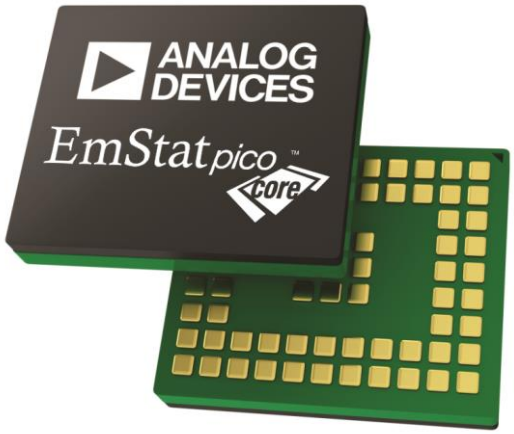


ON-CHIP SYSTEM FOR ELECTROCHEMICAL (BIO)SENSORS

PalmSens

Rev.09-2022-002

Contents

› See for more information:
www.palmsens.com/picocore

On-chip system for electrochemical (bio)sensors

The EmStat Pico Core is a joint development by PalmSens BV and Analog Devices Inc., based on the ADuCM355 and powered by the MethodSCRIPT™ protocol from PalmSens.

The ADuCM355 is an ultralow power, mixed-signal microcontroller based on the Arm® Cortex™-M3 processor. The device features current, voltage, and impedance measurement capability.

The on-board MethodSCRIPT parser on the EmStat Pico Core allows for using the AduCM355 as a generic potentiostat for use with any type of electrochemical sensor or biosensor. MethodSCRIPT allows you to use the full potential of the AduCM355 without reading its datasheets or touching a compiler. The human-readable MethodSCRIPT can be generated with PSTrace for Windows. You can also make use of the extensive MethodSCRIPT documentation with many code examples available.

More information:

- EmStat Pico Core - PalmSens
- PSTrace - PalmSens
- ADuCM355 - Analog Devices Inc.

Advantages and Overview

The EmStat Pico Core is at the heart of the EmStat Pico module. There are two main advantages of the EmStat Pico Core, compared with the EmStat Pico module:

- Economical solution for high volumes
- Smaller footprint

The EmStat Pico Core is an attractive option if you need >10k units. Lower quantities are available for prototyping purposes only.

Pico vs Pico Core

	EmStat Pico module	EmStat Pico Core
▪ Based on ADuCM355	✓	✓
▪ Works with MethodSCRIPT	✓	✓
▪ Minimum Order Quantity	1	10k
▪ Footprint	18 x 30 mm	6 x 5 mm
▪ 1TΩ Input impedance	✓	Optional
▪ Extra 100 nA current range	✓	Optional
▪ Calibration of external TIA resistor(s)	✓	Optional

The optional items depend on the implementation of the PalmSens reference design.

Evaluation with the EmStat Pico module

For evaluating the EmStat Pico Core, it is recommended to use the EmStat Pico module or the EmStat Pico Development Kit, which implements the EmStat Pico Core. Measurement results obtained on the EmStat Pico module will be identical to measurements ran on a system implementing the EmStat Pico Core.

Supported Electrochemical Techniques

The following electrochemical techniques are supported by the EmStat Pico Core:

Voltammetric techniques:

- Linear Sweep Voltammetry — LSV
- Cyclic Voltammetry — CV
- Square Wave Voltammetry — SWV
- Differential Pulse Voltammetry — DPV
- Normal Pulse Voltammetry — NPV

The above techniques can also be used for stripping voltammetry

Techniques as a function of time:

- Chronoamperometry — CA
- Pulsed Amperometric Detection — PAD
- Open Circuit Potentiometry — OCP
- MultiStep Amperometry — MA

Electrochemical Impedance Spectroscopy

- Scanning or fixed frequency mode — EIS

Dual-channel and Bipotentiostat functionality

The second channel of the EmStat Pico Core can be used for running sequential measurements on two different cells each with their own Reference, Counter and Working electrodes. This second channel has a series resistor of typically 110 Ω in series with the WE2 signal in high-speed mode (see also EmStat Pico Main specifications).

The second channel can also be used in Bipotentiostat mode, functioning as second Working Electrode versus the Reference and Counter electrode of channel 1. Both channels are recorded simultaneously in the Bipotentiostat mode. The second Working Electrode (WE2) can either be set at a potential offset with respect to WE1 or at a fixed potential with respect to RE1. The Bipotentiostat mode is supported in Low Speed mode (see table found in the EmStat Pico module specifications) for all techniques, excluding EIS and OCP.

Main specifications

When the EmStat Pico core is implemented according to our reference design, its specifications are identical to those of the EmStat Pico module.

Other

▪ **On-chip storage**	4000 datapoints
▪ **Mass storage**	supports optional external SD card or NAND chip for mass storage
▪ **Package**	6 mm × 5 mm, 72-lead LGA package
▪ **Operation temperature range**	-40 °C to +85 °C

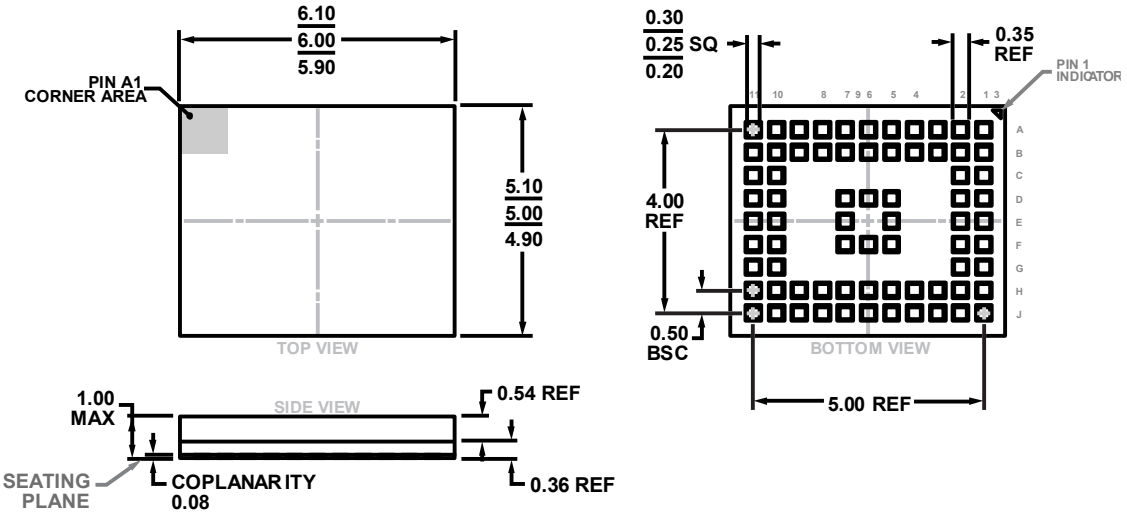
For more technical aspects regarding thermal performance and other factors to take into account when implementing the ADuCM355, please refer to the ADuCM355 Datasheet.

Limits of some technique-specific parameters for EmStat Pico

Normal Pulse and Differential Pulse Voltammetry	Scan rate: Pulse time:	0.02 mV/s (0.280 mV step) to 5 V/s (10 mV step) 1ms to 300ms
Square Wave Voltammetry	Frequency:	1 Hz to 500 Hz
Linear Sweep and Cyclic Voltammetry	Scan rate:	0.02 mV/s (0.280 mV step) to 5 V/s (10 mV step)
Pulsed Amperometric Detection	Interval time: Pulse time: Maximum run time:	1 ms to 10 s 1 ms to 1 s 1000000 s
ChronoAmperometry and Open Circuit Potentiometry	Interval time: Maximum run time:	1 ms to 300 s 1000000 s (> 10 days at 300 s interval)
Multistep Amperometry,	Interval time: Level switching overhead time: Number of levels: Number of cycles: Maximum run time:	1 ms to 300 s ±10 ms 1 to 255 1 to 20000 1000000 s per level

Dimensions

Dimensions shown in millimeters



Reference design

A reference design and documentation for implementation of the EmStat Pico Core is available for customers. The reference design and the documentation explain how to place the EmStat Pico Core into your PCB design for achieving the same functionality and specifications of the EmStat Pico module. The documentation also contains PCB layout recommendations.
The reference design comes with

- 8 hours of technical support,
- and 20 EmStat Pico Core samples for prototyping purposes.

Distribution

The EmStat Pico Core is delivered on reels, distributed via PalmSens BV and Arrow.

MethodSCRIPT™ Scripting Language

The EmStat Pico Core works with the MethodSCRIPT™ scripting language. This language allows developers to program a human-readable script directly into the Pico module by means of a serial (TTL) connection. The simple script language allows for running electrochemical techniques supported by EmStat Pico Core and makes it easy to combine different measurements and other tasks.

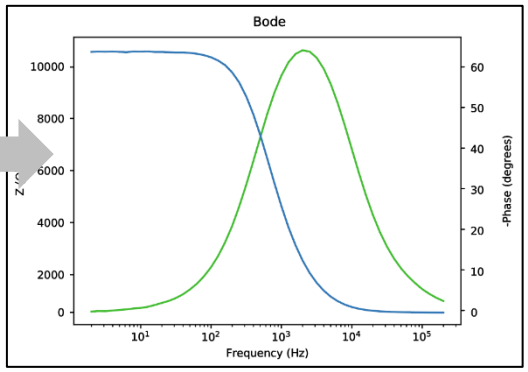
More script features include:

- Use of variables
- (Nested) loops
- Logging results to an SD card
- Digital I/O for example for waiting for an external trigger
- Reading auxiliary values like pH or temperature
- Going to sleep or hibernate mode

Example MethodSCRIPT for EIS measurement on a test circuit

```
e
#Declare variables
var h
var r
var j
#Initialize device
set_pgstat_mode 3
#Set starting current range
set_cr 1m
#Turn cell on for measurement
cell_on
#Start EIS scan from 200kHz to 2 Hz in 41 steps
meas_loop_eis h r j 10m 200k 2 41 0
   #Send results of measurement loop step
   pck_start
   #Send frequency
   pck_add h
   #Send Z real
   pck_add r
   #Send Z imaginary
   pck_add j
   pck_end
   #Continue with next step of EIS scan
endloop
#Turn cell off after measurement
cell_off
```

Scripts can easily be generated in PSTrace for Windows.
See page 10.



Actual measured result on dummy cell ran in Python

More MethodSCRIPT features include:

- Use of variables
- (Nested) loops
- Logging results to internal storage or external SD card
- Digital I/O for example for waiting for an external trigger
- Reading auxiliary values like pH or temperature

MethodSCRIPT™

Code examples are available for

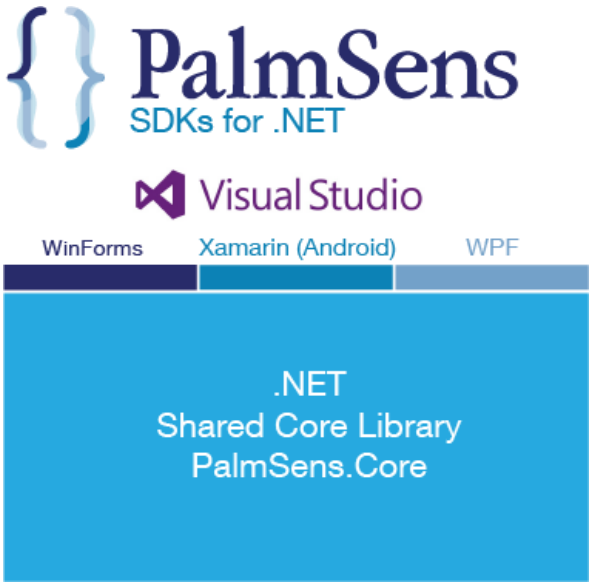
ARDUINO Swift python™ Java

Visual Studio Xamarin C/C++

› See for more information:
www.palmsens.com/methodscript

Software Development Kits for .NET

Develop your own application in no time for use with any PalmSens instrument or potentiostat module or for the EmStat Pico Core.

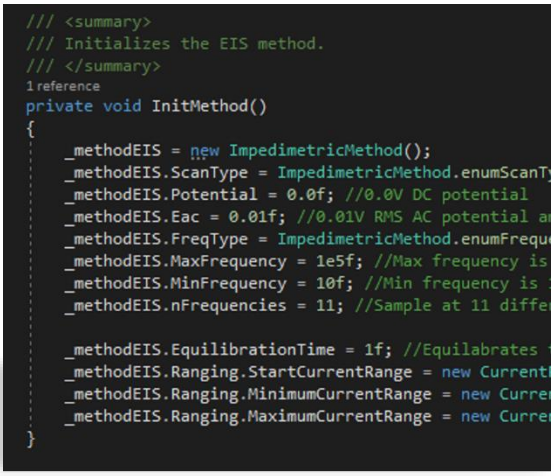


There are three PalmSens Software Development Kits (SDKs) for .NET. Each SDK can be used with any of our instruments or OEM potentiostat modules to develop your own software. The SDK's come with a set of examples that shows how to use the libraries. PalmSens SDKs with examples are available for the following .NET Frameworks:

- WinForms
- Xamarin (Android)
- WPF

Each SDK comes with code examples for:

- Connecting
- Running measurements and plotting data
- Manual control of the cell
- Accessing and processing measured data
- Analyzing and manipulating data
- Peak detection
- Equivalent Circuit Fitting on impedance data
- Saving and loading files

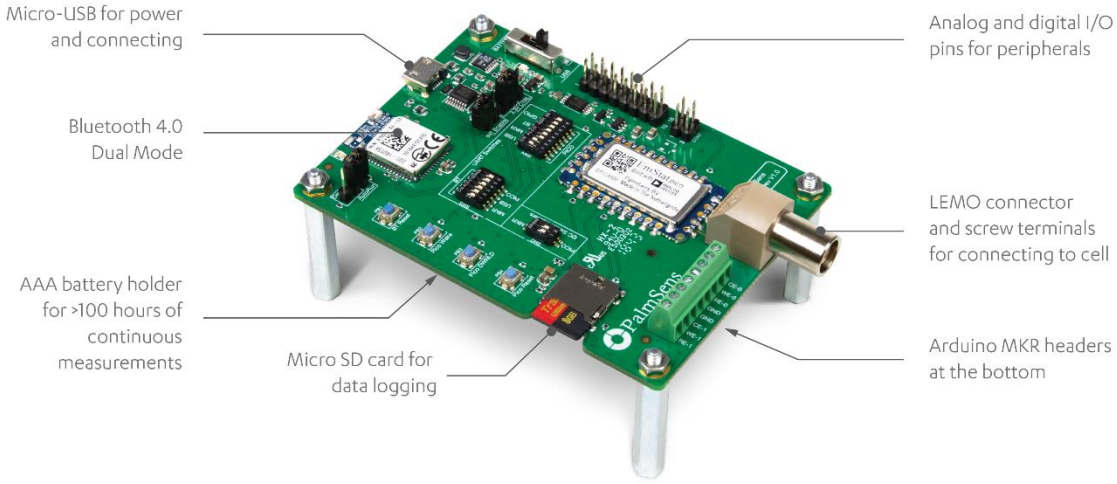


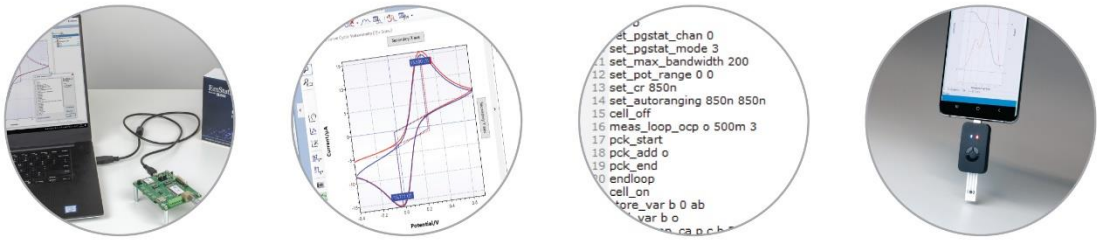
```
/// <summary>
/// Initializes the EIS method.
/// </summary>
1 reference
private void InitMethod()
{
    _methodEIS = new ImpedimetricMethod();
    _methodEIS.ScanType = ImpedimetricMethod.enumScanT
    _methodEIS.Potential = 0.0f; //0.0V DC potential
    _methodEIS.Eac = 0.01f; //0.01V RMS AC potential a
    _methodEIS.FreqType = ImpedimetricMethod.enumFrequ
    _methodEIS.MaxFrequency = 1e5f; //Max frequency is
    _methodEIS.MinFrequency = 10f; //Min frequency is
    _methodEIS.nFrequencies = 11; //Sample at 11 diffe

    _methodEIS.EquilibrationTime = 1f; //Equilabrates
    _methodEIS.Ranging.StartCurrentRange = new Current
    _methodEIS.Ranging.MinimumCurrentRange = new Curre
    _methodEIS.Ranging.MaximumCurrentRange = new Curre
}
```

› See for more information:
www.palmsens.com/sdk

EmStat Pico Development Board

The EmStat Pico Development board allows to run your experiments conveniently in our PSTrace software for electrochemistry.





STEP 1

Connect the EmStat Pico Development Board to a PC running PSTrace

STEP 2

Fine-tune your electrochemistry for optimal use of the EmStat Pico module

STEP 3

Generate the MethodSCRIPT™ snippet for running your measurement on the EmStat Pico

STEP 4

Use the MethodSCRIPT™ snippet to run the exact same measurement on the embedded EmStat Pico in your product

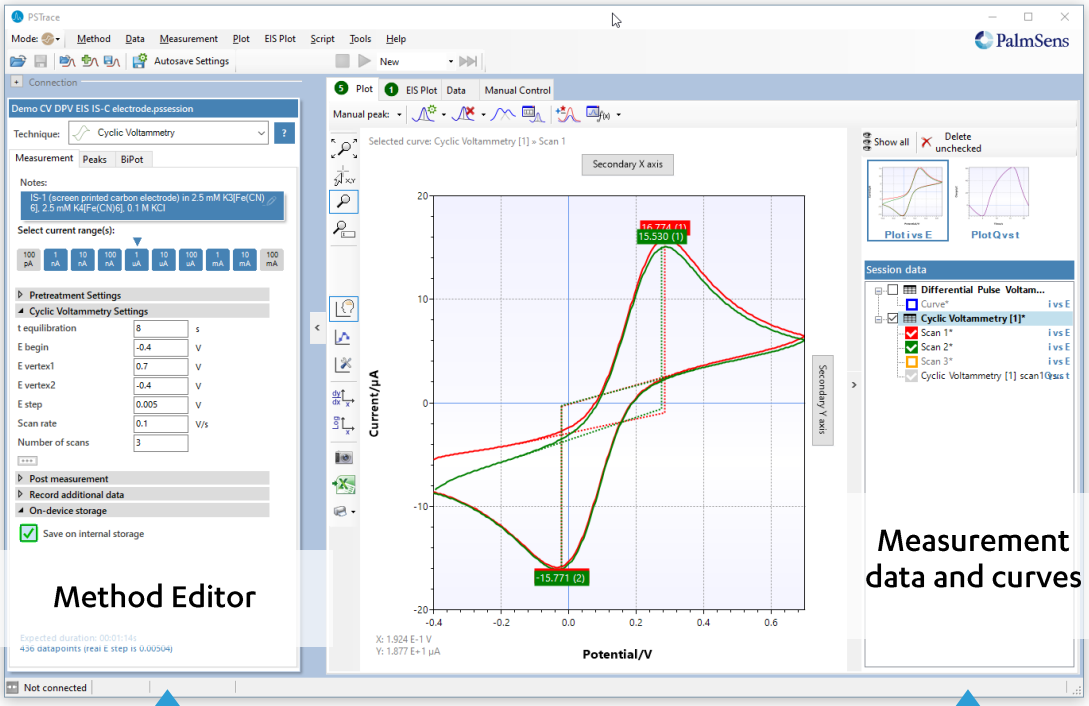
Comes with code examples for: iOS

› See for more information:
www.palmsens.com/picodevkit

Reduce your time-to-market

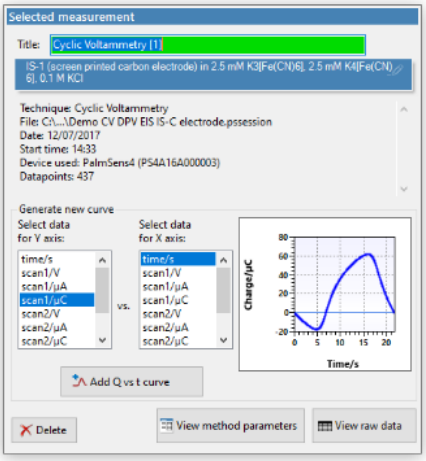
The EmStat Pico Development Board can be used directly with the PSTrace software for Windows. PSTrace automatically sets the EmStat Pico in the optimal mode based on the user specified method parameters. PSTrace

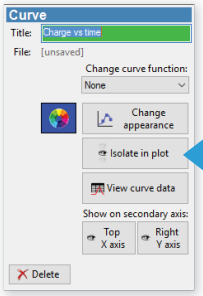
PSTrace 5



Select current ranges for auto ranging and the starting current range.

Switch between plots if curves with different units are available.





Click on a curve in the legend to change its title or appearance.

Click on a measurement in the legend to see the available data and to generate more curves.

› See for more information:
www.palmsens.com/pstrace

Please do not hesitate to contact PalmSens for more details:
info@palmsens.com

PalmSens BV
The Netherlands
www.palmsens.com