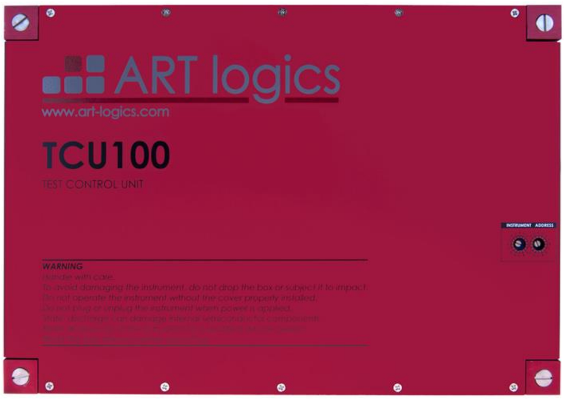
TCU100 Standalone Product

USER MANUAL

www.art-logics.com

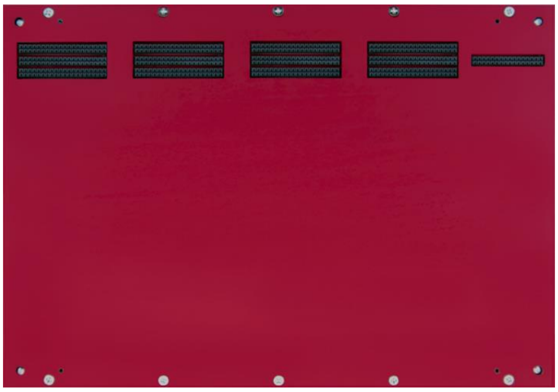
1 TCU100 Test Control Unit Description



The TCU100 is an acquisition station specifically designed to provide a wide range or resources.

It offers relays and multiplexers, voltmeters, ammeters, digital I/Os, signal sources, CAN FD/LIN/K-LINE communication interfaces and handle test sequencing and results logging to an external computer.

The TCU100 has two modes of operation, a connection to a computer monitoring the resources and logging the results and the failures, and a standalone mode where the TCU100 is working without a connection to a controller and logging the results in the built in SD Card.



The connections to all resources of the TCU100 are located at the top of the back panel.

2 Installation

2.1 General Safety Considerations

2.1.1 TO AVOID FIRE OR PERSONAL INJURY

➔ CONNECT AND DISCONNECT PROPERLY.
Do not connect or disconnect wiring harnesses while they are connected to a voltage source.

➔ OBSERVE ALL TERMINAL RATINGS.
To avoid fire or shock hazard, observe all ratings and marking on the product. Consult the product manual for further ratings information before making connections to the product. The common terminal is at ground potential. Do not connect the common terminal to elevated voltages. Do not apply a potential to any terminal (including the common terminal) that exceeds the maximum rating of that terminal.

➔ DO NOT OPERATE WITHOUT COVERS.
Never remove the cover or part of the housing while you are operating the product. This will expose circuits and components and can lead to injuries, fire or damage to the product.

➔ AVOID EXPOSED CIRCUITRY.
Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made by qualified service personnel. Do not replace components with power cable connected. Under certain conditions, dangerous voltages may exist even with the power cable removed. To avoid injuries, always disconnect power, discharge circuits and remove external voltage sources before touching components.

➔ DO NOT OPERATE WITH SUSPECTED FAILURES.
If you suspect there is damage to this product, have it inspected by qualified service personnel.

➔ DO NOT OPERATE IN WET/DAMP CONDITIONS.

➔ DO NOT OPERATE IN A DUSTY OR DIRTY CONDITION.

➔ DO NOT OPERATE IN AN EXPLOSIVE ATMOSPHERE.

➔ KEEP PRODUCT SURFACES CLEAN AND DRY.

➔ PROVIDE PROPER VENTILATION.
Refer to the manual's installation instructions for details on installing the product so it has proper ventilation. Refer to the manual's instructions regarding air filter cleaning and maintenance.

➔ DO NOT SERVICE OR ADJUST ALONE
Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation, is present.

➔ DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT
Because of the danger of introducing additional hazards, do not install substitute parts or perform any unauthorized modifications to the instrument. Return the instrument to ART logics for service and repair to ensure that safety features are maintained.

2.1.2 ABOUT TAGS IN THIS MANUAL

Observing the safety instructions will help prevent personal injury or damage of any kind caused by dangerous situations. Therefore, carefully read through and adhere to the following safety instructions before putting the product into operation. It is also absolutely essential to observe the additional safety instructions on personal safety that appear in other parts of the documentation.

Some tags may appear in this manual:

WARNING
This tag indicates a safety hazard with a medium potential of risk for the user that can result in serious injuries.

ATTENTION
This tag indicates the possibility of incorrect use that can cause damage to the product

Please read the details of the tags, they concern some aspects of the equipment requiring particular attention, or information linked to your safety.

Furthermore, it is your responsibility to use the product in an appropriate manner. This product is designed for use solely in industrial and laboratory environments or in the field and must not be used in any way that may cause personal injury or property damage. You are responsible if the product is used for an intention other than its designated purpose or in disregard of the manufacturer's instructions. ART logics shall assume no responsibility for such use of the product. Using the products requires technical skills and knowledge of English. It is therefore essential that the product be used exclusively by skilled and specialized staff or thoroughly trained personnel with the required skills.

2.2 Inspection.

When you receive your TCU100, inspect it for any obvious damage that may have occurred during shipment. If there is damage, notify the shipping carrier and ART logics immediately.

Inspect the outside for damage, wear, and missing parts. Units that appear to have been dropped or otherwise abused should be checked thoroughly to verify correct operation and performance. It is mandatory to immediately repair defects that could cause personal injury or lead to further damage to the TCU100.

Keep original packaging and wood box for possible future shipment, such as calibration or maintenance.

ATTENTION
The TCU100 is a fragile unit. Use extreme care when handling the unit. Avoid shocks. Do not drop the unit on a hard surface. Protect from ESD. Do not touch the connections if exposed.

2.3 Cleaning

To clean the unit exterior, do the following steps:

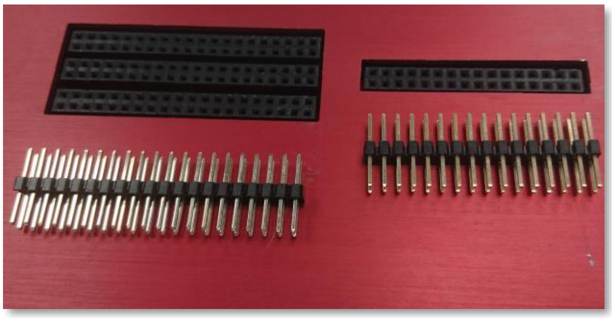
- Remove loose dust on the outside of the housing with a lint free cloth.
- Remove remaining dirt with a lint free cloth dampened in a general-purpose detergent-and-water solution. Do not use abrasive cleaners.

2.4 Instrument Identification

The TCU100 is identified by a unique serial number, such as 10Y1015, visible on a label on the side of the unit. This serial number is also available through the control interface.

2.1 Mounting a TCU100 on a Load Box

2.1.1 PREPARING THE TCU100 CONNECTORS PINS



Prepare double sided male-male DIN connector with 6mm pin.

40 pins: 12 pieces

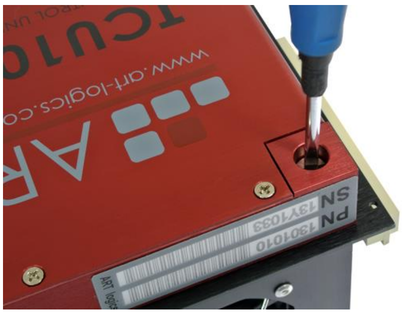
32 pins: 1 piece

2.1.2 CONNECTING THE TCU100 ON A LOAD BOX

Place the TCU100 on the Product Controller.

Align carefully the interconnection pins with the matching connectors.

Check visually that no pin is bended or misplaced.

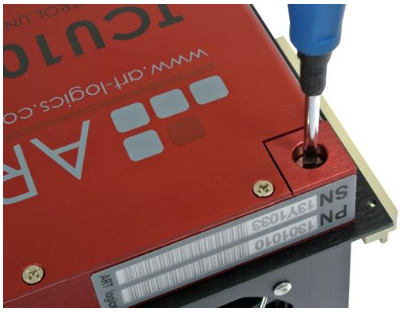


Using a flat blade screwdriver, tighten lightly the 4 screws to lock the TCU100 on the Product Controller. Do not apply excessive torque.

Tighten successively the top-left screw, then bottom-right, top-right, bottom-left, etc, until the TCU is secured on the Product Controller.

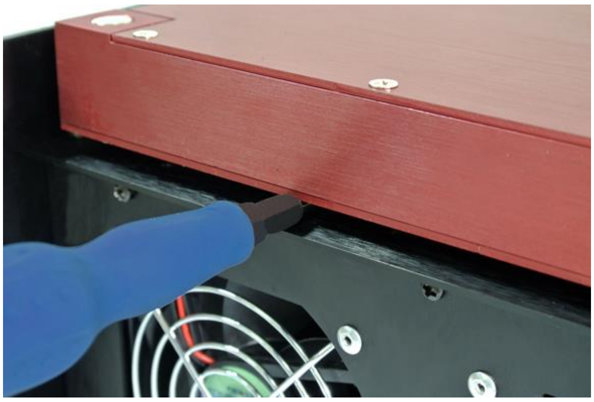
Check that no gap exist between the TCU100 and the panel of the Product Controller.

2.1.3 REMOVING THE TCU100 FROM THE LOAD BOX.



Using a flat blade screwdriver, unscrew the 4 screws to unlock the TCU100 from the Product Controller.

Turn screws fully counter-clockwise until they are released in the upper position.



3 Specifications

3.1.1 MECHANICAL

• Frame Height:	223 mm
• Frame Width:	323 mm
• Frame Depth:	27 mm
• Weight Net:	2 kg
• Cooling:	Convection

3.1.2 DC INPUT RATINGS

• Maximum Power:	80 Watts
• Voltage Range:	24 Volts DC +/- 5%
• Maximum voltage between REF VBAT and REF GROUND:	35 Volts DC
• Maximum voltage between REF GROUND and Frame:	+/- 40 Volts DC

3.1.3 ENVIRONMENT

• Operating temperature range	10°C to 35°C
• Recommended Calibration Interval	1 Year

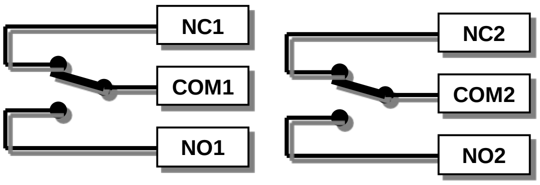
4 Resources Description

The TCU100 provides specific features to setup the appropriate working environment for the DUT, to apply a sequence of signals to the DUT inputs and to make measurements.

Provided resources are:

- Relays DPDT, 15 channels.
- Relays SPDT, 15 channels.
- Voltmeters, 15 channels.
- Ammeters, 5 channels.
- Digital Inputs, 10 channels.
- Digital Outputs, 10 channels.
- Frequency Inputs, 4 channels.
- Frequency Outputs, 8 channels.
- Voltage Output, 8 channels.
- Arbitrary Voltage Generators, 8 channels.
- CAN FD, 2 channels.
- LIN, 4 channels.
- K-Line, 1 channel.

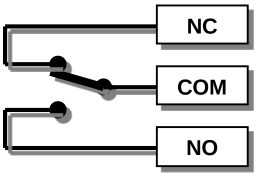
4.1.1 RELAYS DPDT, 15 CHANNELS



Contact form: DPDT
Rated load: 0.5 A at 125 VAC, 2 A at 30 VDC
Rated carry current: 2 A
Maximum switching voltage: 220 VDC, 250 VAC
Maximum switching current: 2 A
Minimum switching current: 100 µA at 10 mVDC
Contact resistance: 75 mΩ maximum

The TCU100 monitor the number of cycles for all relays in order to predict maintenance periods.

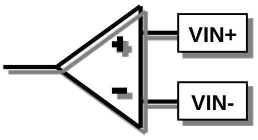
4.1.2 RELAYS SPDT, 15 CHANNELS



Contact form: SPDT
Rated load: 1.2 A at 100 VAC, 2 A at 30 VDC
Rated carry current: 4 A
Maximum switching voltage: 220 VDC, 250 VAC
Maximum switching current: 2 A
Minimum switching current: 100 µA at 10 mVDC
Contact resistance: 50 mΩ maximum

The TCU100 monitor the number of cycles for all relays in order to predict maintenance periods.

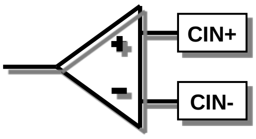
4.1.3 VOLTMETERS, 15 CHANNELS



Input impedance: 100 kΩ
Maximum common voltage range: -70 V to +70 V
Maximum differential voltage: -70 V to +70 V
Accuracy: +/- 0.05%
Resolution: 16bits, 1LSB = 60 µV

Accuracy of voltage measurement channels is guaranteed by a software calibration.

4.1.4 AMMETERS, 5 CHANNELS

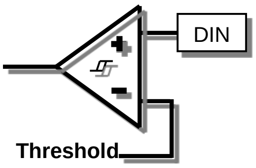


Input impedance: 400 kΩ
Maximum common mode voltage range: -2 V to +60 V
Maximum differential mode voltage range: -40 mV to 40 mV
Accuracy: +/- 0.5%
Resolution: 16 bits, 1LSB = 2 µV

Current measurement channels rely on an external current sense resistor. The value of this resistor defines the measurement range. The full scale is 40 mV.

For example, a 1mOhm resistor is used for a -40 A to +40 A measurement range, with a resolution of 2 mA. Accuracy of current measurement channels is guaranteed by a software calibration.

4.1.5 DIGITAL INPUTS, 10 CHANNELS

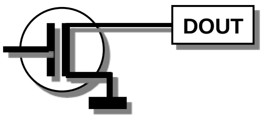


Input impedance: 100 kΩ
Input voltage range: -60 V to +60 V
Adjustable threshold: -10 V to +20 V, resolution 3 mV.
Hysteresis: 17 mV typical.

The threshold voltage is adjusted by software.

All Digital Inputs share the same ground return, connected to the Reference Ground of the TCU100.

4.1.6 DIGITAL OUTPUTS, 10 CHANNELS

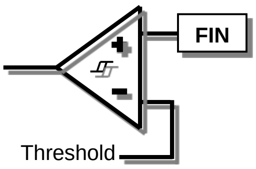


On resistance: 60 mΩ
Off leakage current: 75 µA
Maximum voltage: 35 VDC
Maximum current: 2.0 A

Open drain drivers on Digital Outputs are protected for short circuit to positive battery voltage and over-temperature.

All Digital Outputs share the same ground return, connected to the Reference Ground of the TCU100.

4.1.7 FREQUENCY INPUTS, 4 CHANNELS

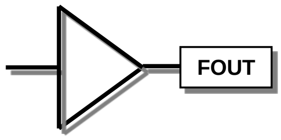


Frequency range: 0.1 Hz to 100 kHz
Duty cycle range: 0.5 % to 99.5 %
Input impedance: 100 kΩ
Input voltage range: -60 V to +60 V
Adjustable threshold: -10 V to +20 V, resolution 2 mV
Hysteresis: 17 mV

The threshold voltage is adjusted by software.

All Frequency Inputs share the same ground return, connected to the Reference Ground of the TCU100.

4.1.8 FREQUENCY OUTPUTS, 8 CHANNELS

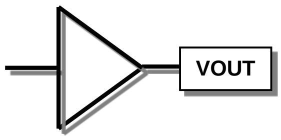


Frequency range: 0.9 Hz to 100 kHz, square wave.
Duty cycle range: 0.5 % to 99.5 %
Slew rate: x V/µs
Output maximum current: 20 mA
Output voltage range: -20V to 20V
Frequency resolution: 0.1 Hz
Duty cycle resolution: 0.5 %
Amplitude resolution: 16 bits, 1 LSB = 60 µV
Offset resolution: 16 bits, 1 LSB = 60 µV

The frequency, duty cycle, amplitude and offset are adjusted by software.

All Frequency outputs share the same ground return, connected to the Reference Ground of the TCU100.

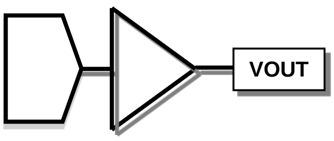
4.1.9 DC VOLTAGE OUTPUTS, 8 CHANNELS



Output maximum current: 20mA
Output voltage range: -20V to 20V
Resolution: 16 bits, 1 LSB = 60 µV

All Voltage outputs share the same ground return, connected to the Reference Ground of the TCU100.

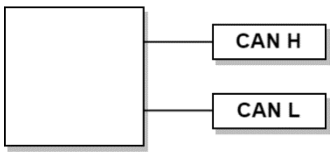
4.1.10 ARBITRARY WAVEFORM GENERATOR OUTPUTS, 8 CHANNELS



Output maximum current: 20mA
Output voltage range: -20V to 20V
Slew rate: X V/µs
Resolution: 16 bits, 1 LSB = 60 µV
Standard waveforms: Sine, Triangle, Square, Arbitrary Waveform and Random Noise.
Standard waveforms frequency range: 0.2Hz to 100kHz
Arbitrary waveform memory: 3072 samples / 16bits.
Arbitrary waveform sampling rate: 1us to 16ms.

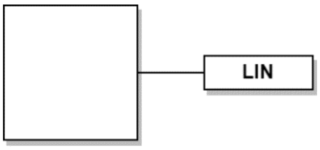
All Arbitrary Waveform Generators outputs share the same ground return, connected to the Reference Ground of the TCU100.

4.1.11 CAN FD, 2 CHANNELS



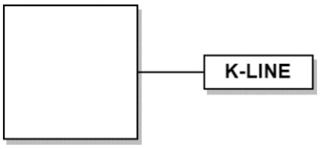
Compliant with ISO 11898-2 Data and Physical Layer
ISO15765-2 Transport Protocol layer.
Configurable nominal bitrate up to 1 Mbit/s.
Configurable data bitrate up to 8 Mbit/s.

4.1.12 LIN, 4 CHANNELS



Compliant with Local Interconnect Network (LIN) Bus Specifications 1.3, 2.0, 2.1 and compliant to SAE J2602.
Internal pull-up resistor and diode.
Configurable data bitrate up to 19200 kbit/s.

4.1.13 K-LINE, 1 CHANNEL



Compliant with the ISO 9141 with a configurable bitrate.
Internal pull-up resistor and diode.
Configurable data bitrate up to 921600 kbit/s.

5 Communication Interface

A control host can communicate with the TCU100 via the **USB-C** 2.0 connection, RS232, RS422 or over an IP network via **TCP** with the 10/100 Mbps Ethernet link.

5.1 RS232/RS422 Communication

The TCU100 has one RS-232/RS422 port that can be used for the communication with the device. The default parameters of the UART are the following:

- **Baud rate**: 921600
- **Data bits**: 8
- **Stop bit**: 1
- **Parity**: None

5.2 USB-C Communication

The TCU100 has one USB Port 2.0 type C that can be used for the communication with the device. It is detected as an USB COM Port and can be used with any serial terminal.

Install the provided device driver before you connect the TCU100.

5.3 Ethernet TCP Communication

If the Ethernet interface is used for the communication, the default parameters are the following:

- **Protocol**: TCP
- **IP address**: 192.168.0.11
- **Gateway address**: 192.168.0.1
- **IP mask**: 255.255.255.0
- **Port number**: 6025

These parameters are not fixed, and can be changed using commands.

1 Control Language

This section briefly describes the language used to remotely control the TCU100.

1.1 TCU100 Command Syntax

The TCU100 is controlled by sending an ASCII chain following the syntax described below.

@	N N	_	command	;
1	2	3	4	5

The first element must always be the character '@'.

The second element "NN" is the address in hexadecimal of the TCU100.

The third element must always be the character '_'.

The fourth element is the command and optional parameters.

The last element is the terminator character ';'.

1.2 TCU100 Commands List

Name	Syntax
CLOSE	@n_CLOSE=<RelayName 1>[,…,<RelayName n>]; @n_CLOSE=<RelayChannelMask>; @n_CLOSE;
OPEN	@n_OPEN=<RelayName 1>[,…, <RelayName n>]; @n_OPEN=<RelayChannelMask>; @n_OPEN;
SETRLY	@n_SETRLY=<RelayChannelMask>;
SETDIG	@n_SETDIG=<Channel 1>[,<Channel2>,..,<Channel n>]; @n_SETDIG=<ChannelMask>; @n_SETDIG;
CLRDIG	@n_CLRDIG=<Channel 1>[,<Channel2>,..,<Channel n>]; @n_CLRDIG=<Mask>;
GETDIG	@n_GETDIG=<Channel 1>[,<Channel2>,..,<Channel n>]; @n_GETDIG=<Mask>; @n_GETDIG;
SETVOLT	@n_SETVOLT=<Channel>,<value>;
GETVOLT	@n_GETVOLT=<Channel>;
SETCURR	@n_SETCURR=<Channel>,<ResisterValue>;
GETCUR	@n_GETCUR=<Channel>;
SETFRQ	@n_SETFRQ=<Channel>,<Frequency>,<DutyCycle>,<ON Volage>,<OFF Voltage>;
GETFRQ	@n_GETFRQ=<Channel>,<FrequencyRange>;
MSGTX	@n_MSGTX=<Port>,<MsgContent>;
MSGRX	@n_MSGRX=<Port>[,<MessageName>,<ByteNumber>,<BufferName>,NOFEEDBACK]; @n_MSGRX=<Port>[,<MessageName>,<ByteNumber>,NEWESTMSG]; @n_MSGRX=<Port>,CLEARMSG[,<ClearMode>];
CONFIG	@n_CONFIG=<Port>,<ParameterList>;
TSTRT	@n_TSTRT;
TSTOP	@n_TSTOP
SETAWG	@n_SETAWG=<Channel>,<Mode>,<WaveformData>; @n_SETAWG=<Channel>,AW<ChIdx><WaveIdx>,<WaveformIndex>,<WaveformData>; @n_SETAWG=<Channel>,SIGNAL<ChIdx>,<SignalIdx>,<SignalCmd>,<SignalData>; @n_SETAWG=<Channel>,STOP;
TEMP	@n_TEMP;
PROCESS	@n_PROCESS=<ID>,DEFINE [,<Granularity>,<TotalStep>]; @n_PROCESS=<ID>,<END|START|STOP|DELETE|RESULT|RESX>; @n_PROCESS=QUERY; @n_PROCESS=<ID>,<StepNum>,<Command>,<Parameter>;
THRESH	@n_THRESH=DI|FI|FO,<Channel>,<Value>;
CAPTURE	@n_CAPTURE=V|C,MAX|MIN,<Channel>; @n_CAPTURE=V|C,HIGH|LOW,<Channel>,<Threshold1>; @n_CAPTURE=V|C,HIGHLOW,<Channel>,<Threshold1>,<Threshold2>; @n_CAPTURE=V|C,STOP,<Channel>;
HELLO	@n_HELLO;
SYSID	@n_SYSID;
PSUV	@n_PSUV=<Voltage>;
PSUC	@n_PSUC=<Current Limit>;
PSU	@n_PSU=ON|OFF;
PSDV	@n_PSDV;
PSDC	@n_PSDC;
ETH	@n_ETH;
RTC	@n_RTC=GET|SET[,<Time>,<Date>];
STORAGE	@n_STORAGE=STATUS|SIZE|DLDELETE|DLSTART|DLSTOP;
UNIT	@n_UNIT=ON|OFF;

2 Operating the TCU100

2.1 Connecting POWER and GROUND references

To ensure quality of the measurements, each TCU100 is provided with several insulation devices.

The measurement core of the TCU100 is insulated from the common TCU's 24V power supply on the back panel using internal DC/DC converter.

The communication interface is insulated from the common TCU's communication line on the back panel using a fast electromagnetic coupler.

There is no electrical connection between two different TCU's Core Measurement Systems.

Voltage and current measurements channels on the TCU are fully differential to achieve the best accuracy.

This strategy insures that no ground loop or ground shift can appear in the power distribution system.

Each TCU Core Measurement System must be connected to the DUT with Reference Ground and Reference VBAT voltage.

These connections act as sense lines, and provide clean ground by avoiding high current returns to flow in the measurement wires. The best place to connect them is on the DUT connector, as close as possible to the supplies pins.

WARNING
It is mandatory that a TCU be connected to ONLY one DUT. A SINGLE TCU cannot control TWO different DUT. Two TCU can be connected to one DUT to increase the measurement capacity of the system.

2.2 Setting TCU100 address

To identify Product Controllers, an address must be dedicated to each one.

This address can be changed using two coding switches located on the TCU100. When the TCU100 is connected to a Product Controller, the address is displayed on the front panel. The address range of the TCU100 is 00 to FF (hexadecimal value). Any adjustment made on the address switches will be effective after a power-on cycle. Changing address switches position when in operation has no effect.

2.3 Allocating the resources

To fulfil requirements from the DUT inputs, different possibilities exist to allocate TCU100 resources. A good understanding of both the DUT and the TCU100 characteristics is necessary to make the appropriate choice. The following guidelines can help setting up the configuration of the inputs of the DUT.

2.3.1 ON/OFF SWITCH

An On/Off Switch can be simulated using a relay channel.

A relay channel provides independent Normally Open and Normally Closed contacts. It can be used as a high side or low side switch. External serial or parallel resistor can be added to simulate contact resistance and current leakage.

A low side switch can also be simulated by an open drain digital output.

As the ground return path for Digital Output is shared by several channels, ground offset or crosstalk must be considered.

2.3.2 RESISTANCE CODED SWITCH

A resistance-coded switch can be simulated by a Voltage Output channel.

The wide voltage range and current capability of Voltage Output channel offer an easy way to recreate the voltage level that takes place when a variable resistor is used on such input. A calculation based on input pull-up resistor and variable resistor values must be made to define appropriate voltage values to apply. As the ground return path for Voltage Output is shared by several channels, ground offset or crosstalk must be considered.

A resistance-coded switch can be simulated by several SPDT relay channels connected to resistances.

This solution may consume more relays resources, but the simulation will be closer to the actual resistance coded switch on the car.

2.3.3 TEMPERATURE SENSOR CTN/CTP

A CTN/CTP temperature sensor can be simulated by a Voltage Output channel.

The wide voltage range and current capability of Voltage Output channel offer an easy way to recreate the voltage level that takes place when a variable resistor is used on such input. A calculation based on input pull-up resistor value and variable resistor physical variation must be made to define appropriate voltage values to apply. As the ground return path for Voltage Output is shared by several channels, ground offset or crosstalk must be considered.

A CTN/CTP temperature sensor can be simulated by a SPDT relay switching two resistances.

If the simulation of the CTN/CTP sensor can be reduced to two min/max values, it's easy to use a the Normally Close/Normally Open contact of a SPDT relay to select between two resistances, one for the minimum value, one for the maximum value of the sensor.

2.3.4 SPEED SENSOR

A speed sensor can be simulated by a Frequency Output channel if a square wave is acceptable, or by an Arbitrary Waveform Generator in any other case.

As the ground return path for Frequency Output or AWG output is shared by several channels, ground offset or crosstalk must be considered.

An external insulation transformer may be added in the load box if the speed sensor is of a coil pickup type. The transformer will be adapted to the frequency range, the output impedance can be adjusted to fulfil the DUT requirements in case a sensor diagnosis if provided for this sensor.

A voltage to current converter can be inserted in between the Frequency Output or the Arbitrary Waveform Generator output if the speed sensor is of a current output type.

2.3.5 CAM/CRANK SENSOR

A cam or a crank sensor can be simulated by an Arbitrary Waveform Generator.

According to the flying wheel definition, the waveform can be drawn using the Waveform Editor, or acquired by a digital scope or a digitizer from an actual sensor.

As the ground return path for AWG output is shared by several channels, ground offset or crosstalk must be considered.

An external insulation transformer may be added in the load box if the speed sensor is of a coil pickup type. The transformer will be adapted to the frequency range, the output impedance can be adjusted to fulfil the DUT requirements in case a sensor diagnosis if provided for this sensor.

A voltage to current converter can be inserted in between the Frequency Output or the Arbitrary Waveform Generator output if the speed sensor is of a current output type.

2.3.6 CRASH SENSOR

A crash sensor can be simulated by a Frequency Output channel. The duty cycle of this output can be changed dynamically, in order to trigger the crash detection.

As the ground return path for Frequency output is shared by several channels, ground offset or crosstalk must be considered.

2.3.7 COMMUNICATION CHANNEL

Two CAN FD, one LIN, one LIN/KLINE are available from the TCU100 for direct connection to the DUT communication ports. The TCU100 supports different baudrates, protocols and message definitions that can be changed at the Test Plan level.

A simple serial communication device can be simulated using an AWG channel sending a constant message. The message can be drawn using the Waveform Editor, or acquired by a digital scope or a digitizer from an actual device. The baudrate can be adjusted by changing the sample rate value. As the ground return path for AWG output is shared by several channels, ground offset or crosstalk must be considered.

2.4 Using Relays

The TCU100 contains a total of 30 independent relays, 15 relays with DPDT contact form and 15 relays with DPDT contact form.

Use the relays for applications that require fully isolated contacts, quality switching of control signals, multiplexed signals, loads selection, etc.

2.4.1 CONTACT RATINGS

For both contact topologies DPDT and SPDT, a safe approach is to keep switched power below 20 Watts. Applied voltage should never exceed 100 VDC or 70 VAC, current should never exceed 1 A AC or DC. At the TCU100's connectors, the channel resistance is about TBD mΩ.

Evaluate carefully inrush current. In a motor or lamp load circuit, an inrush current up to 15 times as large as the steady current is produced. In a circuit with a load of capacitor, inrush current can reach up to 40 times the steady current. High inrush currents may cause contact welding failure.

When switching inductive loads such as electromagnetic relays, solenoids and motors, a high back-electromotive force appears between relay contacts when they break, which causes arc discharge and reduction in life of the contact.

When possible, add protection on the relay contacts when inrush current or arcing is expected.

Particular care should be used when the relays are switching small loads, below 10 µA or 10 mV DC. With such loads the contact self-cleaning is reduced. A non-conductive film can appear on the contact surface, which can cause an increase in contact resistance.

The insulation resistance between opened contacts is at least 500 MΩ. (Temperature: 20 ±15°C, Relative humidity: 65 ±15%).

2.4.2 SWITCHING TIME

Switching time includes relay opening or closing time and processing time due to TCU100 firmware. It is guaranteed not to exceed TDD ms, however the actual value is unpredictable.

2.4.3 RELAYS CYCLE COUNT

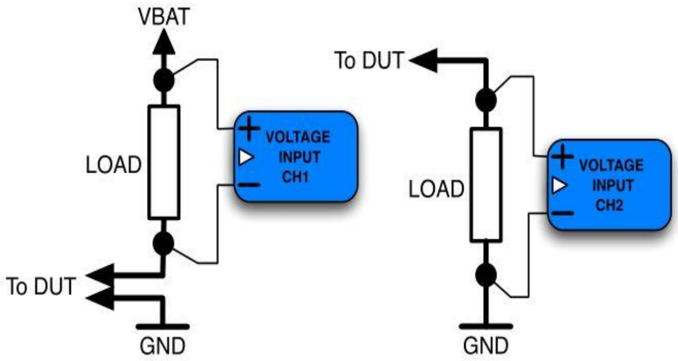
Relays are electromechanical devices that are subject to wear-out failure modes. The life of a relay, or the number of actual operations before failure, is dependent upon how it is used, applied load, switching frequency, and environment. The TCU100 has a relay maintenance system to help to predict relay end-of-life. The unit counts the cycles on each relay and stores the total count in non-volatile memory. The number of cycles will be used during maintenance to define relays that must be replaced.

2.5 Using Measurement Channels

The TCU100 combines precision measurement capability with flexible signal connections for your test system. This section describes voltage, current and frequency measurement channels.

2.5.1 VOLTAGE MEASUREMENT

Voltage channels can be seen as independent voltmeters. Each channel has a balanced input stage, making measurement possible for positive or negative values, above or below ground.



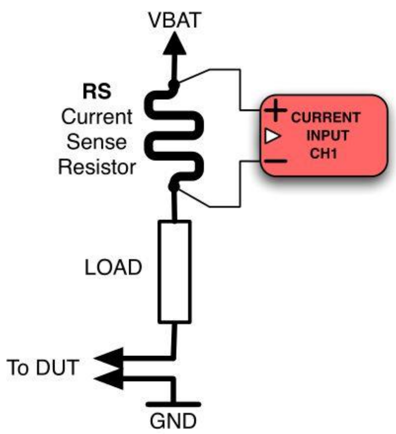
2.5.1.1 WHAT TO CHECK FOR THIS INPUT

The voltage range that can be applied between Positive and Negative inputs (differential mode) should not exceed -40 V to +40 V.

The voltage range that can be applied on Positive or Negative inputs according to ground should not exceed -70 V to +70 V. This means that if you want to get the full differential voltage range of -40 V to +40 V, the common mode on this input should be kept in the range -30 V to +30 V.

The common mode impedance is about 100 kΩ. When connected to a high impedance source, the measured voltage may be affected by the current flowing in or out of the measurement inputs.

2.5.2 CURRENT MEASUREMENT



Current channels can be seen as independent ammeters. Each channel has a balanced input stage, making measurement possible for positive or negative values, above or below ground.

2.5.2.1 HOW TO DEFINE THE CURRENT SENSE RESISTOR

Knowing the maximum current $\mathbf{I_M}$ you want to measure, first apply a safety margin of 50% to get your measurement range $\mathbf{I_R}$.

The measurement resistance is given by:

$$\mathbf{Rs = 0.040 / I_R}$$

The power $\mathbf{P_{RS}}$ this resistor must be able to handle is:

$$P_{RS} = Rs\ I_R^2$$

For example, assuming you want to measure a current up to $\mathbf{I_M}$=10 A, applying a safety margin gives $\mathbf{I_R}$ = 15 A.

This range is obtained using a 2.67 mΩ / 1 W sensing resistor. This value must be entered in the Control Software to get a direct reading of the current value.

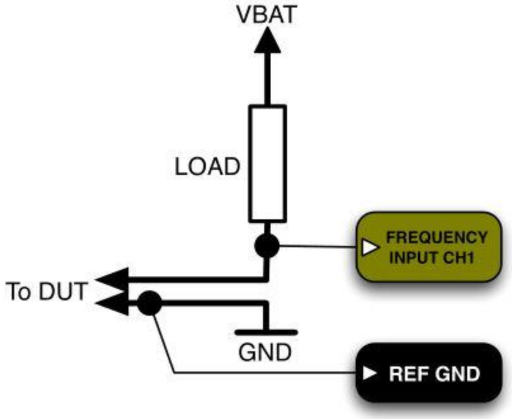
2.5.2.2 WHAT TO CHECK FOR THIS INPUT

The common mode impedance is about 400 kΩ.

The voltage range that can be applied between Positive and Negative inputs (differential mode) should not exceed -40 mV to +40 mV.

The voltage range that can be applied on Positive or Negative inputs according to ground (common mode) should not exceed -2 V to +60 V. Applying a common mode voltage out of this range may permanently damage the input.

2.5.3 FREQUENCY MEASUREMENT



Frequency channels can be seen as independent frequency-meters. Each channel has an asymmetric input referenced to ground, providing frequency and duty cycle measurements with adjustable threshold.

2.5.3.1 WHAT TO CHECK FOR THIS INPUT

The voltage range that can be applied to this input should not exceed -60 V to +60 V. The threshold however is adjustable between -10 V to +20 V.

The input impedance is about 100 kΩ. When connected to a high impedance source, you must check that the signal attenuation is compatible with the system requirements.

When measuring the duty cycle, remember that both the slope of the signal and the threshold value will affect the measured value. Always use an oscilloscope to check the waveform that you want to measure. Evaluate the min and max peak values and the slope of the signal to define the appropriate threshold.

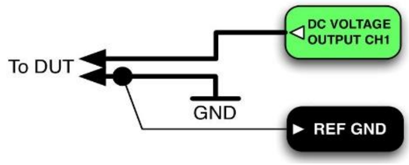
It's mandatory that the REF GROUND sense wire be connected close to the DUT connector for this input to work properly.

2.6 Using Signal Sources

The TCU100 combines precision measurement capability with flexible signal connections for your test system. This section describes continuous voltage, frequency and arbitrary waveforms generators.

2.6.1 DC VOLTAGE OUTPUTS

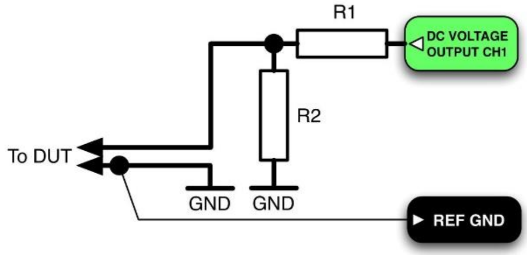
DC Voltage channels can be seen as references voltages that are independently adjustable. Each channel has an asymmetric output referenced to ground, providing a stable voltage. The source can be connected directly to the DUT, or using some resistors or other impedance matching if necessary. Optional interfaces such as voltage to current converters can also be used.



2.6.1.1 WHAT TO CHECK FOR THIS OUTPUT

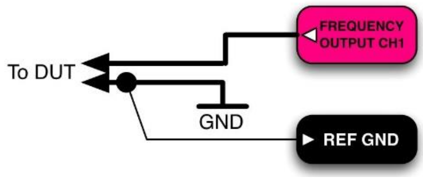
The current that can be delivered or absorbed by the voltage source must be in the range +/-30 mA. The output voltage range is - 20 V to + 20 V.

It's mandatory that the REF GROUND sense wire be connected close to the DUT connector for this output to work properly.



2.6.2 FREQUENCY OUTPUTS

Frequency channels can be seen as square wave generators that are independently adjustable in frequency and duty cycle, amplitude and offset. Each channel has an asymmetric output referenced to ground. The source can be connected directly to the DUT, or using some resistors or other impedance matching if necessary. Optional interfaces such as voltage to current converters can also be used.

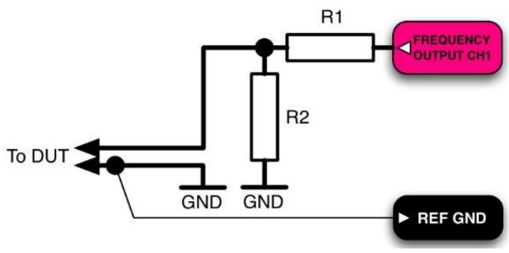


2.6.2.1 WHAT TO CHECK FOR THIS OUTPUT

The current that can be delivered or absorbed by the voltage source must be in the range +/-30 mA. The output voltage range is - 20 V to + 20 V.

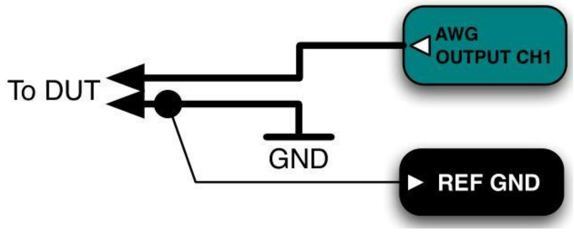
The slew rate of this output must be taken into account if duty cycle values close to 0 or to 1 must be generated.

It's mandatory that the REF GROUND sense wire be connected close to the DUT connector for this output to work properly.

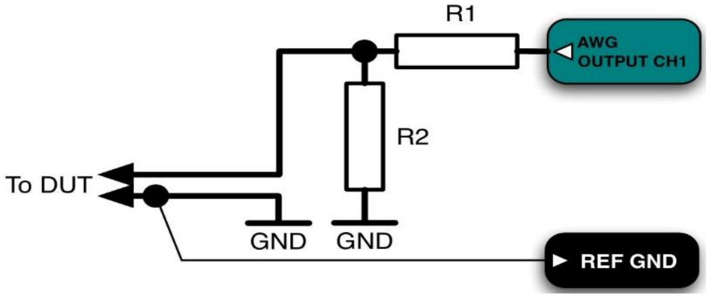


2.6.3 ARBITRARY WAVEFORM GENERATOR OUTPUTS

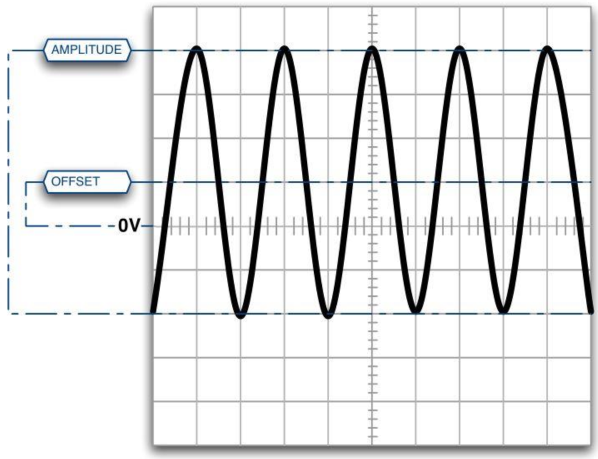
Arbitrary waveform channels can be seen as function generators that are independently adjustable in waveform, frequency and duty cycle, amplitude and offset. Each channel has an asymmetric output referenced to ground, providing a stable voltage. The source can be connected directly to the DUT, or using some resistors or other impedance matching if necessary. Optional interfaces such as voltage to current converters can also be used



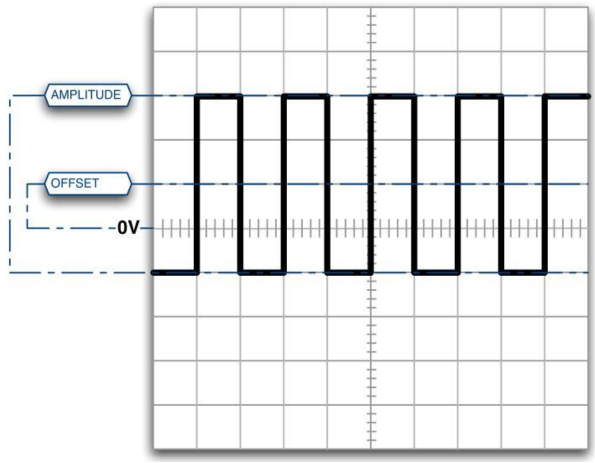
The waveform is produced by digital synthesis, involving a DSP to calculate the waveform and a Digital to Analog Converter to deliver it. Standard waveforms such as sine wave, square wave, triangle, ramps or random noise are already available, but the user can also define any arbitrary waveform by filling a waveform table.



2.6.3.1 SINE WAVEFORM

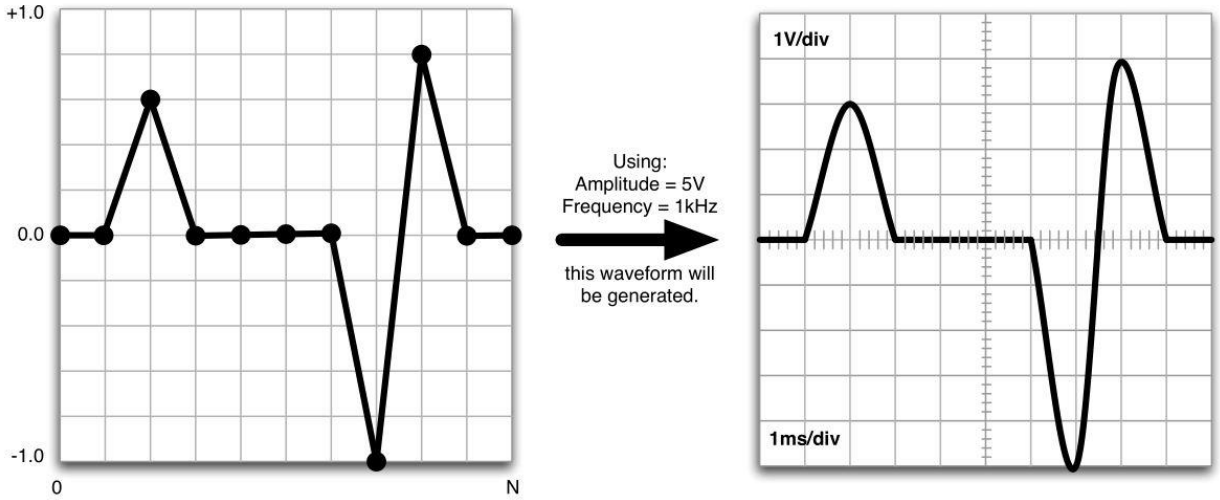


2.6.3.2 SQUARE WAVEFORM



2.6.3.3 ARBITRARY WAVEFORM

In order that the frequency parameter be coherent, the waveform memory must be filled for one complete period of the arbitrary signal. The period definition must provide a value for all of the N points contained in the waveform memory. Undefined values will be generated as a zero voltage output.



In order that the amplitude parameter be coherent, the waveform memory must be filled with values normalized between -1.0 and 1.0. The value -1.0 corresponds to the maximum negative amplitude. The value 1.0 corresponds to the maximum positive amplitude.

The waveform table can be the result of a calculation, produced by simulation software or an actual waveform acquired using a digital oscilloscope. The only requirement is to normalize the amplitude scale to [-1.0, +1.0] and the time scale to [0, N].

The Digital to Analog Converter is followed by a reconstruction low-pass filter, providing a smooth waveform at the output. This filter cut-off frequency is defined for the maximum frequency range of the generator. According to your application, extra filtering may be required.

Please consult the software documentation for complete description of the AWG programming.

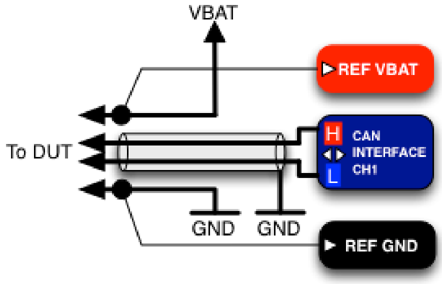
2.6.3.4 WHAT TO CHECK FOR THIS OUTPUT

The current that can be delivered or absorbed by the voltage source must be in the range +/-20 mA. The output voltage range is - 20 V to + 20 V.

It's mandatory that the REF GROUND sense wire be connected close to the DUT connector for this output to work properly.

2.6.4 USING CAN INTERFACE, CAN1 AND CAN2

The TCU100 provides two CAN FD interfaces, CAN1 and CAN2 that can work simultaneously.



The CAN FD interface enables simple connection to the CAN network of the DUT. It can operate at bit-rates up to 8 Mbit/s.

The CAN FD protocol relies on several configuration and message definitions. These definitions must be sent to the TCU100 before the interface can be used. Please consult the software documentation for complete description of the communication interfaces programming.

During the test, to ensure the best integrity of CAN FD signals, shielded cable should be used to connect the interface to the DUT, even if final wiring harness is not expected to use shielded cable. Use an oscilloscope to monitor the signals CAN High and CAN Low during debugging the test system. Check both ends of the cable on the DUT and on the interface. Check that operating margin on the signals is sufficient to allow interoperability across all node of the network.

2.6.4.1 WHAT TO CHECK FOR THIS INTERFACE

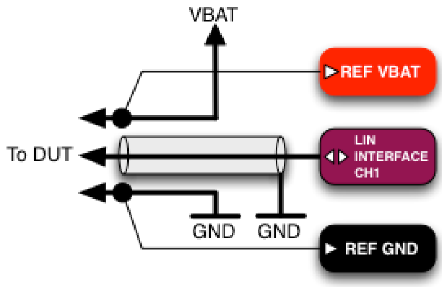
An internal jumper in the TCU100 must be set to activated this CAN interface.

Check if the termination load must be activated for your application. To activate the termination load, an internal jumper must be inserted in the TCU100.

It's mandatory that the REF GROUND and REF VBAT sense wires be connected close to the DUT connector for this output to work properly. The internal CAN driver of the TCU100 is directly powered by the DUT VBAT power supply.

2.6.5 USING LIN INTERFACE, LIN1, LIN2, LIN3 AND LIN4

The TCU100 provides 4 LIN interfaces.



The LIN interface (Local Interconnected Network) enables simple connection to the LIN network channel of the DUT. It can operate at bit-rates up to 19200 KBit/s, as a Master or a Slave node.

The LIN protocol relies on several configuration and message definitions. These definitions must be sent to the TCU100 before the interface can be used. Please consult the software documentation for complete description of the communication interfaces programming.

During the test, to ensure the best integrity of LIN signal, shielded cable should be used to connect the interface to the DUT, even if final wiring harness is not expected to use shielded cable. Use an oscilloscope to monitor the LIN signal during debugging the test system. Check both ends of the cable on the DUT and on the interface. Check that operating margin on the signals is sufficient to allow interoperability across all node of the network.

2.6.5.1 WHAT TO CHECK FOR THIS OUTPUT

An internal jumper in the TCU100 must be set to activate this LIN interface.

Check if the termination load must be activated for your application. To activate the termination load, an internal jumper must be inserted in the TCU100. The internal termination resistance load is 510Ω from LIN bus to battery supply. The 510Ω load corresponds to 1 master and 15 slave nodes.

It's mandatory that the REF GROUND and REF VBAT sense wires be connected close to the DUT connector for this output to work properly. The internal CAN driver of the TCU100 is directly powered by the DUT VBAT power supply.

2.7 Extending Resources

The TCU100 contains a set of resources defined to address most of the control units found in the automotive industry. However, special or new products may request features not yet implemented in a TCU100.

To face such situations, a 16-bit wide bus extension is already included in the TCU100. This extension bus, fully controlled by the main microcontroller and the command language, is available through a connector in the load compartment.

Specific adaptation modules can be designed to add special functions found in a demanding product, and simply plugged in the extension connector. Standard extension board will also soon be introduced. This will open the TCU100 capabilities up to the most demanding applications.

Please contact ART logics for more information about extension modules for the TCU100.

3 Calibration and maintenance

3.1 Firmware Revisions

The TCU100 firmware resides in several microprocessor chips of the main board. Updating firmware may be needed to integrate new features in your TCU100 or apply firmware corrections. This procedure requires the return of the unit to ART logic facilities. During calibration or maintenance, firmware will be updated to the last available version for your equipment.

3.2 TCU100 calibration

The calibration period of the TCU100 is one year.

During maintenance process, all parameters of the TCU100 will be checked and calibrated to be in accordance with the specification. Firmware will be updated to the last version. Relays cycles are monitored in the TCU100 by dedicated counters. Relays exceeding 80% of the expected lifetime will be replaced. A calibration report will be issued.

According to the mission profile programmed in one TCU100, the lifetime of the TCU100 internal relays may be shorter than the calibration period. The user can check at any time the remaining cycles using the software diagnosis tool, and decide the appropriate calibration operation.

Contact ART logics for maintenance service of your equipment.

3.3 Warranty period

This ART logics hardware product is warranted against defects in material and workmanship for a period of two years from date of delivery. ART logics firmware installed on that hardware product are warranted not to fail to execute their programming instructions due to defects in material and workmanship for a period of 90 days from date of delivery. During the warranty period ART logics will, at its option, either repair or replace products that prove to be defective. ART logics do not warrant that the operation of the software, firmware, or hardware shall be uninterrupted or error free.