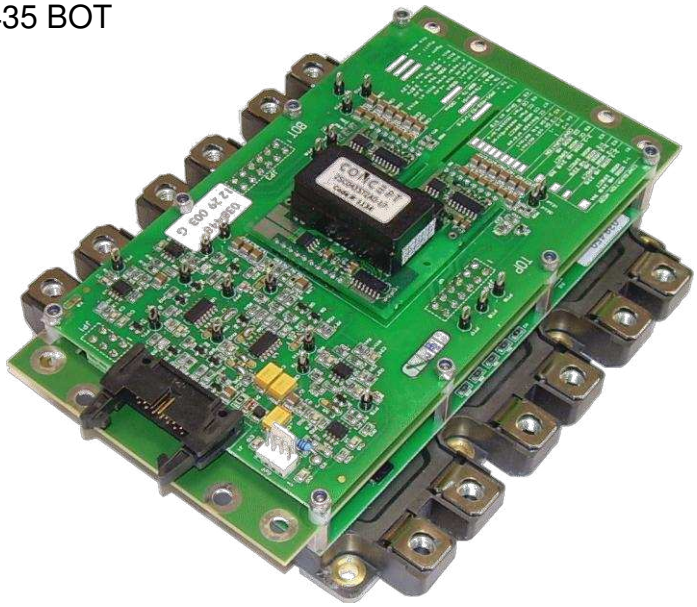
ARCAL E+3P – 435

Double Driver for ECONOPACK+© modules "SCALE TECHNOLOGY"

The ARCAL E+3P-435 module enables to drive an inverter or chopper arm.
All the functionalities needed for the design of power converters are gathered on two electronic boards which have the same mechanical dimensions as the ECONOPACK+© module

The control module ARCAL E+3P includes 3 complementary boards :

- ARCAL E+3P-435 TOP
- ARCAL E+3P-435 SCREEN
- ARCAL E+3P-435 BOT



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BENEFITS

- ✓ **4W / ±35A per output**
- ✓ **Short circuit protection**
- ✓ **Detection of supply default**
- ✓ **Default signal in positive logic**
- ✓ **Adjustable dead times**
- ✓ **+15/-10V Grid input**
- ✓ **"Active Clamping" protection**
- ✓ **Measure of temperature through CTN**
- ✓ **Measure of current by means of an external sensor**
- ✓ **Customer connection at HE10-14 bent or straight**

MAXIMUM ELECTRICAL SPECIFICATIONS

Unless otherwise specified, all data are given for 25°C.

Symbol	Parameter	Min.	Max.	Unit
V_{DD}	Power supply voltage (with reference to exposed conductive part)[1]	0	16	V_{DC}
V_I	Control input	0	V_{DD}	V_{DC}
I_G	Peak grid current	-35	+35	A
P_G	Average power per output @85°C [2]		4	W
V_{ISO}	Isolation test voltage (AC / 50Hz /1min)		4000	V_{eff}
V_{OP}	Permanent operating voltage[3]		1200	V_{DC}
dv/dt	dv/dt immunity @ ΔV=1000V	75		KV/µs
T_A	Operating temperature[4]	-40	+85	°C
T_S	Storage temperature	-40	+90	°C
V_{OC}	Max. voltage of default open collector		40	V
I_{OC}	Max. current of default open collector		10	mA

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ELECTRICAL SPECIFICATIONS

Unless otherwise specified, all data are given for 25°C.

Supplies

Symbol	Parameter	Min.	Typ.	Max.	Unit
V_{DD}	Rated power supply	14.5	15	15.5	V_{DC}
I_{DD_0}	Total off-load supply current[5]		50		mA
I_{DC_0}	Input current of off-load DC/DC converter		30		mA
I_{DD}	Total current of maximum supply[6]		700		mA
η	Efficiency of DC/DC converter		85		%
V_{TH_0}	Trigger threshold of default[7]		12.6		V
H	Hysteresis on supply default[7]		0.7		V

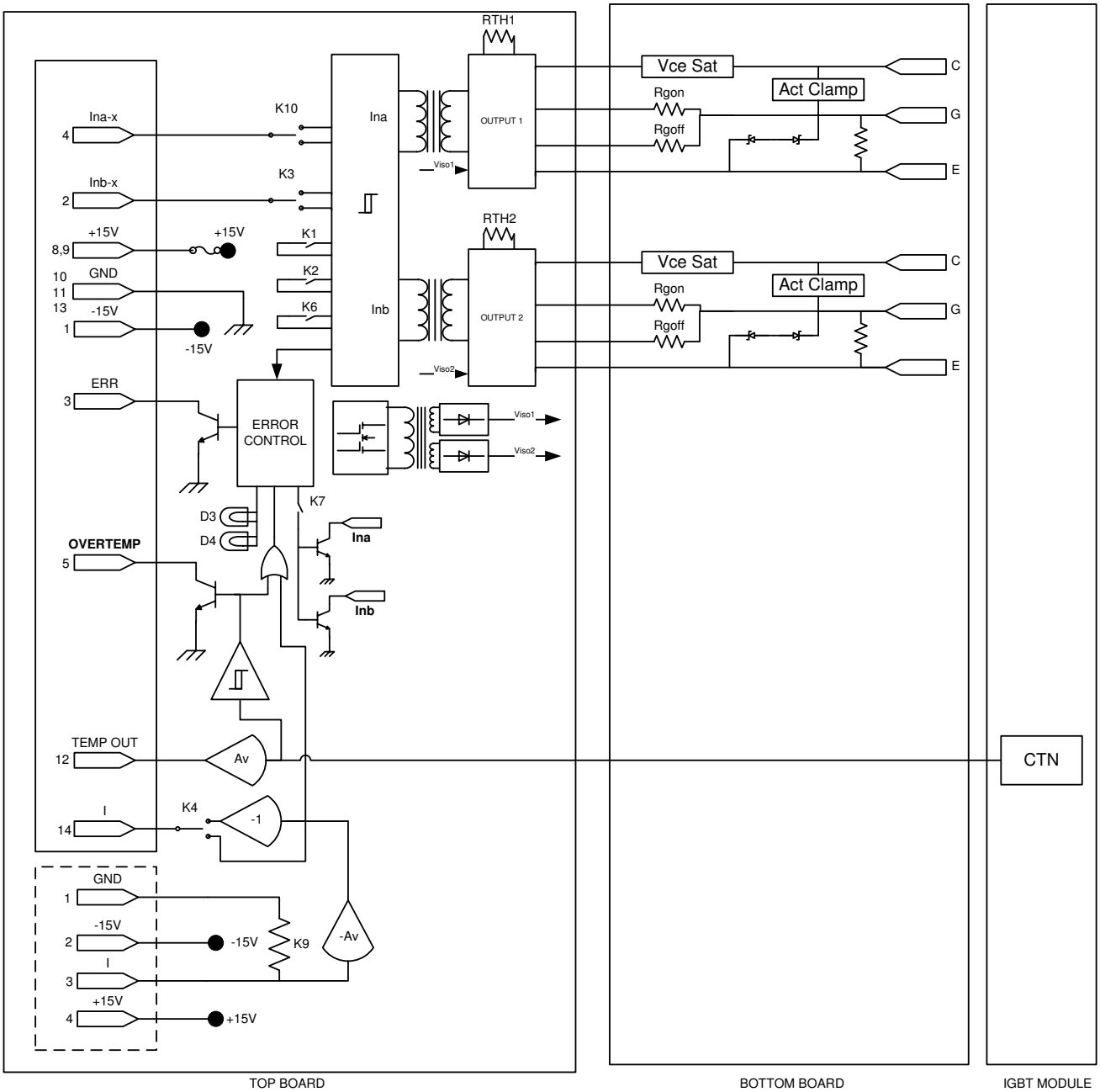
Input stage

Symbol	Parameter	Min.	Typ.	Max.	Unit
V_{IM}	Maximum voltage on logical inputs[1]	0		V_{DD}	V_{DC}
V_{IT+}	Flow threshold at high level (15V)		10		V
F_{SW}	Commutation frequency[8]	0		>100	KHz
α	Control duty cycle	0		100	%
R_{IN}	Input resistance[9]	10	15		KΩ
T_{DT}	Standard dead time[10]		4	4.2	µs

Output stage

Symbol	Parameter	Min.	Typ.	Max.	Unit
I_G	Maximum grid current	-35		+35	A
V_{G+}	Voltage for conduction setting		+15		V
V_{G-}	Cut off voltage		-10		V
T_R	Rising time[11]		20		ns
T_F	Downing time[11]		20		ns
T_{PD+}	Input/output propagation time at conduction setting		80		ns
T_{PD-}	Input/output propagation time at cut off		70		ns
T_B	Cut off time of the inputs after loss of default	20	130	130	ms
T_{ER}	Signalling delay of the defaults		70		ms
T_{TH}	Detection time on V_{CE}[10]		5		µs
V_{THX}	Trigger thresholds on V_{CE}[12]		4.4/2.35		V
OVERTEMP	Trigger threshold of CTN temperature	110	115	120	°C
-I	Gain on measure of current	4.77	4.9	4.97	
TEMPOUT	Measure of CTN voltage (see curve)				

FUNCTIONAL DIAGRAM



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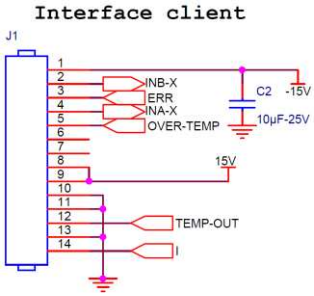
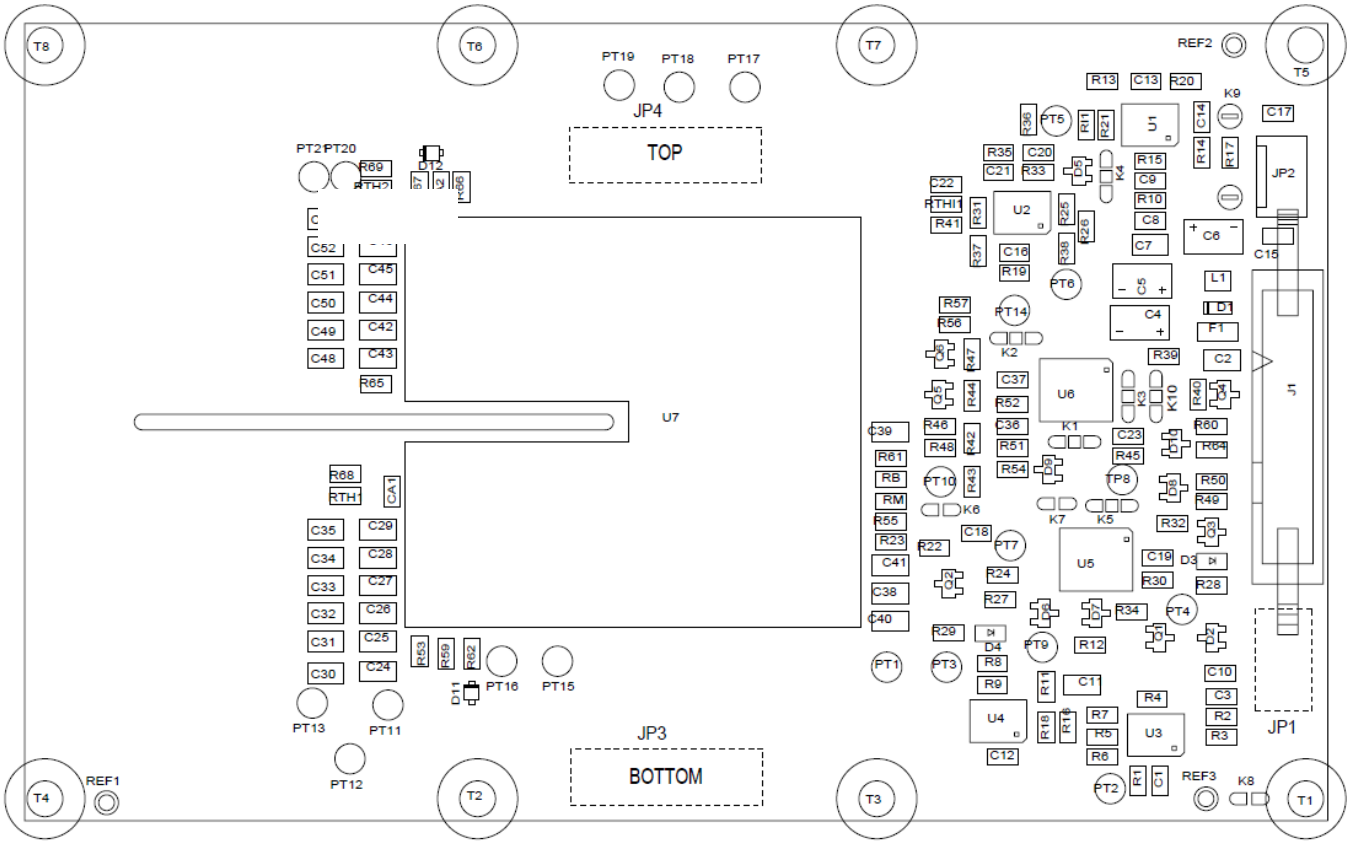


MECHANICAL SPECIFICATIONS



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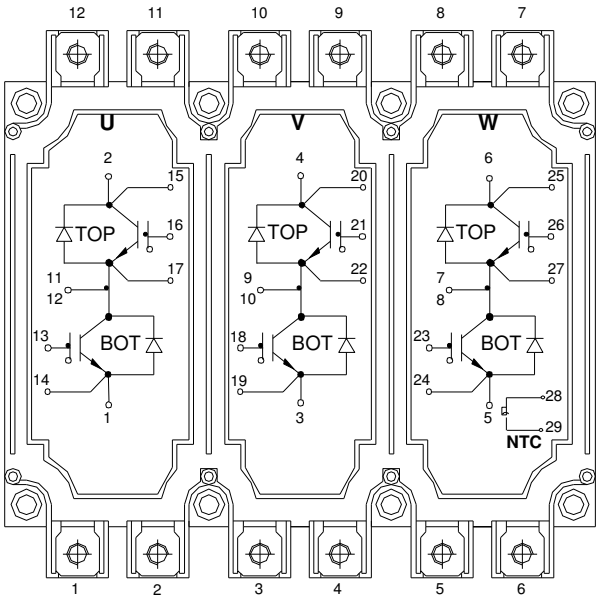


INTERNAL LAYOUT OF THE ECONOPACK+© MODULE

GENERAL PRESENTATION

The ARCAL E+3P-345 driver is based on a SCALE2 module (Scaleable, Compact, All purpose, Low cost and Easy to use), which belongs to the latest generation of CONCEPT drivers.

All the functionalities required to drive power switches (IGBTs) **in full security** are gathered on one single board. Each parameter which may depend on the application can be very easily configured.

Main Specifications

- The ARCAL E+3P-345 driver enables to drive an ECONOPACK+© module in a half bridge structure or in an independent way. This driver enables to convert an ECONOPACK+© module in an independent arm, which can then be used in a high power inverter or chopper. This driver is suitable for IGBTs up to 1700V in its standard version.
- The IGBTs are controlled in +15/-10V.
- The IGBTs protection is ensured by monitoring of the V_{CE}sat and of power supplies.
- An 'Active Clamping' voltage protection is ensured by monitoring of the collector voltage.
- Only one V_{DD} direct supply of 15V ±0.5V is required. The isolated supplies which are required on the power side are internally generated.
- The logical inputs are equipped with Schmitt triggers.
  The logical level of these inputs is selected at 15V (CMOS compatibility).
- The dead time value of each channel can be adjusted by the user.
- The default signal, which is of type open collector, is activated by the driver (short circuit or supply default).
- The connectors have been selected according to their reliability and in order to rationalize the implementation of the driver in existing applications.
- An intermediary board (ARCAL E+3P-345 SCREEN) enables to realize a chip layout which will afford a high CEM immunity, as well as an efficient mechanical protection of the module.
- Output of the CTN temperature information and output of open collector at on-state when the CTN temperature exceeds 115°C.
- It is possible to measure the current by means of a current sensor.

DETAILED TECHNICAL DESCRIPTION

Driver supply

The ARCAL E+3P driver requires a regulated supply of +15V ±0.5V. The maximum power used under normal operating conditions is about 10.5 W.
The current used at the input can be calculated according to the following formula :

$$I_{DD}(A) \approx \frac{P_{GT}(W)}{0.85 \times 15} + 0.060$$

In which, P_{GT} = total power provided by the driver to the IGBTs.

Remark :
This product is dedicated to highly impulsive applications and as such there can't be any efficient protection of the DC/DC converter against overloads. The board feeder however is equipped with a fuse which aims to control long-lasting overload risks. These overloads could possibly damage upstream systems.

Logical Inputs

INAX et INBX inputs are equipped with Schmitt triggers whose tilting thresholds are about 1/3 and 2/3 of 15V voltage supply. A high logical level corresponds to an active input (positive logic).

The input stage of the driver includes protection diodes against negative voltages or voltages greater than VDD. If these limits are exceeded, overheating and/or consumption could occur. Special care must be taken when using the driver with long cables.
Under normal conditions of use, the impedance of these inputs is about 22 KΩ.

Selection of the input signals

The ARCAL-E+3P-435 board enables to switch control signals of Inax and Inbx towards Ina and Inb input signals of the driver, according to the customer's needs.
Each setting range K1, K2, K3, K10 consists of 3 zones, numbered from 1 to 3, zone number 2 being the central one. The two possible configuration therefore are 1-2 or 2-3.

Operating mode	K1	K2	K3	K10
Direct mode : Inax drives IGBT TOP	1-2	1-2	1-2	2-3
Direct mode : Inax drives IGBT BOT	1-2	1-2	2-3	1-2
Direct mode : Inax drives both IGBT TOP and BOT	1-2	1-2	2-3	2-3
Direct mode : Inbx drives both IGBT TOP and BOT	1-2	1-2	1-2	1-2
HB TOP-BOT Mode	1-2	2-3	1-2	2-3
HB INA-INB Mode	1-2	1-2	1-2	2-3

- HB TOP-BOT Mode : in this mode Inax and Inbx signals are complementary without dead time, or with low dead time (1 to 2 µs). Inax is rerouted towards Ina. Inb signal is reset from Inax and Inbx
- HB INA-INB Mode : in this mode Inax représents the control signal which is rerouted towards Ina, and Inbx represents the on/of signal which drives Inb.

Operating modes (K6)

The ARCAL E+3P-345 driver can operate according to 2 different modes :

- The "DIRECT" mode which enables to drive the two outputs independently.
- The "HB" (half-bridge) mode is dedicated to "half-bridge" systems.

Direct Mode :

In this mode, the outputs are driven independently one from the other by INA and INB inputs. The different security systems however stop the two outputs and activate the unique default signal. A high logical level on one of the INX inputs matches with the conduction of the corresponding IGBT.
The two channels being independent, the driver won't generate any dead time. It is therefore possible to activate the two outputs at the same time.
The configuration in DIRECT mode is done by short-circuiting **K6**.

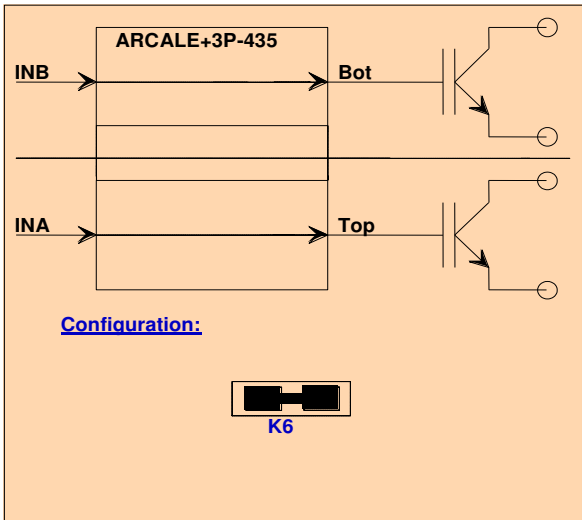
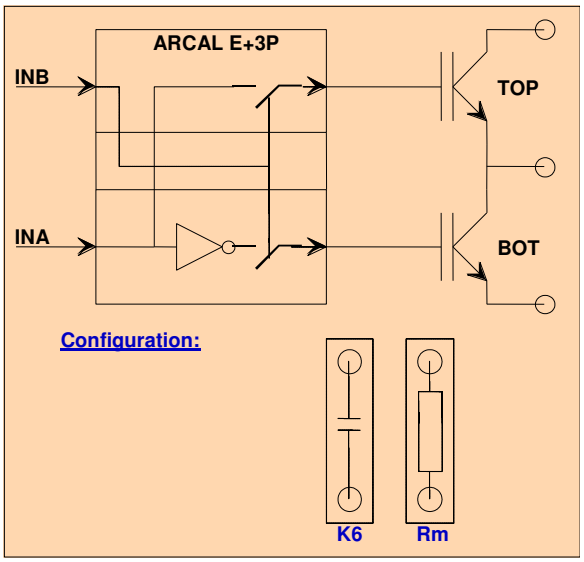


Figure 1 : Mode direct

HB Mode and Dead Times :

The "HALF BRIDGE" or "HB" mode is dedicated to applications which are based on an "ARM" type structure. In this type of structure you have two switches in series controlled in a complementary way. This is the case for example for inverters or choppers in bridge or half-bridge configuration.
In this case, the two outputs are no longer independent : the INA input enables to control the arm state and the INB input is then used as an inhibition signal of the outputs.
A low logical level on INB will force the two outputs to the low level, whatever the state of INA is. When the INB input is at a high logical level, the state of the outputs will depend on the INA input. K6 is then left in open circuit. A 22µF capacitor can also be implemented in this location.



As the two switches are connected in series, for each change of state of the arm, the driver will ensure that no transitory short-circuit interferes in the arm by holding the two outputs at low level during a fixed period called *dead time.*

The user can interfere on the dead time value owing to Rm resistor. Unless otherwise indicated, the dead time value is given for about 4.2µs, owing to a 181kΩ resistor.

The formula below enables to determine the dead time from the basic configuration:

$$\text{Dead time} = \frac{\frac{181xRm}{181+Rm} - 52.7}{31.5} \ \mu s$$

The time out must be included between 0.6 and 4.2 µs.

Default signal

The "DÉFAULT" output is of type open collector. It can resist to a 40V foltage and drain a 10 mA current. An external draught loss must be provided.

- **The default signal is active at high level, if K5 is in position 2-3 (STD)** : In case of default, the output transistor is blocked (high impedance). This is the standard operating mode as a failure of the control cable will be interpreted as a default by the upstream control system.
- **The default signal is active at low level, if K5 is in position 1-2 :** In case of default the output transistor will be conductive.

In case of internal error :

In case of an internal error, the default will be shown during an interval of about 130 ms. The driver will be automatically restarted and the outputs will remain inactive for a minimum time period of 130 ms.
As far as K7 remains in CC, the board will stop Ina et Inb commands at the input of the driver module, as long as the ERR signal appears on HE10-14 connector.
The upstream control system is supposed to block the command pulses as soon as the default appears. Should the opposite happen, and after the default signalling delay, low-rate commutations (about 10µs) can occur on the non-default channel. The default will then be shown again by a 70ms pulse, etc… until the cause of the default has been found out and has disappeared or until the control pulses have stopped.

Remark :
The management of internal defaults is directly done at each output. Thus the default channel is immediately stopped for a minimum period of time of 1s.

Note 1 : Blocking the orders when defaults occur :

- The configuration STRAPP K5 enables to choose as follows :
  - **K7 = CO** : No blocking of the orders at driver input in case of default detection.
  - **K7 = CC** : Blocking the orders in case of default detection (STD)

Note 2 : Fault Leds :

- Leds D3 and D4 allow to have a bright representation of a fault condition.
- D3 shows the state of the ERR output signal
  - K5 = 2-3 : D3 is lighted in case of default
  - K5 = 1-2 : D3 goes off in case of default
- If D5 is lighted it shows a default from the secondary

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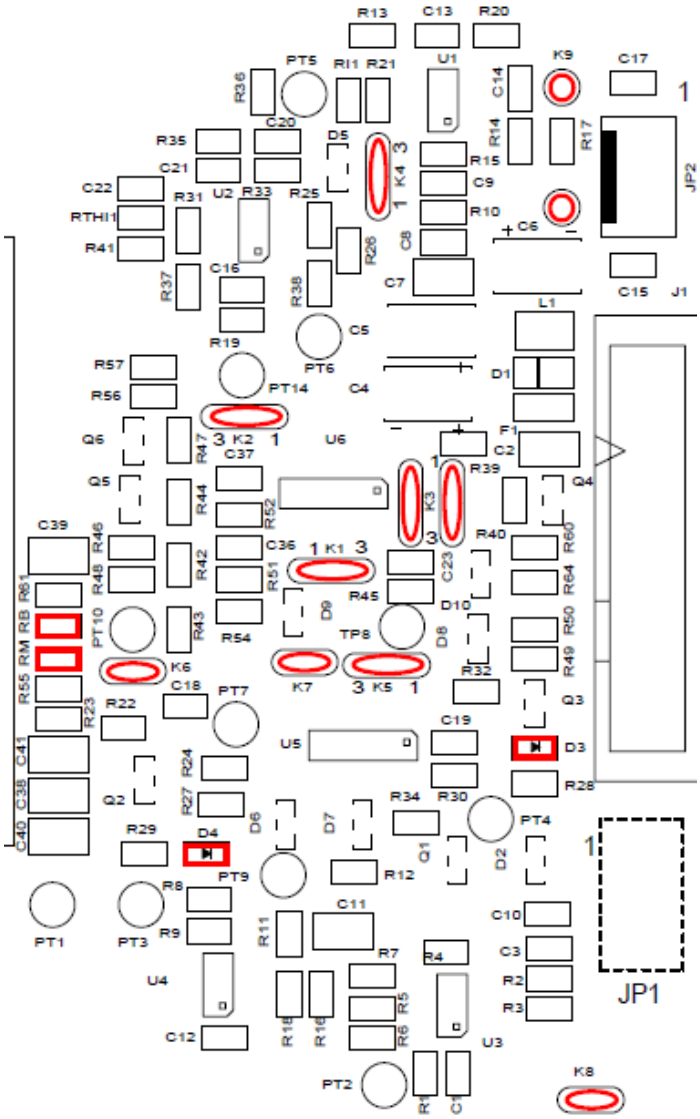

View of LEDS D3 and D4, as well as RM, RB, and the various STRAPP

<u>Driver powering up</u> :

A default pulse (about 70ms) is automatically generated when powering up the driver in order to enable the auxiliary supplies to settle.

Control grid (Rg)

IGBTs are controlled in ±15V. For each output, the conduction setting and the IGBT fade-out are controlled by a grid resistor : **RG**..

Peak current (Rg) :

The peak current provided by the driver depends on the total resistance of the Grid/Emitter loop. Its value can be estimated according to the following formula :

$$I_G\ (A) = \frac{\Delta V_{GE}(V)}{R_G(\Omega)}$$

In which : ΔV_{GE} represents the variation of the grid voltage (in this case, 25V) and R_G the grid resistor

As the I_{Gp} current must not exceed 35A, the theoretical low limit for R_{GON} and R_{GOFF} is 0.7 Ω

Average power :

The average power, P_G, provided by a driver output depends on the gate charge, Q_G, of the component which is used, on the variation of the grid voltage, ΔV_{GE}, and on the commutation frequency, F_{SW} (SI units) :

$$P_G = Q_G \times \Delta V_{GE} \times F_{SW}$$

This power must in no way exceed 4W, under 85°C ambient temperature.

Setting up of the grid resistors :

Grid resistors are implemented on the bottom board, defined as « BOT ».
This card allows the Ron and Roff resistors to be adjusted separately.
As the econopack+ module consists of 6 single IGBT, it is necessary to set up 6 x Ron and 6 x Roff.
Ron and Roff physically consists of 2 CMS resistors size 2210 and connected in parallel. That makes thus a total of 24 resistors to be welded.
The table below shows the torque resistance to be taken into account :

Ron	R21//R22	R33/R34	R25//R26	R38//R39	R43//R44	R49//R49
Roff	R13//R28	R35//R36	R27//R30	R40//R41	R45//R46	R50//R51

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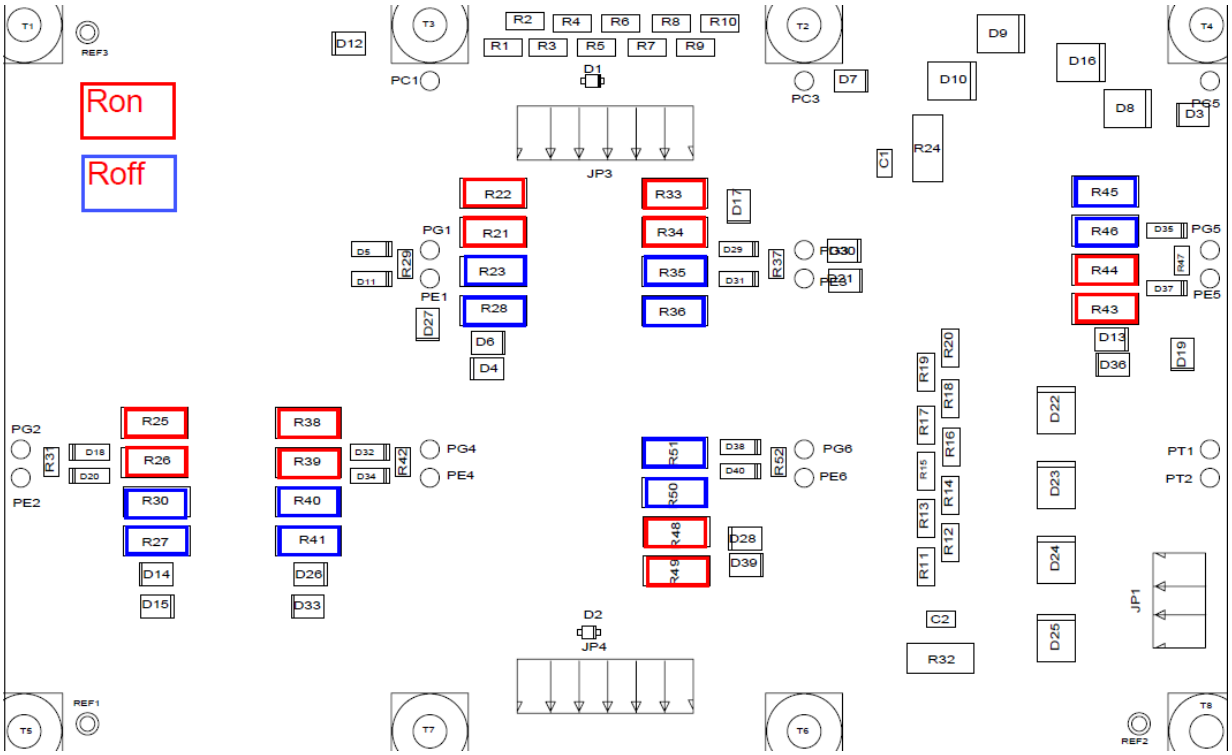
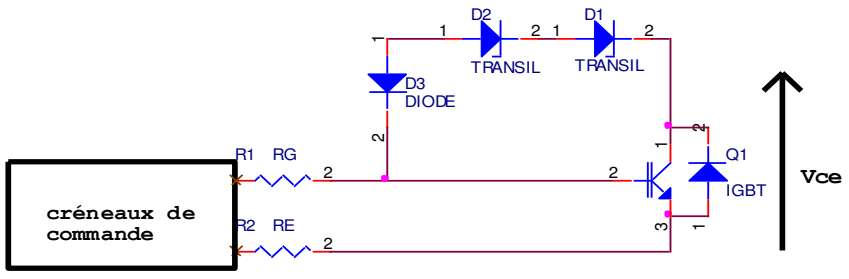


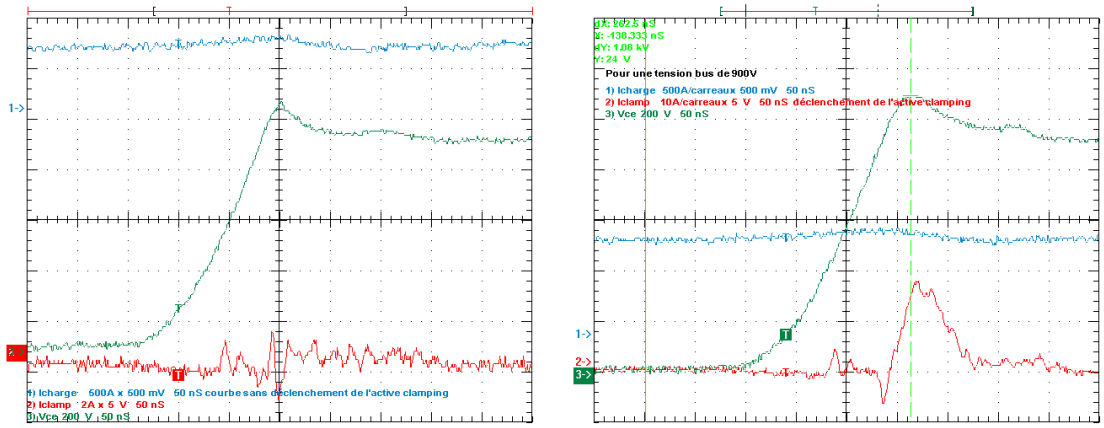
View of grid resistors

'Active clamping' protection

This protection aims to limit the emitter collector overvoltage at the opening of the semiconductor. This overvoltage is the product of the interfering inductance of the loop by the di/dt imposed by the component.
The functional diagram is as follows :



As soon as the Vce voltage exceeds a value determined by the transils, a current is injected in the base of the IGBT thus generating a short renewal phase and enabling to limit de the tension at the terminals. **This device mustn't be used at continuous rating (i.e. at each commutation), as it introduces additional losses which can be damaging for the IGBT**.



The two above oscillograms (the first one with the device and the second one without it) show the influence of the device. You can clearly see the limitation of the overvoltage which results in a clipping.

In the standard version, the voltage protection is set for a 1200V IGBT module. Upon request it is possible to get a protection for a different voltage (1700V for example).

This device enables to limit the overvoltage at the opening to a value close to 1100 volts (according to the dispersion of the components and the energy that has to be dissipated, the clipping voltage varies from 1020 to 1100 volts).

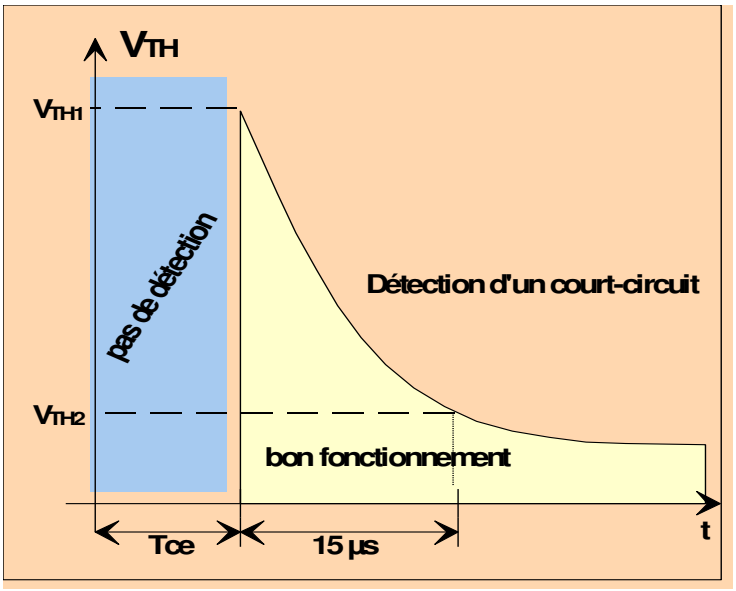
Monitoring of short-circuits

The detection of short circuits is done by comparing the $V_{CE}sat$ voltage of the device with a reference voltage. If this threshold level is exceeded, the concerned channel is stopped and the default signal is activated.

In order to better fit with the IGBT commutation profile, the reference voltage varies according to the elapsed time since the conduction setting.

First of all the detection has to be deactivated during a fixed TCE period. Once this period is over, the detection threshold is equal to $V_{TH}1$ and will progressively decrease (in about 15µs) until it reaches the $V_{TH}2$ value.

For each channel, Tce and V_{TH} parameters can be modified by adjusting parameters CA1, CA2 and RTH1, RTH2.



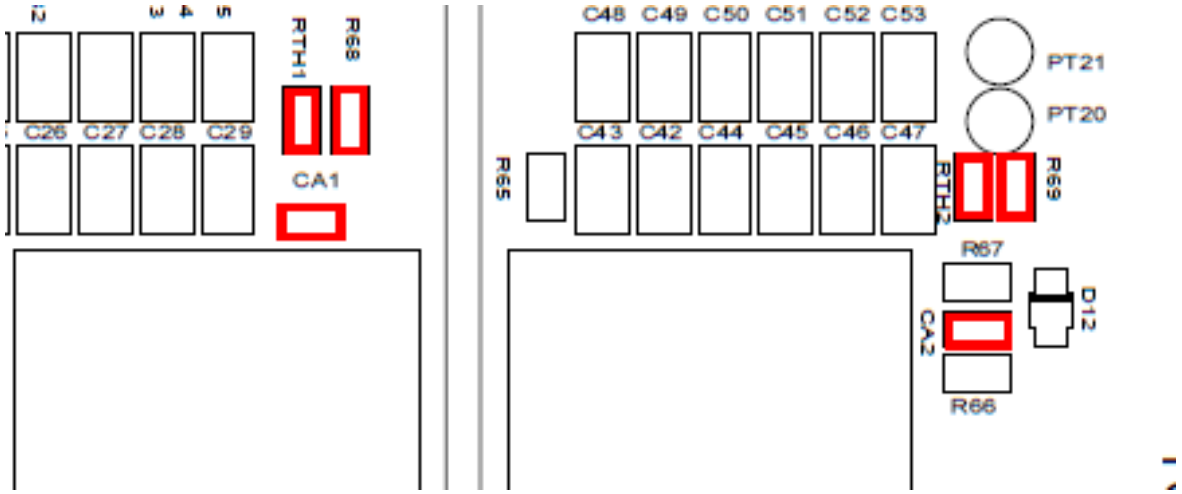
Outline 2 : Profile of the reference voltage V_{TH}

The following diagrame gives you an indication of some values of VCEsat detection in relation to the global RTH resistor in use (RTH in // with 29.4k). The standard value which is implemented in parallel on RTH is 29.4k, i.e. a 4.4 V detection threshold. To get a reference voltage over 4.4V, it is necessary to remove R68 and R69 (24.9k). In the standard version, CA = 47pF, which implies a 5µs response time.

C_{ax} [pF]	R_{thx} [kΩ]/V_{thx} [V]	Response time [µs]
0	43 / 6.45	1.2
15	43 / 6.45	3.2
22	43 / 6.45	4.2
33	43 / 6.45	5.8
47	43 / 6.45	7.8
0	68 / 10.2	1.5
15	68 / 10.2	4.9
22	68 / 10.2	6.5
33	68 / 10.2	8.9
47	68 / 10.2	12.2

Diagram 1 : Choice of RTH for VCEsat detection parameters

Note 1 : This protection is particularly efficient for the so-called dead short circuits or with low impedance. You mustn't rely on this protection for "slow" defaults.
Note 2 : The response time indicated in the diagram depends on the bus voltage. If bus voltage is < 540V it will increase ; on the contrary, it will decrease if bus voltage is > 540V.
Note 3 : If the module is used with a bus voltage >650V or <350V, please contact ARCEL to set up the measure current.



View of the position of the configuration components

Measure of temperature

A CTN is included in the econopack+ housing. The board includes a linearization of this CTN in the useful operating area. The temperature information is available on pin 12 of the HE14 connector.

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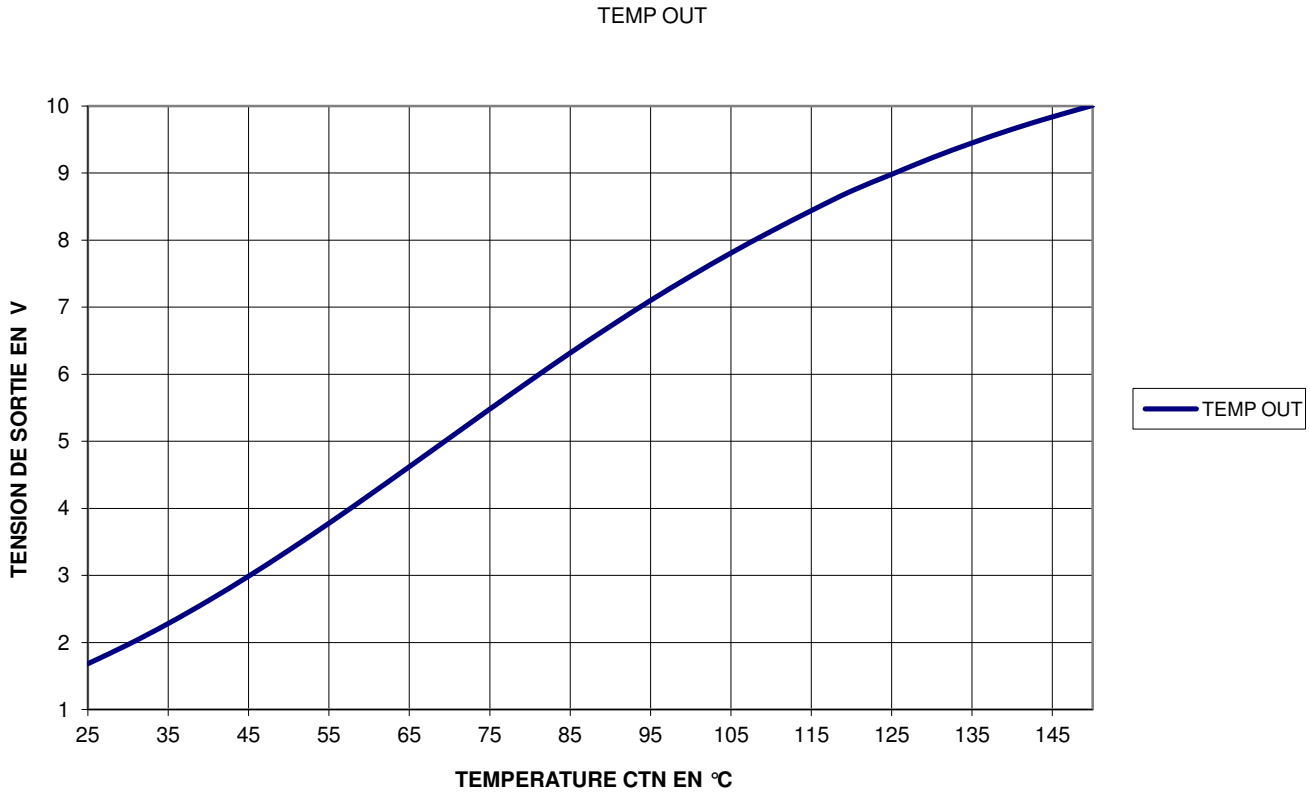

Outline. 5 : Voltage on pin 12 according to CTN temperature

When the CTN temperature exceeds a 115°C threshold, the collector of output transistor (output 5 of HE10-14 connector) is controlled when opening. The transistor is thus normally on-state and opened in case of default.
REMARK : Do not deviate from the maximum specifications of the transistor.

If the CTN temperature exceeds 115°C (which corresponds to a junction temperature of about 125°C), the OVER-TEMP signal available on output 5 of HE10-14 will change state. The open transistor collector stops, and the output changes to high impedance.

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Measure of current

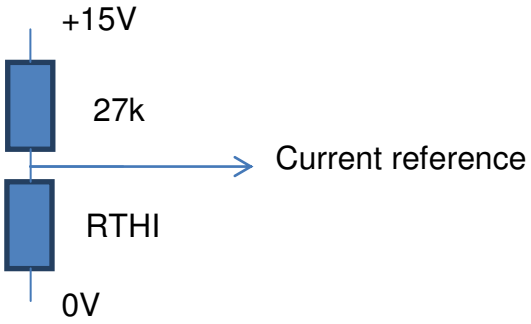
It is possible to connect a current sensor on the JP2 connector. In order to operate it, it is absolutely necessary to supply the HE14 input connector with a -15V voltage on pin 1. On a standard basis K0 load resistor is 10 Ohms ± 1%. The voltage gain on the output stage is -4.9. The output voltage on pin 14 will thus be equal to :

V (pin 14) = - I sensor x 10 x 4.9

The K4 STRAPP allows to choose the current signal which will be sent to terminal 14 of J1 :

- K4 = 1-2 : output current in phase with sensor
- K4 = 2-3 : current in phase opposition with sensor (STD)

The two currents (I et –I)/2 are compared with a voltage reference which can be adjusted by the use owing to RTHI. If the measure is over the set threshold, a default signal is generated. Depending on the configuration of K7, this default will or will not stop the control commands at driver's input



Monitoring of Auxiliary Supplies

A monitoring of the supply values is directly realised on each output channel. If one of the two secondary supplies doesn't exceed 1V, the concerned channel is stopped/blocked and the default signal is activated. As the hysteresis of the detection system is 0.7V, the re-start will only occur once the voltage has gone up again over about 12.2V.

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STANDARD CONFIGURATION

STRAPP	Standard configuration	Remarks
K1	1-2	TOP-BOT
K2	2-3	TOP-BOT
K3	1-2	INB
K10	2-3	INA
K6	CO ou 22nF	MODE HB
K4	2-3	-I
K5	2-3	Positive security
K7	CC	Cut orders
K8	CO	Ground plane not earthed
K9	10 Ohms	Current measure
Clipping	1040V	Approximate clipping voltage
Dead time	4.µs	Dead time
Vce sat	4.4V	Short circuit threshold

In which : CC = Court-Circuit (Short-circuit) 1-2 = link terminals 1 et 2
CO = Circuit Ouvert (Open Circuit) 2-3 = link terminals 2 et 3

[1] The système is protected by zeners and bipolar diodes. Exceeding these values can therefore lead to over heating and / or over consumption. Special care must be taken in case of use of large lengths of cables.

[2] Available power at the output of DC/DC converters.

[3] Direct voltage or peak value of the alternative voltage applied in a permanent way between the secondaries or between the secondaries and the primary. Higher values can be guaranteed through a partial loss of load test (which is not done for the standard version).

[4] Direct voltage or peak value of the alternative voltage applied in a permanent way between the secondaries or between the secondaries and the primary. Higher values can be guaranteed through a partial loss of load test (which is not done for the standard version).

[5] This value is given for 25KHz control signals.

[6] If the output power is exceeded, the DC/DC converter will be in an overload state.

[7] This security aims to protect the semi-conductors. Each secondary voltage is individually monitored.

[8] Within the limit of maximum output power.

[9] Under standard operating conditions.

[10] Can be adjusted by the user, maximum value given for 181kΩ.

[11] First value : with a load made up with a 5.6Ω resistor in series with a 39nF capacitor.
Second value : with a load made up with a 1.8Ω resistor in series with a 250nF capacitor.

[12] Can be adjusted by the user. The two values fit with the detection threshold at Tce and at continuous rating (about 15µs later).

CAUTION : ARCEL reserves the right to modify all its technical documentation without prior notice. Document without any contractual value.

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