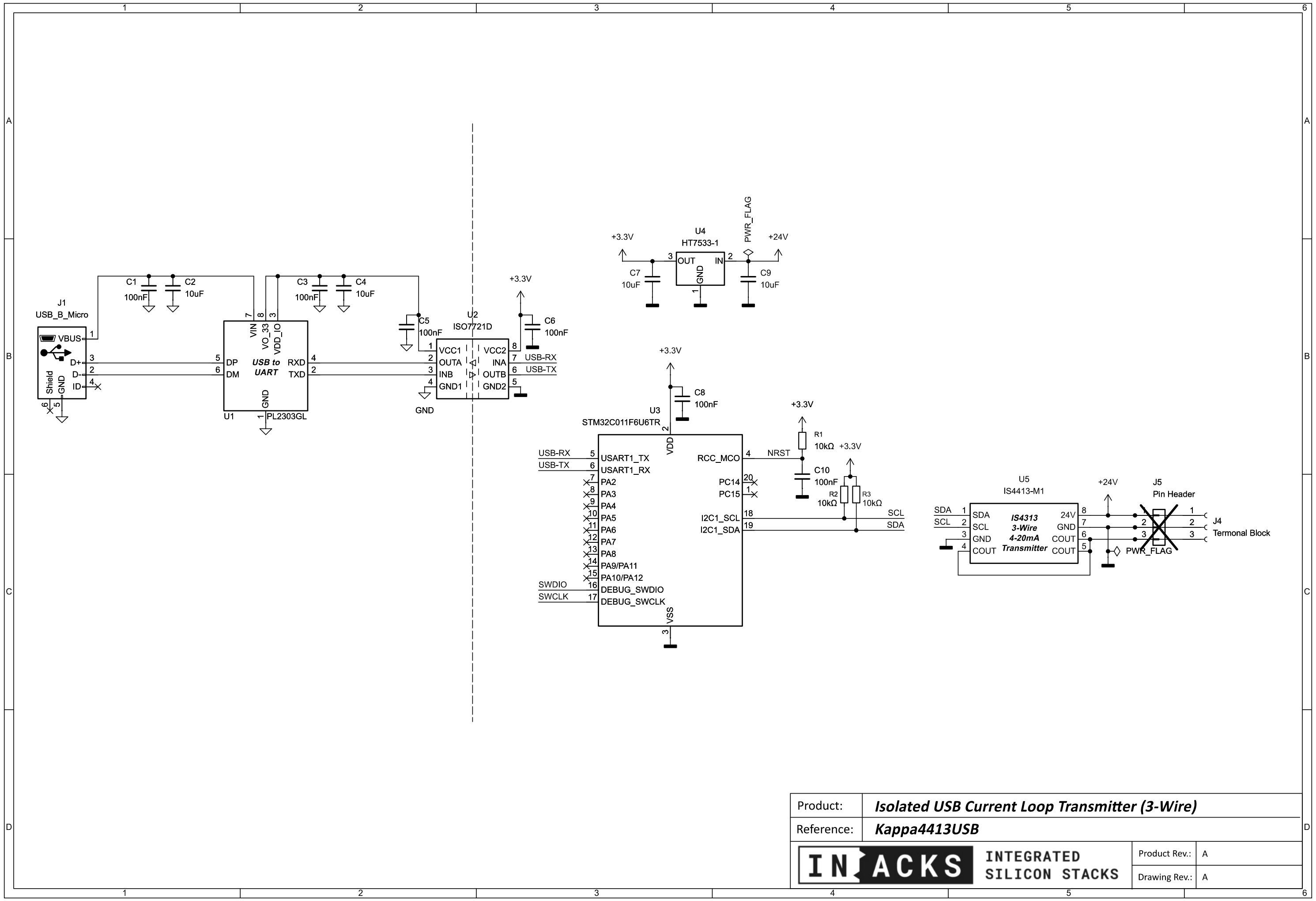
The current loop output pad (COUT) generates the 4–20 mA loop current. It connects to the current loop receiver, typically a PLC input or a 250 Ω resistor to generate a proportional voltage drop.

The 0 V rail of the power supply serves as the voltage reference for the IS4413 module (GND pad), and also serves as the current loop receiver return path. Ensure that this reference is properly connected to the IS4413 module and the current loop receiver.

Important: Verify that your design allows the IS4413 module and the power supply to share the same voltage reference.

INTEGRATED SILICON STACKS

8.2 USB Isolated Current-Loop Transmitter



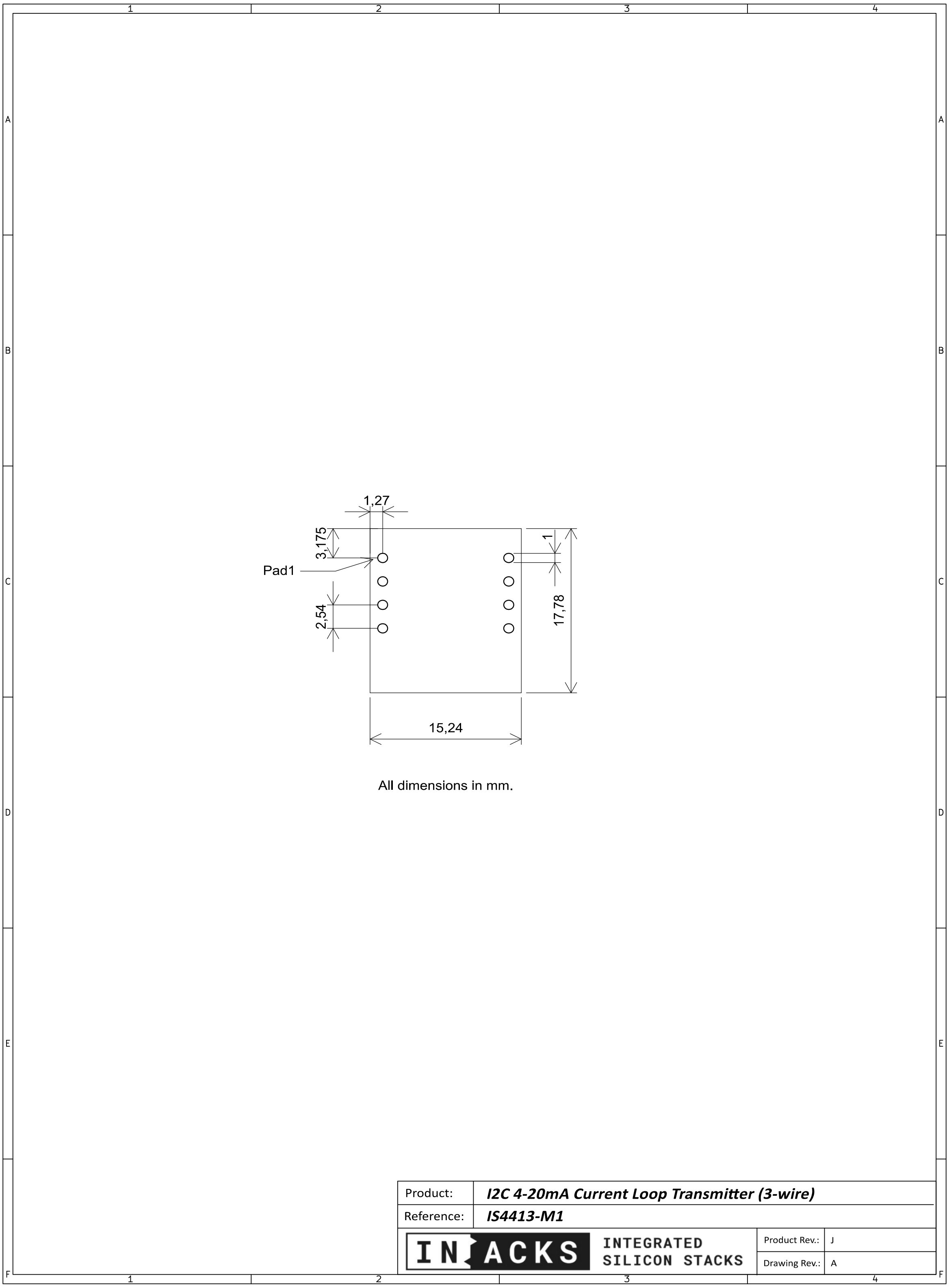
9 Firmware Examples

9.1 Arduino Code Example

The following code sequentially generates 0 mA, 4 mA, 20 mA and 22 mA signals, each for one second.

```
#include <stdint.h>
#include <Wire.h>

#define I2C_ADDRESS  96      // IS4413 I2C slave address

// Sends a 12-bit value (0..4095) to the IS4413.
// eeprom = false -> only updates the output current (normal operation)
// eeprom = true  -> also stores the value as the power-up default
void writeIS4413(uint16_t value, bool eeprom) {
  uint8_t command;

  value &= 0x0FFF;  // Keep only the 12 useful bits (D11..D0)

  if (eeprom == true) {
    command = 96;   // Set Default Value: output + EEPROM
  }
  else {
    command = 64;   // Set Current Value: output only
  }

  uint8_t dataHi = (value >> 4) & 0xFF;   // D11..D4
  uint8_t dataLo = (value & 0x0F) << 4;   // D3..D0, then four unused zeros

  Wire.beginTransmission(I2C_ADDRESS);
  Wire.write(command);
  Wire.write(dataHi);
  Wire.write(dataLo);
  Wire.endTransmission();

  // The EEPROM write needs time to finish before the next command
  if (eeprom == true) {
    delay(50);
  }
}

void setup() {
  Wire.begin();
}

void loop() {
  writeIS4413(0, false);      // 0 mA
  delay(1000);
  writeIS4413(725, false);    // around 4 mA
  delay(1000);
  writeIS4413(3640, false);   // around 20 mA
  delay(1000);
  writeIS4413(4095, false);   // around 22 mA
  delay(1000);
}
```

10 Mechanical



Content

Appendix

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feedback@inacks.com

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