3.10 IO Interface

Via the IO interface connector the following interfaces and functions are provided.

- Programmable GPIOs
- I²C bus
- SPI interface
- Two analog inputs (balanced)
- Power supply
- Backup supply
- VDD supply
- On/Off switch of the TC65 Terminal
- Pulse counter

The total cable length of the digital lines for I²C and SPI interfaces should not exceed 150mm.

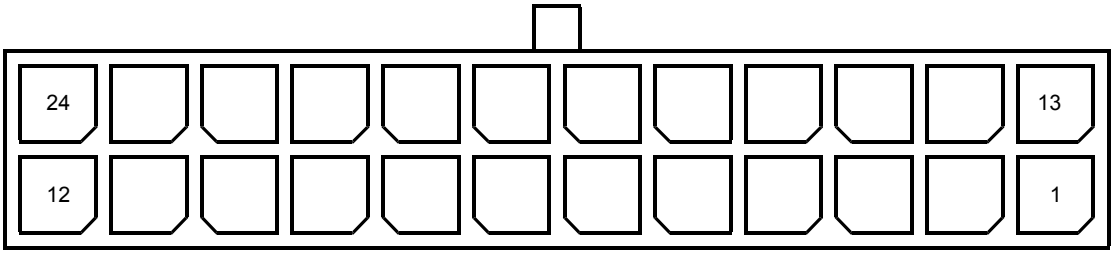


Figure 10: IO interface connector front view

Table 6: Assignment of the IO interface connector

Pin	Signal name	I/O	Description
1	I2CCLK_SPICLK	O	I2C or SPI Clock
2	I2CDAT_SPIDO	I/O	I2C Data or SPI Data out
3	GPIO3	I/O	Programmable GPIO
4	GPIO4	I/O	Programmable GPIO
5	GPIO5	I/O	Programmable GPIO
6	GPIO6	I/O	Programmable GPIO
7	GPIO1	I/O	Programmable GPIO
8	GPIO2	I/O	Programmable GPIO
9	ADC2_IN_P	I	Balanced analog 2 positive input
10	ADC2_IN_N	I	Balanced analog 2 negative input
11	BACKUP	I	Backup battery
12	GND		Ground for power supply
13	SPICS	O	SPI Select
14	SPIDI	I	SPI Data In
15	GPIO9	I/O	Programmable GPIO
16	GPIO10	I/O	Programmable GPIO/ Pulse counter
17	GPIO7	I/O	Programmable GPIO
18	GPIO8	I/O	Programmable GPIO
19	VDD	O	Signal supply voltage
20	ONOFF	I	Ignition
21	ADC1_IN_P	I	Balanced analog 1 positive input
22	ADC1_IN_N	I	Balanced analog 1 negative input
23	GND		Signal ground
24	POWER	I	Power supply

3.10.1 GPIOs

The TC65 Terminal provides 10 GPIO pins at the IO interface connector. Each GPIO line is ESD protected and a serial resistor of 100 Ohm is added.

This avoids short circuits and is especially important in the first stages of development where the Java application is not yet fully implemented.

The signal direction (input/output) of the GPIO lines is selectable with AT commands.

Figure 11 shows the position of the GPIO pins at the IO interface connector.

Alternatively GPIO pin10 can be used to configure, to start or stop a pulse counter for an input range of 0 to 1000 pulses per second. If the pulse counter is active the pin10 is not available for GPIO signals.

The GPIOs and the pulse counter can be configured via the following AT commands: AT^SPIO, AT^SCPIN, AT^SCPOL, AT^SCPORT, AT^SDPORT, AT^SGIO, AT^SSIO, AT^SCCNT, AT^SSCNT. For details please refer to [1].

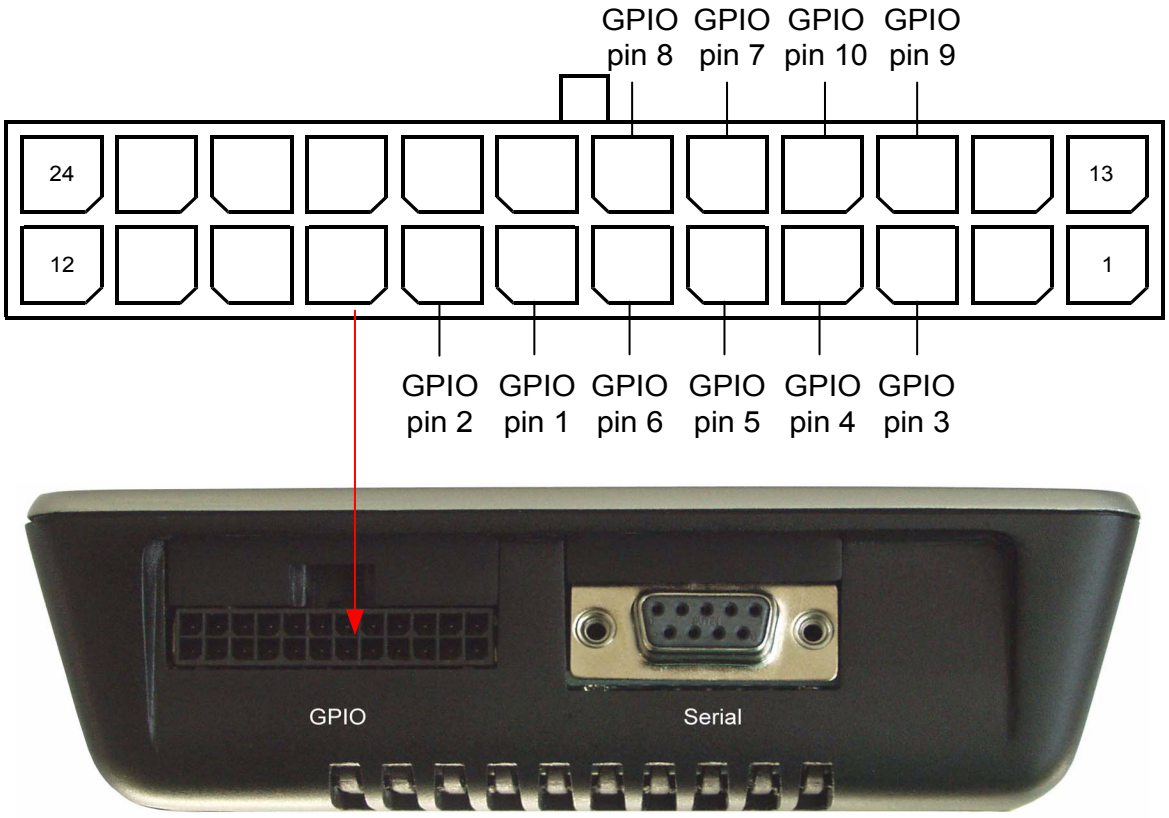


Figure 11: Location of GPIO pins

3.10.2 Using GPIO Pin10 as Pulse Counter

The GPIO10 pin can be assigned two different functions selectable by AT command:

- The AT^SCPIN command configures the pin for use as GPIO.
- With AT^SCCNT and AT^SSCNT the pin can be configured and operated as pulse counter.

Both functions exclude each other. The pulse counter disables the GPIO functionality, and vice versa, the GPIO functionality disables the pulse counter.

Detailed AT command descriptions can be found in [1].

The pulse counter is designed to measure signals from 0 to 1000 pulses per second. It can be operated either in Limit counter mode or Start-Stop mode. Depending on the selected mode the counted value is either the number of pulses or the time (in milliseconds) taken to generate a number of pulses specified with AT^SCCNT.

The Limit counter mode, the displayed measurement result (URC "^SSCNT: <count>") implies an inaccuracy <5ms. In Start-Stop mode, you can achieve 100% accuracy if you take care that no pulses are transmitted before starting the pulse counter (AT^SSCNT=0 or 1) and after closing the pulse counter (AT^SSCNT=3).

3.10.3 I²C Interface

The I²C interface is located at the IO interface connector of the TC65 Terminal.

I²C is a serial, 8-bit oriented data transfer bus for bit rates up to 400kbps in fast mode. It consists of two lines. These are the serial data line I2CDAT and the serial clock line I2CCLK.

The TC65 Terminal acts as a single master device, e.g. the clock I2CCLK is driven by the Terminal. The connection I2CDAT is a bi-directional line.

Each device which is connected to the bus is software addressable by a unique address and simple master/slave relationships exists at all times. The Terminal operates as master-transmitter or as master-receiver. The customer application transmits or receives data only on request of the Terminal. To configure and activate the I^2C interface use the AT^SSPI command described in [1].

The I^2C interface is only available if the pins 1 and 2 of the IO interface connector are not used as SPI interface.

Table 7: I²C interface – signal description

Signal name	Pin	Description
I2CDAT_SPIDO	1	Data in/out – bidirectional serial data line
I2CCLK_SPICLK	2	Serial clock line

3.10.4 SPI Interface

The SPI interface is located on the IO interface connector of the TC65 Terminal.

The SPI (Serial Peripheral Interface) is a synchronous serial interface for controlling and data transfer between the TC65 Terminal and a connected application. Only one application can be connected to the Terminal's SPI.

The SPI consists of four lines. These are the two data lines SPIDI/SPIDO, the clock line SPICLK and the chip select line SPICS.

The TC65 Terminal acts as a single master device, e.g. the clock SPICLK is driven by the TC65 Terminal. Whenever the SPICS pin is in a low state, the SPI bus is activated and data can be transferred from the Terminal and vice versa. The SPI interface uses two independent lines for data input (SPIDI) and data output (SPIDO). The interface supports transmission rates up to 6.5Mbit/s. Transfer rates >1.083Mbps and a length of the cable >150mm are not recommended.

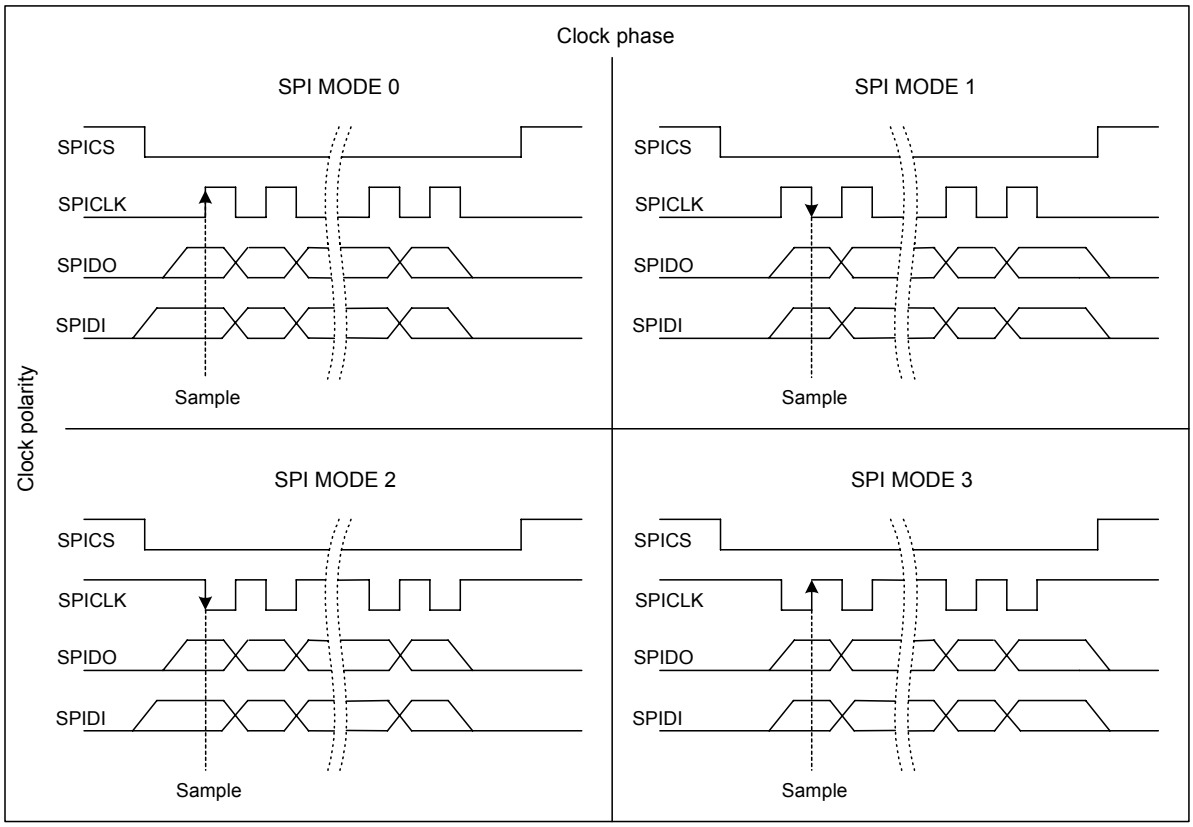
The SPI interface is only available if the pins 1 and 2 of the IO interface connector are not used as I^2C interface.

Table 8: SPI interface – signal description

Signal name	Pin	Description
SPICS	13	Chip select – selects and activates the external device via a low signal.
SPIDI	14	Data in – serial data input line (from the external device to the TC65 Terminal)
I2CDAT_SPIDO	1	Data out – serial data output line (from the TC65 Terminal to the external device)
I2CCLK_SPICLK	2	Serial clock line

The SPI Interface can be used in 4 different modes.

Table 9 : SPI Timing diagram



3.10.5 Analog-to Digital Converter (ADC)

The two balanced analog inputs are used for measuring external DC voltages in a range of 0V to 5.0V.

Note: Only positive differential voltage can be handled because of the input requirement of ADC.

Table 10: ADC signal description

Signal name	Pin	Description
ADC1_IN_N	22	Negative voltage
ADC1_IN_P	21	Positive voltage (must be more positive than ADC2_IN_N)
ADC2_IN_N	10	Negative voltage
ADC2_IN_P	9	Positive voltage (must be more positive than ADC2_IN_N)

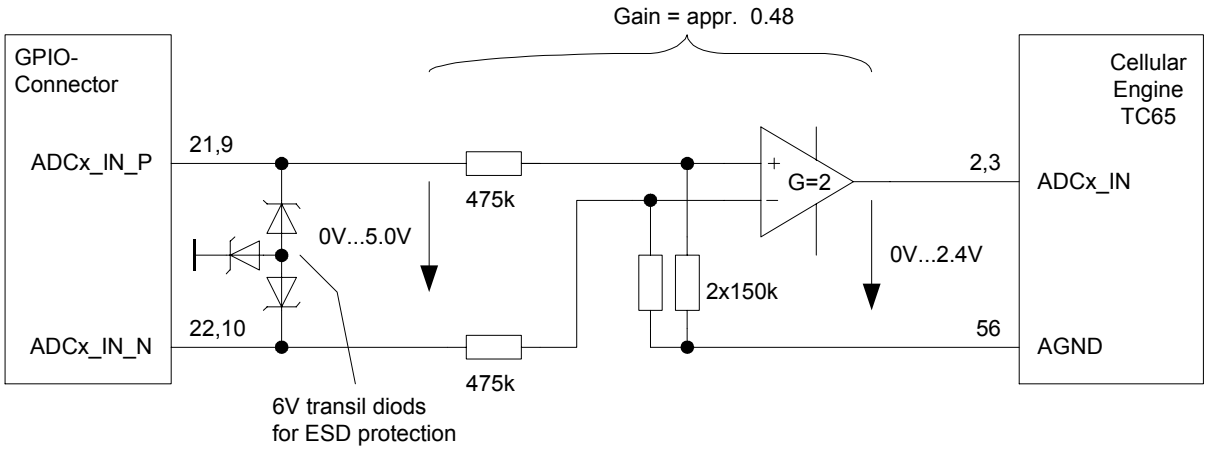


Figure 12: ADC balanced amplifier

Use the command AT^SRADC described in [1] to configure the analog inputs and to get the measurement results.

Note:

It is necessary to recalculate measurement results because an amplifier is used to scale down the ADCx_IN input voltage of the TC65 Terminal (5V) to the ADCx_IN input voltage of the in-built TC65 module (2.4V).

Two parameters (determined and stored by factory) have to be used for offset compensation and for consideration of gain and tolerances:

Use the command AT^SAADC described in [1] to read out the required parameters:

<ofsx>: Offset

<ampx> :Amplification factor (Gain*4096) x=1 for Input 1 or 2 for input 2

To recalculate the exact voltages [mV] measured at the ADCx_IN input use the following equation:

Value[mV] = (<value> from AT^SRADC - <ofsx>) * <ampx> / 4096

3.10.6 RTC Backup Supply

The Real Time Clock (RTC) is supplied from a separate voltage inside the TC65T Terminal which is also active when the GSM module is in POWER-DOWN mode. An alarm function is provided for activating/deactivating GSM module (activating only to alarm mode).

You can use the BACKUP pin on the 24pole I/O connector to backup the RTC from an external battery (rechargeable or non-chargeable).

Table 11: RTC signal description

Signal name	Pin	Description
BACKUP	11	External battery
GND	12	Ground

If no backup battery is connected then a 100uF capacitor supplies the RTC about 6s during power interruptions.

3.10.7 Power Supply

The two pins of the power supply at the IO interface connector are directly connected to two pins of the Western Jack for power supply. This allows supplying the TC65 Terminal by using the Power connector or via the IO interface connector.

3.10.8 VDD Supply

The VDD pin at the IO interface connector may be used for supplying external circuit devices or applications and indicates the following states of the TC65 Terminal:

- VDD output voltage = 2.9V @ max. 50mA indicates Normal Operation mode or Airplane mode
- VDD output voltage = 0V indicates Power Down mode

3.10.9 ON/OFF Switch

If the ONOFF pin at the IO interface connector is active low. It can be used to switch on or switch off the TC65 Terminal.

For more information to switch on or off the Terminal please refer to chapter 3.5.1 and 3.5.3.

5.7 Characteristics of the GPIOs

Table 27: Characteristics of the GPIOs

Function	Signal name	IO	Signal form and level	Comment
General Purpose Input/Output	GPIO1	I/O	$R_O \approx 100\Omega$ V_{OL}max = 0.4V at I = 2mA V_{OH}min = 2.50V at I = -0.5mA V_{OH}max = 3.05V V_{IL}max = 0.8V V_{IH}min = 2.0V V_{IH}max = 3.05V	If unused keep pins with a pull up or pull down resistor while the GPIO is set to input.
	GPIO2	I/O		
	GPIO3	I/O		
	GPIO4	I/O		
	GPIO5	I/O		
	GPIO6	I/O		
	GPIO7	I/O		
	GPIO8	I/O		
	GPIO9	I/O		Alternatively GPIO10 can be used as pulse counter.
	GPIO10	I/O		

5.8 Characteristics of the Pulse Counter

Table 28: Characteristics of the pulse counter

Function	Signal name	IO	Signal form and level	Comment
Pulse Counter	GPIO10	I	V_{IL}max = 0.8V V_{IH}min = 2.0V V_{IH}max = 3.05V pulse ~|_____|~~~~~|_____|~~~ | ≥ 450µs | ≥ 450µs | slew rate ≤ 1µs	Counter range = 0 … 1000 pulses per second

5.9 Characteristics of the I²C interface

Table 29: Characteristics of the I²C interface

Function	Signal name	IO	Signal form and level	Comment
I²C interface	I2CCLK_SPICLK	O	$R_O \approx 33\Omega$ V_{OL}max = 0.25V at I = 2mA V_{OH}min = 2.50V at I = -0.5mA V_{OH}max = 3.05V	I2CDAT is configured as Open Drain and needs a pull-up resistor in the host application. According to the I²C Bus Specification Version 2.1 for the fast mode a rise time of max. 300ns is permitted. There is also a maximum V_{OL}=0.4V at 3mA specified. The value of the pull-up depends on the capacitive load of the whole system (I2C Slave + lines). The maximum sink current of I2CDAT and I2CCLK is 4mA. If lines are unused keep pins open.
	I2CDAT_SPIDO	I/O	$R_O \approx 33\Omega$ V_{OL}max = 0.25V at I = 2mA V_{IL}max = 0.8V V_{IH}min = 2.0V V_{IH}max = 3.05V	

5.10 Characteristics of the SPI interface

Table 30: Characteristics of the SPI interface

Function	Signal name	IO	Signal form and level	Comment
SPI Serial Peripheral Interface	I2CCLK_SPICLK	O	$R_O \approx 33\Omega$ V_{OL}max = 0.25V at I = 2mA V_{OH}min = 2.50V at I = -0.5mA V_{OH}max = 3.05V Fmax = 6.5MHz (possible) 1.083 MHz (recommended)	If the Serial Peripheral Interface is active the I²C interface is not available.
	I2CDAT_SPIDO	O		
	SPICS	O		
	SPIDI	I	V_{IL}max = 0.8V V_{IH}min = 2.0V V_{IH}max = 3.05V	If lines are unused keep pins open.

5.11 Characteristics of the ADC Interface

Table 31: Characteristics of the ADC interface

Function	Signal name	IO	Signal form and level	Comment
Analog/ Digital Converter balanced input	ADC1_IN_P ADC1_IN_N		Single ended or differentioal input voltage ADCx_IN_N = GND or negative voltage ADCx_IN_P = positive voltage V_I min = 0V V_I max = 5V Ri single ended ≈ 600kOhm Ri balanced ≈ 1200kOhm Cut-off-frequency, fg = 70Hz Common-mode rejection ratio, CMRR > 50dB Inaccuracy ±1mV Linear error ±1mV Temperature error ±1mV Burst error ±1mV	ADC1_IN and ADC2_IN are balanced lines and multiplexed with an analog switch. Both inputs are filtered by a low pass
	ADC2_IN_P ADC2_IN_N			

5.12 Characteristics of the RTC Supply

Table 32: Characteristics of the RTC supply

Function	Signal name	IO	Signal form and level	Comment
RTC backup	BACKUP	I/O	R_I ≈ 2kΩ V_{IN}max = 4.7V Module power down V_{IN}min=2.4V at Imax = 10µA Module active V_{IN} =<3.6V I_{IN} = 0µA V_{IN} =>3.7V I_{IN} = 10µA	If unused, keep pin open.