
ARCAL 2108



Dual IGBTs and MOSFETs Driver "SCALE-2 TECHNOLOGY"

The ARCAL2108 board is an intelligent double IGBTs and MOSFETs driver.

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

- **High isolation and dv/dt immunity**
- **1W / $\pm 8A$ per output**
- **Short-circuit protection**
- **Power supply monitoring**
- **high or low logic error feedback**
- **CMOS or HCMOS input level**
- **Tuneable dead time**
- **-8/+15Vⁱ Gate voltage**
- **Active clamping protection**



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1. ABSOLUTE MAXIMUM RATINGS

All data refer to 25°C and V_{DD}=15V unless otherwise specified.

Symbol	Parameter	Min.	Max.	Unit
V _{DD}	Supply voltage (referred to ground) ⁱⁱ	0	16	VDC
V _I	Logic input voltage	0	V _{DD}	VDC
I _G	Peak Gate current	-8	+8	A
P _G	Output power for each channel ⁱⁱⁱ		1	W
V _{ISO}	Isolation test voltage (AC / 50Hz / 1min)		4000	V _{eff}
V _{OP}	Operating voltage ^{iv}		1500	V _{PEAK}
dv/dt	dv/dt immunity @ ΔV=1000V	75		KV/μs
T _A	Operating temperature	-20	+85	°C
T _S	Storage temperature	-40	+90	°C
V _{OC}	Error feedback open collector max. voltage		40	V
I _{OC}	Error feedback open collector max. current		20	mA

2. ELECTRICAL SPECIFICATIONS

All data refer to 25°C and V_{DD}=15V unless otherwise specified.

2.1. Power Supplies

Symbol	Parameter	Min.	Typ.	Max.	Unit
V _{DD}	Nominal supply voltage	14.5	15	15.5	VDC
I _{DD0}	No-load max. supply current ^v		35		mA
V _{TH0}	power supply monitoring threshold voltage ^{vi}				
	Secondary side:				
	Set fault	11.5	12	12.5	V
	Clear fault	12.1	12.6	13.1	V
V _{TH0}	Primary side:				
	Set Fault	11.3	12	12.7	V
	Clear fault	11.9	12.6	13.3	V
H	Power supply monitoring hysteresis ⁷	0.35			V

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2.2. Input stage

Symbol	Parameter	Min.	Typ.	Max.	Unit
V _{IM}	Max. logic input voltage ²	0		V _{DD}	V _{DC}
V _{IT+}	Low to High input threshold voltage		9		V
V _{IT-}	High to Low input threshold voltage		6		V
F _{SW}	Switching frequency ^{vii}	0		50	KHz
α	Duty cycle	0		100	%
R _{IN}	Input resistance ^{viii}		22		K Ω
T _{DT}	Standard dead time ^{ix}	0.5	3.8	3.8	μ s

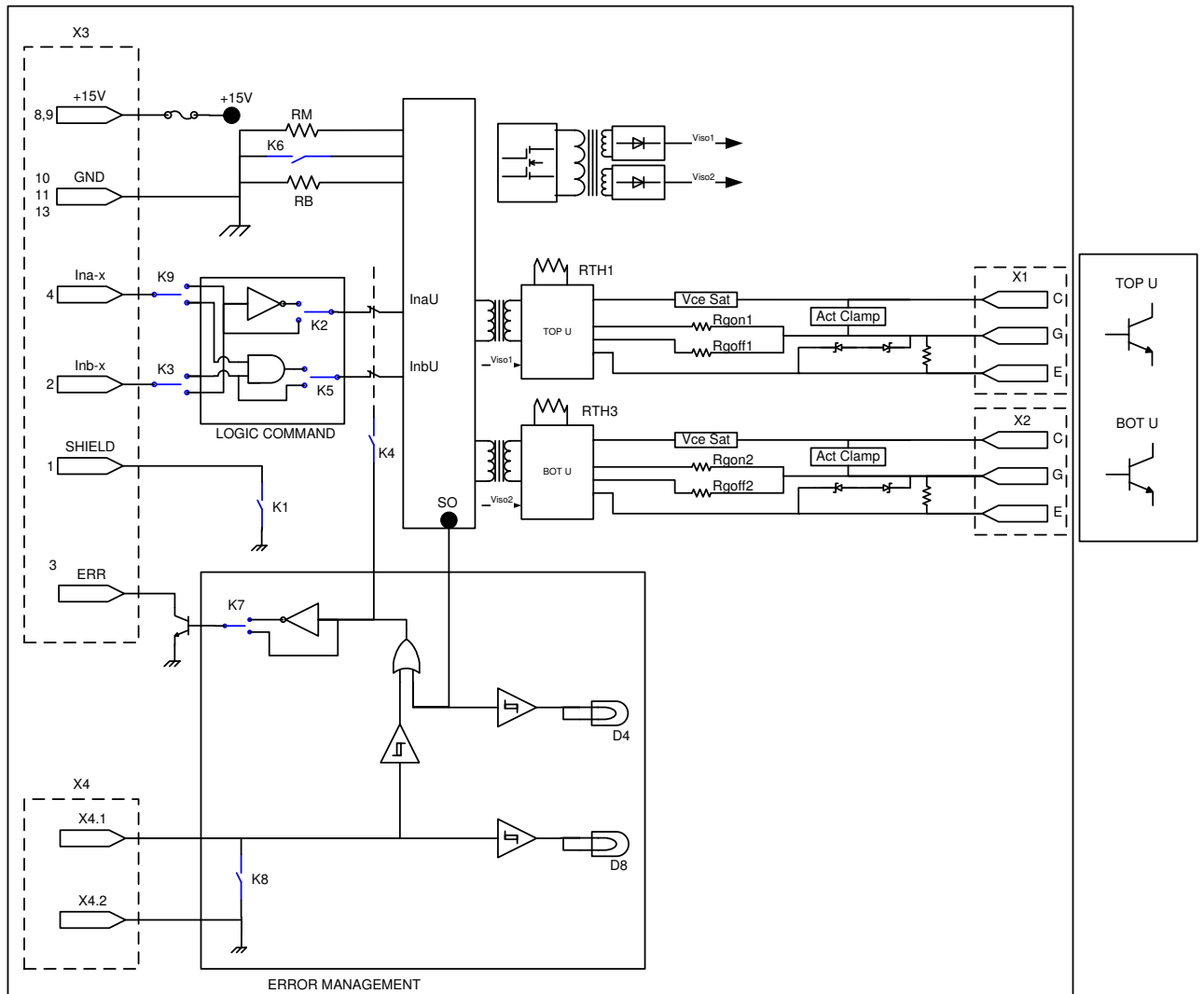
2.3. Output stage

Symbol	Parameter	Min.	Typ.	Max.	Unit
I _G	Max. gate current	-8		+8	A
V _{G+}	Turn-on gate output voltage		+15		V
V _{G-}	Turn-off gate output voltage ¹		-8		V
T _R	Rise time ^x		17		ns
T _F	Fall time ^x		15		ns
T _{PD+}	Input / output turn-on delay time		150		ns
T _{PD-}	Input / output turn-off delay time		140		ns
T _B	Blocking time after failure	20	130	130	ms
T _{ER}	fault feedback duration		10		ms
T _{CE}	VCE monitoring reaction time ^{ix}		360		μ s
V _{THX}	VCE monitoring threshold voltage		6.45		V

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3. BLOCK DIAGRAM



X1,X2 : MOLEX 41791

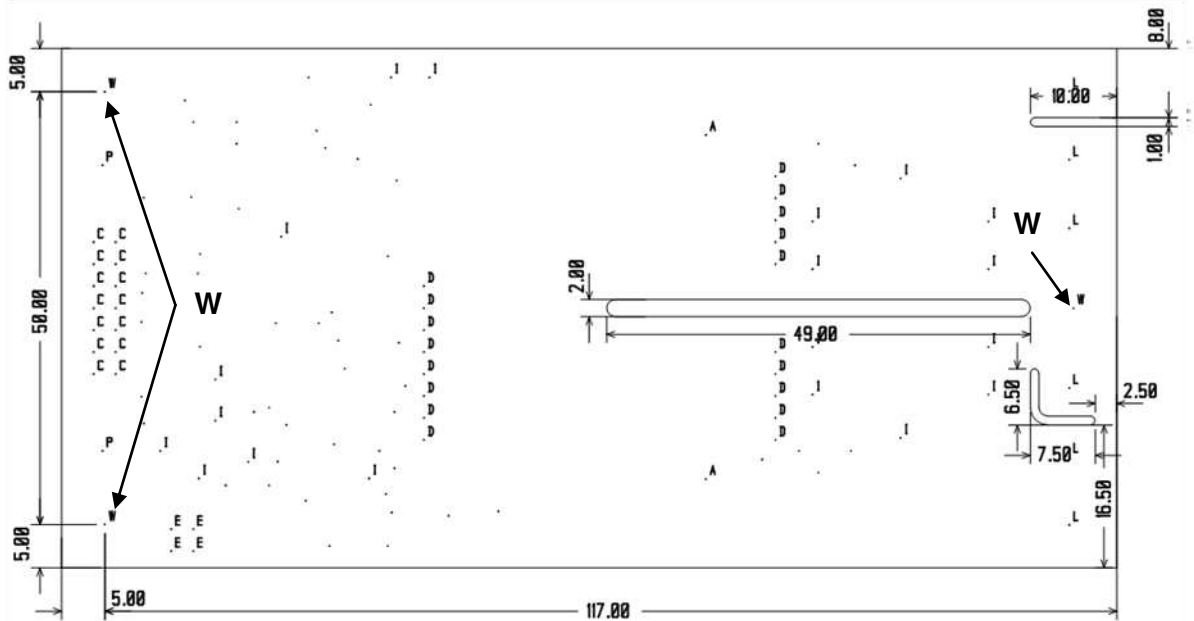
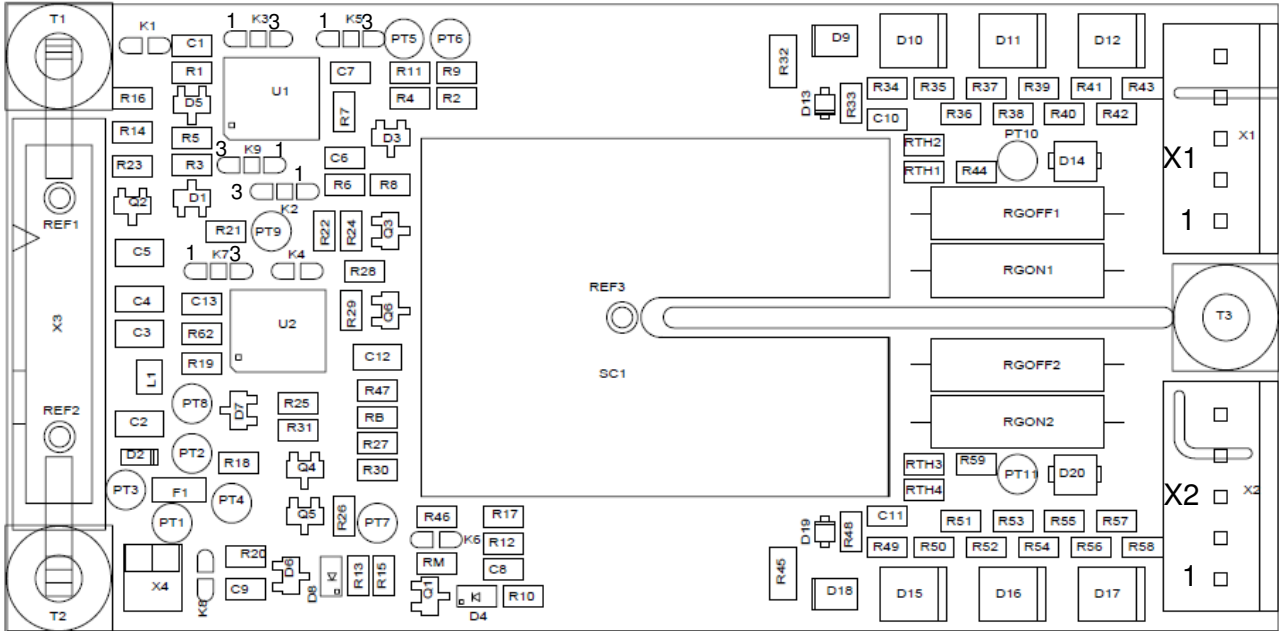
X3 : 14-DIN41651

X4 : Phoenix Contact NPT0.5/2-2.54 (screwed)^{xi}

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4. MECHANICAL DATA



Diameter of W fixing holes (2 on the left, 1 on the right): 4mm.

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5. OVERVIEW

ARCAL21086 driver is based on SCALE-2 (Scaleable, Compact, All purpose, Low cost and Easy to use) module, last driver generation.

All the necessary functions for a **safe** IGBTs control are embedded on a single board. Each parameter depending on the application can be adjusted by the end user.

Main characteristics

ARCAL2108 driver allows 2 IGBTs driving as a half-bridge or as two independent switches. ARCAL2108 drives all IGBTs with VCE up to 1200V. On demand, the ARCAL 2108 can drive 600V and 1700V IGBTs.

If a single IGBT is used, terminals C and E of the unused output must be shorted.

IGBTs gate voltage is -8/+15V in standard version.

IGBTs protection is ensured by Vcesat (VDson) and secondary side power supplies monitoring.

A single +15V \pm 0.5V supply is required. Required isolated power supplies are generated.

All logic inputs are Schmitt trigger type.

The dead time output can be tuned independently.

The error feedback signal can be activated by the driver (short-circuit or under voltage) or by an external signal.

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

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6.DETAILED DESCRIPTION

6.1 Driver supplies

ARCAL2108 driver needs a regulated +15V ±0.5V DC supply voltage. The maximum power consumption is about 2.9W.

The input supply current can be approximated by the following formula :

$$I_{DD} (A) \approx \frac{P_{GT} (W)}{0.85 \times 15} + 0.035$$

Where : P_{GT} = total power provided to IGBTs by the driver.

Remark:

Due to high power pulses required in applications which this drive is dedicated to, the DC/DC converters are not protected against overload. However, the short-circuits row up are limited by a fuse.

6.2 Shielding (K1)

If a shielded cable is used, it can be connected to pin X3.1 and coupled to the board ground by a short-circuit on **K1**.

6.3 Operating Modes (K2, K3, K5, K6, K9)

ARCAL2106 driver can operate on three modes :

- "DIRECT" mode allows driving separately the two outputs.
Caution : Ina input drives X2 output, Inb input drives X1 output.
- 2 "HB" (half-bridge) modes dedicated to "half-bridge" type systems :
 - HB TOP-BOT mode
 - Ina-x and inb-x are two complementary signals without dead time
 - Ina-x is the basis to generate X1 and X2 signals with dead times. Ina-x and Inb-x are associated to generate the inb on/off signal

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- HB INA-INB mode
 - Ina-x is the control signal, the driver creating X1 and X2 signals by generating dead times.
 - Inb is the on/off signal. If Inb = 0V, then the two X1 and X2 outputs will be at -8V.

Choice of inputs

K3 and K9 configuration strapps enable to direct Ina-x and Inb-x towards X1 or X2 (Ina or Inb).

	K 3	K9
1-2	<u>Inb-x = Inb</u>	Inb-x = Ina
2-3	Inb-x=Ina	<u>Ina-x = Ina</u>

The standard configuration is the one which is underlined.

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, no dead time is generated. Thus, it is possible to switch on both outputs at the same time.

The different mode configurations are reported in the table.

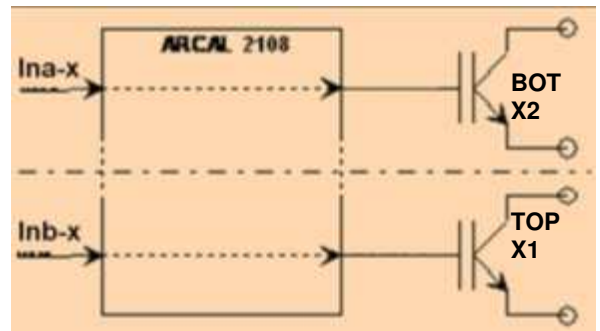


Figure 1 : Direct mode

HB Modes

Half-bridge mode is especially dedicated to structures where two IGBTs operate in series as complementary switches (eg. inverters, H bridges...).

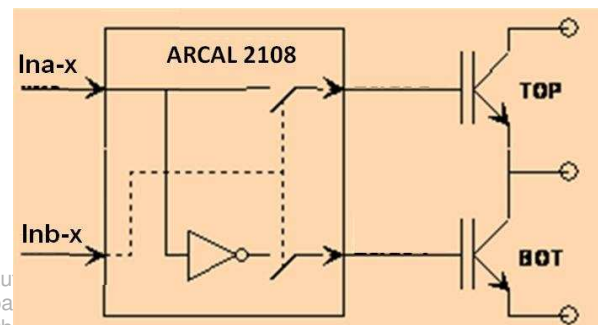


Figure 2 : HB mode

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In this case, both outputs are not independent anymore: InA input allows the half-bridge control and InB output operates as an "enable" signal.

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 final user can modify the dead time value of both outputs thanks to a R_M resistor. The standard dead time value is set about $3.8\mu s$

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

$$R_M = \frac{(33 \times T_D + 56.4) \times 182}{182 - (33 \times T_D + 56.4)}$$

With $0.5\mu s < T_D < 3.8\mu s$ and $0.67k < R_M < 122k\Omega$. If $R_M = 0$, $T_D = 3.8\mu s$

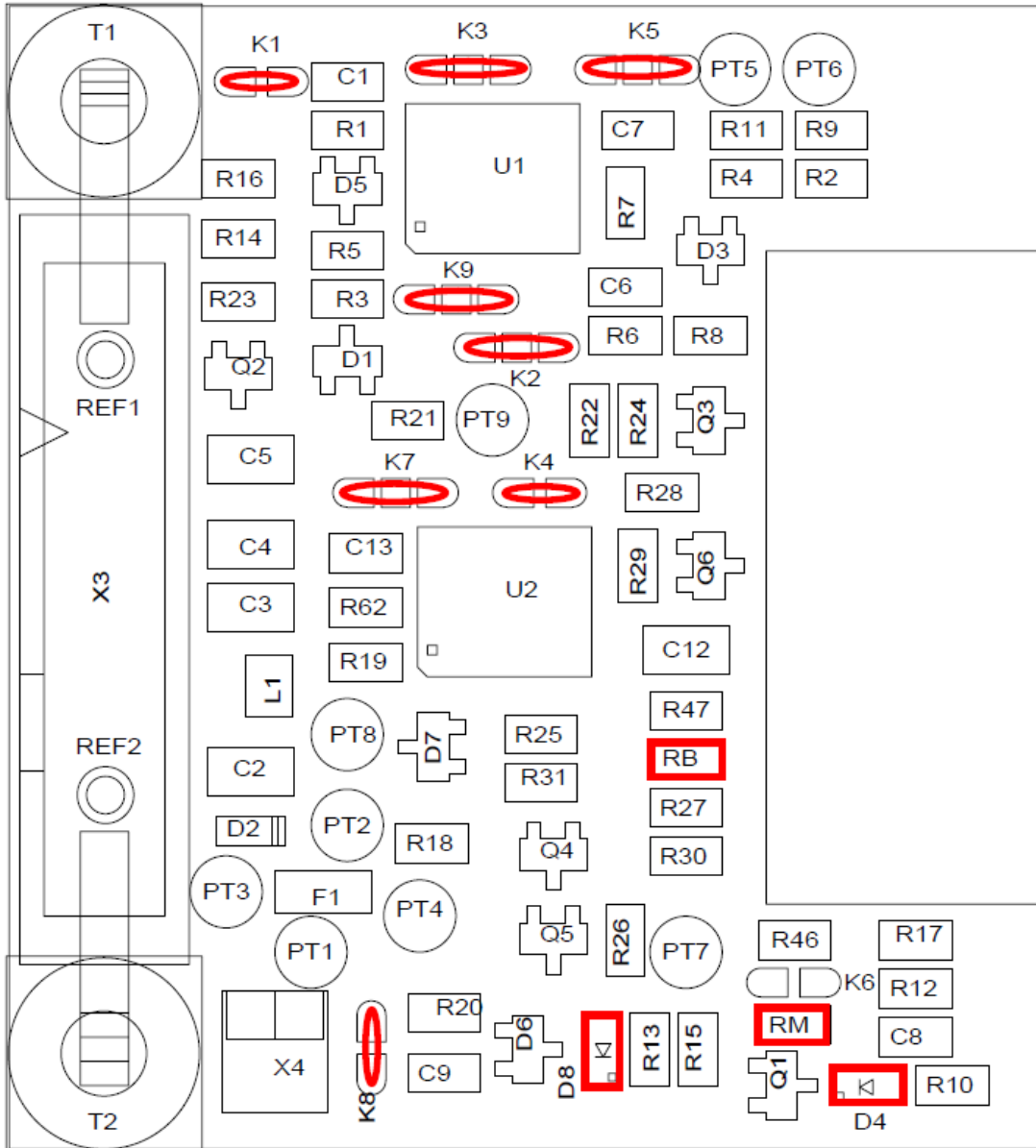
Here is a table introducing some remarkable values of T_{DT} depending on R_M :

R_M Value (kohm)	T_{DT} Value (μs)
0	3.8
1063	3
587	2.5
374	2
253	1.5
176	1
122	0.5

NB: The initial formula was $R_M = 33 \cdot T_{DT} + 56.4$ with $73 < R_M < 182k\Omega$. In standard configuration, a $182k\Omega$ resistor is already connected on the board ($T_{DT}=3.8\mu s$), another resistor in parallel is implemented to modify the dead time value.

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Overview of the main setting points and LED fault signals

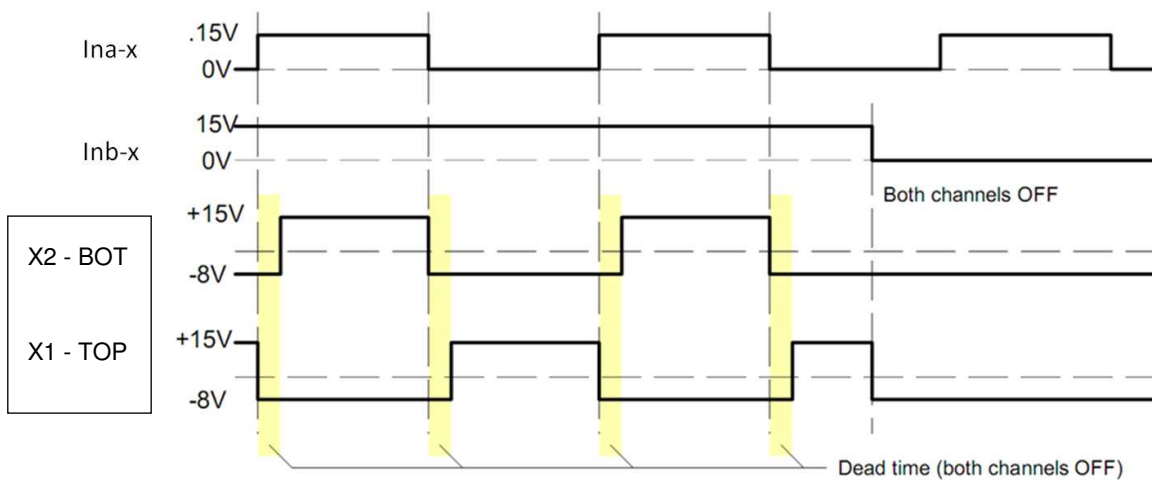
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Selection of HB INA-INB modes

Standard configuration is ARCAL 2106 type HB mode. Ina controls X1. Pins 1-2 of **K2** and 2-3 of **K5** are short-circuited.

Ina-x represents the controlling signal and Inb-x the on/off signal



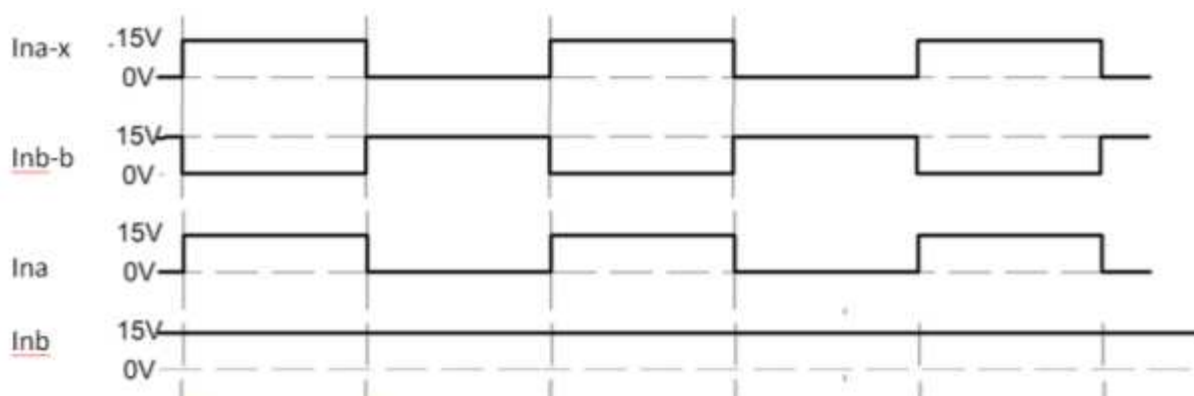
HB Mode, ACAL2106 Type

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HB TOP-BOT Mode

The TOP-BOT mode enables to send complementary signals Ina-x and Inb-x, in order to generate the “start/stop” signal on Inb channel from these two signals. In order to achieve this, pins 2 and 3 of K5 must be linked.



Signals with TOP-BOT configuration

Remark : Ina-x and Inb-x are X3 output instructions ; Ina and Inb are the driver inputs.

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6.4 Fault feedback signal (K7)

The fault feedback signal is open collector type. It can support a 0.7V voltage and a 20mA current. An external pull-up resistor must be provided.

K7 allows selecting the fault mode:

- **Low logic** : pins 1 and 2 are linked. In this case, a fault will close the output transistor (it will sink current).
- **High logic** : pins 2 and 3 are linked. In this case, a fault will open the output transistor (it stops sinking current). This is the fault mode of the driver. We recommend using this 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** : a short-circuit on an output or a supply problem has occurred.
- **External error** : X4 input is high impedance. This input can be used to connect an external element such as a bimetal thermal trip for the heatsink over-temperature monitoring or for any other problem which would require the driver to stop immediately.

Internal error case

In the internal error case, the fault feedback signal will be activated during about 10ms. The driver will automatically reset and the outputs will stay in off-state during approximately 130ms (T_B).

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 10 μ s) can occur on the non-fault output. The error feedback will then be set again by a pulse of 130 ms, etc... This will go on until the fault cause has disappeared or driving pulses have been stopped.

Remark:

After the blocking time, the driver will start over only on a rising edge of the concerned input (or I_{nA} in HB mode).



External error case (X4)

The **X4** connector can receive a dry contact or an open collector signal. The permanent current through this contact is about 150µA with a 30mA peak corresponding to a capacitor discharge.

An open circuit (or high impedance) will be considered as a fault by the driver. The fault feedback will be activated until the circuit is closed and will remain active for about 10ms after.

If this input is not used, it is necessary to short-circuit the 2 **X4** pins by linking them to **K8**.

Both outputs are forced to off-state during the whole fault feedback duration and the driver will start over only on a rising edge of Inx inputs (InA in HB mode).

T_B Blocking time selection

The blocking time of the driver on launching of the fault is adjustable by the final user.

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

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

$$R_B = 1 \cdot T_B + 51 \quad \text{with } R_B \text{ in kohms and } T_B \text{ in ms.}$$

In standard configuration, a 181 kohm resistor is implemented, setting a 130ms blocking time. A parallel resistor can be implemented by the final user to adjust this value.

R _B	T _B
Standard	130ms
1000k	102ms
360k	70ms
240k	52ms
180k	40ms
120k	21ms

Power on

When powering, a fault feedback signal is automatically activated for about 130ms in order to allow the auxiliary power supplies to stabilize.

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6.5 Gate control

The standard version of ARCAL2108 provides a +15V/-8V gate voltage. On request, a 0/15V version can be provided.

For each output, a gate resistor must be mounted on the corresponding pins (Rgon1 and Rgon2, Rgoff1 and Rgoff2). The resistor value depends on the IGBT manufacturer's recommendations and on the application.

Peak current (RG1, RG2)

The peak gate current depends on the total impedance of the gate loop. it can be estimated by the following formula :

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

where : ΔV_{GE} is the gate voltage variation (here 23V).

The IGP current must never exceed 8A. Thus, the theoretic lower RG resistor value is 2.9 Ω .

Average power

The average power PG supplied by a driver output depends on the total gate charge QG of the component, the ΔV_{GE} gate voltage and the Fsw switching frequency (SI units) :

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

This power must never exceed 1W with 85°C ambient temperature.

If higher power is required, refer to ARCAL2315..

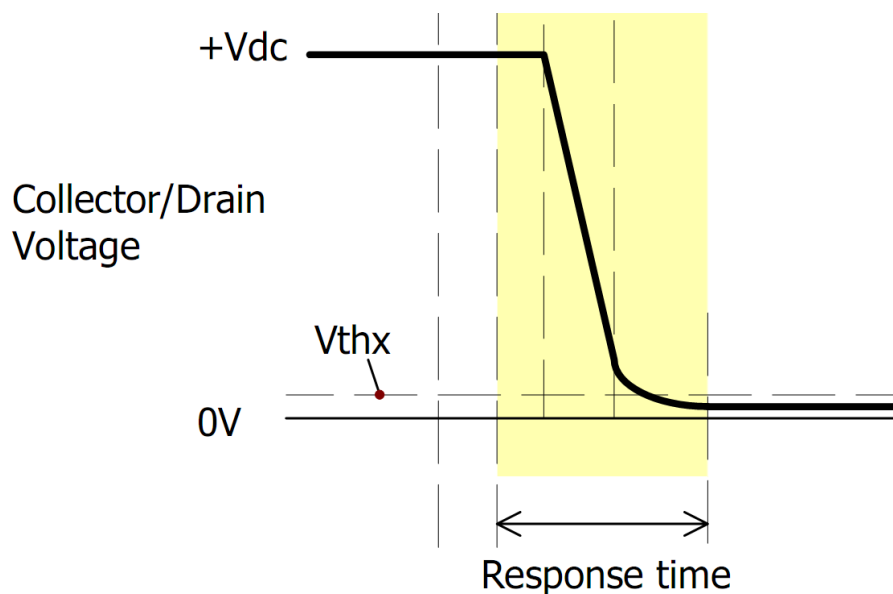


6.6 Short-circuits monitoring

For short-circuit detection, the IGBT V_{CEsat} is compared to a reference voltage. If the V_{CEsat} exceeds the reference voltage, a short-circuit is detected.

To fit the switching waveform of IGBTs, the reference voltage is not constant:

First, the short-circuit detection stays inactive during the response time T_{ce} . Afterwards, the detection becomes active and the reference voltage is set at V_{TH} .



The standard response time is 4.2 μ s.

For each output, the V_{CEsat} threshold detection is set by a resistor (R_{TH1} and R_{TH3}). The final user can modify the fault threshold value by adding a parallel resistor (R_{TH1} and R_{TH3}).

The following table gives some parameter set values depending on the R_{TH1} and R_{TH3} resistor used. The selected value must be added in parallel onto the 43k resistor, already implemented, R_{TH2} and R_{TH4} . C10 and C11 capacitors allow to adjust the response time. The response time also depends on the trigger point.

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Rth	Vth
Standard	6.45 V
180 k	5.2 V
120 k	4.7 v
43 k	3.3 V
20 k	2V

Table 1 : RTH selection for VCESAT detection parameters with implemented capacitor

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 2 : Setting for RTH selection / capacitor

V_{CEsat} Measurement

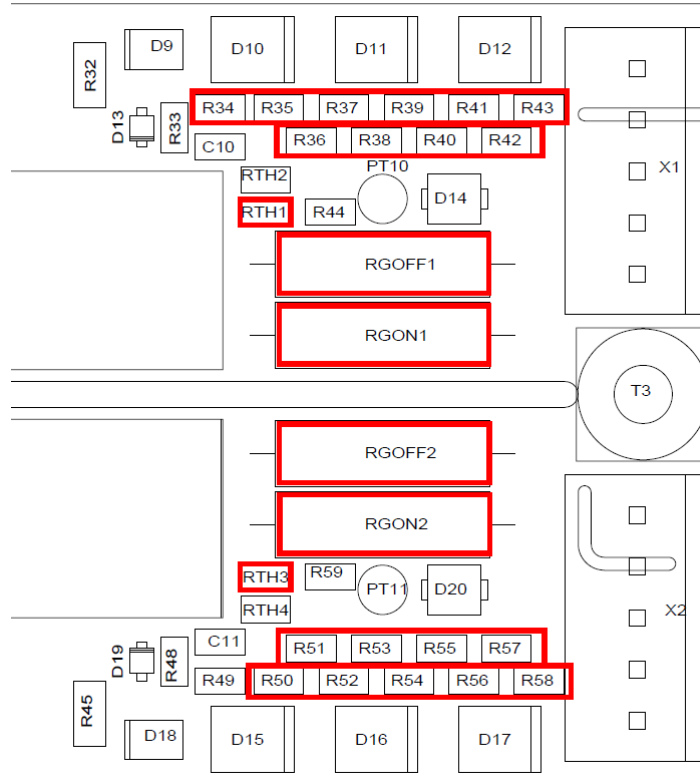
The fault detection is performed by measuring V_{CE} and comparing with a reference value V_{ref}. V_{CE} measurement needs that the input current be between 0.6 and 1mA. That's why R_{VCE} resistor must be set up to the BUS voltage :

R _{VCE}	U _{bus}
Standard (8*120k)	576 – 960 V
9*120k	648 – 1080 V
10*120k	720 – 1200 V
11*120k	792 – 1320 V
3*120k	216 – 360 V (IGBT 600V)

To modify the original setting of the board, please contact ARCEL.

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6.7 Monitoring of auxiliary supplies

Monitoring of the supplies values is done directly on each output channel. If one of the two secondary supplies is under 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.

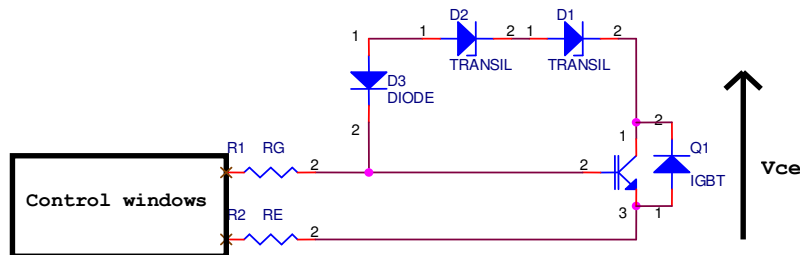
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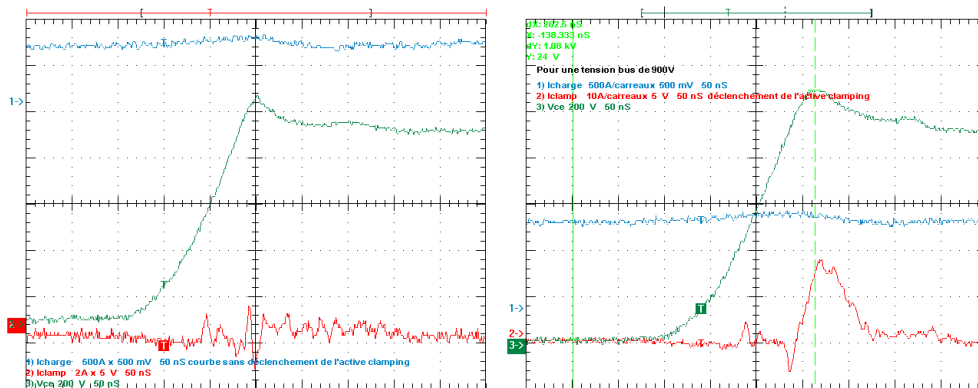
6.8 'Active Clamping' Protection

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 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).

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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 1020V to 1100V). (The board can be configured upon request for IGBTs 600V or 1700V).

7 CONFIGURATION : ABSTRACT TABLE

Parameters		TERMINALS								
		K1	K2	K3	K4	K5	K6	K7	K8	K9
Mode	DIRECT INA-X → X2 / BOT INB-X → X1 / TOP		1-2	1-2		1-2	CC			2-3
	DIRECT INA-X → X1 / TOP INB-X → X2 / BOT		1-2	2-3		1-2	CC			1-2
	HB TOP-BOT INB-X->BOT (X2)		1-2	2-3		2-3	CO			1-2
	HB TOP-BOT INA-X->BOT (X2)		1-2	1-2		2-3	CO			2-3
	HB INA-INB INA-X ->TOP (X1)		2-3	1-2		1-2	CO			2-3
	HB INA-INB INA-X->BOT (X2)		1-2	1-2		1-2	CO			2-3
	Orders in fault	BLOCKED				CC				
	NOT BLOCKED				CO					
Fault feedback	ERROR = OPEN							CC 2-3		
	ERROR = CLOSED							CC 1-2		
Vce detection	CHANNEL 1									Rth1
	CHANNEL 2									Rth3
Shielding	YES	CC								
	NO	CO								
Connector X4	YES								CO	
	NO								CC	

8

With SC = Sort-Circuit

OC = Open-Circuit

Grey cells represent the standard factory configuration.

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Parameter	Resistor
T_{DT}	R_M
T_B	R_B
I_{VCE}	R_{VCE}
I_{GON}	R_{GON}
I_{GOFF}	R_{GOFF}

In case only one channel is used (chopper mode), please take special care with the configuration to be applied.

9 NOTES

 Before printing think about **environment and costs!** N'imprimez ce document que si nécessaire.

- ⁱ 0/+15V only on request.
- ⁱⁱ The system is protected by zener and bipolar diodes. Exceeding those values may result in an overheating and/or overload. Special care must be taken when using long connection lines.
- ⁱⁱⁱ Available power on DC/DC converter outputs.
- ^{iv} Maximum continuous or repeatedly-applied DC voltage or peak value of the repeatedly-applied AC voltage between all inputs and all outputs. However, types that have been measured and selected for higher partial-discharge voltages (e.g. for 1700V IGBT modules) can be provided. The partial discharge is not measured for the standard types.
- ^v For 25KHz driving signals.
- ^{vi} For IGBTs protection. Each auxiliary voltage is monitored.
- ^{vii} With respect to the max. output power.
- ^{viii} In nominal operating conditions.
- ^{ix} Tuneable by the end user.
- ^x Without load.
- ^{xi} Except for series 9912XXX-B, where X4 : MOLEX Mini KK 6410/7395 – 2pin.

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