ARCAL-ED

Double driver for ECONODUAL module

The ARCAL-ED driver board allows to drive one ECONODUAL module.

All functions needed for power converters development are embedded on a small size, very versatile single electronic board .

- **High isolation and dv/dt immunity**
- **4W / ±35A per output**
- **Short-circuit protection**
- **Active Clamping protection, active SSD**
- **Undervoltage detection**
- **Adjustable dead times**
- **-10/+15V gate voltage**
- **Measure of internal CTN temperature of the module**
- **Measure of output current (by means of a Hall effect sensor)**
- **HB or direct mode logic**
- **SIC modules driving possible**

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1. ABSOLUTE MAXIMUM RATINGS

All data are given for 25°C unless otherwise specified.

Symbol	Parameter	Min.	Max.	Unit
V_{DD}	Supply voltage (referred to ground)[i]	0	16	V_{DC}
V_I	Logic input voltage	0	V_{DD}	V_{DC}
I_G	Peak gate current	-35	+35	A
P_G	Average output power per output		4	W
V_{ISO}	Isolation test voltage (AC / 50Hz /1min)		5000	Veff
V_{OP}	Permanent operating voltage		1700	V_{PEAK}
dv/dt	dv/dt immunity @ ΔV=1000V	75		KV/µs
T_A	Operating temperature	-40	+85	°C
T_S	Storing temperature	-40	+90	°C
I_{OC}	Max. current of default open collector		20	mA

2. ELECTRICAL SPECIFICATIONS

All data are given for 25°C unless otherwise specified.

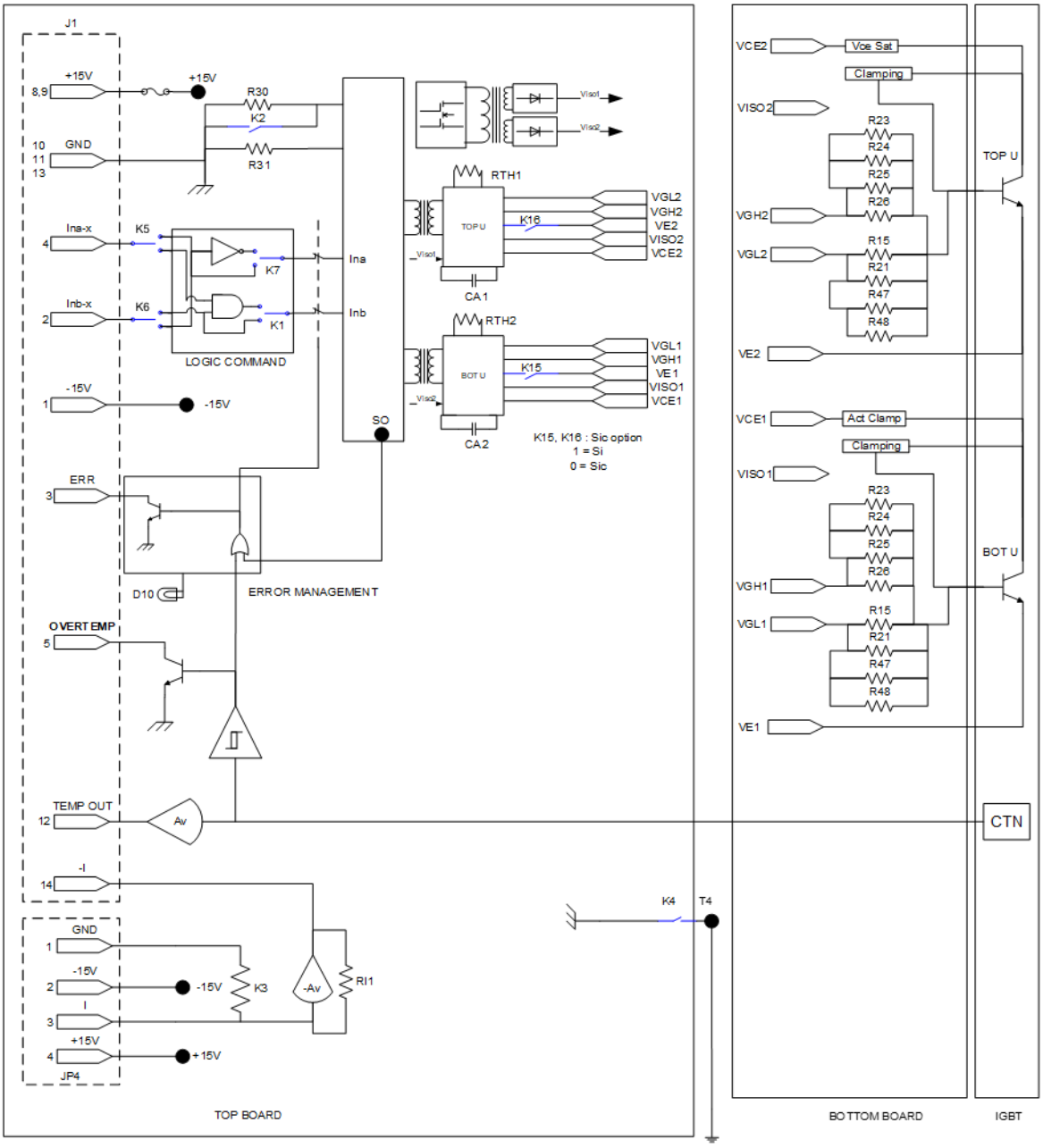
2.1. *Power supplies*

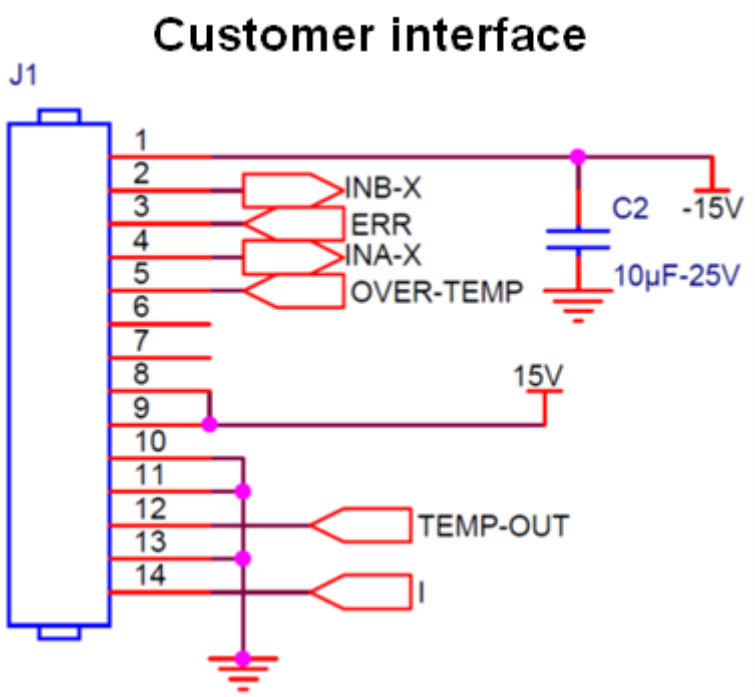
Symbol	Parameter	Min.	Typ.	Max.	Unit
V_{DD}	Rated supply voltage	14.5	15	15.5	V_{DC}

2.2. *Output stage*

Symbol	Parameter	Min.	Typ.	Max.	Unit
I_G	Maximum supply current	-35		+35	A
V_{G+}	Voltage for conduction setting (Si)		+15		V
	Voltage for conduction setting (Sic)		+18		V
V_{G-}	Cut off voltage (Si)		- 10		V
	Cut off voltage (Sic)		- 07		V
T_R	Rising time		20		ns
T_F	Downing tme		20		ns
T_{PD+}	Input/output propagation time at conduction setting		100		ns
T_{PD-}	Input/output propagation time at cut off		100		ns

3. BLOCK DIAGRAM





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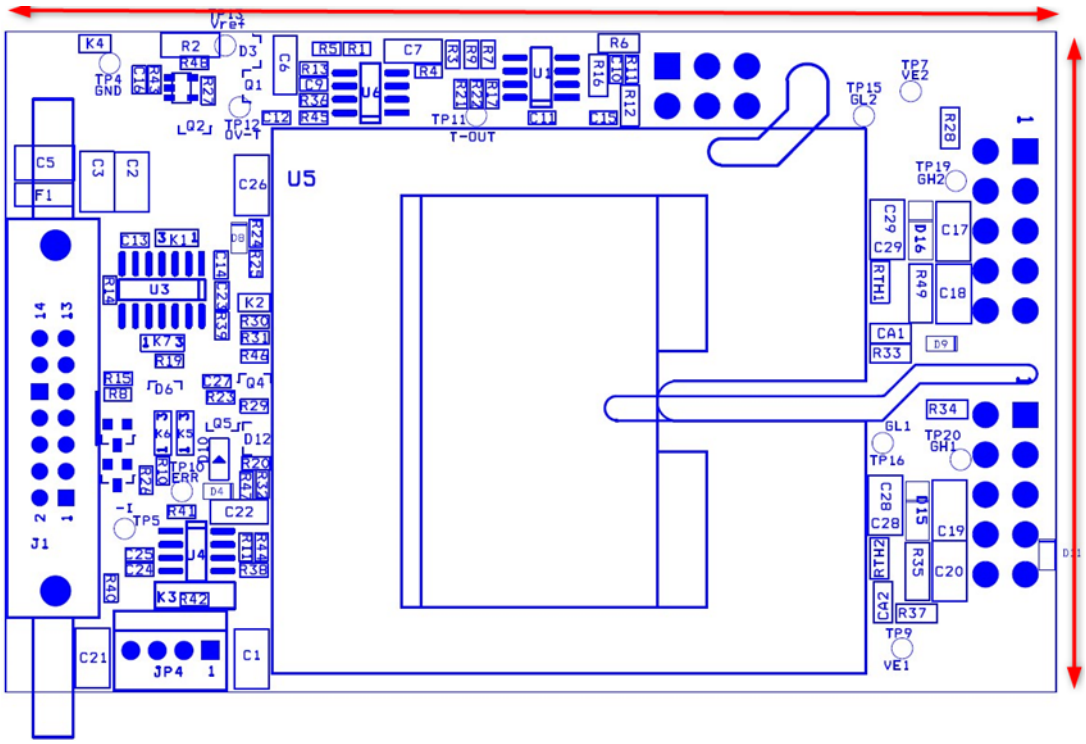
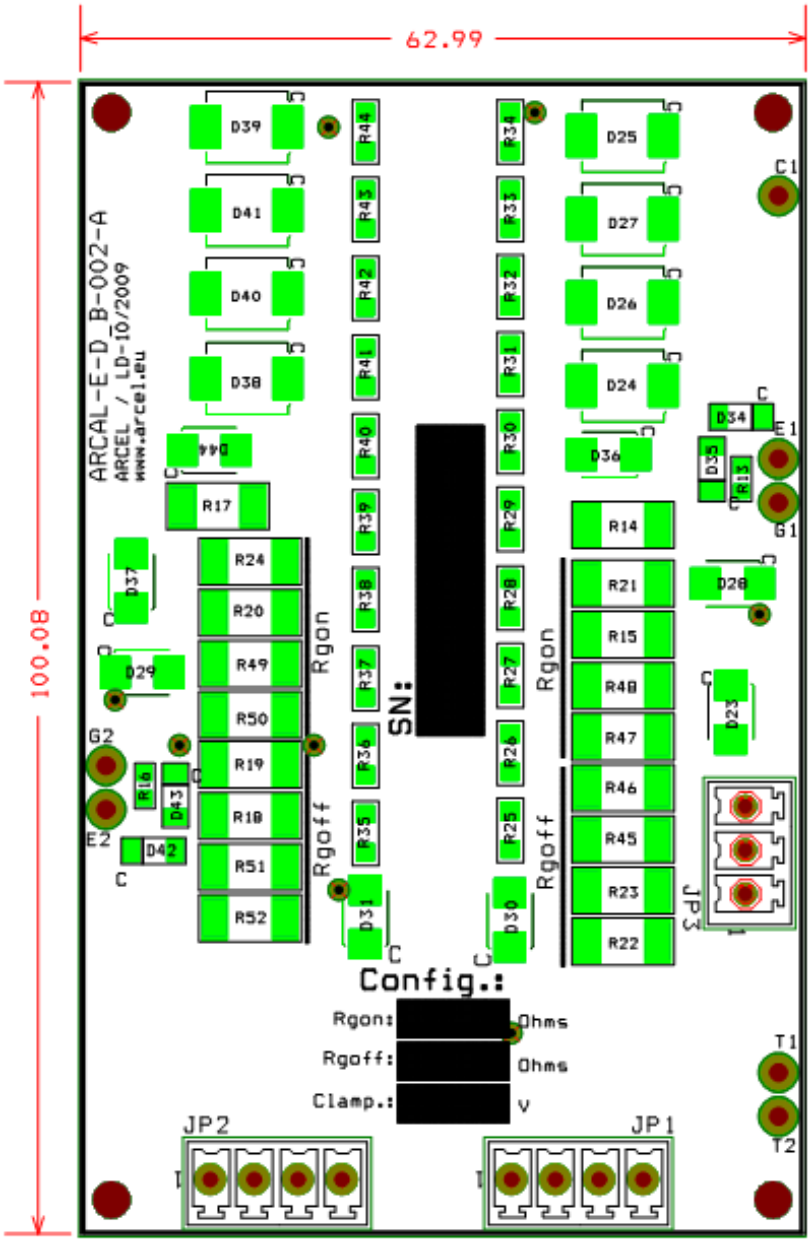
4. MECHANICAL DATA

100mm



TOP board view



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5. OVERVIEW

The ARCAL-ED driver is based on a SCALE-2 module (Scalable, Compact, All purpose, Low cost and Easy to use), last generation of IGBT drivers.

All the functionalities required for driving power switches **safely** are embedded on a single board. Each parameter depending on the application can be adjusted by the end user.

Main specifications

The ARCAL-ED driver allows to drive one ECONODUAL© module in a half bridge structure or in an independent way. This driver makes it possible to convert an ECONODUAL© 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 1200V in its standard version.

The IGBT is controlled in (-10 / +15V) in the standard version of the driver.

The IGBT protection is ensured by monitoring of 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.

All logic inputs are Schmitt trigger type.

The dead time values can be adjusted (on request).

The fault feedback signal, which is of type open collector, can be activated either by the driver itself (short-circuit or supply default), or by an external signal (temperature and current sensors).

The connectors have been selected for to their reliability and in order to rationalize the implementation of the driver in existing applications.

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.

6. DETAILED TECHNICAL DESCRIPTION

6.1. DRIVER POWER SUPPLY

The ARCAL-ED driver requires a regulated supply of +15V ±0.5V. The maximum power used under normal operating conditions is about 10W.

The current used at input can be calculated according to the following formula :

$$I_{DD}(A) \approx \frac{P_{GT}(W)}{0.85 \times 15} + 0.065$$

In which : PGT = 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.

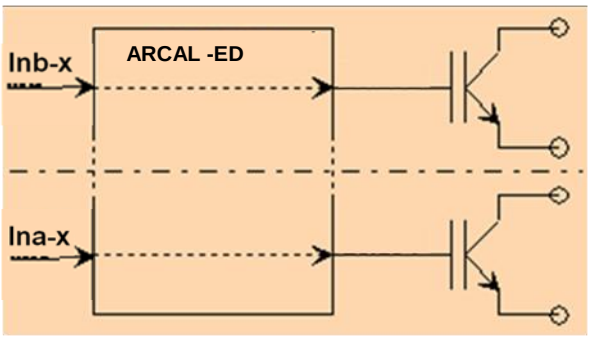
6.2. Operating modes (K2)

The ARCAL-ED driver can operate in three modes :

- "DIRECT" mode allows driving separately the two outputs.
- "HB" (half-bridge) mode is dedicated to "half-bridge" type systems
  HB modes can be generated in TOP-BOT or INA-INB controls

Direct Mode

In this mode, both outputs are driven separately by INA and INB inputs. Nevertheless, the various securities still stop both outputs and activate the error feedback signal. A high logic level on an input turns on the corresponding output.



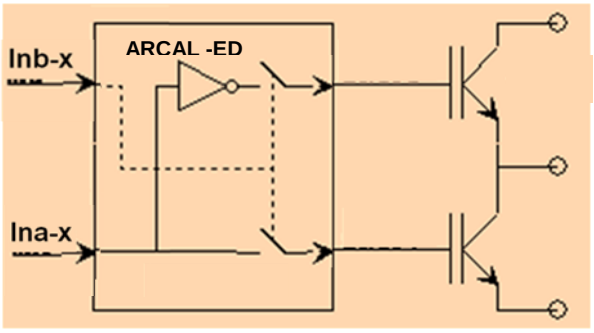
Considering the two outputs independent from one another, no dead time is generated. Thus, it is possible to switch on both outputs at the same time.

The configuration of the driver in DIRECT mode is done by short circuiting **K2**, and linking terminals 1-2 of **K1**.

HB Modes

The "HALF-BRIDGE" or "HB" mode is especially dedicated to structures where two IGBTs operate in series as complementary switches (eg. inverters, H bridges…)

In this case, both outputs are no longer independent : INA input allows the half-bridge control and INB input operates as an ‘’enable’’ signal.



Outline 2 : HB Mode (Half-bridge)

A low logic level on INB forces both outputs off, whatever INA level is.

When INB is at a high logic level, both output levels depend on INA.

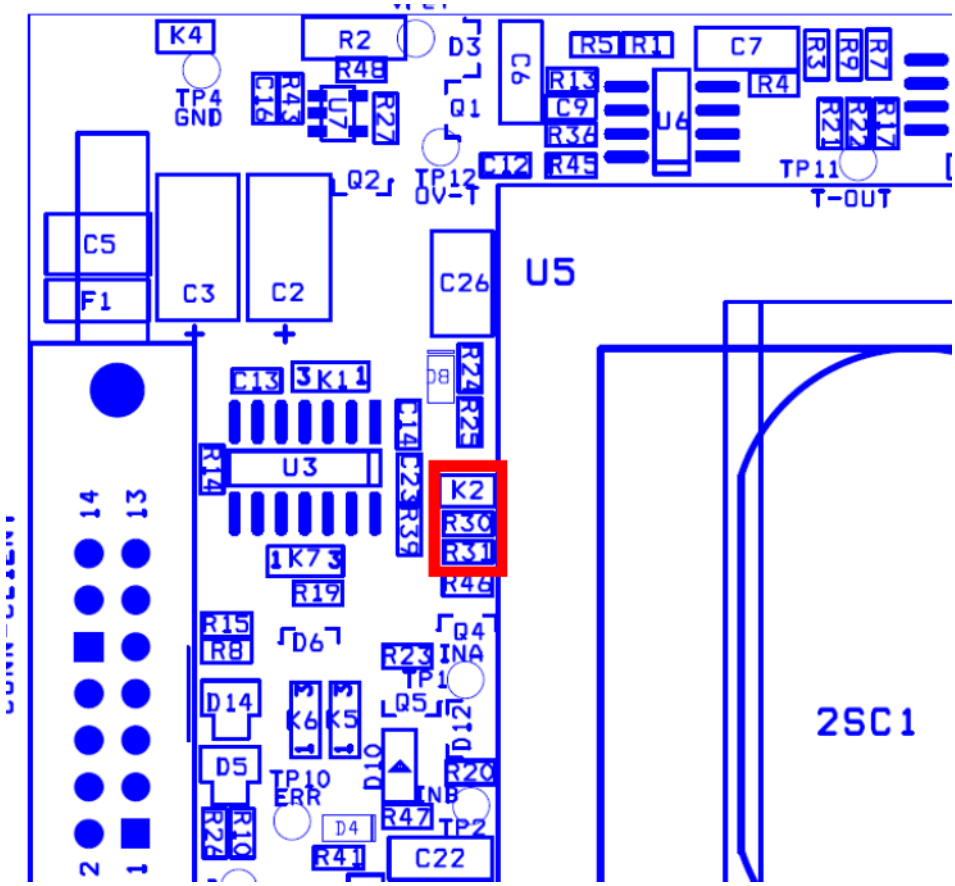
Because the two switches are in a series connection, for every arm state switching, the driver makes sure no transient short-circuit occurs by keeping the two outputs at a low level during a fixed period called *dead time*.

The user can modify the dead time value of both outputs thanks to R_M resistor. The standard dead time value is set to about 1.5µs.

The dead time setting is performed thanks to the following calculation :

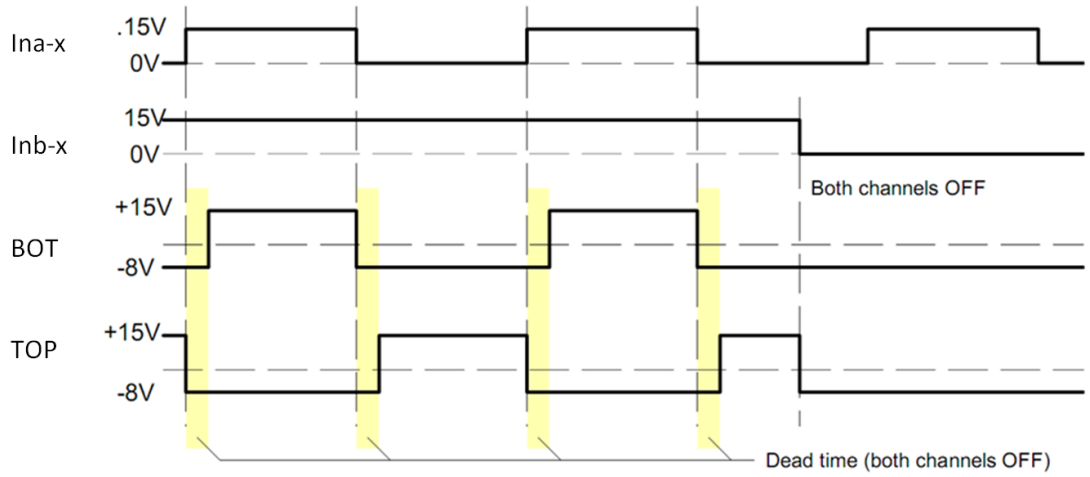
$$R_M = 31.5 \times T_D + 52.7$$

With 0.5µs < T_D < 4.1µs and 73<R_M<182kohms.



Location of K2, R30 (RM) and R31 (RB)

Standard configuration of HB mode. Ina controls the IGBT BOT. **K2** is open.

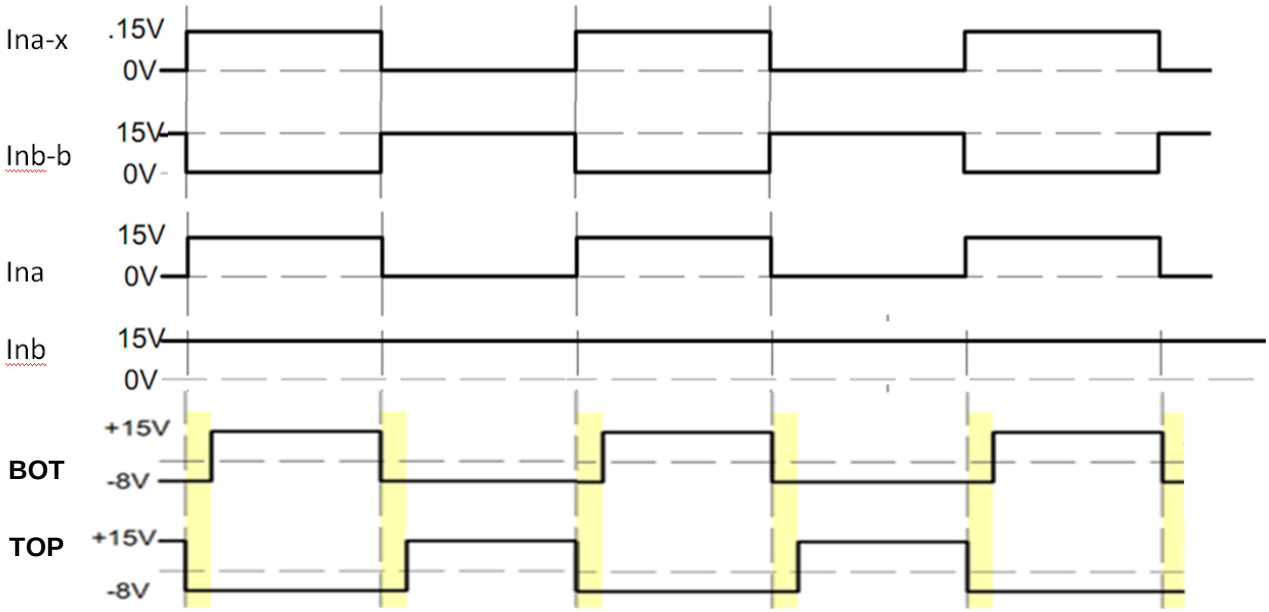


HB Mode

HB TOP-BOT mode or Ina-Inb

TOP-BOT mode allows to send complementary Ina-x et Inb-x signals, and to generate the on/off signal on Inb using these two signals. To achieve this, terminals 2 and 3 of **K1** must be linked.

Ina-Inb mode is used to send an on/off signal directly onto inb, using inb-x. In this case, terminals 1 and 2 of **K1** must be linked.



Signals in TOP-BOT mode

NOTA : Ina-x and Inb-x match with X3 output instructions and Ina and Inb match with the driver inputs.

Logical inputs

Ina and Inb inputs are equipped with Schmitt triggers whose tilting thresholds are about 1/3 and 2/3 of the selected logical level. Un A high logical level fits with an active input (positive logic).

The input stage of the driver includes protection diodes against negative voltages or against voltages higher than V_{DD}. If the voltages exceed these limits, an abnormal temperature rise and/or over-consumption could occur. Safe practice should be taken in case of use of the driver with large lengths of cable.

Under normal operating conditions the impedance of these outputs is about 22KΩ.

Selection of input signals

ARCAL-ED-003 driver board makes it possible to carry out the routing of Inax and Inbx control signals towards Ina and Inb input signals of the driver, depending on the customers' needs.

Each configuration range K1, K5, K6, K7 includes 3 zones numbered from 1 to 3, zone 2 being the central one. The two possible configurations are thus 1-2 or 2-3.

Operating mode	K7	K5	K6	K1
Direct mode : Inax drives TOP IGBT	1-2	1-2	2-3	1-2
Direct mode : Inax drives BOT IGBT	1-2	2-3	1-2	1-2
Direct mode : Inax drives both TOP and BOT IGBT	1-2	2-3	2-3	1-2
Direct mode : Inbx drives both TOP and BOT IGBT	1-2	1-2	1-2	1-2
HB TOP-BOT mode (STD)	1-2	2-3	1-2	2-3
HB INA-INB mode	1-2	2-3	1-2	1-2

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

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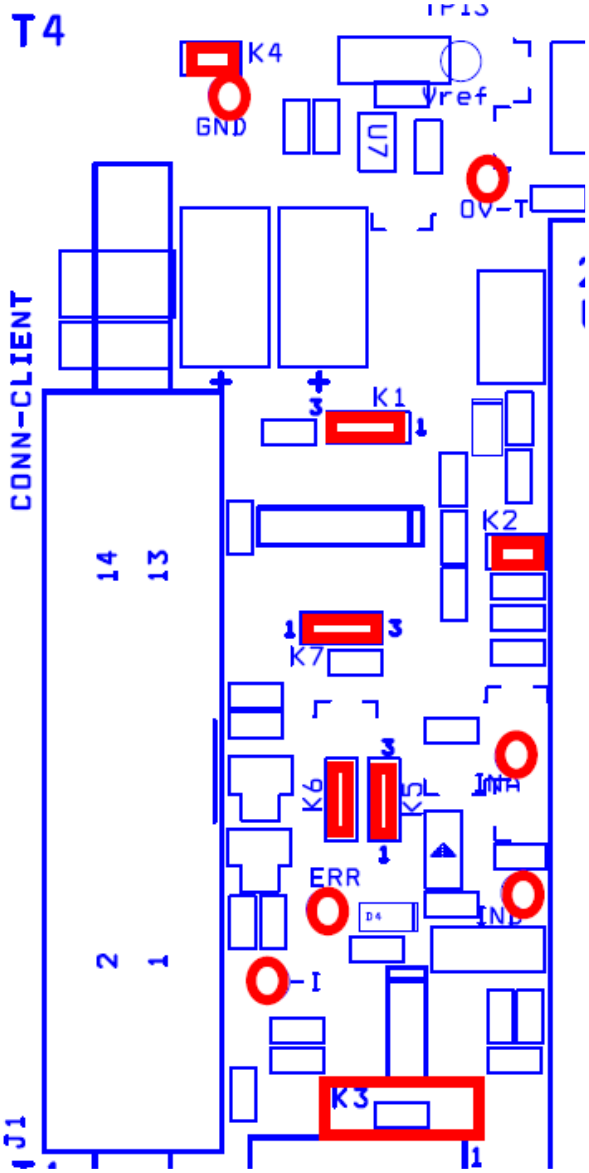

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6.3. Fault feedback signal

The fault feedback signal is open collector type. It can support a 40V voltage and a 20mA current. An external pull-up resistor must be provided.

In case of a default, **the output transistor is blocked** (high impedance). This is the standard operating mode because it will naturally take into account a bad connection of the fault wire to the main board.

The fault signal can be activated by two different events :

- **Internal error** : Output short-circuit or power supply problem has occurred.
- **External error** : the measure of temperature has exceeded the authorized reference level.

Internal error case

In case of an internal error, the fault feedback signal will be activated during a fixed period of about 100ms (T_B). The driver will automatically re-set and the outputs will stay in off-state for at least 100ms (T_B). As a matter of fact, T_B is used both as signaling time and blocking time.

The main control system is supposed to stop all driving pulses as soon as an error signal occurs. If not, and after the fault feedback signal has been reset, short pulses (about 10µs) can occur on the non-fault output. The error feedback will then be set again by a pulse of 100 ms, etc... This will go on until the fault cause has disappeared or driving pulses have been stopped.

Remark 1 :

After the pulse blocking time, the driver will start over again only on a rising edge of the concerned Inx input (or In_A in HB mode).

Remark 2 :

The short-circuit measuring device is optimized for protection during arm short-circuit, thus a very low inductance. For short-circuits with a larger inductance, protection should be performed with a traditional measurement of the current using a current sensor.

External error case

If the measure reveals an excessive temperature, default processing will be the same as in the case of internal error. The potential of terminal 3 of HE14 J1 connector is returned to “0” to indicate the error.

Setting of T_B blocking time

The blocking time of the driver on launching of the fault can be adjusted by the final user.

The blocking time is included between 20ms < T_B < 130ms.

To perform the setting, a resistor is connected on pin 5 of the driver such as :

$R_B = 1*T_B + 51$ with R_B in kohms and T_B in ms.

In standard configuration, a 180kohms resistor is implemented, setting a 130ms blocking time.

Driver switching on

By switching on, a fault feedback signal (about 10 ms) is automatically generated in order to allow the auxiliary power supplies to settle.

6.4. Gate control

The standard version of ARCAL-ED provides a +15V/-10V gate voltage. For each output, conduction and extinction of the IGBT are controlled by a grid resistor : **Rg**.

Peak current

The peak current value provided by the driver depends on the total resistance of the Gate / emitter loop. The value is given by the calculation of the following formula :

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

In which : ΔV_{GE} is the variation of the gate voltage (25V in this case).

As the I_{Gp} current mustn’t exceed 35A, the theoretical low limit for R_G is 0.71Ω.

Average power

The average power P_G supplied by a driver output depends on the total gate charge Q_G of the component, on the variation of gate voltage ΔV_{GE} and on the switching frequency F_{SW} (SI units) :

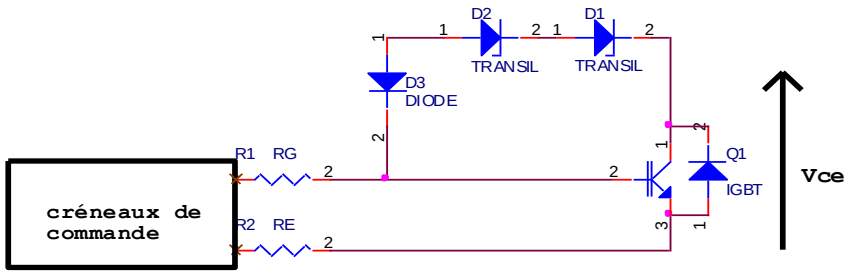
$$P_G = Q_G \times \Delta V_{GE} \times F_{SW}$$

This power must never exceed 4W (with 85°C ; 6W with 70°C).

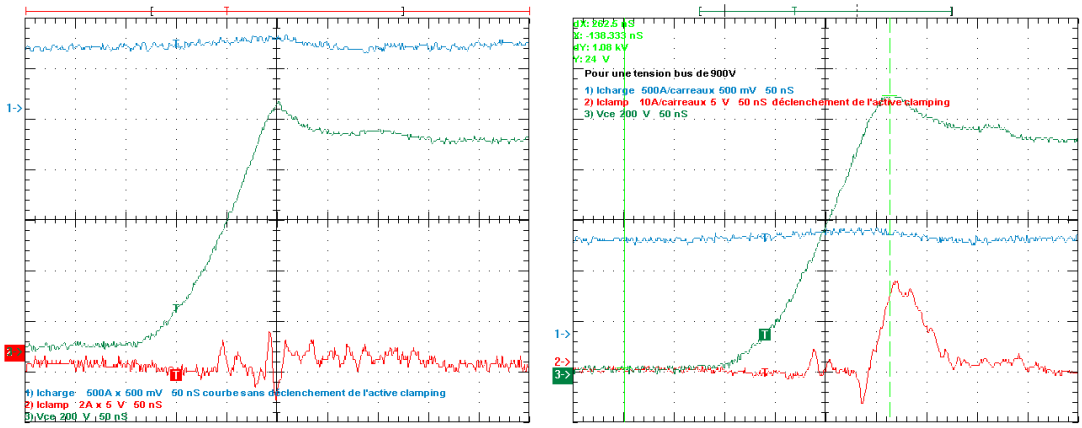
6.5. 'Active clamping' protection

This protection aims to limit the emitter collector overvoltage at the opening of the semi-conductor. 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 the voltage 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. It clearly shows 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).

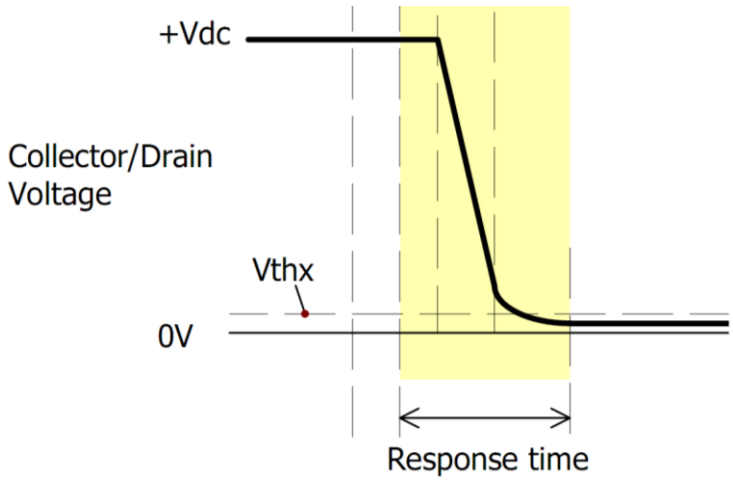
This device enables to limit the overvoltage at the opening to a value close to 1100 volts (according to the dispersion of the components and the energy that has to be dissipated, the clipping voltage varies from 1020 to 1100 volts).

6.6. 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 relevant 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 inhibited during a fixed TCE period. Once this period is over, the detection threshold is equal to V_{TH}.



For each output, the VCEsat threshold detection is set by a resistor (R_{TH1} and R_{TH2}).

The following table gives some values of the VCEsat detection paramaters according to the R_{th} resistor used. The standard value of implemented R_{TH} is 29.4k, i.e. a detection threshold of 4.4V. To obtain a reference voltage over 4.4V, R_{HT1} and R_{HT2} values will have to be modified. In standard, CA = 47pF, which gives a response time of 5µs.

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

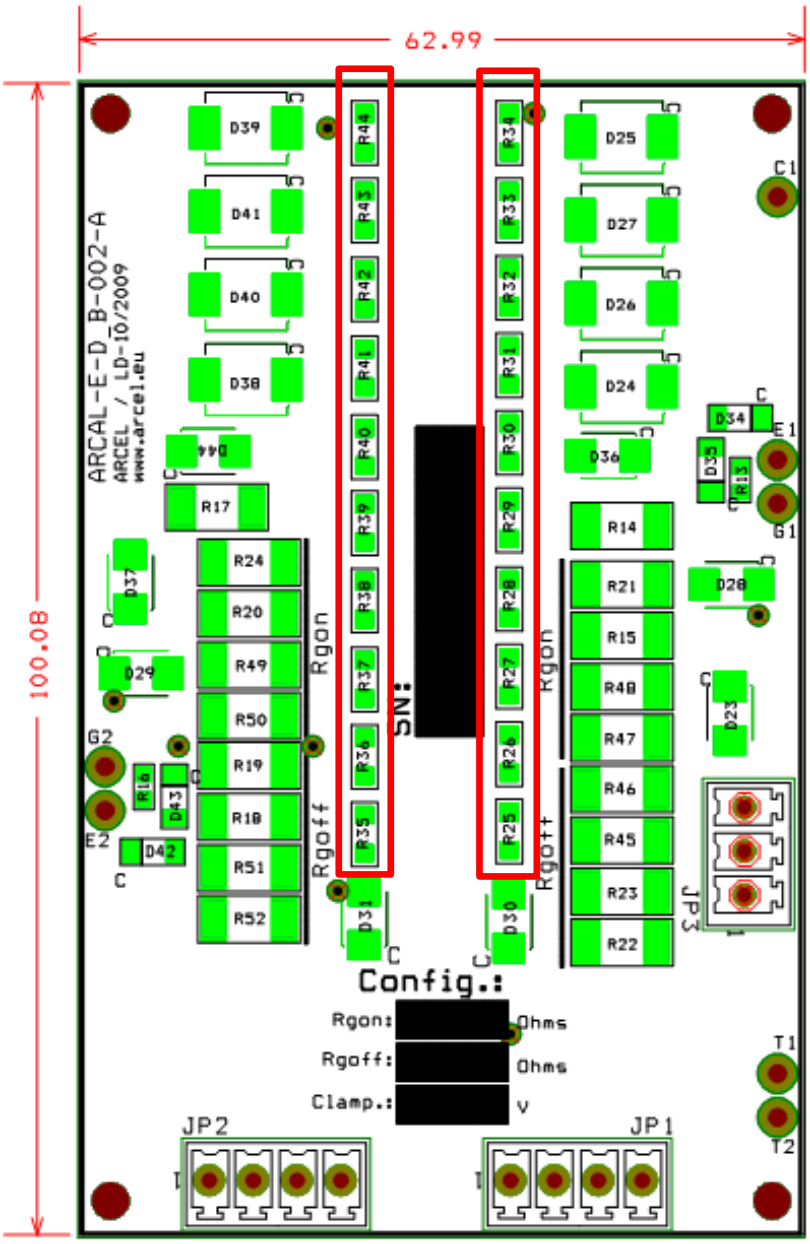
Table 1 : RTH selection for VCEsat detection parameters

Remark 1 : this protection is particularly efficient for so called « frank » short-circuits or low impedance. It isn't reliable in case of « slow » defaults.

Remark 2 : the given response time depends on the bus voltage. It increases if the bus voltage is < 540V, and decreases if bus voltage > 540V.

Fault detection is done by measuring V_{CE} and comparing it to Vref. The measurement of V_{CE} requires an incoming current between 0.6 and 1mA, that's the reason why the R_{VCE} resistor may be adjusted according to the BUS voltage :

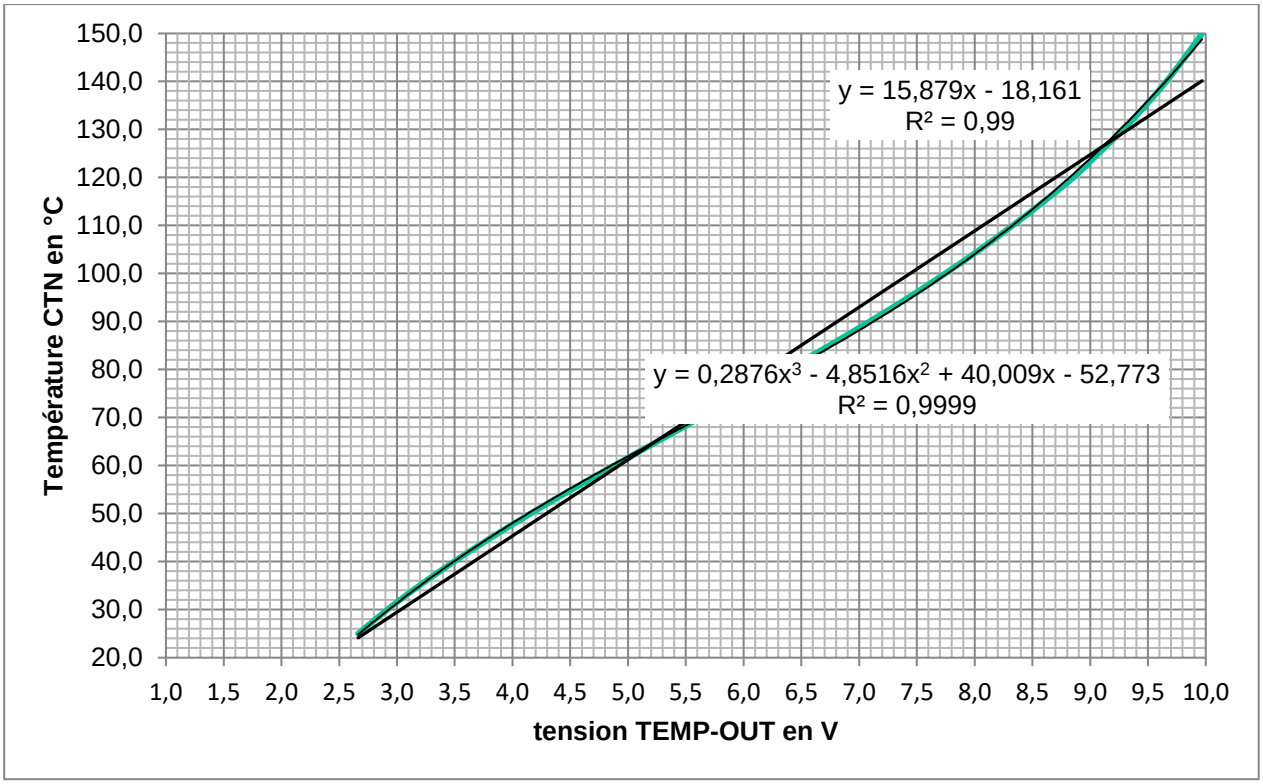
R_{VCE}	Ubus
Fault (8*100k)	**480 – 800 V**
9*100k	540 – 900 V
10*100k	600 – 1000 V
4*100k	240 – 400 V (IGBT 600V)



Resistors for setting the measuring current. Rgon and Rgoff are also shown for each channel.

6.7. Measure of temperature

A CTN is included in the EconoDual housing. The board includes a linearization of this CTN in the useful operating area as well as an isolation amplifier. The temperature information is available on pin 12 of HE14 J1 connector.



Outline 5 : This shows the voltage available on pin 12 depending on CTN temperature

If the CTN temperature exceeds 115°C, the OVER-TEMP signal available on output 5 of HE14 connector will be returned to 0V, via the collector of the output transistor.

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6.8. Measure of current

It is possible to connect a current sensor on JP4 connector. In order to have JP4 operated, it is essential to supply HE14 input connector with -15 volts voltage on pin 1. In the standard version, K0 grid resistor is 10 Ohms 1% and can be modified thanks to K3 plot whose terminals can be equipped with a parallel. The voltage gain on the output stage is -4.87. The output voltage on pin 14 will thus be equal to :

$$V\ (pin\ 14) = -\ I\_sensor \times 10 \times 4.87$$

In the standard configuration, –I is sent back to pin 14 because of the implementation of the sensor in the stack assembly.

6.9. Monitoring of auxiliary supplies

Monitoring of the supplies values is done directly on each output channel. If one of the two secondary supplies is below 12V, the relevant channel is blocked and the default signal is activated.

As the detection system is with hysteresis, re-start is only possible once the voltage rises over about 12.6 V.

7. OPTION : SIC MODULES CONTROL

Sic MOSFETS can be driven owing to this driver. A voltage offset system makes it possible to modify Vgon and Vgoff applied on the gate of the Sic component.

The Sic version of the driver must be controlled with a configurated TOP board, item code : **043081**. However, you will find hereafter the explanations regarding the differences which are applied to this version.

Strapps K15 and K16 are open to separate the driver VEs from the module VEs.

A voltage shift is achieved with a zener/resistor set. This implies that the value of the filter capacity of the output voltages is lower and goes from 33µF to 22µF. Under these conditions, the maximum possible gate load is thus 10µC.

8. STANDARD CONFIGURATION : ABSTRACT TABLE

STRAPP	Standard configuration	Remarks
K1	2-3	TOP-BOT
K2	CO ou 22nF	MODE HB
K3	10 Ohms	Measure of current
K4	CO	Ungrounded floorplan
K5	2-3	Ina = Inax
K6	1-2	Inb = Inbx
K7	1-2	No inversion of Inax
K15 to K16	CC	Sic Option
Clipping	1040V	Approximate clipping voltage
Dead time	4.µs	Dead time
Vce sat	4.4V	Short-circuit threshold

.

With : CC = Court Circuit (short circuit)

CO = Circuit ouvert (Open circuit

Parameter	Resistor
T_{DT}	R30
T_B	R31
I_{VCE}	R_{VCE} (R25 to R34 and R35 to R44)

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9. NOTES

Before printing think about **environment** and **costs!**

CAUTION : ARCEL reserves the right to modify its technical documents without prior notice. These documents have no contractual value.

[i] The system is protected by zener and bipolar diodes. Exceeding these values can therefore lead to over heating and/or over consumption. Special care should be taken in case of use with large lengths of cable.

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