



# **Signal Conditioners and Conditioner Adapters**

User's Guide

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# 1 Contents

This range of signal conditioning products has been discontinued. This helpfile is supplied as a reference to existing users only.

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## 2 Introduction

Our aim at Pico Technology is to provide high-performance, cost-effective data acquisition solutions. By offering a range of electronic and software products that are designed to work together, we have greatly simplified the process of measurement.

For some applications, it is possible to use a product like our TC-08, which includes both a thermocouple signal conditioner and an analog to digital converter: just connect it to the computer, plug in a thermocouple and the PicoLog software starts displaying temperature readings.

For applications involving less common sensors, or a mixture of sensors of different types, our signal conditioner modules and adapters connect directly to Pico analog to digital converters and provide a quick and easy way of interfacing to sensors.

Pico Technology signal conditioners connect directly to a wide range of standard sensors and transmitters, both providing power or excitation and amplifying the sensor output to provide an output in the range -2.5V to +2.5V. The sensors plug into a signal conditioner adapter that provides power and routes the signals from each conditioner to a separate input on the converter.

### Conditioners

The following signal conditioners are currently available:

Type	Description	Parameter	Unregulated power
<a href="#">CM004</a>	Pt100	Temperature (-200 to 370 °C)	No
<a href="#">CM005</a>	Type K	Temperature (-270 to 1370 °C)	No
<a href="#">CM006</a>	Resistance/ Thermistor	Resistance (10k to 1M) Temperature (0 to 70 °C)	No No
<a href="#">CM007</a>	4-20 mA	Various, incl. Pressure	Medium (20 mA)
<a href="#">CM008</a>	4-20 mA	Various, incl. Pressure	No
<a href="#">CM013</a>	Humidity	Humidity/temperature	No
<a href="#">CM015</a>	V bridge	Pressure	Low (5 mA)
		Load	High (80 mA)
<a href="#">CM018</a>	LEM-HEME Current clamp	Mains quality DC Current	High (100 mA)
<a href="#">CM019</a>	Current transformer	AC Current Mains power	No

### Unregulated power

Where possible, the signal conditioner modules take power only from the 5V supplies. Some, however, require higher voltages or high current: these use the unregulated power supply.

For conditioners that do not use unregulated power, a single conditioner module can be plugged directly into the ADC-16, without needing to use a signal conditioner adapter.

Conditioners that use medium or high power are not suitable for portable (battery operated) applications. When used with EnviroMon, each converter will require a DC power supply from a Mains adapter.

## Adapters

Signal conditioner adapters provide power and mechanical support for the signal conditioners, and route the output signal to an analog to digital converter.

The EL036 also has a built-in analog to digital converter.

Type	Description	No of Channels	Usage
<a href="#">EL036</a>	EnviroMon	2	Works with the EnviroMon stand-alone data logger. Each EnviroMon logger can connect to up to ten EL036 converters, which can be up to 400 metres from the logger.
<a href="#">CM001</a>	Scope	2	The scope signal conditioner adapter is easy to use with either a high-speed data acquisition product, for example the Pico ADC200, or with a standard oscilloscope.
<a href="#">CM002</a>	ADC16	4	The ADC-16 connects directly to a computer. It is ideal for accurate, low-speed measurement over relatively short periods.

## Scaling

Scaling is the process of converting a voltage measurement into the units of the measured parameter. PicoScope, PicoLog and EnviroMon all provide full support for scaling from a wide range of sensors.

For some sensor types, the scaling is built into Pico Software: for others, the information is held in a [scale file](#) (.PSC). Pico provides scaling files with details of a wide range of sensors: in addition, it is easy to create a 'user' scaling file for a sensor that does not appear in our list.

When using the ADC-16 converter, the software can automatically detect the type of conditioner connected. For other products, it is necessary to select the converter from a list. The computer then offers a list of the sensors (built-in, Pico PSC and user PSC) that work with the specified converter.

## 3 Signal conditioners

### 3.1 CM004 Pt100 platinum resistance

The Pt100 platinum resistance thermometer (PRT) signal conditioner works with standard 2-, 3- or 4-wire Pt100 sensors. It provides high accuracy, high stability temperature measurement over a wide range.

#### Specification

Sensor type	Pt100 2, 3 or 4 wire
Temperature range	-200 °C to 380 °C
Accuracy	0.2 °C at ambient 1 °C at 380 °C (calibrated version available)
Sense current	250 A
Output voltage range	190 mV to 2500 mV (non-linear)
Operating temp range	0 to 70 °C
Power requirements	2 mA @ 5V
Input connector	4 x screw terminal
Output connector	D25 male
Enclosure	Encapsulated

#### Connections

Most four-wire sensors have two red wires and two white wires. Connect these up according to the label on the CM004. For a 2- wire sensors, it is necessary to short together the two screw terminals labelled Red and the two labelled white, then connect the sensor to one screw terminal of each colour.

#### Scaling

The scaling for CM004 is built in to PicoLog, PicoScope and EnviroMon loggers V15 and above.

## 3.2 CM005 Type K thermocouple

The type K signal conditioner works with any type K thermocouple. It provides good accuracy over the full temperature range. It has built in cold junction compensation.

### Specification

Sensor type	Type K thermocouple
Temperature range	-270 °C to 1370 °C
Accuracy	0.5 °C and 0.2%
Temperature compensation	Built-in semiconductor sensor
Output voltage range	190 mV to 2500 mV (non-linear)
Operating temp range	0 to 70 °C
Power requirements	2 mA @ 5V
Input connector	miniature thermocouple
Output connector	D25 male
Enclosure	Encapsulated

### Connections

The thermocouple connector plugs directly into the signal conditioner.

Safety note: When working with bare-wire thermocouples, do not place in contact with anything that could become live.

### Scaling

The scaling for CM005 is built into PicoScope, PicoLog and EnviroMon loggers V15 and above.

### 3.3 CM006 Resistance

The resistance conditioner can be used with any resistor whose resistance varies between 10k and 1M over the range to be measured. It is primarily intended for use with a precision thermistor, which offers 0.1 °C accuracy over the 0 to 70 °C range.

#### Specification

Sensor type	Resistor
Accuracy	0.2%
Stability	0.07% over operating temp range
Output voltage range	$V_{out} = 5 * R / (R + 100k) - 2.5$
Bandwidth	DC to 100 kHz
Operating temp range	-20 to 70 °C
Power requirements	1 mA @ 5 V
Input connector	FCC68 4/4 pins 1 and 2
Output connector	D25 male
Enclosure	Encapsulated

#### Connections

The conditioner is fitted with an FCC68 4/4 connector, and it measures the resistance between pins 1 and 2. For resistances around 100k, a cable length 100 metres will have an effect of 0.02% on the resistance, and a negligible effect on the temperature.

#### Scaling

The scaling for resistance is built in to PicoScope and PicoLog.

The scaling for use with the EL015 thermistor is built in to PicoScope, PicoLog and EnviroMon.

For other types of sensor, it is necessary to define a lookup table using the following equation. The output voltage from this equation is in millivolts:

$$V_{out} = 5000 * R / (R + 100k) - 2500$$



### 3.4 CM007 4-20mA (powered)

The powered 4-20mA signal conditioner works with two-wire 4-20mA transmitters that are powered by the current loop. This type of transmitter is very practical because the two-wire circuit provides both sensor power and signal return: being current-based, it offers very good immunity to electrical noise.

The conditioner provides power for the current loop from the conditioner adapter's unregulated power line. A typical conditioner adapter provides 12 to 18 volts, and this voltage, less about 500 mV for the conditioner, is available to power the transmitter.

Note: some transmitters require a minimum of 12 volts: the CM007 is not suitable for this type of transmitter.

Other transmitters have four connectors- the transmitter is powered through one pair of contacts, and it sources the 4-20 mA loop through the other pair of contacts. Use the CM008 for this type of transmitters.

#### Specification

Sensor type	4-20 mA 2-terminal
Accuracy	±0.3%
Loop voltage	11 to 18V unregulated
Output voltage range	4 mA: 471 mV 20 mA: 2355 mV
Bandwidth	DC to 100 kHz
Operating temp range	-20 to 70 °C
Power requirements	2 mA @ ±5 V 20 mA @ unreg
Overvoltage protection	±20 V
Input connector	Screw terminal
Output connector	D25 male
Enclosure	Encapsulated

#### Connections

The signal conditioner has two connectors, labelled + and -. These should be connected to the appropriate terminals on the transmitter. DO NOT USE with any transmitter that has more than two terminals.

#### Scaling

PicoScope, PicoLog and EnviroMon can use the PSC scaling files which contain information on a wide range of 4-20 mA sensors. If you wish to create your own PSC files, you should specify the Raw values in milliamps.

### 3.5 CM008 4-20mA (Isolated)

The CM008 4-20 mA signal conditioner works with transmitters that have their own power supply and supply the current for a 4-20 mA output.

The input circuit of the conditioner is electrically isolated from the input, and so it is suitable for use with devices whose 4-20 mA output is not, or must not be, tied to ground. The input circuit of the CM008 is powered by the 4-20 mA loop from the transmitter.

Note: for transmitters that are intended to be powered by the loop current, you should use the CM007 (powered) 4-20 mA conditioner.

#### Specification

Sensor type	4-20mA independently powered
Accuracy @25C	offset $\pm 0.05\%$ gain $\pm 0.3\%$
Temperature coefficient	40 ppm/ °C
Min. CM008 loop voltage	7 V
Output voltage range	4 mA: 471 mV 20 mA: 2355 mV
Bandwidth	DC to 10kHz
Isolation (in to out)	5 kV
Operating temp range	-20 to 70 °C
Power requirements	2 mA @ $\pm 5$ V
Overcurrent protection	$\pm 50$ mA
Input connector	Screw terminal
Output connector	D25 male
Enclosure	Encapsulated

#### Connections

The CM008 plugs into a CM001, CM002 or EL036 conditioner adapter. Connect the terminal marked + on the CM008 to the positive output terminal on the transmitter, and the terminal marked - on the CM008 to the negative output terminal on the transmitter.

Note that the CM008 is a current input device: you should not connect it to voltage source that does not limit the current.

#### Safety

Although the unit offers high isolation between the input and the output, you should be aware that the screw terminal inputs and the solder pins on the back of the PCB may be at the input voltage. If you intend to operate the input connections at high voltage, you should take appropriate precautions to make sure that any point connected to the input does not come into contact with any person or with any metal object.

#### Scaling

PicoScope, PicoLog and EnviroMon can use the PSC scaling files which contain information on a wide range of 4-20mA sensors. If you wish to create your own PSC files, you should specify the Raw values in milliamps.

### 3.6 CM013 Temperature and humidity

The temperature and humidity signal conditioner works with the Pico Technology EL030 temperature and humidity sensor. It requires two channels, of which the first is humidity and the second is temperature.

#### Specification

Sensor type	EL030 temperature and humidity	
	Humidity	Temperature
Range	0 to 100%	-40 to 85 °C
Accuracy	5% @ 25 °C (uncal.) 2% @ 25 °C (cal.)	0.2 °C (0 to 70 °C)
Temperature coefficient	0.00216 per C	
Response time	approx 1 minute	
Nominal output voltage range	0% = -1644 mV 100% = 1399 mV	
Operating temp range	-40 to 85 °C	
Power requirements	2 mA @ 5 V	
Input connector	FCC68 4/4 socket	
Output connector	D25 male	
Enclosure	Encapsulated	

#### Connections

The signal conditioner is supplied with an EL030 temperature and humidity sensor: it connects to the CM013 using the supplied 5-metre cable.

#### Scaling

For EnviroMon, it is easier to use the EL026 converter to connect to the temperature and humidity sensor.

The CM013 module requires two channels: the first is the humidity and the second is temperature. Both channels must be enabled. PicoLog has built-in scaling for both sensors, and automatically adjusts for the temperature coefficient of the humidity sensor.

### 3.7 CM015 10V bridge

The 10 volt bridge signal conditioner works with standard 4 or 6 wire pressure sensors or load cells. It provides excitation at 10 volts, and accepts input voltages up to 100 mV.

#### Specification

Sensor type	4 or 6 wire bridge
Input range	100 mV
Accuracy	0.2%
Stability	0.07% over operating temp range
Bridge resistance	250 to 10 k ohms
Drive current	max 40mA
Output gain	x 23.936 i.e. 100 mV sensor gives 2393.6 mV output
Output voltage range	2500 mV
Bandwidth	DC to 100kHz
Operating temp range	0 to 70 °C
Power requirements	2 mA @ 5 V 2 x bridge current @ unreg
Input connector	6 x screw terminal
Output connector	D25 male
Enclosure	Encapsulated

#### Connections

Connect as indicated in the sensor instructions. For four-wire sensors, make the following connections at the signal conditioner:

- +drive to +sense
- drive to -sense

#### Scaling

PicoScope, PicoLog and EnviroMon can use the PSC scaling files which contain information on a wide range of 10V bridge sensors.

### 3.8 CM018 LEM-Heme Current clamp

The CM018 signal conditioner works with the LEM-Heme range of current clamps. The conditioner provides +/-15 volts at 15 mA for the sensor, and it accepts voltage inputs.

There are several current ranges, and both DC and RMS versions are available. The DC version is suitable for DC current measurement and for AC signal quality measurement. RMS versions are suitable for power measurement with mains signals, however using a CM019 with a current transformer may be more cost effective.

When working with mains, EnviroMon and the ADC16 are suitable only for use with RMS version.

#### Specification

Sensor type	Current clamp
Input range	5 V
Accuracy	1 %
Power supply	+/-15 V +/-2%
Max current	15 mA
Output gain	divide by 2
Output voltage range	2500 mV
Bandwidth	DC to 100kHz
Operating temp range	0 to 70 °C
Power requirements	2 mA @ 5 V 60 mA @ unreg
Input connector	4 x screw terminal
Output connector	D25 male
Enclosure	Encapsulated

#### Connections

LEM-HEME current clamps are normally fitted with a cable containing cores with the following cable colours. If in doubt, please consult the manufacturer.

Red	+15V
Blue	-15V
Green	Ground
White	Signal

The current clamp should be clipped round a single core of the mains cable. It will not give correct readings if live, neutral and earth wires all pass through the current clamp.

#### Safety note:

LEM-Heme current clamps are intended to simply clip round a mains cable. It is not necessary to make an electrical connection to the cable, and doing so may be dangerous.

If you wish to work on uninsulated high-voltage cables, please check the suitability of the current clamp for this usage.

### 3.9 CM019 Current transformer

The CM019 is intended for use with current transformers. This type of probe is ideal for AC current or power measurement.

Current transformers require no power and are available in a wide variety of formats, from 200 A clamp-on units to 5000 A fixed-core transformers.

These devices that typically generate an AC signal of 1 mV for each ampere flowing through a cable. The CM019 outputs a DC voltage that is a true RMS equivalent of the input AC voltage: this DC voltage can conveniently be measured using an ADC-16 or an EnviroMon system.

#### Specification

Sensor type	current transformer
Max input voltage	2 V RMS AC
Max overvoltage	10 V
Input impedance	> 1 M
Output voltage range	0 to 2 V DC
Offset error	300 $\mu$ V typical 500 $\mu$ V maximum
Gain error (Sine wave)	< 200 mV RMS: 0.3%typ, 0.5%max < 1 V RMS: 1.2%typ, 2%max
Frequency range	20 Hz to 30 kHz (for 1% accuracy)
Response time	100 ms
Operating temp range	-20 to 70 °C
Power requirements	2 mA @ $\pm$ 5 V
Input connector	4 mm banana (3/4" separation)
Output connector	D25 male
Enclosure	Encapsulated

#### Connections

Most current transformers are fitted with banana plugs, so that they are suitable for use with multimeters. Connect the two banana plugs on the current transformer into the banana sockets on the CM019. The polarity is not important.

The current clamp should be clipped round a single core of the mains cable. It will not give correct readings if live, neutral and earth wires all pass through the current clamp.

#### Safety note

Current transformers are intended to simply clip round a mains cable. It is not necessary to make an electrical connection to the cable, and doing so may be dangerous.

If you wish to work on uninsulated high-voltage cables, please check the suitability of the current transformer for this usage.

## 4 Conditioner adapters

### 4.1 EL036 EnviroMon signal conditioner converter

The EL036 signal conditioner converter plugs into the EnviroMon network in the same way as any other EnviroMon converter, and accepts two signal conditioning modules.

12 V DC socket

The EnviroMon logger provides power for all of the converters on the network, so it is not normally necessary to connect a mains adapter to the 12V DC socket.

For safety reasons, it limits the available current to 100 mA. If you use a signal conditioner that requires unregulated power, you should check that the total power requirement for converters (at about 10 mA each) and signal conditioners is less than 100 mA. If not, you should connect a mains adapter to the DC power socket on the signal conditioner adapter.

See the table in the [introduction](#) for a summary of unregulated power requirements.

### 4.2 CM001 Scope signal conditioner adapter

The CM001 is supplied in the same box as the ADC-200. It accepts two signal conditioner modules, and has two BNC connectors which go to the ADC-100 or ADC-200 inputs. There are two DC connectors: These are connected in parallel, so that a mains adapter can be connected to one socket and the other socket can be connected to an ADC-200.

If only a single channel is required, this unit can also be used with the ADC-40 and ADC-42.

The CM001 is primarily intended for use with high-speed signals, from (for example) a pressure or load cell, but it can also be used for slower signals as well.

### 4.3 CM002 ADC16 signal conditioner adapter

The CM002 sits on top of an ADC-16, and provides sockets for four signal conditioner modules. The conditioner outputs connect to channels 1 to 4 of the ADC-16, and the conditioner type signals to channels 5 to 8.

Dual-output conditioners, eg CM013 temperature and humidity, must be plugged into socket 1 (to use channels 1 and 2) or into socket 3 (to use channels 3 and 4). The adjacent socket must be left empty.

The CM001 has a DC power socket: a mains adapter must be plugged in before using the unit.

## 5 Mechanical construction

Signal conditioner modules are made using a single circuit board which is encapsulated in a block 41 mm x 17 mm.

There is a D25 male connector at one end: this plugs into a signal conditioner adapter. The other end has the appropriate connectors for the sensors that it is to be used with.



## 6 Signal conditioner connections

Each signal conditioner module has a 25-pin male right-angle connector that provides connectors to the conditioner adapter. The pin assignments are as follows:

Pin	Function
1	Primary signal out
2	Secondary signal out
3-4	Reserved for serial interface
5	Conditioner type
6	Unregulated power
7	Unregulated ground
8-10	Can be grounded
10	Ground
11	2.5 V Reference
12	+5V power
13	-5V power
14-25	Can be grounded

### Primary signal out

This is the main analog output from the signal conditioner. It is a voltage in the range  $\pm 2.5V$ , and feeds into an impedance of 1 megaohm or above.

### Secondary signal out

For signal conditioners which require two channels, this is the second analog output. It is a voltage in the range  $\pm 2.5 V$ , and feeds into an impedance of 1 megaohm or above.

### Reserved for serial interface

These pins may be used at a future date to implement a serial interface to a microprocessor on a conditioner board. The conditioner module should leave them floating, and a conditioner adapter that does not use them should ground them.

### Conditioner type

This signal is used to identify the type of signal conditioner plugged into a given socket. Each conditioner module contains a 100 k resistor to ground and an identifying resistor to 5 V. The conditioner adapter (or ADC) contains a 1 megaohm pull-down to ground so that an empty slot can be detected. See [conditioner type detection](#) for a list of assigned resistor values.

### Unregulated power

This is used by devices which require large amounts of power, or voltages greater than  $\pm 5 V$ . The conditioner adapter will be able to supply at least 100 mA to each conditioner adapter, at a minimum of 12 V.

### 2.5 V reference

This is a precision 2.5 V reference, and ideally should be the reference used by the converter. Signal conditioners should draw a maximum of 10  $\mu A$  from this pin.

### +5 V power

This is a 5 V power source. The conditioner module should draw a maximum of 10 mA. If more current use required, the unregulated supply should be used.

#### -5 V power

This is a -5 V power source. The conditioner module should draw a maximum of 10 mA: if more current use required, the unregulated supply should be used.

#### Signal Ground

This is the ground line for the data, and reference voltage, and also for the +/-5 V power lines.

#### Unregulated ground

This is the ground line for the unregulated power: ideally, it should be separate in both the conditioner adapter and the conditioner from the signal ground.

#### Can be grounded

Where possible, these pins should be connected to signal ground in both the conditioner and the conditioner adapter.

## 7 Conditioner type detection

Signal conditioners may be identified by measuring the voltage of the Type pin. This is connected by a type-specific resistor to 5 V and by a 100 k resistor to ground.

The following values are assigned:

Resistance	Part number	Conditioner type	Parameter
100k	CM004	Pt100	Temperature
110k	CM005	Type K Thermocouple	Temperature
120	CM006	Resistance	Resistance, temperature
150	CM013	Humidity/temp	Humidity
180	CM012	Unipolar 5V	Light
210	CM015	Resistance Bridge (10V)	pressure, load cell
240			
270			
300			
330	CM007 CM008	4-20mA current loop	note: both powered and isolated use same ID
360			
430			
470			
510	CM018	Lem-Heme $\pm 15V$	Mains voltage/current RMS
560	CM019	Current transformer	Current/power
620			
690			
7			
750k			
820k		User 1	
910k		User 2	

## 8 Scale files (.PSC)

Pico Technology supplies a group of .PSC files, one for each manufacturer, that contains scaling information for a wide range of sensors. This scaling information is used by PicoScope, PicoLog and EnviroMon. The EnviroMon system only supports scaling for the EL016, EL036 and EL037 converters.

We do not recommend modifying these files, as any modifications would get lost next time you upgrade your software, however you can create a user scale file, USER.PSC, that will not be overwritten during software upgrades.

You can copy an entry from one of the standard .PSC files to USER.PSC, then make changes as required. Remember to change the Sensor number to a value in the user range (1-99) so that it does not clash with the entry that you copied. You can edit .PSC files using the Windows Notepad program. You can alternatively use a word processor, but remember to save the file in text file format.

Pico software carries out scaling using a lookup table- a list of pairs of values, where each pair is made up of a raw value (in millivolts, unless the signal conditioner measures something different) and a scaled value in the appropriate parameter units.

For a sensor with a linear response, exactly two pairs (or points) are required- ideally, the top and bottom of the measured range. For a sensor with a non-linear response, more points will be required. Note that a large number of points will slow down scaling in PicoScope, and may cause memory shortage problems in the EnviroMon.

If, for example, you wish to use a pressure sensor that generates 100mV at 5psi, and it is connected to a CM015 signal conditioner (input range 100mV), the two scale points are:

```
0 0
100 5
```

For each scale that you require, there is a section like this:

```
[Scale1]
Name=Honeywell 26PC 0-5psi
Conditioner=15
Sensor=121
Units=psi
OutOfRange=2
Places=3
Method=0
NoOfPoints=2
Raw1=0
Scaled1=0
Raw2=100
Scaled2=5
```

Name=Honeywell 26PC 0-1psi

This is the name of the scaling method. The same scaling method could be used for multiple sensors (in this case, for example, the pressure from a number of different sensors of this type).

Conditioner= 15

This specifies the type of conditioner that the sensor will work with. If this sensor does not require a signal conditioner, set the conditioner type to zero.

For the the 0-2.5V channel on the EL037 V/A converter, you need to set  
Conditioner=371, the 0-10V channel 372 and the 4-20mA channel 373.

Sensor=121

This is a unique reference for this scaling method. If you add your own sensors,  
please use sensor numbers in the range 1 to 99.

Units=psi

The units appear next to the parameter value on graphs, reports etc

Places=3

This is the number of decimal places. The options are 0, 1, 2 and 3. With places=1.  
The value 15 would be displayed as 15.0. With places=2, the same number would  
appear as 15.00.

Method=0

This specifies the scaling method. At the moment, 0 (table lookup) is the only  
method.

Onoff=No

This parameter is currently used only for EnviroMon.

For numeric parameters, Onoff should be No. For parameters that can have only two  
values (on or off), this should be set to Yes, and the scaling should be set so that for  
places = 1, on = 100 and off = 0. The logger will then display On or Off for the  
parameter, and reports will show the percentage of time that the parameter was On.

OutOfRange= 0

This specifies what to do if the raw value is outside the range of the table lookup. The  
options are:

- 0 - treat as a sensor fail
- 1 - clip the value to the minimum or maximum table value
- 2 - extrapolate the value using the nearest two table entries.

NoOfPoints=2

This is the number of table lookup points.

Raw1=0

Raw2= 16.7

These are the raw values for the first and second points. The raw value is normally in  
millivolts, however the CM007 (4-20mA) conditioner, it is in mA.

Scaled1=0

Scaled2=1

These are the scaled values for the first and second points (Raw1 corresponds to  
Scaled1, etc). It is in the units specified by the [Units](#) parameter.

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