SICO2 V3.0

General

The signal converter *SICO2* is a universal converter for voltage signals, digital (frequency) signals, logical signals (requires optional extension), signals from a serial port and signals from a *Controller Area Network* (CAN). The acquired signals can be assigned to any output of the *SICO2*. These are voltage signal outputs, digital signal outputs (e.g. frequency), logical signal outputs (requires optional extension), signals for a *CAN* and signals which are passed on to a host PC via a further serial port. Furthermore, up to eight signals can be displayed on the integrated LCD.
Before using the signal converter, it must first be set up. This is done by defining a parameter set with the PC program *TEMES* (Windows 95/NT4), and then by transferring this parameter set via a serial connection (COM1). *TEMES* also provides means to calibrate a voltage signal either at one known point (offset adjustment) or at two known points (two-point calibration). After everything is set up, the signal converter can do its job without necessarily being connected to the PC.

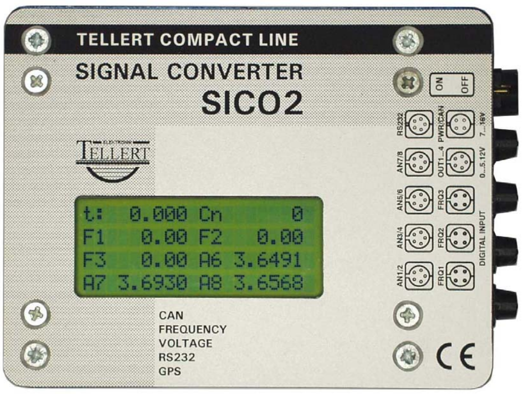

Figure 1: Signal converter SICO2.

Cycle Time / Sample Rate

The signal converter *SICO2* supports three task cycles. The duration of the first cycle (also called *sample rate*) is adjustable and lies within the range of 500 μs to 15 s (in steps of 250 μs). It is used for the voltage signal inputs, the frequency signal inputs and for frequency signal output.
The second cycle, which is used for *CAN* signals, digital signal outputs and calculated signals, runs at a default rate of 10 ms. If the operations are not too complex, the second cycle rate can be reduced down to 2 ms (CPU load should not exceed 80 %).
The third cycle runs at a fixed rate of 10 ms with lowest priority. This cycle is used for logical input and output signals and display refresh.

Voltage Signal Input

The signal converter can acquire up to eight voltage signals with a resolution of 10 bits. These signals must lie within the voltage range from 0 V to 5.12 V where 0 V correspond to bit value 0, and where 5.12 V correspond to bit value 1023. These raw signal values are always acquired with a sample rate of 250 μs, and an average value over a period of the sample rate with a resolution of 16 bits is used to represent the value of the voltage signal (5.12 V correspond to bit value 65472). The internal impedance of each voltage input is greater than 10 MΩ.
Voltage input signals can optionally be linearized via a table look-up with a refresh rate of 10 ms. For this purpose user defined characteristic curves with up to 33 sampling points are used. Look-up values for input values, which lie between two sampling points, are obtained by linear interpolation.

Digital Signal Input

The signal converter has three channels for digital signals. If used as signal input, following signal types are supported:
Frequency Signal: The input voltage level (TTL, CMOS) may lie within the range from 0 V to 20 V. The resolution of each single measurement period is 108 ns. The frequencies to be measured may lie in the range from 0.1 Hz to 30 kHz. This range can accordingly be extended with an integrated integer prescaler from 1 to 65535. Note that the sum over all three prescaled input frequencies must not be greater than 30 kHz.
The digital signal can be triggered either with the raising or with the falling edge of the input signal, and is represented by the average value over a period of the sample rate.
Each digital input connector has a pin to supply a preamplifier (over a 220 Ω protective resistor) with the operating voltage of the signal converter.
Switch State: Depending on the voltage level of the digital input, the digital signal is taken either as bit value 0 or as bit value 1. This signal type can be used for markers or to reset counter readings (see *calculated signals*).
Quadrature Signal: In this mode, the digital channel provides inputs for two voltage signals (e.g. from a *glass-scale* or an *incremental displacement transducer*) with a 90° phase difference. Depending on these two input signals (which may lie within the

range from 0 V to 5 V), the current 16-bit-position value is either incremented or decremented (see *calculated signals* to reset the current position value).

Pulse Width Measurement: The signal converter can detect the width of a pulse with a resolution of 108 ns. The largest detectable pulse width is 1.8 s with a resolution of 27.8 µs.

Logical Signals: The state of all digital input signals (from all three digital channels) are available as a combined 6-bit-value. This value can be accessed like other logical input signals (via the I²C-bus for logical signals with a reserved internal bus address, see *logical input signals* for details).

Serial Ports

The signal converter has two serial ports. The first serial port is used for the communication between signal converter and host PC. The second serial port is used for one of the following signal sources (or sinks):

NMEA-protocol: If the baud rate is set to either 4800 baud or 38400 baud, the signal converter expects *NMEA* sentences from a GPS-receiver, and extracts 5 input signals (*speed*, *longitude*, *latitude*, *height* and *time)* from the sentences *GGA*, *RMC*, and *VTG*.

F6-protocol: If the baud rate is set to 9600 baud or higher (except 38400 baud), the signal converter polls up to five 16-bit-signals from a device which supports the F6-protocol (i.e. *SICO1*, *SICO2*, *DL16*, *DL16CAN*, *FU16uP*).

LIN-subbus: The signal converter receives/transmits up to 8 messages from/to a LIN-subbus (see below).

Logical Signal Input

The signal converter has three 16-bit input signals, which can be (in groups of 8 bits) fed into the signal converter over an I²C-bus with a refresh rate of 10 ms. For each of the three 16-bit signals a bus address for the lower significant byte, and a bus address for the higher significant byte can be specified. External devices (which are connected to the signal converter) have bus addresses from 1 to 7.

To get further information about the current state of the signal converter the following bus address can be used:

Bus Address 256 (Internal 6-bit-logical-input):

bit 0	State of hardware pin *FRQ1 pin3*
bit 1	State of hardware pin *FRQ1 pin4*
bit 2	State of hardware pin *FRQ2 pin3*
bit 3	State of hardware pin *FRQ2 pin4*
bit 4	State of hardware pin *FRQ3 pin3*
bit 5	State of hardware pin *FRQ3 pin4*
bit 6	= 0 (reserved)
bit 7	= 0 (reserved)

Note that *pin4* of the corresponding digital channel is only accessible in operating mode *quadrature signal*.

Logical Signal Output

The signal converter cannot only acquire signals via the I²C-bus, it can also put out up to three 16-bit signals (in groups of 8 bits). For each of the 16-bit signals a bus address for the lower significant byte, and a bus address for the higher significant byte can be specified. Bus addresses of external devices lie within the range from 1 to 7.

Multiple Purpose Channels

Standard Multiple Purpose Channels: Beneath the hardware signal sources like voltage input, digital input and serial input, the signal converter has 54 *standard multiple purpose channels*. Each of these channels is used to represent the value of either a CAN-signal or the result of a calculation.

Virtual Multiple Purpose Channels: Beneath the standard multiple purpose channels, the signal converter has further 44 *virtual multiple purpose channels*. These channels can be used like the standard ones with the restriction that there is only limited support to transfer their values online to the PC (only by polling each signal value instead of acquiring entire samples).

The assignment of multiple purpose channels is done automatically by *TEMES*.

CAN

The signal converter can be connected to a *CAN* (Controller Area Network). It has the ability to receive or transmit up to 14 *CAN messages* (with either 11-bit or 29-bit message identifiers). The messages (to be received or to be transmitted) are refreshed during the calculation cycle.

Input signals are embedded within a received message. To extract them, following properties are supported: *start bit* within a message, *bit length* (max. 16 bits), *data type* (*unsigned* or *signed*) and *byte order* (*Intel* or *Motorola*).

Multiplex signals are only supported for message reception (and not for transmission).

The signal converter hardware (physical layer) is compatible to a *high speed CAN* (usually run at

125 kBit/s, 500 kBit/s or 1 MBit/s). An optional adapter is required to integrate the signal converter in a *low speed CAN* (usually run at 83.3 kBit/s, 100 kBit/s or 125 kBit/s).
Note, that each of the two ends of a *high speed CAN* must be terminated (typically with a 120 Ω resistor between *CAN_H*-wire and *CAN_L*-wire).

LIN

The signal converter can be connected over an optional available adapter to a *LIN-subbus* (*Local Interconnect Network*). It can be configured to work either as a *master control unit* or as a *slave control unit*. The signal converter has the ability to receive or to transmit up to 8 *LIN messages*. The messages (to be received or to be transmitted) are refreshed during the calculation cycle.
Input signals are embedded within a received message. To extract them, following properties are supported: *start bit* within a message, *bit length* (max. 16 bits), *data type* (*unsigned* or *signed*) and *byte order* (*Intel* or *Motorola*).
Multiplex signals are only supported for message reception (and not for transmission).
However, the signal converter ignores bus-sleep-requests and wake-up-signals.
As master control unit, the signal converter supports one schedule table with up to 8 *identifier-frame_time*-entries (where *frame_time* must be an integer multiple of the calculation cycle time).
The LIN baud rate must lie within the range from 2.4 to 20 Kbaud. If the signal converter is used as a master control unit, the baud rate should be 576000/*i* baud with integer *i* from 29 to 240 (to comply with the smaller baud rate deviation allowed for master control units). Hence, the recommended baud rates 2400, 9600 and 19200 baud are supported even if the signal converter is used as master control unit.
Note that the signal converter requires an optional *LIN-TX-socket* (which is only build-in on request) in order to transmit messages or to work as master control unit.

Calculated Signals

The signal converter supports operations with signal values. For this purpose the signal values are treated as unsigned 16-bit integer values with little-endian (= Intel) byte order. Following operations are already built in the firmware: definition of constants; basic arithmetic (sum, difference, product, ratio); bit manipulations (AND, OR, XOR, mirror bits, byte order change from Intel to Motorola and vice versa); comparisons (=, <, ≤); condition (use signal s_1 if condition is true, otherwise use signal s_2); delay (e.g. for derivation or signal filtering); counter operations (e.g. for 32-bit-counters or for integration).
More complex operations can be obtained by using the result of a single operation as an operand for following operations.

Voltage Signal Output

The signal converter has four 12-bit-D/A-converters to put out up to four voltage signals with a refresh rate of the used sample rate. The output voltage lies within the range from 0 V to 5.12 V. Each output has an internal impedance of 510 Ω.

Digital Signal Output

Each of the three digital channels can also be used as signal output. The frequency of the output signal lies within the range from 0.3 Hz to greater than 100 kHz. Internally, four different frequency ranges with different frequency resolutions are distinguished and automatically selected by TEMES. The voltage level of the output signal lies within the range from 0 V to 5.12 V. Each output has an internal impedance of 510 Ω.
If a digital channel is used to put out a signal, it can only be used in operating mode *switch state* for input signals at the same time.

Display

The LCD (liquid-crystal display) has four lines with 20 alphanumeric characters per line. The LCD is considered as a 4×2 matrix with 8 cells and 10 characters per cell. Each cell shows one of the following display items: static text; signal value (either as fixed point value, hexadecimal value or binary value) or status information (like CPU load or sample rate).
A user-defined text can be displayed during the start-up of the signal converter (two lines). This can be used to display the name of the parameter set or the device number.

Multiplexer Support

In order to control multiplexed input signal sources, the signal converter can broadcast the next control byte to connected multiplexers over its logic I/O port at the end of each sample cycle. This synchronization minimizes signal crosstalk between two neighboring channel time slices since the command to switch to the next channel is sent as soon as possible. The list of control bytes contains 16 items, where the 4 least significant bits of a control byte represent the channel number, and where the 4 most significant bits of a control byte can be used for the corresponding operation range.
Signal crosstalk can be further reduced or even entirely avoided by defining a duration during which the signal converter ignores the voltage input signal while the multiplexer shifts to the next channel. This

duration should include the max. duration for broadcasting the control byte (2.5 ms), possible switch times (e.g. 3.5 ms for thermocouple amplifier *TH16MI*) and transient times for the multiplexer. This yields a recommended suppression duration of 20 ms for thermocouple amplifier *TH16MI.*
Optionally, the channel number (0...15) can be copied to the four least significant bits of the input signal.

Sample Buffer

There are two supported ways to obtain the current signal values with a PC. The first method is asking for the current value of each signal by polling. The second (more sophistic) method is to define the signals of interest in advance. These signals are then permanently sampled by the signal converter with the user defined sample rate and buffered in a 1200-bytes queue (= sample buffer). The PC can then read from this queue to obtain not only the signal values but also a precise time stamp for each signal value.

Technical Data

Power supply:	6.5 V to 18 V DC
Current consumption:	about 85 mA
Sample rate:	from 500 μs to 15 s in steps of 250 μs
RS232-port:	4800 bps to 115.200 bps
CAN-Bit rate:	Up to 1 MBit/s; (1 MBit/s) / *k*, where *k* is an integer from 1 to 64
Box size without plugs, sockets, buttons and sliders:	90 × 70 × 24 mm

PC Software

The signal converter can be set up with the PC software TEMES. TEMES requires a PC with Windows 95/98/ME/NT4.0/2000/XP. The current version can be downloaded from the internet (http://www.tellert.de).

Further functions of TEMES are:

- **Online-Calibration:** The voltage input signals can be calibrated either at one known point (offset adjustment) or at two known points (two-point calibration).
- **Online-View:** The online-view displays a curve chart of the current signal values in the upper part of its window. The lower part of the window is used to display these values as numbers in physical units.
- **Exporting Measurements:** A measurement (see below for *Online-Recording*) can be exported to *ASCII*, *DIADEM*, *TurboLab* or *x-y Recorder* format. TEMES provides a documented DLL interface for accessing TEMES measurement files. This allows programmers to read TEMES measurement files without knowing the internal file structure.

Following TEMES functions require an optional available single-PC license:

- **Online-Recording:** The current signal values which are displayed in the online-view can be saved to a PC file.
- **Import of ASCII files:** Measurements can be imported from ASCII files.

Additional Properties

The signal converter has further properties, which are not already supported by the recent program version of TEMES.
User defined functions: It is possible to integrate self-written assembler routines within the sample-rate-loop or 10-ms-loop of the signal converter. User defined functions can be provisionally implemented with TEMES V1.0 by embedding the hex dump of the corresponding binary file within the device comment of a TEMES parameter set.
Assignment of regions: The signal converter has an operation, which divides the 16-bit-number-space into ranges. The result of this operation is the range number, which belongs to the input signal.
Variable text output: The signal converter has the ability to select one item of a string list (by using the signal value as list index) and to display that string.

Scope of supply

The delivery of a signal converter *SICO2* includes:

- *SICO2* box
- 4-pin-cable for power supply (12 V DC) and CAN with open wire ends
- PC-connection cable with 9-pin SUB-D-socket
- PC-software (TEMES)
(requires Windows 95/98/ME/NT4.0/2000/XP)

Optional Accessories

General accessories:

- Power transformer (Euro plug; 100-230 V AC; 50-60 Hz)
- Accu-pack (with rechargeable Ni-MH battery cells) *AC230*, *AC230/12* and *AC230/24*
- Low speed CAN adapter *LCC719* (to connect the *SICO2* to a low speed CAN)
- LIN-subbus adapter *LIN719*

Accessories for digital input:

- Hall effect sensor *HS-M10X1* (to detect passing magnets)

- Hall effect sensor *FPS* (to measure the frequency of steal teeth wheels, even at lowest frequencies; requires preamplifier *FP1*)
- Preamplifier *FP1* for hall effect sensor *FPS*
- Preamplifier *PP3* for AC-coupled signals (for magnetic sensors)

Accessories for voltage input:
- Passive voltage transformer *BNC-PI2* or *RVT2*
- Galvanically isolated preamplifier *INA1*
- Acceleration sensor *DAC50*
- NTC temperature sensor *NTC10K* (operating point 25 °C) and *NTC2K* (operating point 66 °C) for temperatures from –40 °C to 150 °C
- Thermal sensor amplifier *TH2*
- DC-bridge amplifier *DCBA2*/*DCBA8*
- Barometric height meter *HM2*
- Signal multiplexer *MPX16* (e.g. for NTC-temperature sensors or humidity sensors)
- Galvanically isolated thermal sensor amplifier *TH16MI* (16 channels, multiplexed)
- Thermal sensor amplifier *TH16M* (16 channels, multiplexed)

Accessories for logical signals:
- Switch/button *SW1* for *SICO2* digital input
- Input for eight logical signals *LI8*
- Output for eight logical signals *LO8*

Version History

Signal Converter *SICO2 V2.2*: First release of the signal converter *SICO2 Version 2* series.

Signal Converter *SICO2 V2.2 R5*: Support for pulse width measurement (digital input signal).

Signal Converter *SICO2 V2.7*: Expanded with an I²C-bus connector for logical signals (input/output).

Signal Converter *SICO2 V2.9*: Expanded with LIN-subbus-support and user definable calculation cycle time. Support for NMEA sentence *VTG*. Fields of NMEA sentences may now contain an arbitrary number of digits. Support for high-speed NMEA baud rate (38400 baud). Better synchronization of multiplexed input signals. Reduced sample buffer from 1500 bytes to 1200 bytes. Reduced number of standard multiple purpose channels from 56 to 54.

Signal Converter *SICO2 V3.0*: Better crosstalk suppression for multiplexed voltage input signals by suspending the input signal sampling during channel shifting for a user-defined duration. Multiplexed signals can now optionally be overlaid with the corresponding channel number.

Pin Assignment

The sockets and plugs of the signal converter are manufactured by *Binder* and parts of *Binder Series 719*. The socket pins (in front view) are numbered clockwise starting with the first pin after 12 o'clock position. The plug pins are numbered correspondingly anti-clockwise. The first pin is respectively labeled at the solder side (back view).

POWER/CAN: This plug supplies the signal converter with voltage and connects the signal converter to a CAN.

Pin	Assignment [Cable Color]
1	Supplying voltage (7 V to 20 V DC inverse-polarity protected) [red]
2	Ground [brown]
3	CAN_L [black]
4	CAN_H [orange]

RS1/2: This plug provides two serial ports. Note, that the signal converter is either shipped with option *GPS* (standard) or option *RS232* (on request).

Pin	Assignment	SUB-D-Plug of host PCs [Comment]
1	TX1	Pin 2
2	Ground	Pin 5
3	RX1	Pin 3
4	U_B – 1 V	Option *GPS*
	TX2	Option *RS232* [Serial data output]
5	RX2	[Serial data input, i.e. GPS]
		Pins 7 and 8 are bridged
		Pins 1, 4, 6 and 9 are bridged

AN1/2: This socket provides inputs for the *voltage input signals* 1 and 2.

Pin	Assignment
1	Supplying voltage – 1 V
2	Ground
3	Analog input 1
4	Analog input 2
5	5.12 V Reference voltage (max. 20 mA for AN1-AN8)

AN3/4: This socket provides inputs for the *voltage input signals* 3 and 4.

Pin	Assignment
1	Supplying voltage – 1 V
2	Ground
3	Analog input 3
4	Analog input 4
5	5.12 V Reference voltage (max. 20 mA for AN1-AN8)

AN5/6: This socket provides inputs for the *voltage input signals* 5 and 6.

Pin	Assignment
1	Supplying voltage – 1 V
2	Ground
3	Analog input 5
4	Analog input 6
5	5.12 V Reference voltage (max. 20 mA for AN1-AN8)

AN7/8: This socket provides inputs for the *voltage input signals* 7 and 9.

Pin	Assignment
1	Supplying voltage – 1 V
2	Ground
3	Analog input 7
4	Analog input 8
5	5.12 V Reference voltage (max. 20 mA for AN1-AN8)

FRQ1: This socket provides a connection to the first digital (frequency) signal.

Pin	Assignment
1	Supplying Voltage – 1 V (R_i = 220 Ω)
2	Ground
3	Digital input 1 (connected over 100 kΩ to 5 V)
4	Frequency output or second input for quadrature signal

FRQ2: This socket provides a connection to the second digital (frequency) signal.

Pin	Assignment
1	Supplying Voltage – 1 V (R_i = 220 Ω)
2	Ground
3	Digital input 2 (connected over 100 kΩ to 5 V)
4	Frequency output or second input for quadrature signal

FRQ3: This socket provides a connection to the third digital (frequency) signal.

Pin	Assignment
1	Supplying Voltage – 1 V (R_i = 220 Ω)
2	Ground
3	Digital input 3 (connected over 100 kΩ to 5 V)
4	Frequency output or second input for quadrature signal

AOUT: This socket provides outputs for four voltage signals.

Pin	Assignment
1	Analog output 1 (0 V to 5.12 V; R_i = 510 Ω)
2	Analog output 2 (0 V to 5.12 V; R_i = 510 Ω)
3	Analog output 3 (0 V to 5.12 V; R_i = 510 Ω)
4	Analog output 4 (0 V to 5.12 V; R_i = 510 Ω)
5	Ground

LOGIC I/O: This socket provides access to an I^2C-bus for logical input and output signals.

Pin	Assignment
1	Supplying voltage – 1 V
2	Ground
3	SDA (serial data line)
4	SCL (serial clock line)

LIN TX (optional): This optional socket is required for sending data over a *LIN*.

Pin	Assignment
3	TX2
4	Supplying voltage – 1 V

SICO2B

The display of signal converter *SICO2B* is larger than that of *SICO2*. Furthermore, it is disengageable backlit.
The pin assignment of *SICO2B* is the same as that of *SICO2*.

Figure 2: Signal converter *SICO2B*.

Box size (without plugs, sockets, buttons and sliders):
115 mm × 70 mm × 30 mm

SICO2I

The signal converter *SICO2I* has the same display as the signal converter *SICO2B*. The voltage outputs and digital channels are implemented as *bayonet nut connector* (BNC) sockets. The direction of the digital channels is set either to input or output via sliders. The voltage signal inputs are fed in via a SUB-D-socket. The connectors for POWER/CAN and RS232 are from Binder Series 711 and Binder Series 712 (Pin assignment is identical to that of SICO2).
SICO2I does not support quadrature signals (unlike SICO2 or SICO2B).

Figure 3: Signal converter SICO2I (Connectors).

Figure 4: Signal converter SICO2I.

SUB-D-socket (Type HD15) pin assignment:

Pin	Assignment
1	Analog input 1
2	Analog input 2
3	Analog input 3
4	Analog input 4
5	Analog input 5
6	Analog input 6
7	Analog input 7
8	Analog input 8
9	
10	
11	Ground
12	Supplying voltage – 1 V
13	5.12 V Reference voltage (max. 20 mA for AN1-AN8)

Box size (without plugs, sockets, buttons and sliders):
120 mm × 118 mm × 42 mm

SICO2BI

The signal converter *SICO2BI* is an extended version of *SICO2I*. Instead of the SUB-D-socket, the voltage signal input connectors are the same as the connectors of SICO2 (Binder Series 719). Optionally, preamplifiers for the analog input signals (e.g. *TH2* or *DCBA2*) can be integrated within the case of the *SICO2BI*. These preamplifiers can be bypassed with sliders (where each slider controls the bypass for two adjacent voltage input signals).
Additionally to SICO2I, the digital channels are also connectable via sockets of type Binder Series 719 (same as *SICO2*).

Box size (without plugs, sockets, buttons and sliders):
120 mm × 118 mm × 56 mm