

## Getting started with the STEVAL-DIGAFEV1 evaluation board for the TSC1641

### Introduction

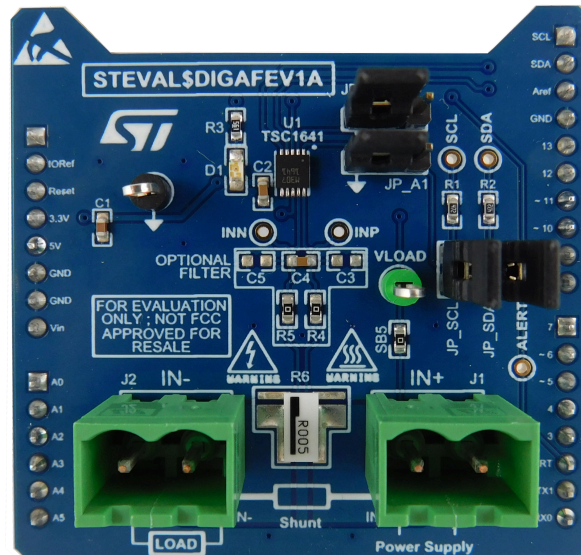
The **STEVAL-DIGAFEV1** allows to evaluate the measurement performance and features of the **TSC1641**, designed to measure current, voltage and power.

The board can accept external voltage and current to measure and evaluate the conversion performance of the **TSC1641** conversion performance, based on its Delta-Sigma ( $\Delta\Sigma$ ) modulators.

Thanks to a led on the board, it is easy to monitor if the alert pin is active.

The **STEVAL-DIGAFEV1** can be supplied in standalone mode. It can also be connected to a **NUCLEO-H503RB** development board that hosts an STM32 microcontroller, allowing further signal processing and communication with the PC.

**Figure 1. STEVAL-DIGAFEV1 reference design kit**



## 1 Getting started

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### 1.1 Features

- 16 bit dual channel for current, voltage, and power monitoring
- Temperature monitoring
- Simple digital connection with I<sup>2</sup>C up to 1MHz and compatible with MIPI I3C up to 12.5MHz
- From 128µs to 32.768ms total conversion time
- 2.7 to 3.6 V power supply
- Alert signals generated in case of over/under voltage, over/under current, overpower or over temperature
- Load voltage sensing from 0 to 60 V

### 1.2 Main component

#### 1.2.1 TSC1641

The **TSC1641** is a high precision current, voltage, power, and temperature monitoring analog front-end (AFE). It monitors current into a shunt resistor and load voltage up to 60 V in a synchronized way.

The current measurement can be high-side, low-side and bidirectional.

The device integrates high precision 16-bit dual channel ADC with a programmable conversion time from 128 µs to 32.7 ms.

The digital bus interface is flexible from an I<sup>2</sup>C/SMBus 1 MHz data rate to an MIPI I3C 12.5 MHz data rate. This allows connectivity to most of the recent STM32 products.

## 2 How to use the board

### 2.1 Standalone

The STEVAL-DIGAFEV1 can be used directly with your testing device or I<sup>2</sup>C/I3C controller.

- Step 1.** Connect ground and supply voltage  
On the CN1 connector, connect your supply voltage according to the board serigraphy.

Figure 2. CN1 connector for 3.3V power supply



- Step 2.** Connect the I<sup>2</sup>C/I<sup>3</sup>C bus  
On connector CN2, the two top connections are for SDA (data) and SCL (clock). Connections are clearly labeled in the serigraphy.

**Figure 3. CN2 connector for I<sup>2</sup>C/I<sup>3</sup>C connection**

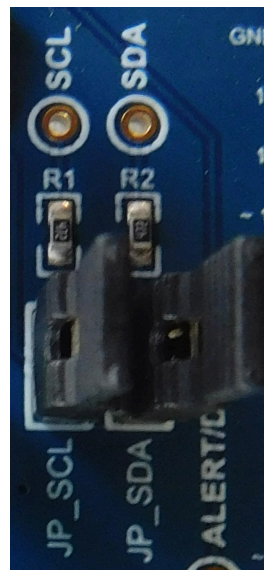


#### I<sup>2</sup>C

I<sup>2</sup>C communication bus requires pull-up resistors. The STEVAL-DIGAFEV1 has two 4.7k ohm pull-up resistors on SDA and SCL lines.

These pull-up resistors can be connected thanks to JP\_SDA and JP\_SDL jumpers.

**Figure 4. Jumpers to connect SDA and SCL pull-up resistors**



It is also needed to give to the TSC1641 a static address by changing the with the A0/A1 value thanks to JP\_A0 and JP\_A1 jumpers.

Figure 5. Jumpers to set I<sup>2</sup>C static address

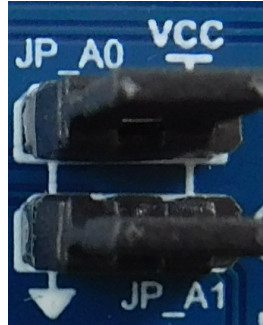


Table 1. Table of static addresses and I3C PIDs

| A1  | A0  | Target address (binary) | Target address (h) | Provisional ID (PID) value (h) |
|-----|-----|-------------------------|--------------------|--------------------------------|
| GND | GND | 1000000                 | 40                 | 0208020A0001                   |
| GND | VS  | 1000001                 | 41                 | 0208020A1001                   |
| VS  | GND | 1000010                 | 42                 | 0208020A2001                   |
| VS  | VS  | 1000011                 | 43                 | 0208020A3001                   |

**I3C**

I3C communications do not require pull-up resistors, hence JP\_SDA and JP\_SDL jumpers must be unplugged.

The maximum communication speeds are detailed table for I<sup>2</sup>C & I3C speeds.

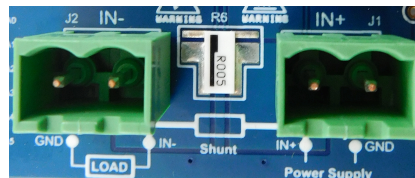
Table 2. Table for I<sup>2</sup>C & I3C speeds

| Communication type | Speed    |
|--------------------|----------|
| I <sup>2</sup> C   | 1 MHz    |
| I3C                | 12.5 MHz |

**Step 3.** Connect load and Vload power to supply

For high-side measurement, connect your power supply (the vload to measure) to the J1 connector, and the load to the J2 connector.

Figure 6. J1 and J2 connectors for LOAD connection



## 2.2 With a NUCLEO-STM32

To use the board, follow below procedure:

**Step 1.** Plug the STEVAL-DIGAFEV1

The STEVAL-DIGAFEV1 is compatible with the wide majority of Nucleo board thanks to its Arduino pinout.

Connecting the STEVAL-DIGAFEV1 to a nucleo make it supplied by the 3.3V of the nucleo board. For a better interconnection, it is better to use the NUCLEO-H503RB which support I3C communications.

**Table 3.** Table for the connection to the NUCLEO-H503RB

| NUCLEO-H503RB | STEVAL-DIGAFEV1 SPI pin |
|---------------|-------------------------|
| PB8           | SCLK                    |
| PB9           | SDA (data)              |
| PA10          | ALERT/CVRDY             |

### 3 Communication with the TSC1641

#### Option A: use the STSW-DIGAFEV1 GUI

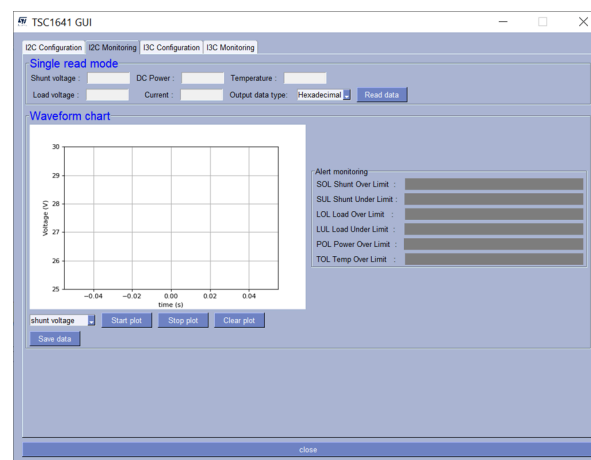
The STEVAL-DIGAFEV1 can be used with the STSW-DIGAFEV1GUI. It is necessary to program the nucleo-64 H503RB with the STSW-DIGAFEV1FW to use it.

The STSW-DIGAFEV1FW runs on an STM32 Nucleo-64 development board NUCLEO-H503RB. It communicates with the TSC1641 of the STEVAL-DIGAFEV1 through the I<sup>2</sup>C and I3C protocols.

The STSW-DIGAFEV1GUI allows the user to write configuration registers, monitor current, voltage, and power and plot data on a graph. It is also a tool to save values measured by the TSC1641 in a .csv file.

For more information on the STSW-DIGAFEV1GUI, go to the relevant ST web page.

Figure 7. STSW-DIGAFEV1GUI graphical user interface



#### Option B: use the STEVAL-DIGAFEV1 directly with your test solution

The STEVAL-DIGAFEV1 can be plugged directly to your solution.

The I<sup>2</sup>C/I<sup>3</sup>C communication to access the TSC1641 registers is shown in the table:

**Table 4. Map register of the TSC1641**

| Pointer address (hex) | Register name            | Type | Default value | Reset after POR | Reset after Shutdown mode | Reset after Idle mode | Reset after RST |
|-----------------------|--------------------------|------|---------------|-----------------|---------------------------|-----------------------|-----------------|
| 00h                   | Configuration register   | R/W  | 0037h         | yes             | no                        | no                    | yes             |
| 01h                   | Shunt voltage register   | R    | 0000h         | yes             | no                        | no                    | yes             |
| 02h                   | Load voltage register    | R    | 0000h         | yes             | no                        | no                    | yes             |
| 03h                   | DC power register        | R    | 0000h         | yes             | no                        | no                    | yes             |
| 04h                   | Current register         | R    | 0000h         | yes             | no                        | no                    | yes             |
| 05h                   | Temperature register     | R    | 8000 h        | yes             | no                        | no                    | yes             |
| 06h                   | Mask register            | R/W  | 0000h         | yes             | no                        | no                    | yes             |
| 07h                   | Flags register           | R    | 0000h         | yes             | no                        | no                    | yes             |
| 08h                   | Rshunt register          | R/W  | 0000h         | yes             | no                        | no                    | no              |
| 09h                   | SOL alert limit register | R/W  | 0000h         | yes             | no                        | no                    | no              |
| 0Ah                   | SUL alert limit register | R/W  | 0000h         | yes             | no                        | no                    | no              |
| 0Bh                   | LOL alert limit register | R/W  | 0000h         | yes             | no                        | no                    | no              |
| 0Ch                   | LUL alert limit register | R/W  | 0000h         | yes             | no                        | no                    | no              |
| 0Dh                   | POL alert limit register | R/W  | 0000h         | yes             | no                        | no                    | no              |
| 0Eh                   | TOL alert limit register | R/W  | 0000h         | yes             | no                        | no                    | no              |
| FEh                   | Manufacturing id         | R    | 0006h         | yes             | no                        | no                    | no              |
| FFh                   | DiE ID register          | R    | 1000 h        | yes             | no                        | no                    | no              |



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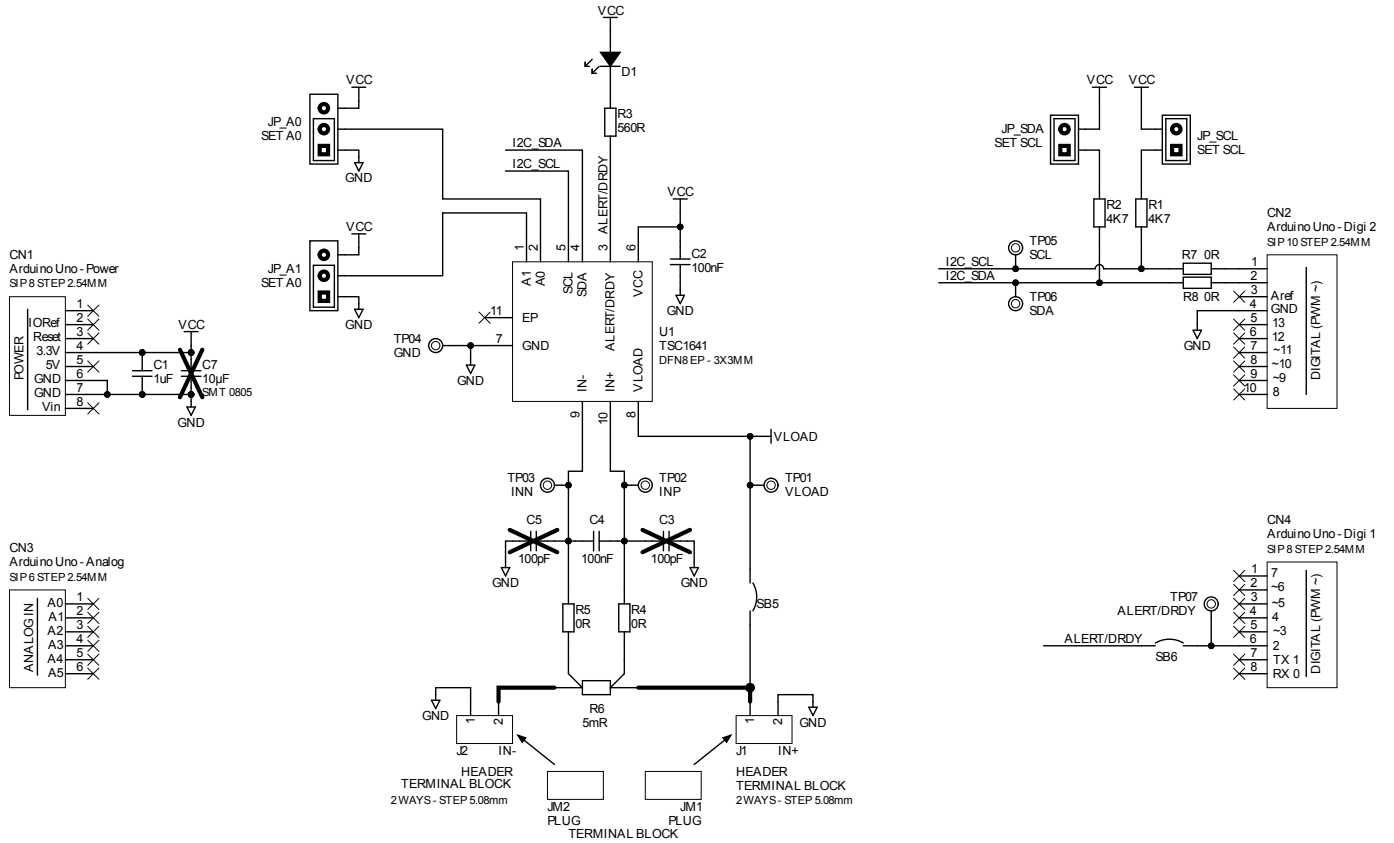
## 4 Precautions for use

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The board is not immune to the disturbance generated from intense radiant sources, according to EN IEC 61000-4-3. During the radiated immunity testing, the board obtained level B, meaning that the board was not damaged during the test, but showed a performance degradation of over 2% in voltage and current measurement.

## 5 Schematic diagrams

Figure 8. STEVAL-DIGAFEV1 circuit schematic



## 6 Bill of materials

**Table 5. STEVAL-DIGAFEV1 bill of materials**

| Item | Q.ty | Ref.                         | Part/value      | Description  | Manufacturer               | Order code           |
|------|------|------------------------------|-----------------|--|----------------------------|----------------------|
| 1    | 1    | C1                           | 1uF             | Ceramic capacitors   | TDK                        | CGA3E3X5R1H105K080AB |
| 2    | 1    | C2                           | 100nF           | Ceramic capacitors   | TDK                        | C1608X5R1H104K080AA  |
| 3    | 0    | C3, C5                       | 100pF           | Ceramic capacitors   | MURATA                     | GCM1885C2A101JA16D   |
| 2    | 1    | C4                           | 100nF           | Ceramic capacitors   | TDK                        | C1608X5R1H104K080AA  |
| 4    | 0    | C7                           | 10µF            | Ceramic capacitors   | MURATA                     | GRM21BR6YA106KE43L   |
| 5    | 1    | CN1                          | SIP 1X8 FEMALE  | Connector header   | AMP - TE CONNECTIVITY      | 826629-8             |
| 6    | 1    | CN2                          | SIP 1X10 FEMALE | Connector header   | AMP - TE CONNECTIVITY      | 1-826629-0           |
| 7    | 1    | CN3                          | SIP 1X6 FEMALE  | Connector header   | AMP - TE CONNECTIVITY      | 826629-6             |
| 8    | 1    | CN4                          | SIP 1X8 FEMALE  | Connector header   | AMP - TE CONNECTIVITY      | 826629-8             |
| 9    | 1    | D1                           | RED COLOR       | LED  | WURTH ELECTRONIC           | 150080RS75000        |
| 10   | 2    | J1, J2                       | HEADER          | Connector – terminal Block   | BUCHANAN - TE CONNECTIVITY | 282825-2             |
| 11   | 2    | JM1, JM2                     | PLUG            | Connector – terminal Block   | BUCHANAN - TE CONNECTIVITY | 796634-2             |
| 12   | 2    | JP_A0, JP_A1                 | SIP 1X3 MALE    | Connector header   | WURTH ELEKTRONIK           | 61300311121          |
| 13   | 2    | JP_SCL, JP_SDA               | SIP 1X2 MALE    | Connector header   | WURTH ELEKTRONIK           | 61300211121          |
| 14   | 4    | JU_A0, JU_A1, JU_SCL, JU_SDA | BLACK COLOR     | Jumper   | WURTH ELEKTRONIK           | 609002115121         |
| 15   | 2    | R1, R2                       | 4K7             | Resistor   | VISHAY / DALE              | CRCW06034K70FKEC     |
| 16   | 1    | R3                           | 560R            | Resistor   | VISHAY / DALE              | CRCW0603560RFKEA     |
| 17   | 4    | R4, R5, R7, R8               | 0R              | Resistor   | VISHAY / DALE              | RCA06030000ZSEA      |
| 18   | 1    | R6                           | 5mR             | Resistor – Kelvin shunt  | OHMITE                     | FC4L64R005FER        |
| 19   | 2    | SB5, SB6                     | 0R              | Resistor   | PANASONIC                  | ERJPA3F6800V         |
| 20   | 1    | TP01                         | GREEN COLOR     | Testpoint  | Any                        |                      |
| 21   | 1    | TP04                         | BLACK COLOR     | Testpoint  | Any                        |                      |
| 22   | 1    | U1                           | TSC1641         | Digital Current Sense AFE, with I <sup>2</sup> C / SMBus and MIPI I3C compatible interface | ST                         | TSC1641              |

## 7 Board versions

**Table 6. STEVAL-DIGAFEV1 versions**

| PCB version                      | Schematic diagrams                   | Bill of materials                   |
|----------------------------------|--------------------------------------|-------------------------------------|
| STEVAL\$DIGAFEV1A <sup>(1)</sup> | STEVAL\$DIGAFEV1A schematic diagrams | STEVAL\$DIGAFEV1A bill of materials |

1. This code identifies the STEVAL-DIGAFEV1 evaluation board first version. The STEVAL\$DIGAFEV1A code is printed on the board.

## 8 Regulatory compliance information

### **Notice for US Federal Communication Commission (FCC)**

For evaluation only; not FCC approved for resale

FCC NOTICE - This kit is designed to allow:

1. Product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and
2. Software developers to write software applications for use with the end product.

This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter 3.1.2.

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For evaluation purposes only. This kit generates, uses, and can radiate radio frequency energy and has not been tested for compliance with the limits of computing devices pursuant to Industry Canada (IC) rules.

À des fins d'évaluation uniquement. Ce kit génère, utilise et peut émettre de l'énergie radiofréquence et n'a pas été testé pour sa conformité aux limites des appareils informatiques conformément aux règles d'Industrie Canada (IC).

### **Notice for the European Union**

This device is in conformity with the essential requirements of the Directive 2014/30/EU (EMC) and of the Directive 2015/863/EU (RoHS).

### **Notice for the United Kingdom**

This device is in compliance with the UK Electromagnetic Compatibility Regulations 2016 (UK S.I. 2016 No. 1091) and with the Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment Regulations 2012 (UK S.I. 2012 No. 3032).

## Revision history

**Table 7. Document revision history**

| Date        | Revision | Changes          |
|-------------|----------|------------------|
| 03-Aug-2023 | 1        | Initial release. |

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