EmStat pico™

Built with ANALOG DEVICES

Data Sheet

General Description

The EmStat Pico is a miniaturized OEM potentiostat module designed for integration into products requiring electrochemical measurement functionality. The system has two potentiostat circuits which can be used simultaneously in Low Speed mode (up to 100 Hz) and a High Speed mode (up to 200 kHz) which can be applied to each channel alternately. The system features power saving modes for use in battery operated systems. Its footprint is small while maintaining standard 2.54 mm (100 mil) connections along with castellations for ease of integration into prototype systems.

Built With Analog Devices

The EmStat Pico is a joint development by PalmSens BV and Analog Devices Inc. PalmSens is known for introducing the first commercially available handheld potentiostat. Over the last decade these have evolved to become smaller and more versatile. Together with Analog Devices, PalmSens now proudly presents the world smallest potentiostat module available on the market.

Applications

- Gas detection
- Food quality
- Environmental sensing (air, water, soil)
- Blood glucose meters
- Life sciences and bio-sensing analysis
- Bio-impedance measurements
- General amperometry, voltammetry and impedance spectroscopy functions
- Wearables

Features

Analog

- 5 analog inputs including 2 high impedance (1 TΩ)
- 2 current measurement channels each with max. current of ±3 mA and min. resolution of 5.5 pA on lowest current range
- 16-bit, analog-to-digital converter (ADC)
- Two 12-bit voltage output DACs, range 0.2 to 2.4 V (±2.2 V voltage potential to sensor)
- Two potentiostat circuits with impedance measurement capability <10 Ω to 100 MΩ,
- 0.016 Hz to 200 kHz
- Internal temperature sensor, ±2°C accurate

Digital

- UART
- I²C
- SPI
- 8 GPIO
- SD card support

Optional extras

On-board temperature sensor (accuracy ±0.25 °C).

Dimensions

30.5 mm X 18 mm X 2.6 mm

ROHS statement

The EmStat Pico is ROHS compliant.

Table of Contents

Terminology

PSTAT: Potentiostat circuit
CA: Control Amplifier
CF: Current Follower
TIA: Trans Impedance Amplifier
CE: Counter Electrode
RE: Reference Electrode
WE: Working Electrode
EIS: Electrochemical Impedance Spectroscopy
PGA: Programmable Gain Amplifier
AAF: Anti-Aliasing Filter
LDO: Low Drop Out
OCP: Open Circuit Potentiometry

Revision history

Rev.3-2019-001: First published.
Rev.3-2019-002: Min. freq range for EIS to 0.016 Hz

Functional block diagram

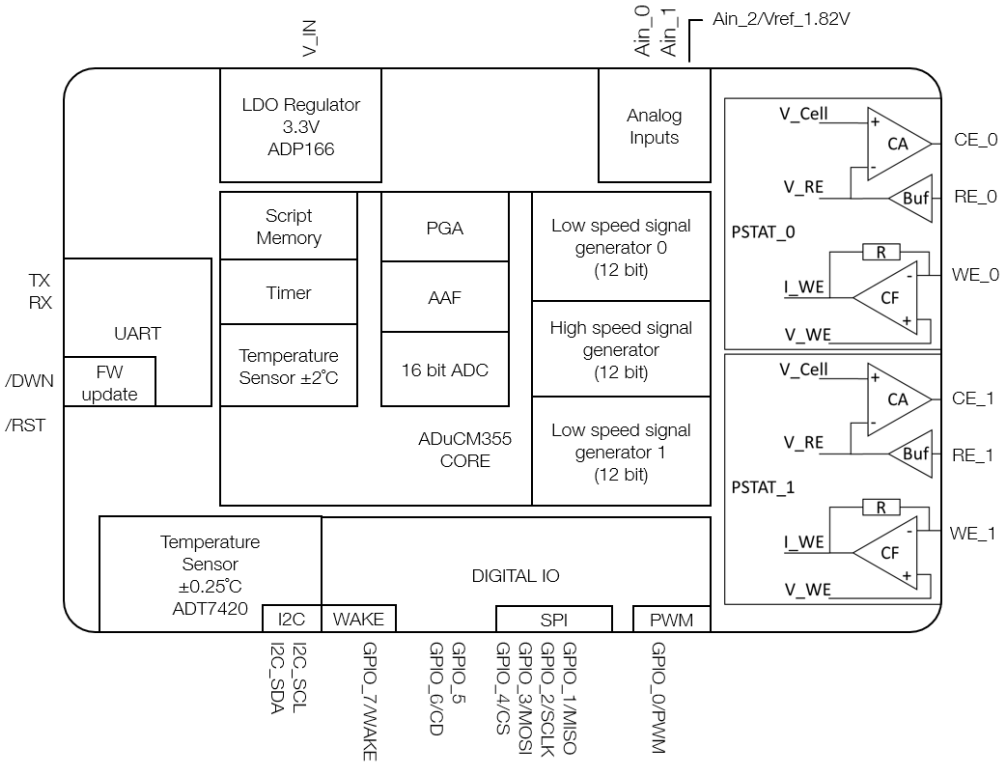

Figure 1: EmStat Pico functional block diagram

Mechanical drawing

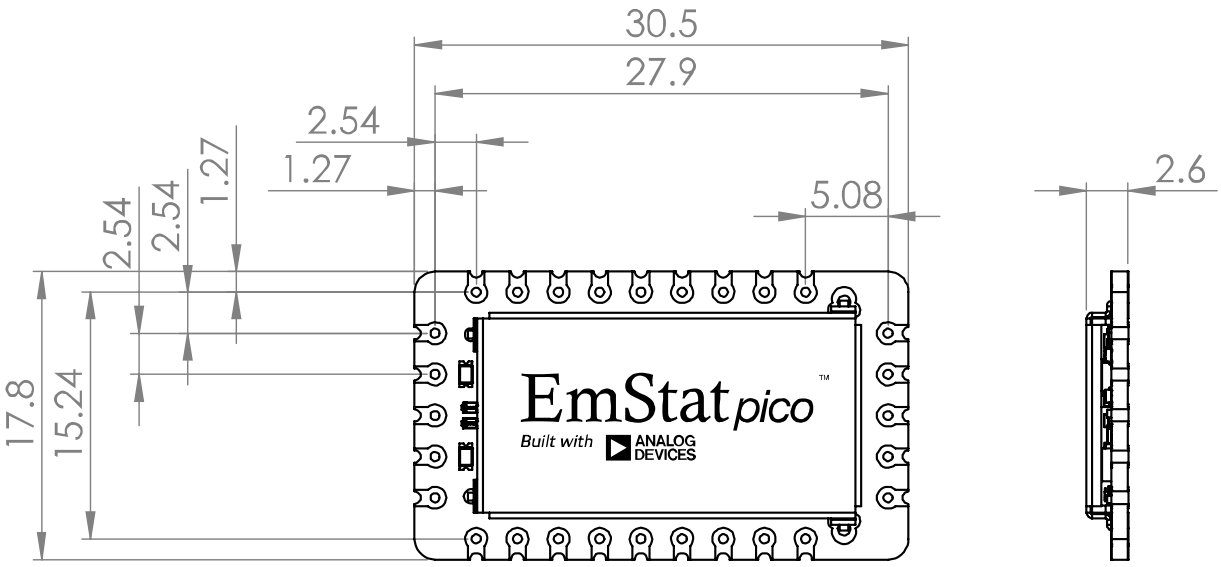

Figure 2: EmStat Pico module dimensions (all values in millimeters)

Pinout

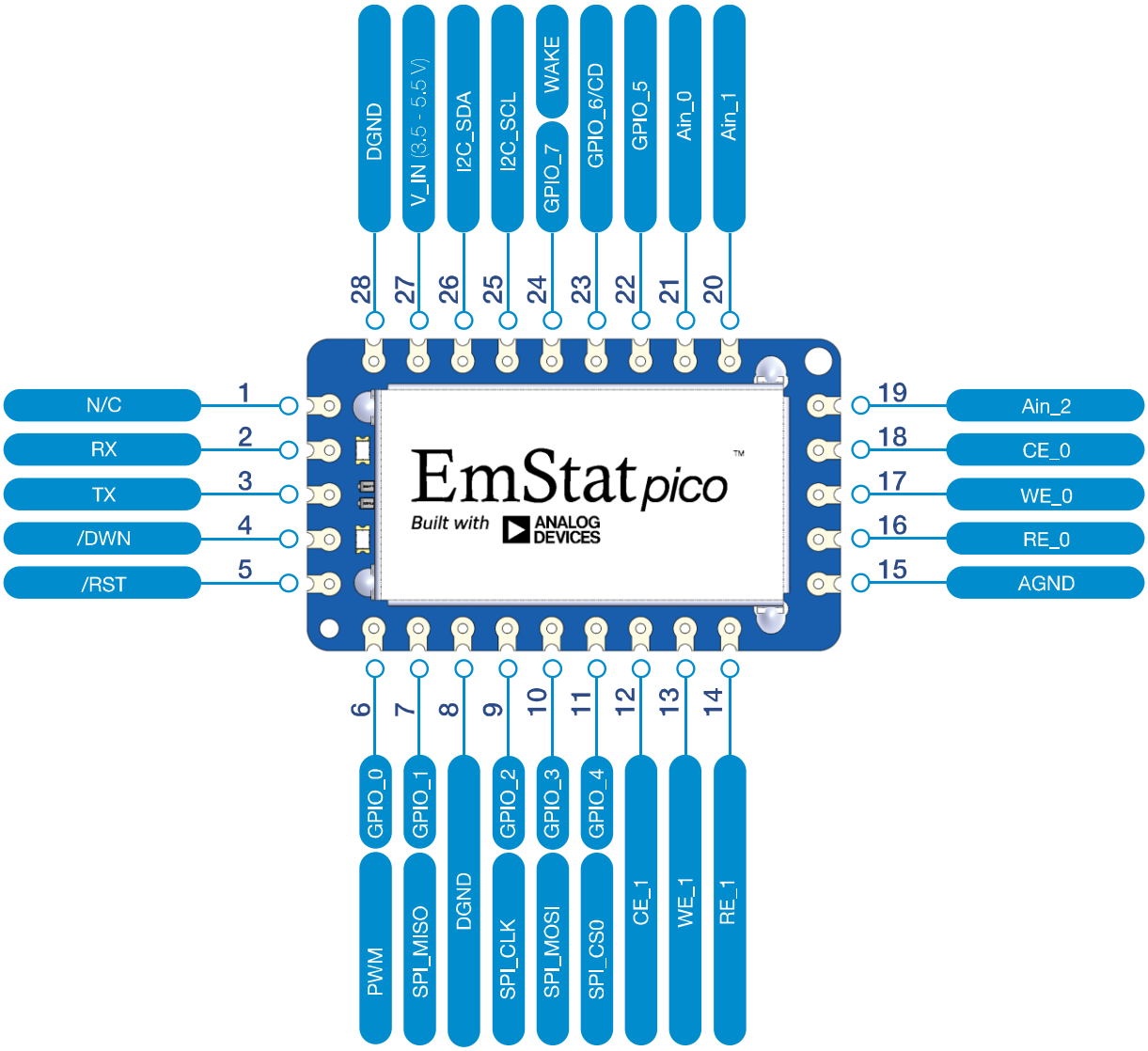

Figure 3: EmStat Pico pinout

Pin functions

Table 1: Pin function description

Pin No.	Name	Type	Description
1	N/C	Reserved	Factory use only
2	RX	DIO	UART receive. Baud rate: 230400 Bd
3	TX	DIO	UART transmit. Baud rate: 230400 Bd
4	/DWN	DIO	Initiates bootmode. Firmware download begins on exiting reset. (Active Low). This pin is pulled up to 3.3 V by a 10 kΩ resistor.
5	/RST	DIO	Resets the module processor. (Active Low). This pin is pulled up to 3.3 V by a 10 kΩ resistor.
6	GPIO_0	DIO	General-Purpose Input/Output Port 0 / PWM Output. This pin defaults as tri-state.
7	GPIO_1	DIO	General-Purpose Input/Output Port 1 / SPI_MISO. This pin defaults as tri-state.
8	DGND	GND	High speed digital signal GND return. The module has a single continuous Gnd plane
9	GPIO_2	DIO	General-Purpose Input/Output Port 2 / SPI_CLK. This pin defaults as tri-state.
10	GPIO_3	DIO	General-Purpose Input/Output Port 3 / SPI_MOSI. This pin defaults as tri-state.
11	GPIO_4	DIO	General-Purpose Input/Output Port 4 / SPI_CS. This pin defaults as tri-state.
12	CE_1	V_out	Potentiostat 1 output. This pin is connected to a Counter Electrode when measuring electrochemical sensors. Optionally, this pin can be used as a DAC output.
13	WE_1	I_in	Potentiostat 1 current measurement TIA input. For electrochemical measurements this pin is connected to the Working Electrode.
14	RE_1	V_in	Potentiostat 1 high impedance reference input. For electrochemical measurements this pin is connected to the Reference Electrode. Optionally, this pin can be used as an ADC input. If unused, it is recommended to connect this pin to AGND.
15	AGND	GND	Analog signal Gnd. The module has a single continuous Gnd plane
16	RE_0	V_in	Potentiostat 0 high impedance reference input. For electrochemical measurements this pin is connected to the Reference Electrode. Optionally, this pin can be used as an ADC input. If unused, it is recommended to connect this pin to AGND.
17	WE_0	I_in	Potentiostat 0 current measurement TIA input. For electrochemical measurements this pin is connected to the Working Electrode.
18	CE_0	V_out	Potentiostat 0 output. This pin is connected to a Counter Electrode when measuring electrochemical sensors. Optionally, this pin can be used as a DAC output.
19	Ain_2	V_in	ADC Input / 1.82 V buffered voltage reference. Decouple reference to GND via a 100 pF capacitor. The maximum load current = 200 µA.

20	Ain_1	V_in	ADC Input.
21	Ain_0	V_in	ADC Input.
22	GPIO_5	DIO	General-Purpose Input/Output Port 5. This pin defaults as tri-state.
23	GPIO_6/CD	DIO	General-Purpose Input/Output Port 6. Card Detect input for use with SD cards. This pin defaults as tri-state.
24	GPIO_7	DIO	General-Purpose Input/Output Port 7 / WAKE. This pin is pulled up to 3.3 V in Sleep and Hibernate modes and is used to wake the device. This pin defaults as tri-state.
25	I2C_SCL	DIO	Interface Clock for I^2C. This pin is pulled up to 3.3 V by a 10 kΩ resistor.
26	I2C_SDA	DIO	Interface Data for I^2C. This pin is pulled up to 3.3 V by a 10 kΩ resistor.
27	V_IN	Power	3.5 V to 5.5 V vs GND
28	DGND	GND	Power supply GND return. Module has a single continuous GND plane

Absolute maximum ratings

Parameter	Rating
V_IN to GND	-0.3 V to +6.5 V (see ADP166)
Analog Input Voltage to GND	-0.3 V to +3.6 V
Digital Input Voltage to GND	-0.3 V to +3.6 V
Total Positive GPIO Pins Current	30 mA
Total Negative GPIO Pins Current	-30 mA
Storage temperature	–65 °C to +100 °C
Operating temperature	–40 °C to +85 °C
ESD Human Body Model (HBM)	4 kV
ESD Field-Induced Charged Device Model (FICDM)	1 kV
Hand Soldering (10 seconds per pin)	400 °C

Stresses at or above those listed under Absolute Maximum Ratings may cause permanent damage to the product. This is a stress rating only; functional operation of the product at these or any other conditions above those indicated in the operational section of this specification is not implied. Operation beyond the maximum operating conditions for extended periods may affect product reliability.

ESD caution

ESD (Electrostatic discharge) sensitive device.
The EmStat Pico features protection circuitry on all Inputs and Outputs. However high energy ESD due to improper handling may cause damage or degradation of performance. Proper ESD precautions should be taken to prevent this.

Electrical specifications

Table 2: EmStat Pico electrical characteristics. Determined at 25 °C.

Parameter	Min	Typ	Max	Unit	Details
ADC					
Input Voltage Range	0.2		2.1	V	
Data Rate		800		kSPS	
Resolution	16			Bits	
Analog inputs					
Leakage Current	-1.5	±0.5	1.5	nA	Ain_0 to Ain_3, WE_0, WE_1 (OFF)
Leakage Current		±10		pA	RE_0, RE_1
EIS measurement					
Frequency range	0.016		200k	Hz	
Excitation Amplifier Bandwidth		3		MHz	
Impedance Measurement Range	10		10M	Ω	
Potentiostat circuit (Low speed)					
WE Input Bias Current		80	300	pA	WE input, 25 °C
RE Input Bias Current		10		pA	RE input, 25 °C
Offset voltage		50	150	µV	
Source/Sink current	–750		750	µA	
Potentiostat circuit (High speed)					
WE Input Bias Current		1		nA	WE input, 25 °C
RE Input Bias Current		10		pA	RE input, 25 °C
Offset voltage		50	150	µV	
Source/Sink current	-3		3	mA	
DAC					
Resolution	12			Bits	
Voltage Range (Low speed)	0.2		2.4	V	
Voltage Range (High speed)	0.2		2.8	V	
Buffered reference voltage output					
Voltage	1.815	1.82	1.825	V	TA = 25°C, capacitive load to ground 100 pF
Load Current			200	µA	

GPIO					
Input Voltage Low			0.825	V	
Input Voltage High	1.88			V	
Output Voltage Low			0.3	V	Sink current = 2 mA
Output Voltage High	2.9			V	Source current = 2 mA
Short-Circuit Current		11.5		mA	
Temperature sensor (default ADuCM355)					
Resolution		0.3		°C	
Accuracy		±2		°C	
Temperature sensor (optional ADT7420)					
Resolution		0.0078		°C	
Accuracy		±0.25		°C	
Power requirements					
V_IN voltage range	3.5	5	5.5	V	
Normal (High speed 1 Chan)		30		mA	
Normal (Low speed 1 Chan)		10		mA	
Normal (Low speed 2 Chan)		15		mA	
Sleep (Static 1 Chan)		8		mA	
Sleep (Static 2 Chan)		13		mA	
Hibernate mode		0.5		mA	

For more detailed specs see datasheets for ADuCM355, ADT7420, ADP166 and AD8606.

Power supply

The EmStat Pico has an on-board 3.3 V LDO (ADP166) and supply filtering. This provides clean operation from a USB or a 3.5 V to 5.5 V supply. Driving the EmStat Pico V_IN directly from a switching regulator may introduce measurement noise. Care should be taken to provide clean power to the V_IN pin.

Power modes	
Normal mode	CPU running. PSTAT channels configured by the user (OFF, OCP, Low Speed, High Speed). Measurement performed.
Sleep mode	CPU is not running. PSTAT channels configured by the user (OFF, OCP, Low Speed, High Speed). All voltages are still applied, but no measurements can be done.
Hibernate	CPU is not running. PSTAT channels are OFF.

Digital interface

The EmStat Pico features the following digital interfaces:

- UART with baud rate of 230400 Bd
- SPI port with SD card support. (EmStat Pico as master only). For SPI timings see ADuCM355.
- I2C port. (EmStat Pico as master only). Note: The ADT7420 temperature sensor is connected to this bus and both the SCL and SDA lines have 10 kΩ pullup resistors to 3.3 V
- 1 PWM output
- 8 GPIO

Calibration

The EmStat Pico has on-board 1 kΩ and 100 kΩ precision resistors (accuracy: ±0.1%, temperature coefficient: ±25 ppm/°C) for self-calibration.

Analog interface

DAC modes

The EmStat Pico has 2 low speed DACs and one high speed DAC. The 2 low speed DACs have an output range of 0.2 V to 2.4 V and can be used simultaneously. The single high speed DAC has an output range of 0.2 V to 2.8 V and can be used on one channel at a time.

Potentiostat channels

The applied cell potential is the voltage between RE and WE (voltage supplied at CE and controlled at RE by potentiostat loop) of the Potentiostat Channel. WE is maintained at 1.1 V or higher to allow headroom for the TIA to operate. Thus the applied potential ranges are:
High speed DAC: -1.7 V to 2 V.
Low speed DAC: -1.25 V to 2 V.

The EmStat Pico uses the 2 potentiostat channels of the ADuCM355 with the addition of high impedance buffers (AD8606) on the RE inputs. See links below for further details.

Analog inputs

The EmStat Pico features a 16-bit, 800 kSPS, successive approximation register (SAR) analog-to-digital converter (ADC) with multiplexer, input buffers, built-in anti-aliasing filter (AAF), and programmable gain amplifier (PGA). The input range of 0.2 V to 2.1 V. The multiplexer switches between the analog input channels (Ain_0 to Ain_2) and the current and voltage measurement channels of PSTAT_0 and PSTAT_1. For further details see ADuCM355 documentation.

Application example

The EmStat Pico is designed to operate with a minimum of external components. The application shown in Figure 4 shows a fully functional USB potentiostat with the addition of a USB to UART convertor (UMFT234XD-NC) and an SPE Connector (DS1020-03ST1D) to interface with a BVT Screen printed electrode (AC1.W1.R1). Figure 5 shows an EmStat Pico controlled by a microcontroller (Arduino MKR) in a typical OEM setup.

USB potentiostat

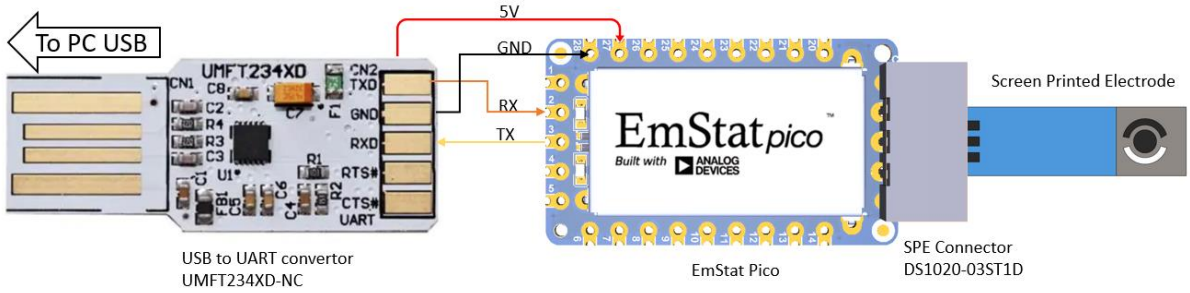

Figure 4: EmStat Pico USB setup

OEM potentiostat

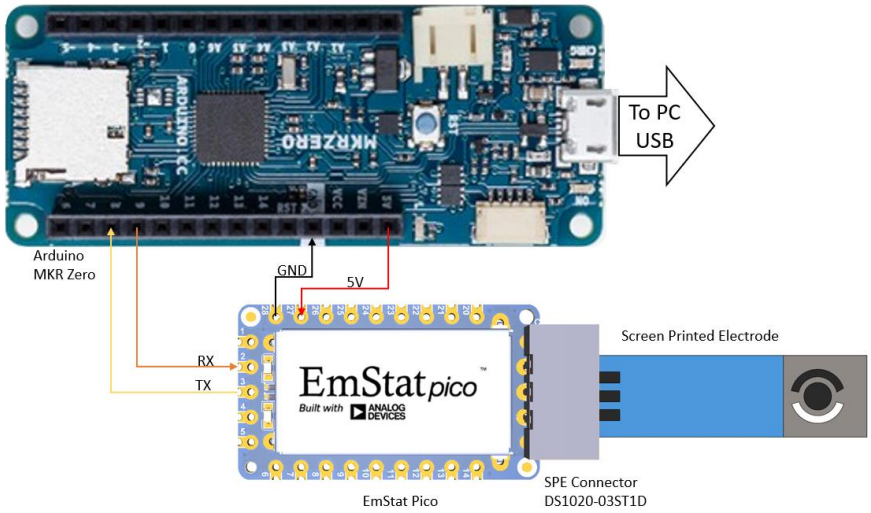

Figure 5: EmStat Pico Arduino MKR setup

Layout

Surface mount PCB footprint

Figure 6 shows the recommended SMT footprint for the EmStat Pico for hand soldering directly to a PCB using the castellated pads. Pads are 3 mm long by 1.5 mm wide.

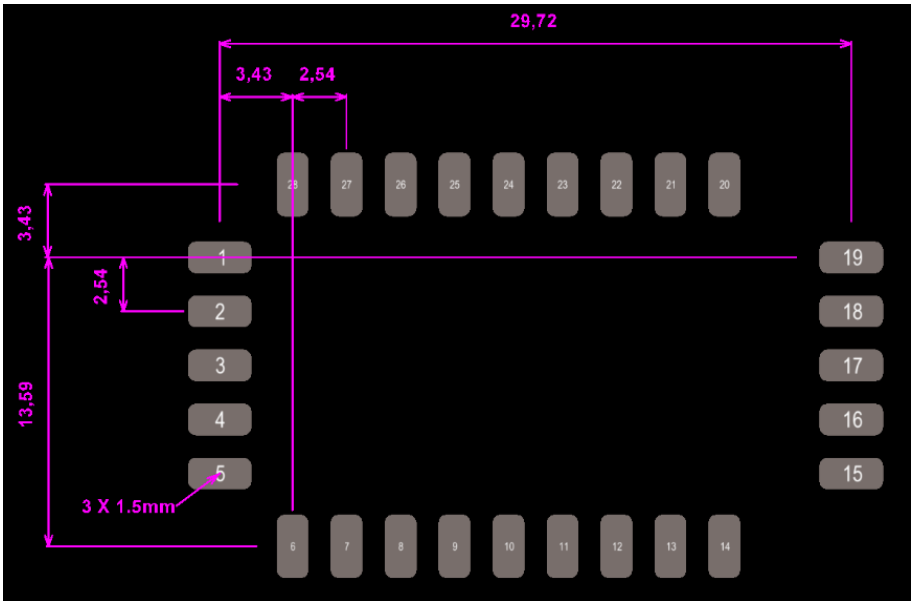

Figure 6: EmStat Pico surface mount footprint.

Through hole PCB footprint

Figure 7 shows the recommended through hole footprint for the EmStat Pico for mounting with Samtec TS-112-T-A-1 pins. Pads are 1.5 mm diameter with 0.8 mm diameter hole spaced on a 2.54 mm (100 mil) grid.

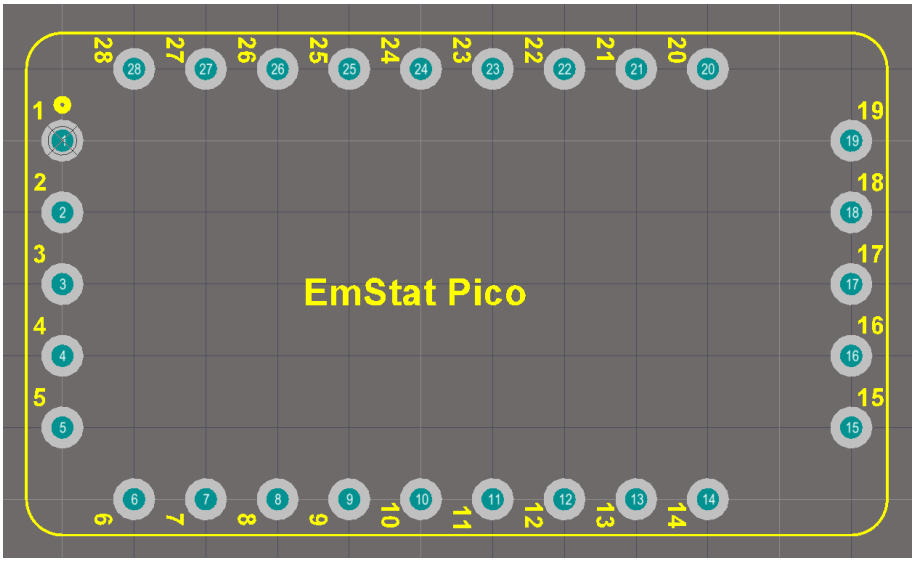

Figure 7: EmStat Pico through-hole footprint. Grid is 2.54 mm (100 mil).

Layout considerations

The EmStat Pico has 3 GND pins. Pin 28 is the power supply GND return. Pin 8 is located beside the SPI lines to provide a high speed digital GND return. Pin 15 is located beside the Analog pins to reference single ended analog signals and to connect to external shielding. The module has a single continuous GND plane so all 3 pins are connected together.
When laying out a PCB to carry the EmStat Pico it is recommended to use a single continuous GND plane and to zone the board as shown in Figure 8. If desired, separate analog and digital GND planes can be used with the EmStat Pico providing the connection between the two planes.

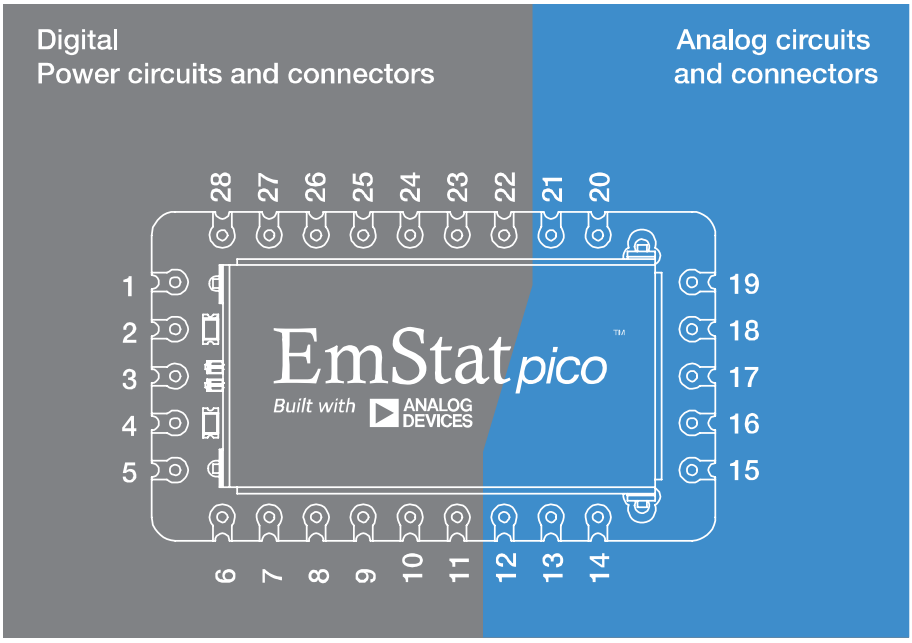

Figure 8: Recommended PCB zoning.

Assembly

SMT board-to-board soldering

The EmStat Pico has castellated pads on each side to allow surface mount board-to-board soldering. It is recommended to use hand soldering onto the footprint detailed above using a 1.2 mm chisel tip at 370°C and dwell for no more than 10 seconds on each pad.

Pin mount

The EmStat Pico through hole pads have an internal diameter of 0.76 mm (30 mil). These are designed to accept 0.64 mm (25 mil) diameter pins such as Samtec TS-112-T-A-1. The through hole pads are located on a 2.54 mm (100 mil) grid to match standard prototyping board. It is recommended to hand solder the pins into the EmStat Pico using a 1.2 mm chisel tip at 370°C and dwell for no more than 10 seconds on each pad. Use Low Residue Tin (No-Clean Flux Core Solder).

Ordering information

When ordering high volumes, the EmStat Pico module can be ordered with limited licenses to include only specific electrochemical techniques. Secondly the module can be populated with or without the high precision temperature sensor. Contact PalmSens BV for more information

Links

Module components

ADUCM355:
https://www.analog.com/en/products/aducm355.html
ADT7420:
https://www.analog.com/en/products/adt7420.html
ADP166:
https://www.analog.com/en/products/adp166.html
AD8606:
https://www.analog.com/en/products/ad8606.html
TS-112-T-A-1:
https://www.samtec.com/products/ts-112-t-a-1

Design resources

3D model
embed.palmsens.com/emstat-pico-module
Symbol & PCB Footprint (Altium):
embed.palmsens.com/emstat-pico-module
Development board:
embed.palmsens.com/emstat-pico-development-kit/
Software development:
embed.palmsens.com/knowledgebase

Accessories

- USB to UART convertor: UMFT234XD-NC
- SPE connector: DS1020-03ST1D

See for more accessories:
http://embed.palmsens.com/accessories

Please don't hesitate to contact PalmSens for more details:
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