LABORATOIRE DE PHYSIQUE DES LASERS

Atelier d'électronique

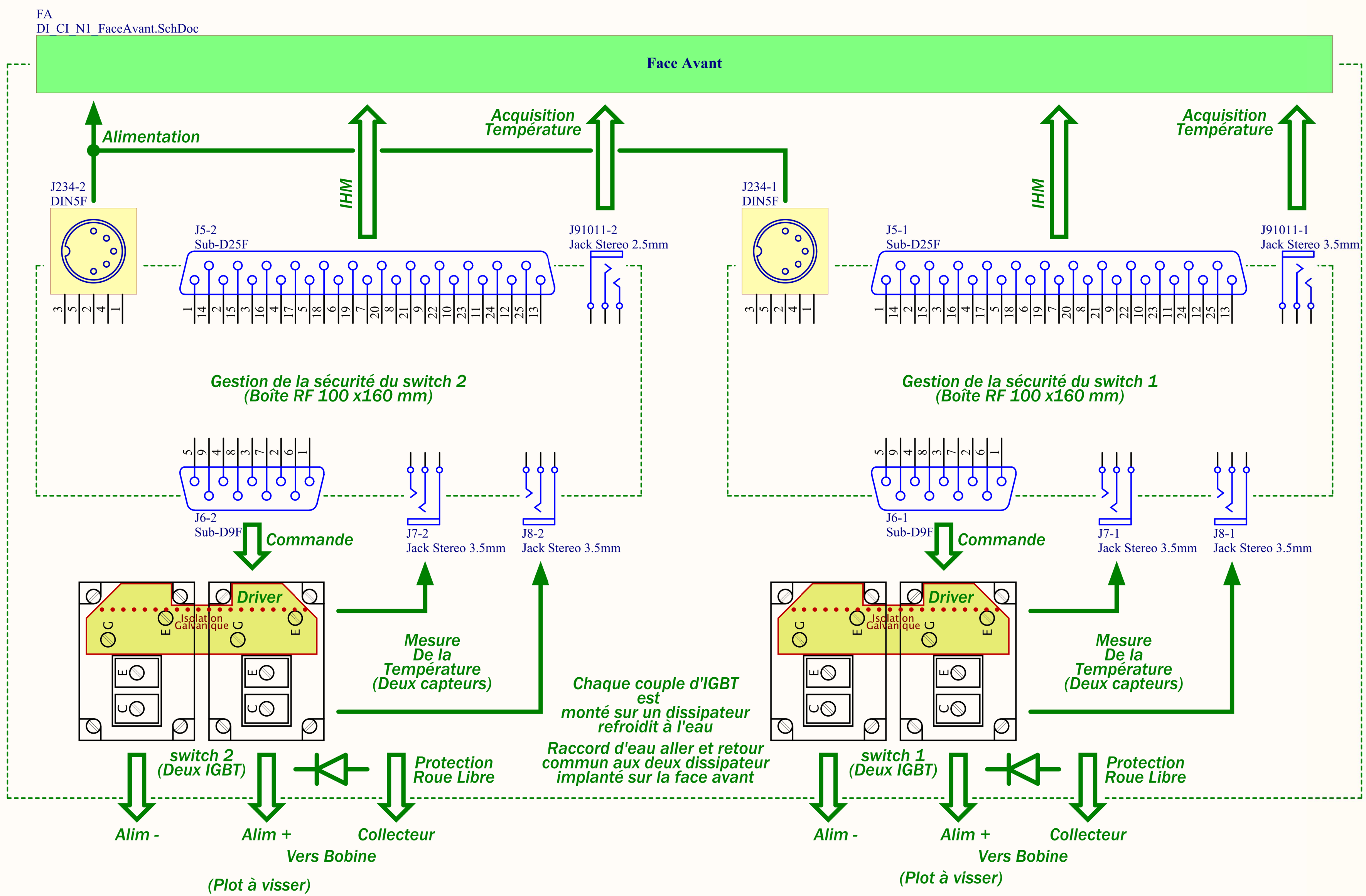
Double Drivers IGBT sécurisés

Description

Réf. : DriverIGBT

Equipe : BEC

Auteur : Haniffe MOUHAMAD



Title	**Câblage du châssis avec deux switch IGBT**
Author : H. Mouhamad	Size: A4 Sheet N° of Ttl
Created : 29/11/2013	Modified : 09/07/2013 Rev : 0
File: Z:\Equipe\Projet\1301_DriverIGBT\CAO\CBG_ChassisIGBT\DI_ChassisIGBT.SchDoc	

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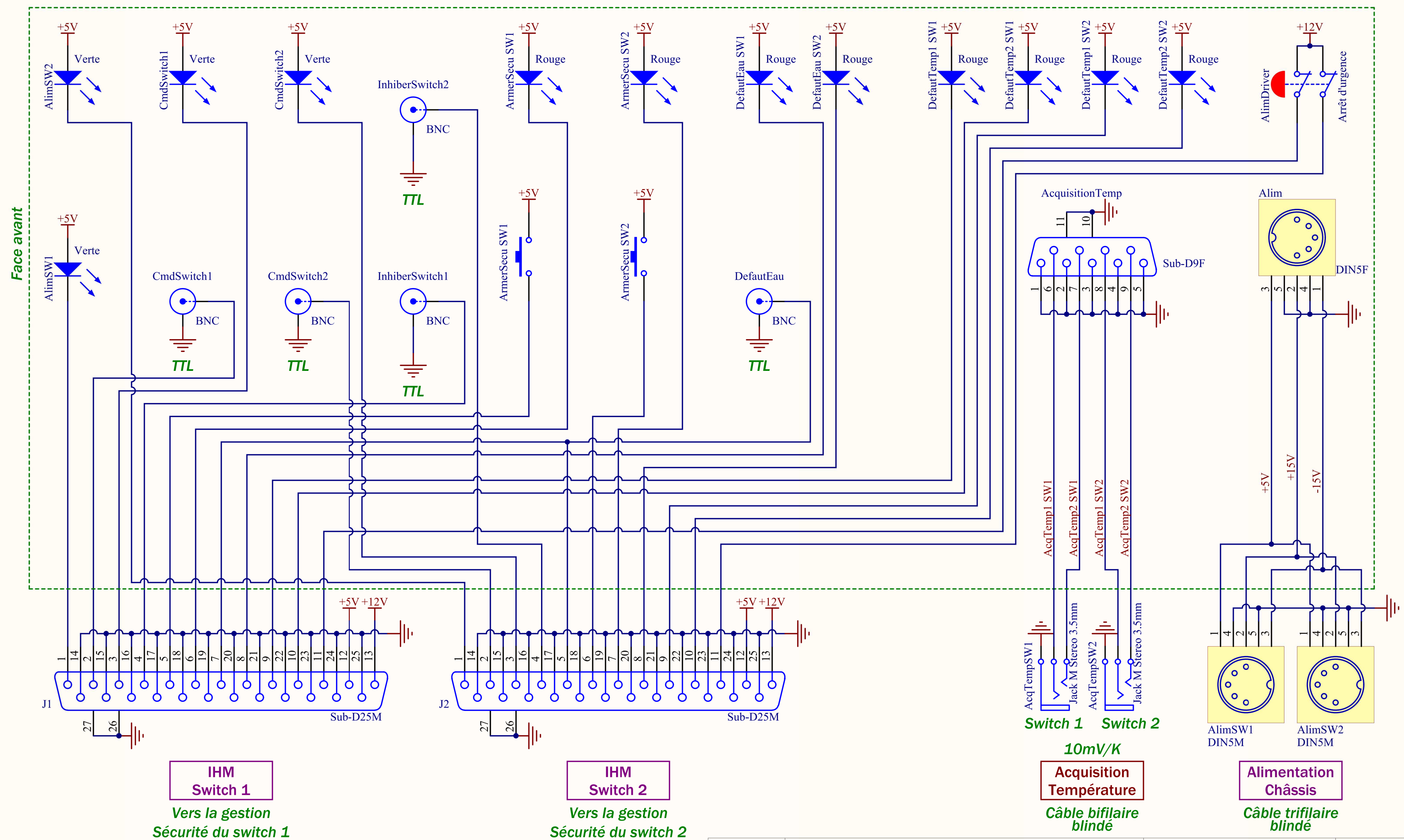
Université Paris 13 - Institut Galilée
99, avenue Jean-Baptiste Clément
Villetaneuse (93)
France



Title **Câblage de la face avant**

Author : H. Mouhamad | Size: A4 | Sheet N° of Ttl

Created : 29/11/2013 | Modified : 25/09/2013 | Rev : 0

File: Z:\Equipe\Projet\1301_DriverIGBT\CAO\CBG_ChassisIGBT\DI_CI_N1_FaceAvant.SchDoc

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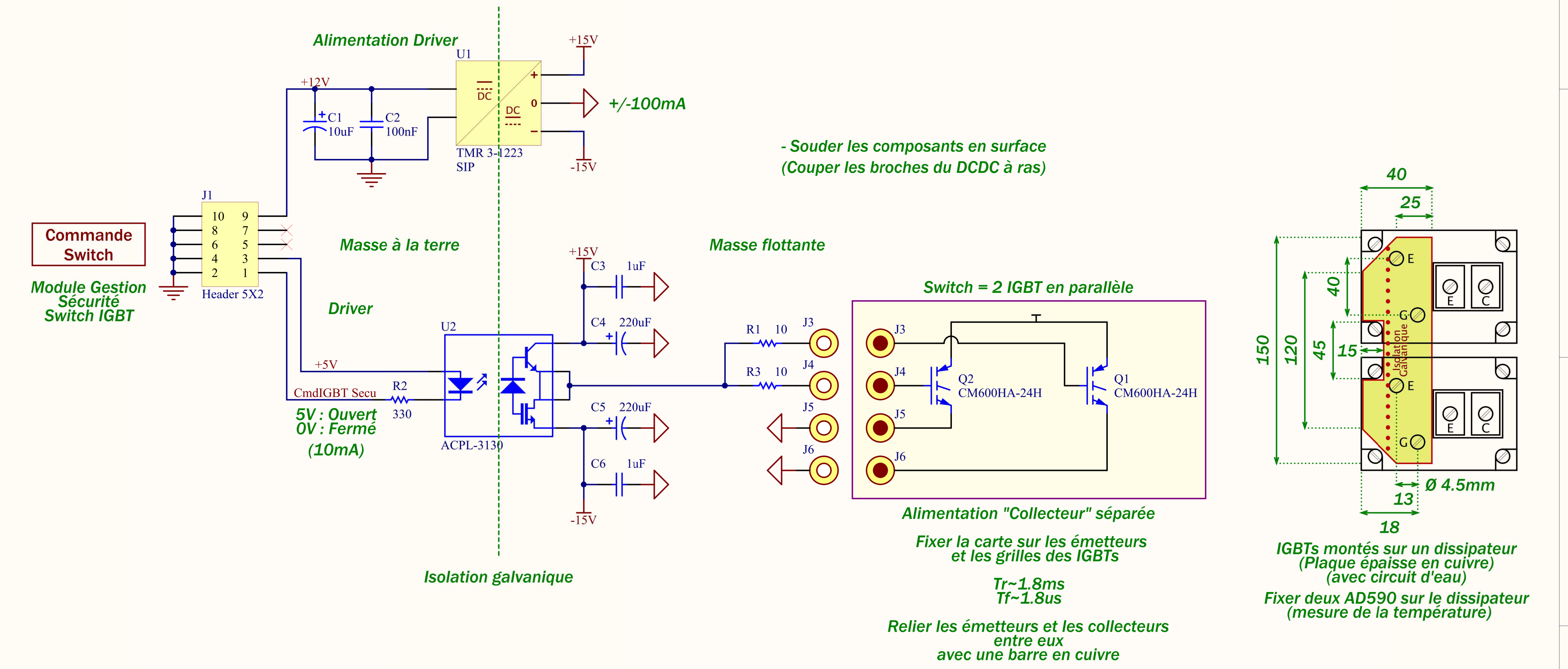

Title **Module de pilotage d'un switch IGBT**

Author : H. Mouhamad | Size: A4 | Sheet N° of Ttl

Created : 29/11/2013 | Modified : 06/06/2013 | Rev : 0

File: Z:\Equipe\Projet\1301_DriverIGBT\CAO\PCB_DriverIGBT\DriverIGBT.SchDoc

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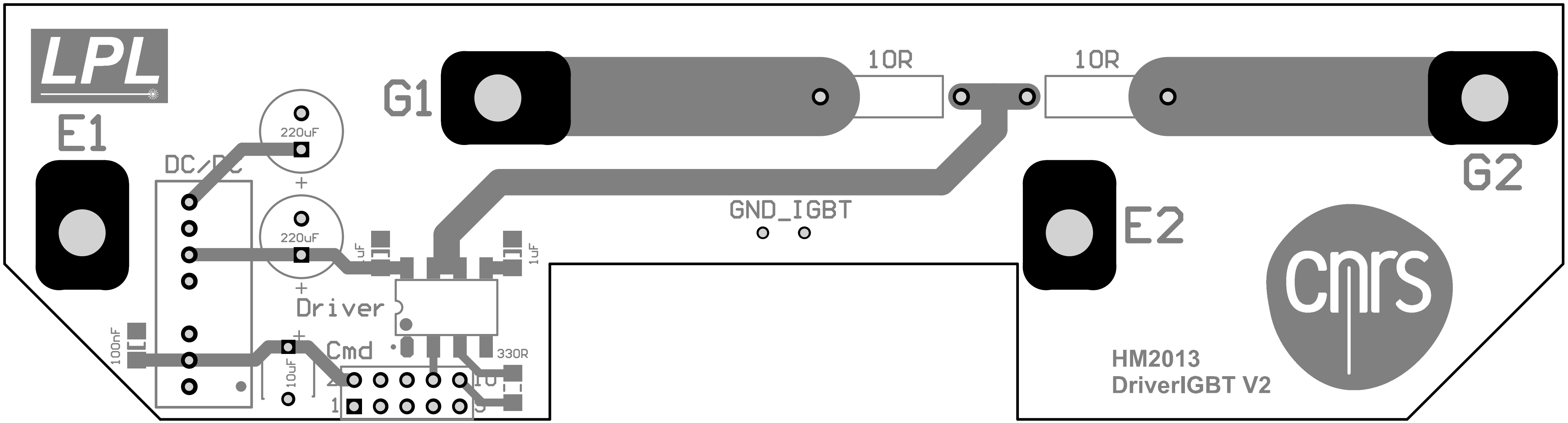
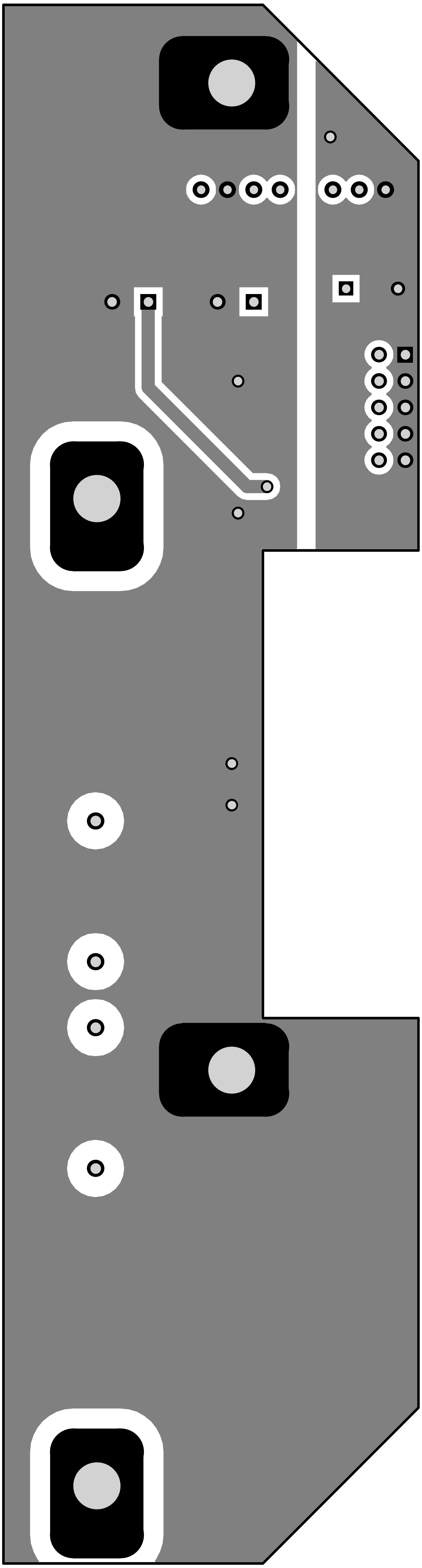
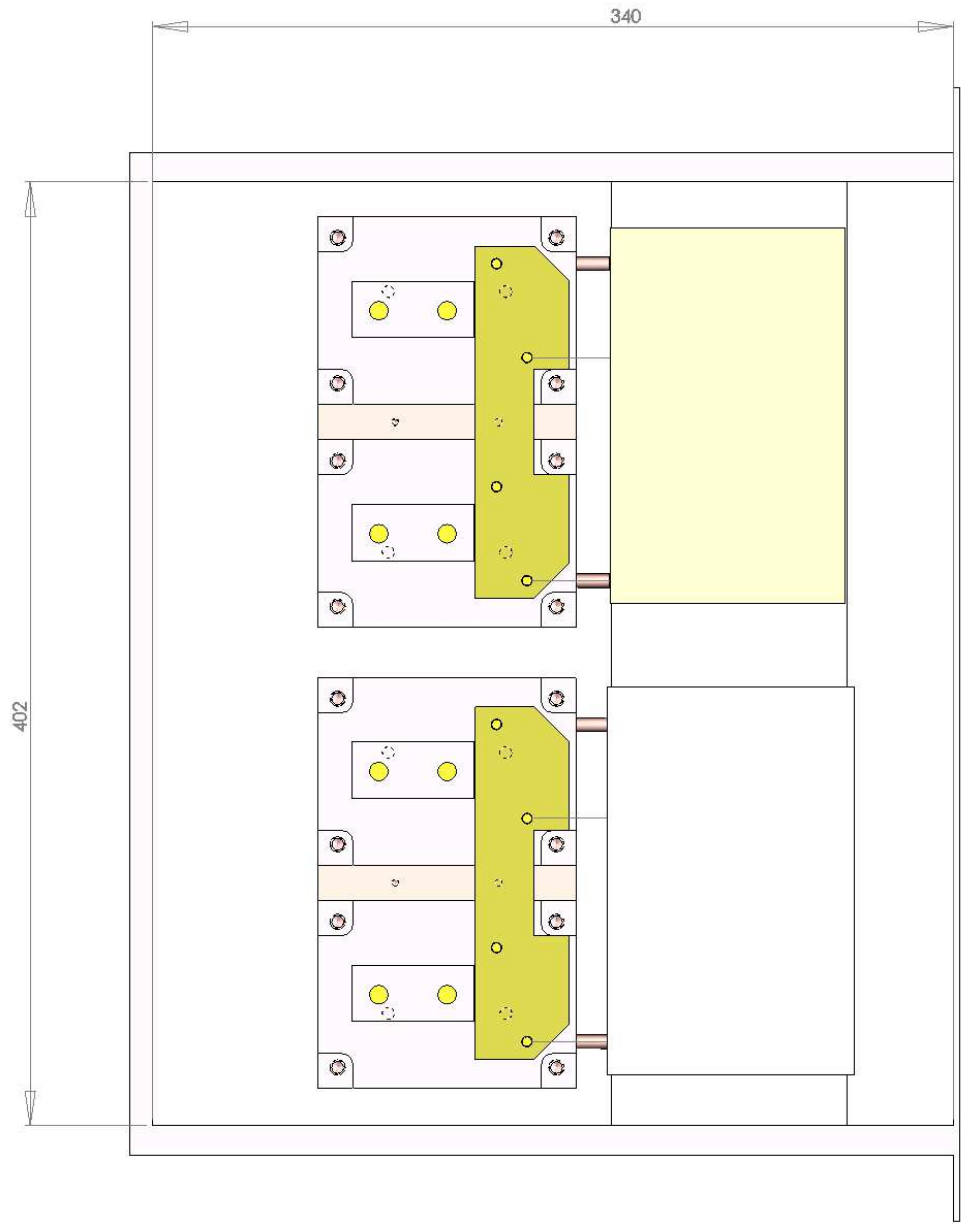
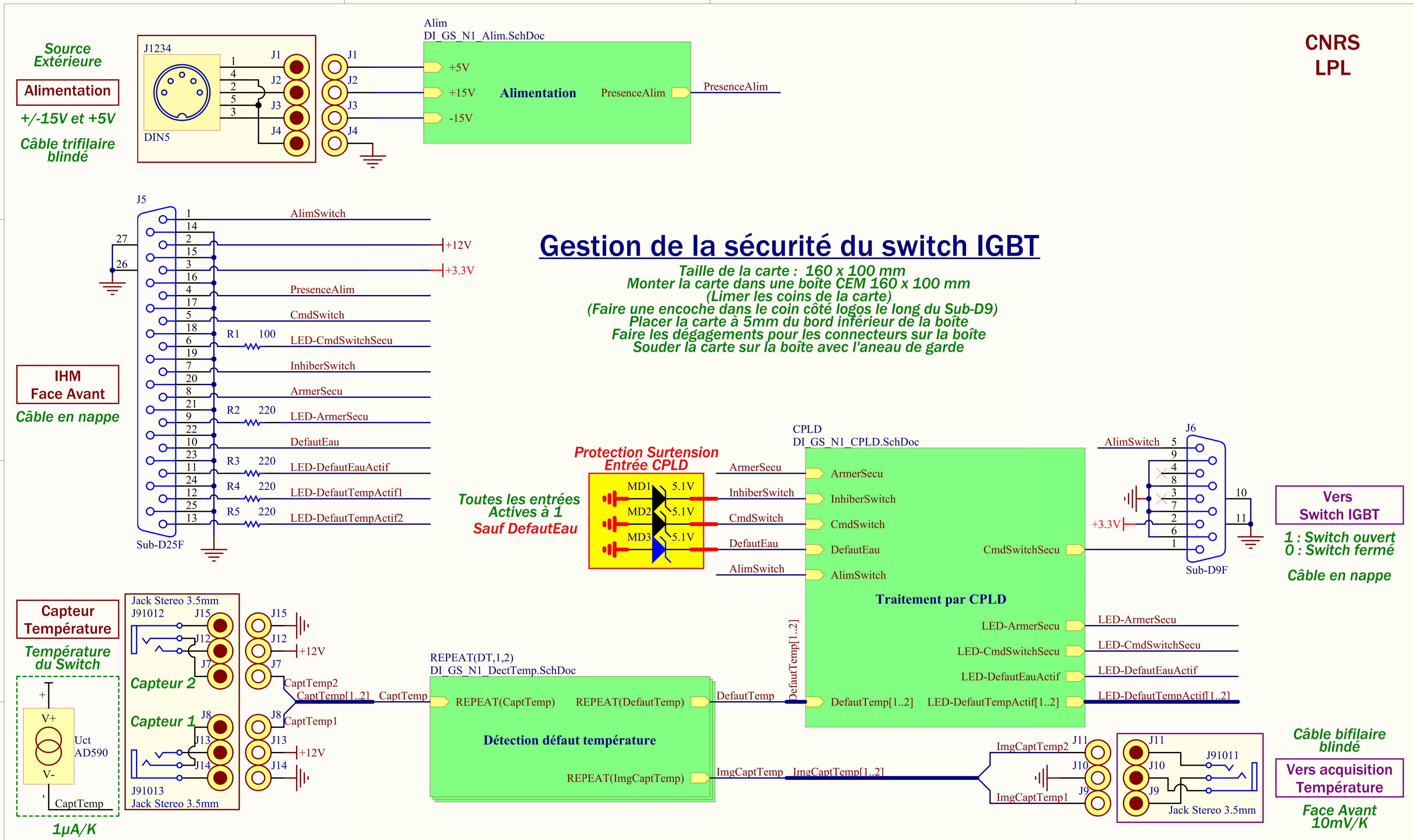

LPL
E1
G1
10R
10R
G2
E2
220uF
220uF
DC/DC
GND_IGBT
Driver
Cmd
1uF
1uF
330R
100nF
10uF
HM2013
DriverIGBT V2




340
402



Title: *Gestion de la sécurité du driver IGBT*

Author: H. Mouhamad | Size: A4 | Sheet N° of Ttl

Created: 29/11/2013 | Modified: 14/11/2013 | Rev: 0

File: Z:\Equipe\Projet\1301_DriverIGBT\CAO\PCB_GestionSecu\DI_GestionSecu.SchDoc

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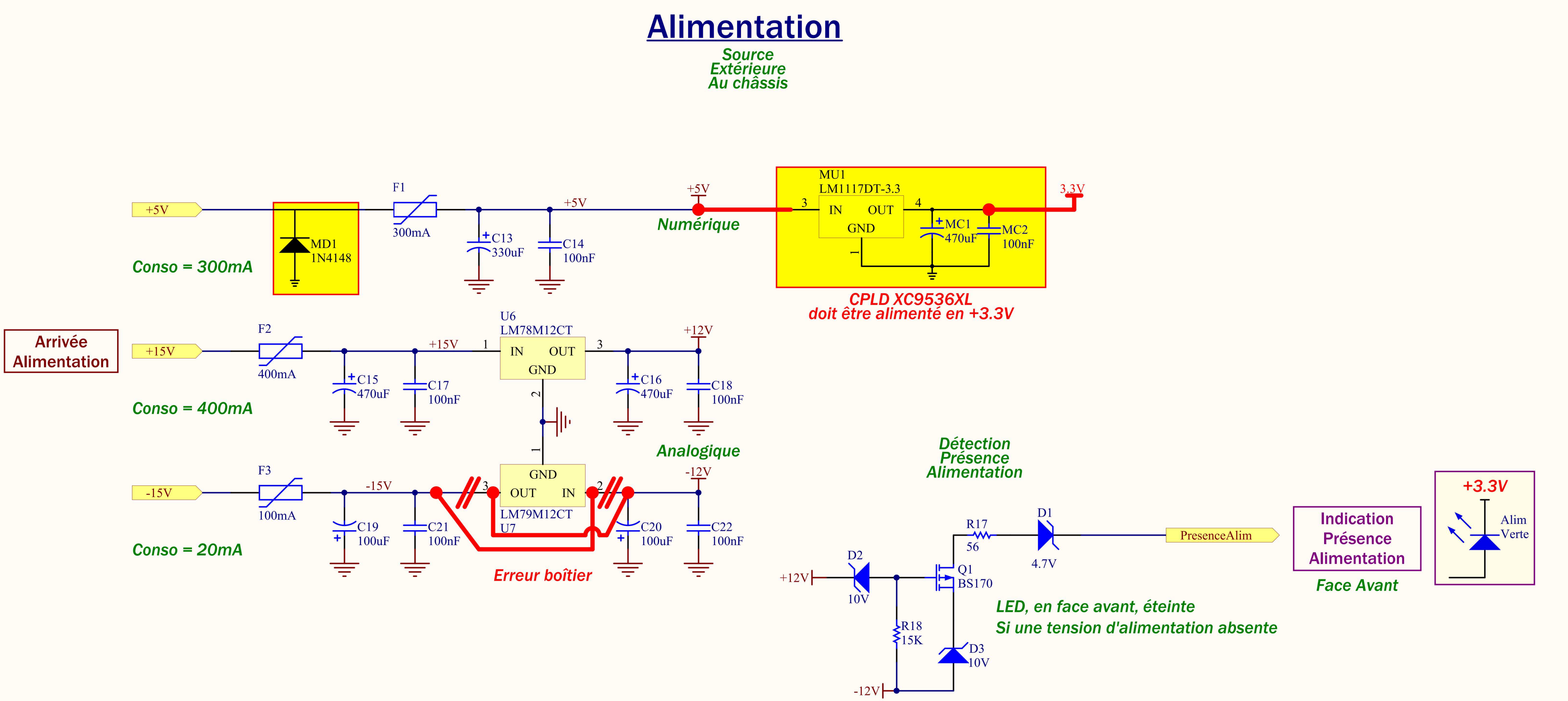

Title **Alimentation**

Author : H. Mouhamad | Size: A4 | Sheet N° of Ttl

Created : 29/11/2013 | Modified : 14/11/2013 | Rev : 0

File: Z:\Equipe\Projet\1301_DriverIGBT\CAO\PCB_GestionSecu\DI_GS_N1_Alim.SchDoc

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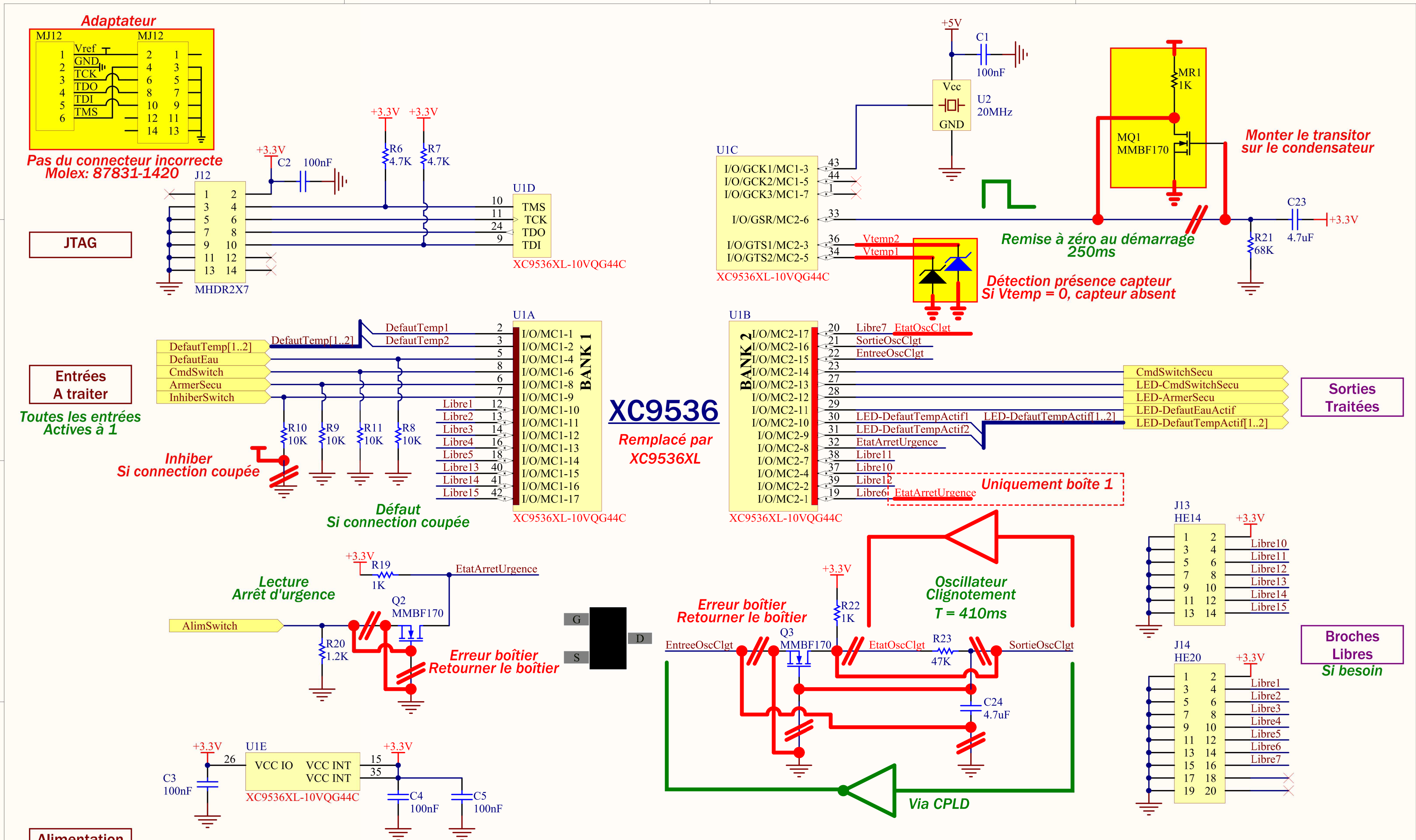

Title **Traitement par CPLD**

Author : H. Mouhamad | Size: A4 | Sheet N° of Ttl

Created : 29/11/2013 | Modified : 22/11/2013 | Rev : 0

File: Z:\Equipe\Projet\1301_DriverIGBT\CAO\PCB_GestionSecu\DI_GS_N1_CPLD.SchDoc

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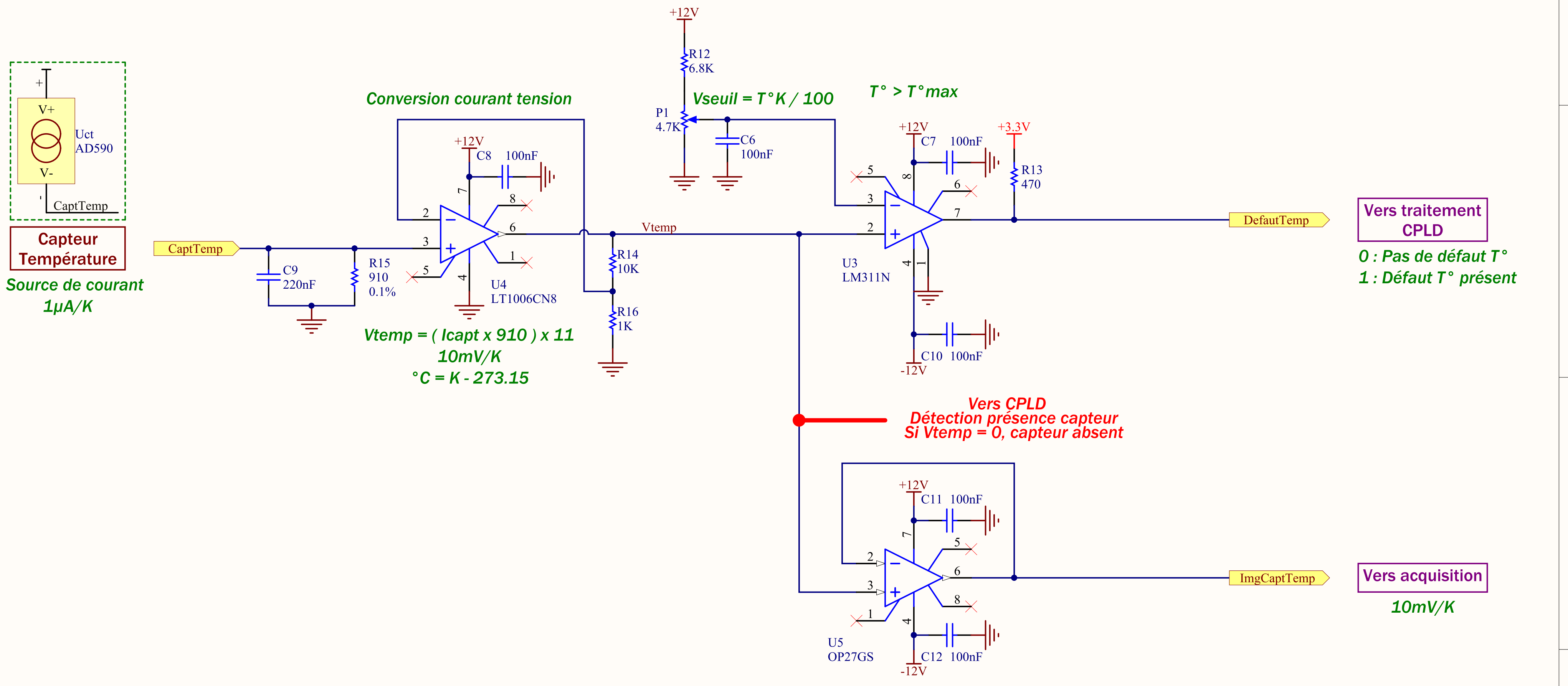

Title **Détection défaut température**

Author : H. Mouhamad | Size: A4 | Sheet N° of Ttl

Created : 29/11/2013 | Modified : 14/11/2013 | Rev : 0

File: Z:\Equipe\Projet\1301_DriverIGBT\CAO\PCB_GestionSecu\DI_GS_N1_DectTemp.SchDoc

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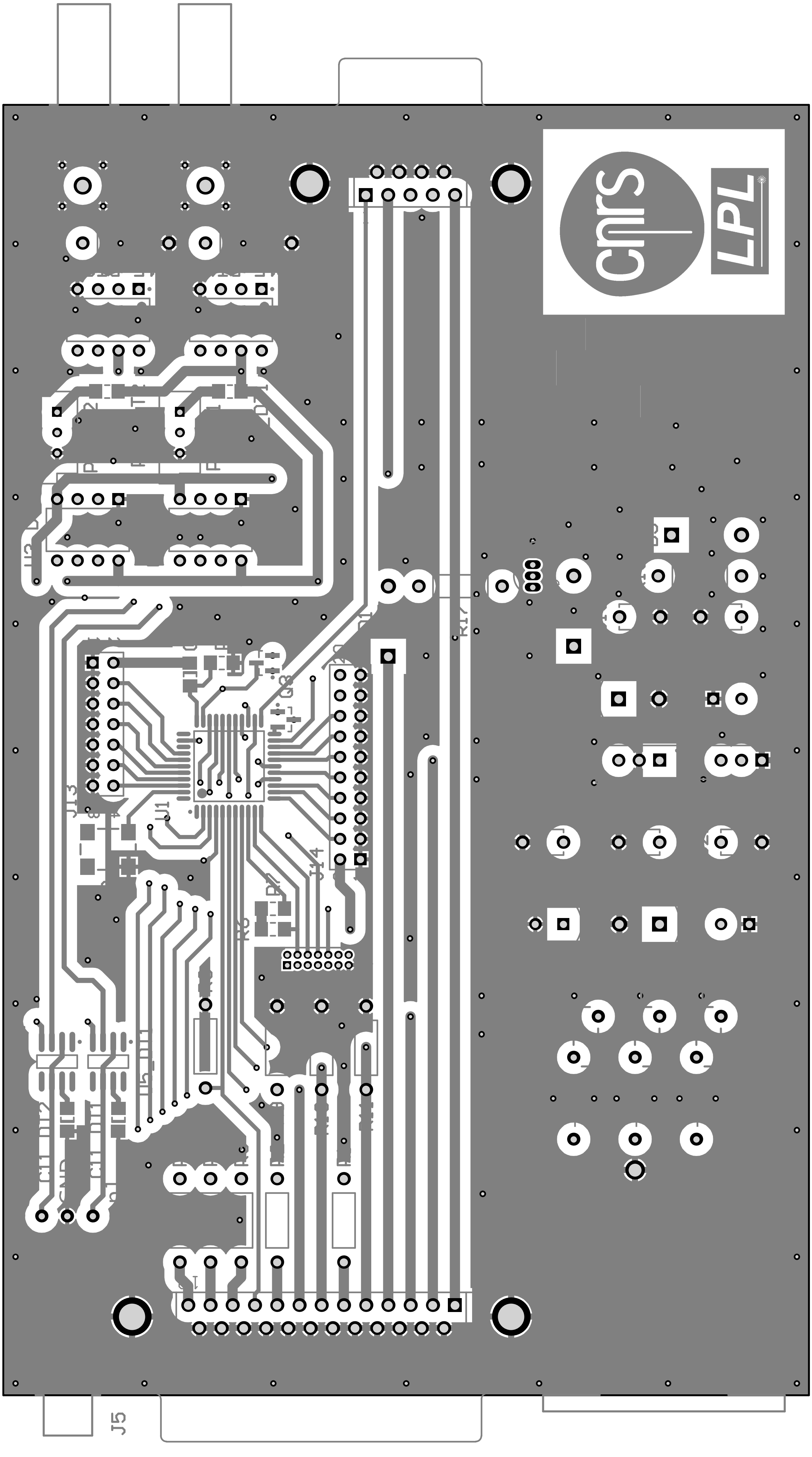
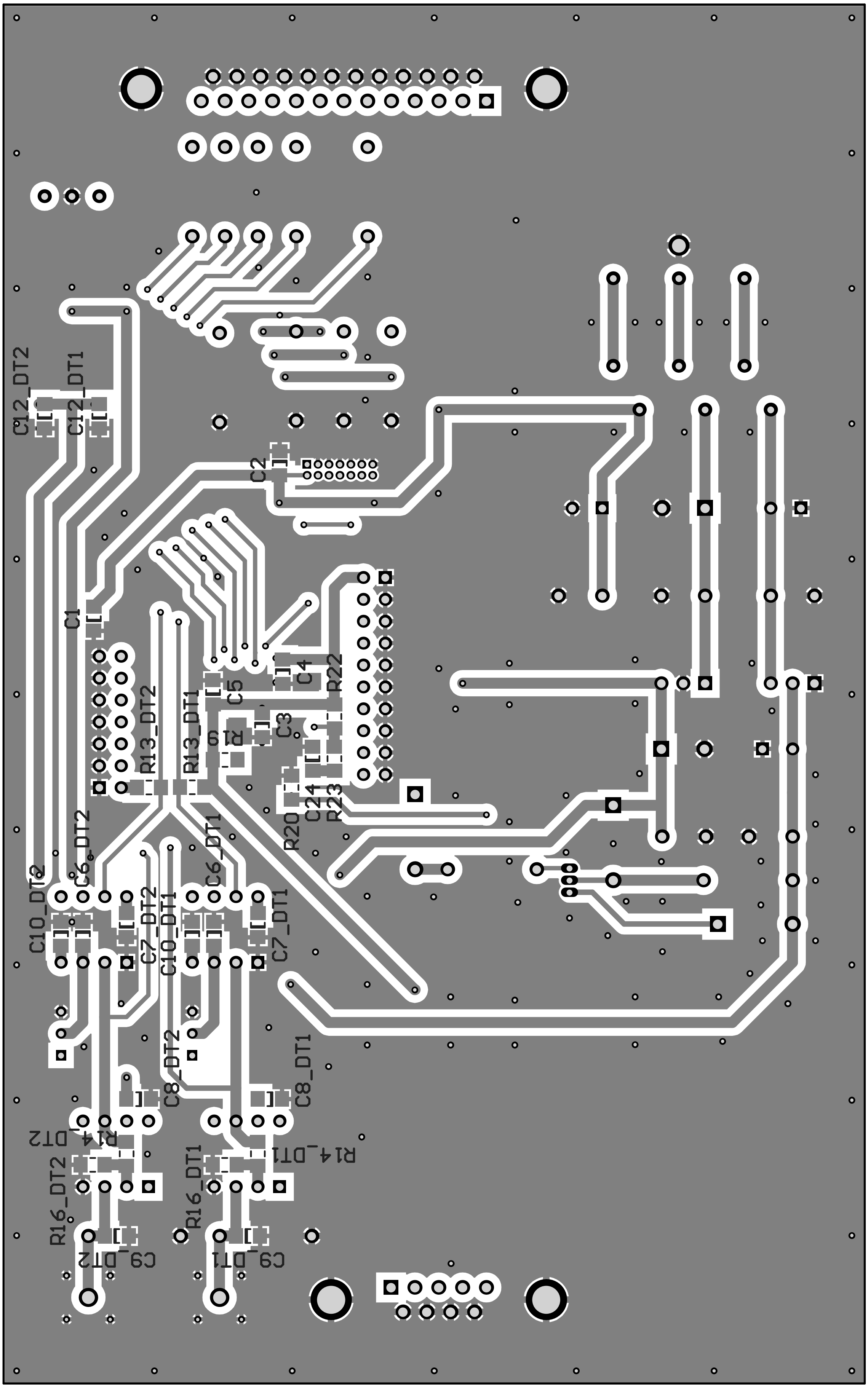

J13
R17
J5


C12_DT2
C12_DT1
C2
C1
R13_DT2
R13_DT1
C5
C4
C3
R22
R19
C24
R23
R20
C6_DT2
C6_DT1
C10_DT2
C7_DT2
C10_DT1
C7_DT1
C8_DT2
C8_DT1
R14_DT2
R14_DT1
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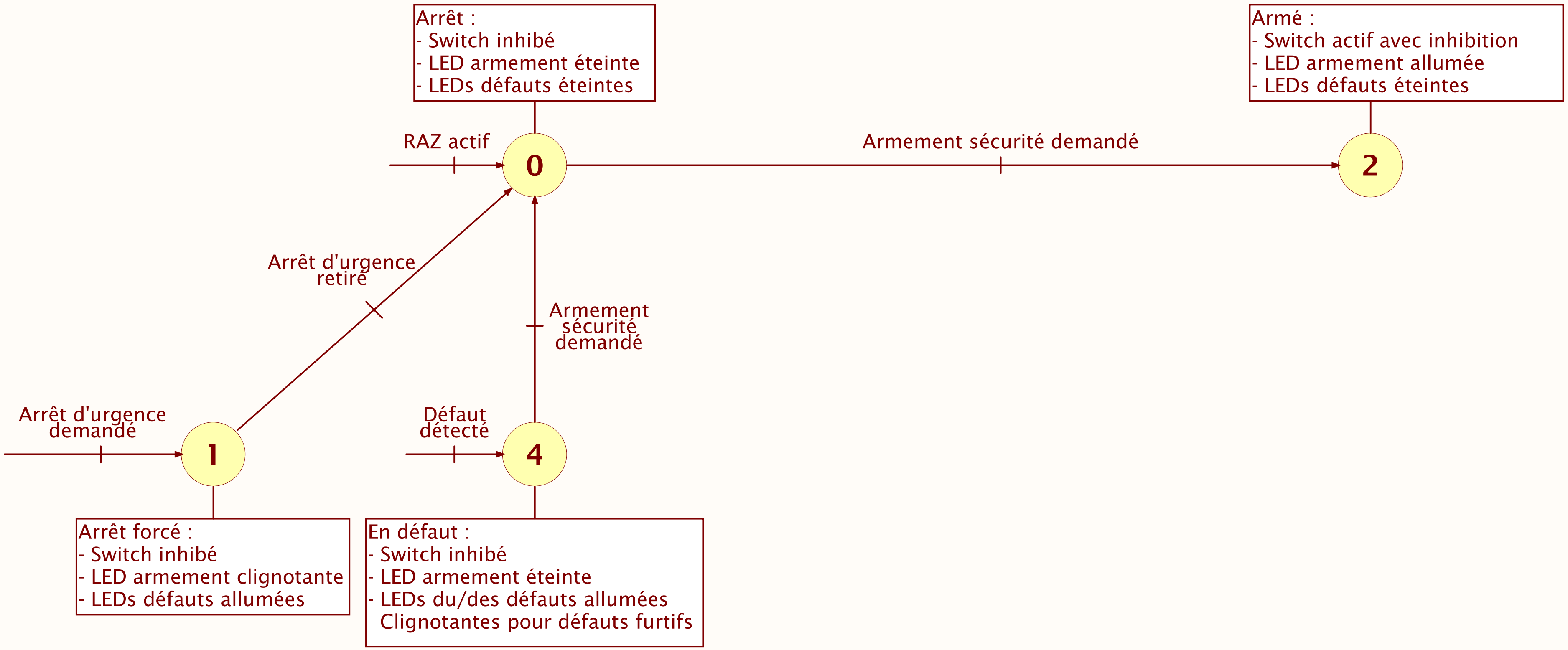
R16_DT1
C9_DT2
C9_DT1



Title **_Diagramme d'états du CPLD_**

Author : H. Mouhamad	Size: A4	Sheet N° of Ttl	
Created : 29/11/2013	Modified : 06/06/2013	Rev : 0	

File: Z:\Equipe\Projet\1301_DriverIGBT\CAO\SYNO_CPLD\DI_DgEtat_CPLD.SchDoc

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Villetaneuse (93)
France

```vhdl
-----------------------------------------------------------------------------------
-- CNRS - Laboratoire de Physique des Lasers - Université Paris 13 Villetaneuse
-- Haniffe Mouhamad
--
-- Composant : XC9536
-- Projet : Driver_IGBT
--
-- GESTION DE LA SECURITE DE COMMANDE D'UN SWITCH A IGBT
--
-- Avril 2013
--
-----------------------------------------------------------------------------------
library IEEE;
use IEEE.STD_LOGIC_1164.ALL;
use IEEE.std_logic_arith.all;
use IEEE.std_logic_unsigned.all;




-- ENTITE DE BASE
entity GestionSecu is
    Port (  RAZ : in  STD_LOGIC;
            H : in  STD_LOGIC;

            EntreeOsc : out  STD_LOGIC;
            SortieOsc : in  STD_LOGIC;
            EtatOsc : out  STD_LOGIC;

            ArretUrgence : in  STD_LOGIC;
            InhiberSwitch : in  STD_LOGIC;
            ArmerSecu : in  STD_LOGIC;
            LED_ArmerSecu : out  STD_LOGIC;

            -- Ordre des défauts
            -- Temp 1 + Temp 2 + Eau
            -- '1' : Défaut présent
            Defauts : in  STD_LOGIC_VECTOR (2 downto 0);
            LED_Defauts : out  STD_LOGIC_VECTOR (2 downto 0);
            -- CaptTemp 1 + CaptTemp 2
            -- '0' : Capteur absent
            PresenceCaptTemp : in STD_LOGIC_VECTOR (1 downto 0);
```

```
            CmdSwitch : in  STD_LOGIC;
            CmdSwitchSecu : out  STD_LOGIC;
            LED_CmdSwitchSecu : out  STD_LOGIC);
end GestionSecu;




-- ARCHITECTURE
architecture Behavioral of GestionSecu is

   -- DECLARATION

   -- Type énuméré
   type ETATS is (ARRET, ARRET_FORCE, ARMEE, EN_DEFAUT);

   -- Signaux internes
   signal Etat : ETATS;
   signal MemoDefauts : STD_LOGIC_VECTOR (2 downto 0);
   signal RegDefauts : STD_LOGIC_VECTOR (2 downto 0);
   signal Clignotante : STD_LOGIC;

   -- Constantes
   Constant LED_ETEINTE : STD_LOGIC := '1';
   Constant LED_ALLUMEE : STD_LOGIC := '0';
   Constant SWITCH_OUVERT : STD_LOGIC := '1';
   Constant ACTIF : STD_LOGIC := '1';
   Constant INACTIF : STD_LOGIC := '0';

begin


   -- MACHINE D'ETATS

   Process (H, RAZ)
   begin


      -- Initialisation par remise à zéro (Priorité 1)
      if RAZ = ACTIF then
```

```vhdl

            Etat <= ARRET;
            CmdSwitchSecu <= SWITCH_OUVERT;
            LED_CmdSwitchSecu <= LED_ETEINTE;
            LED_ArmerSecu <= LED_ETEINTE;
            LED_Defauts <= LED_ETEINTE & LED_ETEINTE & LED_ETEINTE;
            MemoDefauts <= "111";


         -- Arrêt d'urgence (Priorité 2)
         elsif ArretUrgence = ACTIF then

            Etat <= ARRET_FORCE;
            CmdSwitchSecu <= SWITCH_OUVERT;
            LED_CmdSwitchSecu <= LED_ETEINTE;
            LED_ArmerSecu <=  Clignotante;
            LED_Defauts <= LED_ALLUMEE & LED_ALLUMEE & LED_ALLUMEE;


         -- Défauts (Priorité 3)
         -- '0' : Défaut présent
         -- Allumage de la LED défaut concernée
         elsif RegDefauts < "111" then

            Etat <= EN_DEFAUT;

            -- Mise à jour des défauts
            if RegDefauts(0)='0' then MemoDefauts(0) <= '0'; end if;
            if RegDefauts(1)='0' then MemoDefauts(1) <= '0'; end if;
            if RegDefauts(2)='0' then MemoDefauts(2) <= '0'; end if;

            CmdSwitchSecu <= SWITCH_OUVERT;
            LED_CmdSwitchSecu <= LED_ETEINTE;
            LED_ArmerSecu <= LED_ETEINTE;
            LED_Defauts <= ( ( Clignotante & Clignotante & Clignotante ) or MemoDefauts ) and RegDefauts;


         -- ETAT DE LA MACHINE
         elsif H'Event and H ='1' then
            case Etat is


```

```
            when ARRET_FORCE =>
               if ArretUrgence = ACTIF then  Etat <= ARRET_FORCE;
               else                          Etat <= ARRET;
               end if;


            when ARRET =>
               CmdSwitchSecu <= SWITCH_OUVERT;
               LED_CmdSwitchSecu <= LED_ETEINTE;
               LED_ArmerSecu <= LED_ETEINTE;
               LED_Defauts <= LED_ETEINTE & LED_ETEINTE & LED_ETEINTE;

               if ArmerSecu = ACTIF then  Etat <= ARMEE;
               else                       Etat <= ARRET;
               end if;


            when ARMEE =>
               Etat <= ARMEE;
               CmdSwitchSecu <= not ( CmdSwitch and not InhiberSwitch );
               LED_CmdSwitchSecu <= not ( CmdSwitch and not InhiberSwitch );
               LED_ArmerSecu <= LED_ALLUMEE or ( InhiberSwitch and Clignotante );
               LED_Defauts <= LED_ETEINTE & LED_ETEINTE & LED_ETEINTE;


             when EN_DEFAUT => -- LED défaut(s) concernées(s) clignotantes
               CmdSwitchSecu <= SWITCH_OUVERT;
               LED_CmdSwitchSecu <= LED_ETEINTE;
               LED_ArmerSecu <= LED_ETEINTE;
               LED_Defauts <= ( Clignotante & Clignotante & Clignotante ) or MemoDefauts;

               if RegDefauts = "111" and ArmerSecu = ACTIF then      Etat <= ARRET;
                                                                     MemoDefauts <= "111";
               else                                                  Etat <= EN_DEFAUT;
               end if;


            when others => null;
         end case;
      end if;
   end process;

```

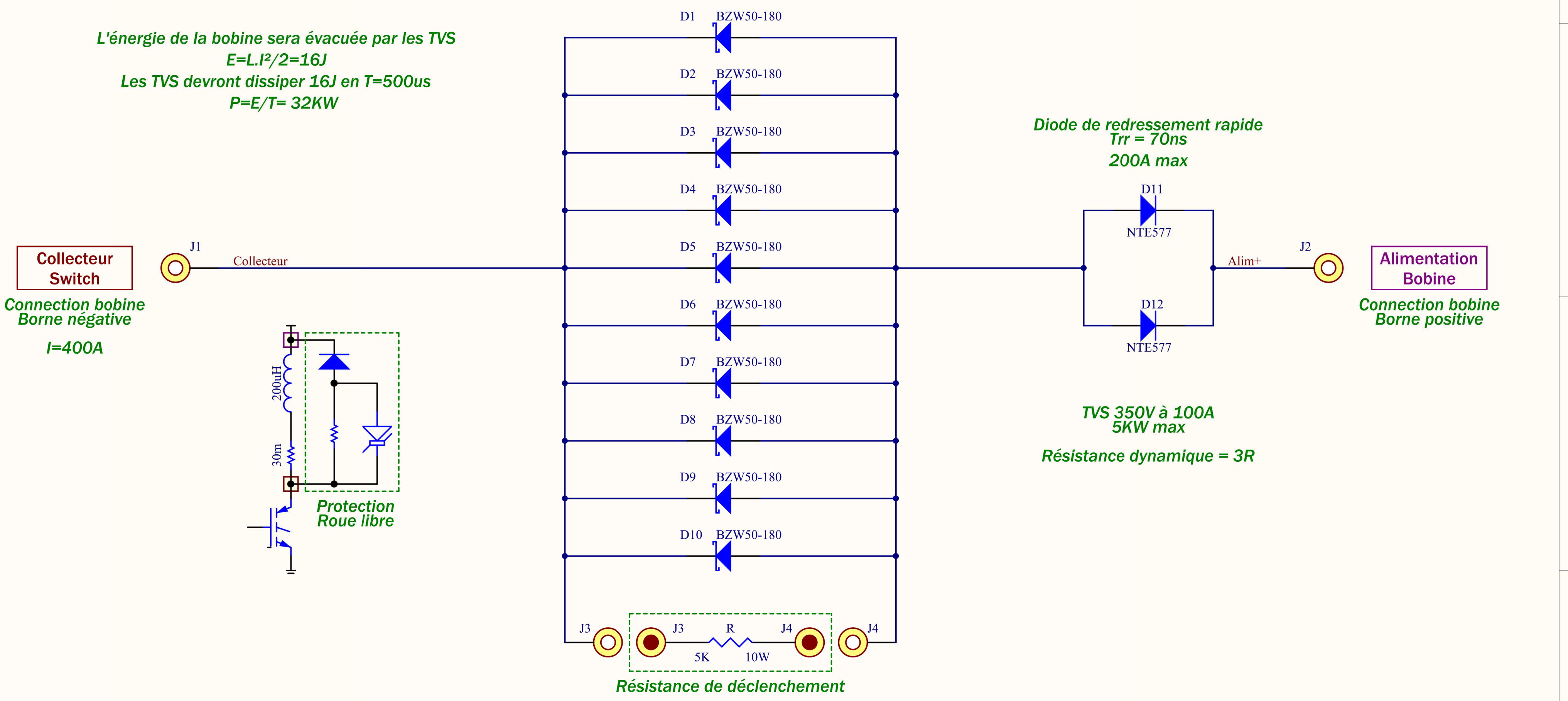
```

    -- Clignotement à 410ms
    Clignotante <= SortieOsc;


    -- Oscillateur
    -- Période 410 ms
    EntreeOsc <= not SortieOsc;
    EtatOsc <= SortieOsc;


    -- Registre des défauts
    -- Temp 1      + Temp 2       + Eau
    -- CaptTemp 1  + CaptTemp 2
    -- '0' : Défaut présent
    RegDefauts(2) <= Defauts(2); -- Si Défaut actif 0, ne pas mettre "not"
    RegDefauts(1) <= not Defauts(1) and PresenceCaptTemp(1);
    RegDefauts(0) <= not Defauts(0) and PresenceCaptTemp(0);


end Behavioral;
```

CNRS
LPL

Circuit de protection roue libre V3 pour switch à deux IGBT

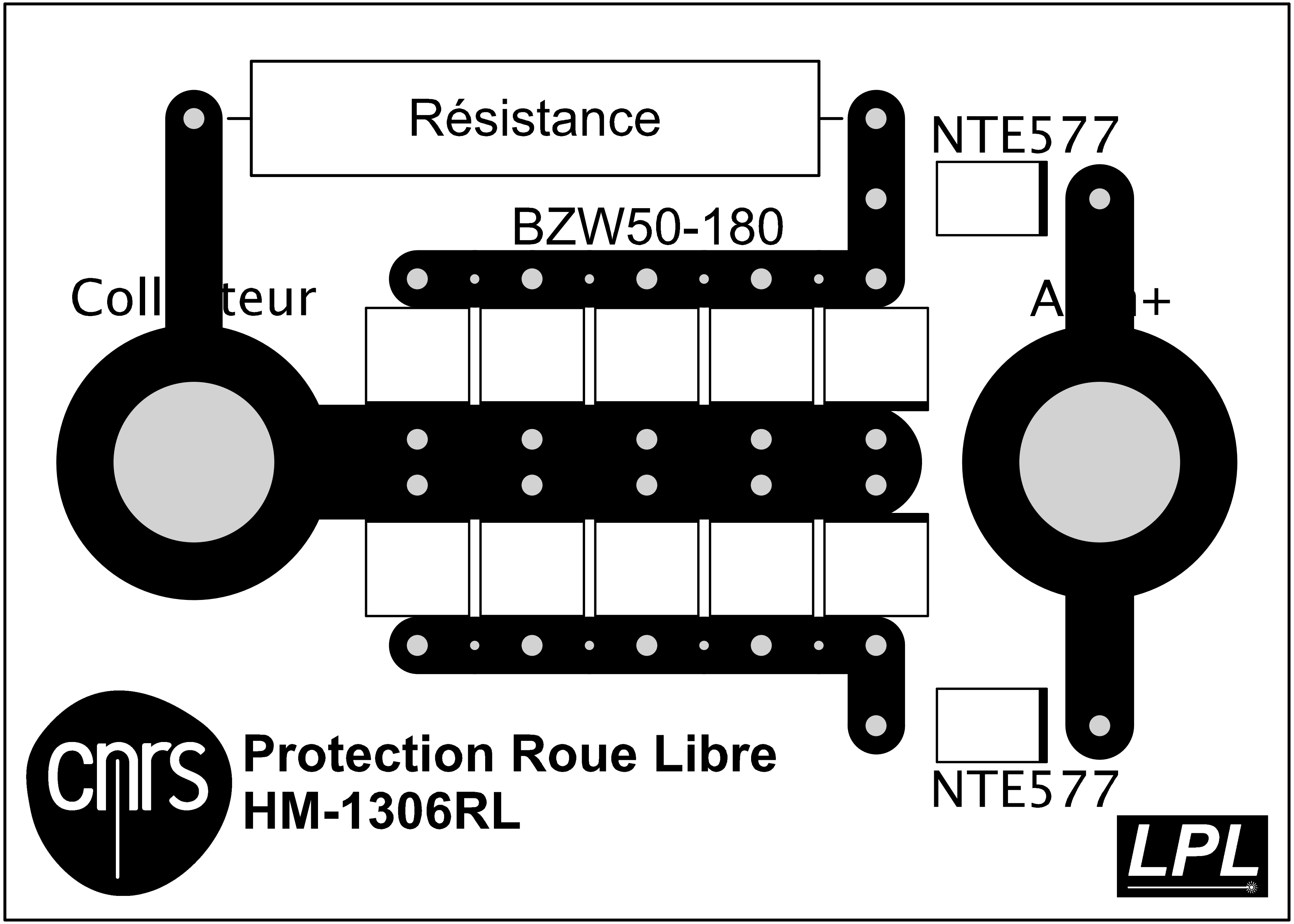
Vcemax IGBT = 1200V

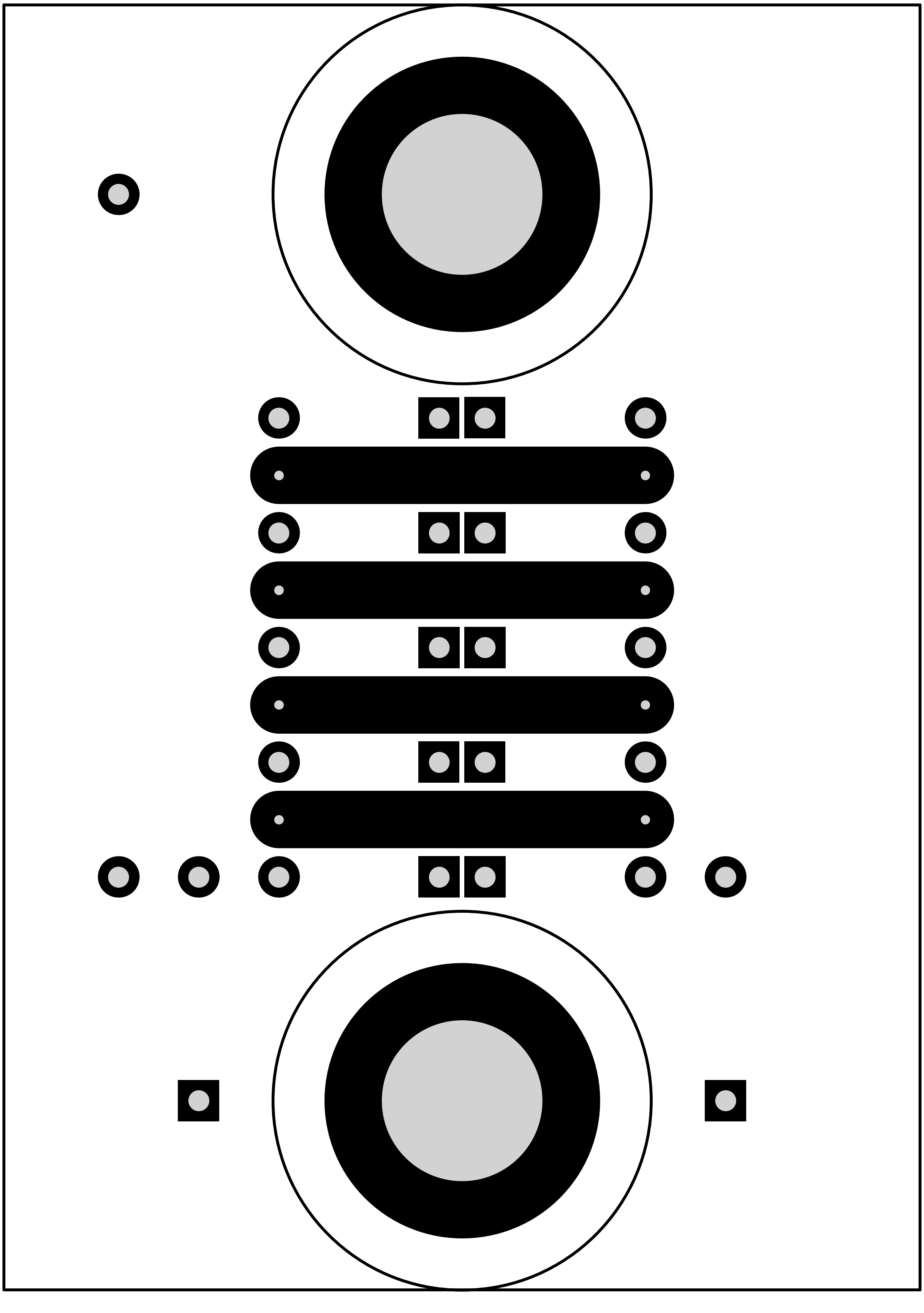
Carte 80x115mm

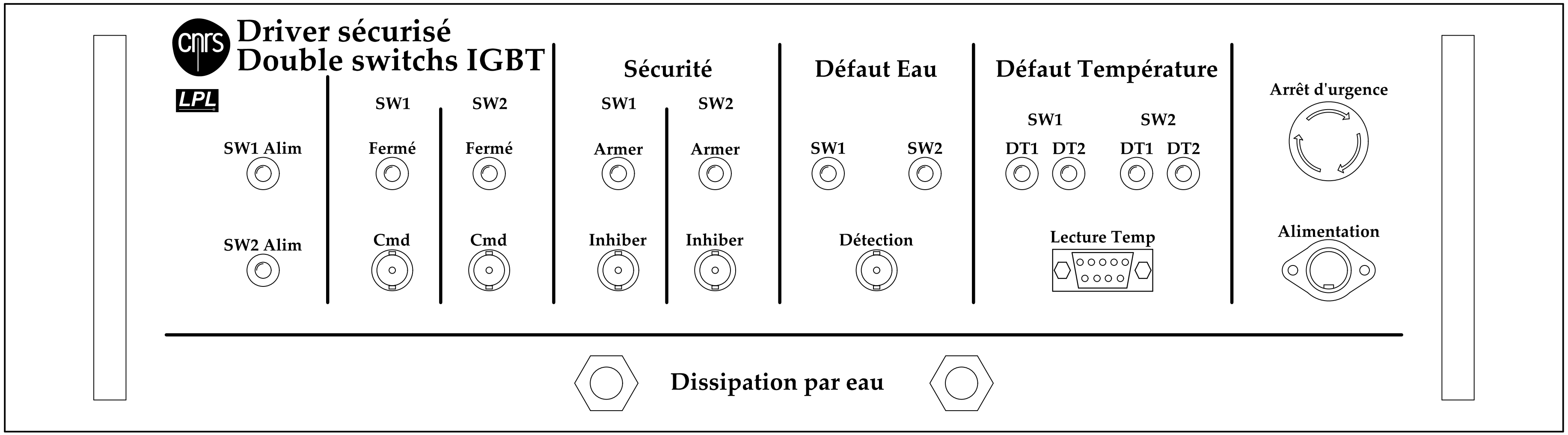


Title: Protection Roue Libre			Laboratoire de Physique des Lasers Université Paris 13 - Institut Galilée 99, avenue Jean-Baptiste Clément Villetaneuse (93) France
Author : H. Mouhamad	Size: A4	Sheet N° of Ttl	
Created : 29/11/2013	Modified : 16/10/2013	Rev : 0	

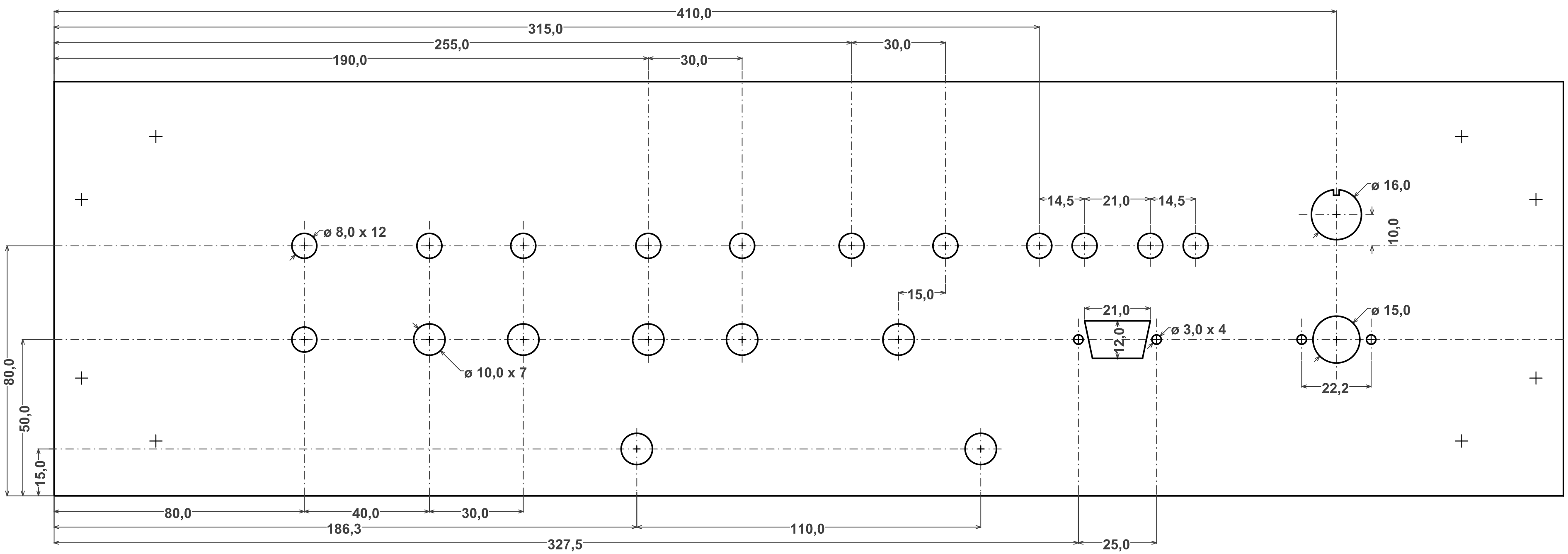
File: Z:\Equipe\Projet\1301_DriverIGBT\CAO\PCB_RoueLibre_V2\DI_RoueLibre_V2.SchDoc


Résistance
NTE577
BZW50-180
Coll teur
A n+
NTE577
Protection Roue Libre
HM-1306RL
LPL





Driver sécurisé
Double switchs IGBT
LPL
SW1 Alim
SW2 Alim
SW1
SW2
Fermé
Fermé
Cmd
Cmd
Sécurité
SW1
SW2
Armer
Armer
Inhiber
Inhiber
Défaut Eau
SW1
SW2
Détection
Défaut Température
SW1
SW2
DT1
DT2
DT1
DT2
Lecture Temp
Arrêt d'urgence
Alimentation
Dissipation par eau

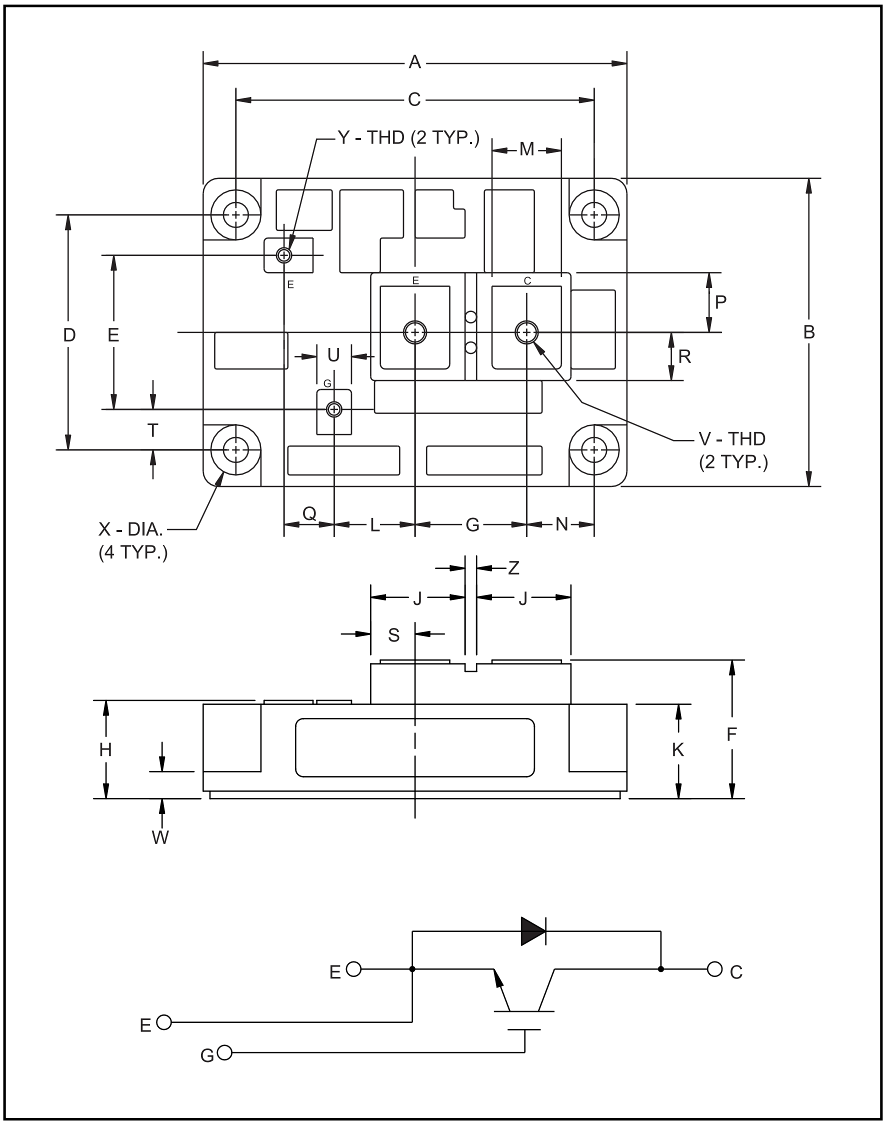


410,0
315,0
255,0
30,0
190,0
30,0
14,5
21,0
14,5
ø 16,0
ø 8,0 x 12
10,0
15,0
21,0
ø 15,0
ø 3,0 x 4
12,0
ø 10,0 x 7
22,2
80,0
50,0
15,0
80,0
40,0
30,0
186,3
110,0
327,5
25,0

Powerex, Inc., 200 Hillis Street, Youngwood, Pennsylvania 15697-1800 (724) 925-7272

Single IGBTMOD™ H-Series Module

600 Amperes/1200 Volts



Outline Drawing and Circuit Diagram

Dimensions	Inches	Millimeters
A	4.33	110.0
B	3.15	80.0
C	3.66±0.008	93.0±0.25
D	2.44±0.008	62.0±0.25
E	1.57	40.0
F	1.42 Max.	36.0 Max.
G	1.14	29.0
H	1.00 Max.	25.5 Max.
J	0.96	25.0
K	0.94	24.5
L	0.83	21.0
M	0.71	18.0

Dimensions	Inches	Millimeters
N	0.69	17.5
P	0.61	15.5
Q	0.51	13.0
R	0.49	12.5
S	0.45	11.5
T	0.43	11.0
U	0.35	9.0
V	M8 Metric	M8
W	0.28	7.0
X	0.256 Dia.	Dia. 6.50
Y	M4 Metric	M4
Z	0.12	3.04

Description:

Powerex IGBTMOD™ Modules are designed for use in switching applications. Each module consists of one IGBT Transistor in a single configuration with a reverse-connected super-fast recovery free-wheel diode. All components and interconnects are isolated from the heat sinking baseplate, offering simplified system assembly and thermal management.

Features:

- ☐ Low Drive Power
- ☐ Low $V_{CE(sat)}$
- ☐ Discrete Super-Fast Recovery (135ns) Free-Wheel Diode
- ☐ High Frequency Operation (20-25kHz)
- ☐ Isolated Baseplate for Easy Heat Sinking

Applications:

- ☐ AC Motor Control
- ☐ Motion/Servo Control
- ☐ UPS
- ☐ Welding Power Supplies
- ☐ Laser Power Supplies

Ordering Information:

Example: Select the complete part module number you desire from the table below -i.e. CM600HA-24H is a 1200V (V_{CES}), 600 Ampere Single IGBTMOD™ Power Module.

Type	Current Rating Amperes	V_{CES} Volts (x 50)
CM	600	24

Powerex, Inc., 200 Hillis Street, Youngwood, Pennsylvania 15697-1800 (724) 925-7272

CM600HA-24H
Single IGBTMOD™ H-Series Module
600 Amperes/1200 Volts

Absolute Maximum Ratings, T_j = 25 °C unless otherwise specified

Ratings	Symbol	CM600HA-24H	Units
Junction Temperature	T_j	–40 to 150	°C
Storage Temperature	T_{stg}	–40 to 125	°C
Collector-Emitter Voltage (G-E SHORT)	V_{CES}	1200	Volts
Gate-Emitter Voltage	V_{GES}	±20	Volts
Collector Current	I_C	600	Amperes
Peak Collector Current	I_{CM}	1200*	Amperes
Diode Forward Current	I_F	600	Amperes
Diode Forward Surge Current	I_{FM}	1200*	Amperes
Power Dissipation	P_d	4100	Watts
Max. Mounting Torque M8 Terminal Screws	–	95	in-lb
Max. Mounting Torque M6 Mounting Screws	–	26	in-lb
Module Weight (Typical)	–	560	Grams
V Isolation	V_{RMS}	2500	Volts

* Pulse width and repetition rate should be such that device junction temperature does not exceed the device rating.

Static Electrical Characteristics, T_j = 25 °C unless otherwise specified

Characteristics	Symbol	Test Conditions	Min.	Typ.	Max.	Units
Collector-Cutoff Current	I_{CES}	$V_{CE} = V_{CES}$, V_{GE} = 0V	–	–	2.0	mA
Gate Leakage Current	I_{GES}	$V_{GE} = V_{GES}$, V_{CE} = 0V	–	–	0.5	µA
Gate-Emitter Threshold Voltage	$V_{GE(th)}$	I_C = 60mA, V_{CE} = 10V	4.5	6.0	7.5	Volts
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C = 600A, V_{GE} = 15V	–	2.5	3.4**	Volts
		I_C = 600A, V_{GE} = 15V, T_j = 150°C	–	2.25	–	Volts
Total Gate Charge	Q_G	V_{CC} = 600V, I_C = 600A, V_{GS} = 15V	–	3000	–	nC
Diode Forward Voltage	V_{FM}	I_E = 600A, V_{GS} = 0V	–	–	3.5	Volts

** Pulse width and repetition rate should be such that device junction temperature rise is negligible.

Dynamic Electrical Characteristics, T_j = 25 °C unless otherwise specified

Characteristics		Symbol	Test Conditions	Min.	Typ.	Max.	Units
Input Capacitance		C_{ies}	V_{GE} = 0V, V_{CE} = 10V, f = 1MHz	–	–	120	nF
Output Capacitance		C_{oes}		–	–	42	nF
Reverse Transfer Capacitance		C_{res}		–	–	24	nF
Resistive	Turn-on Delay Time	$t_{d(on)}$	V_{CC} = 600V, I_C = 600A,	–	–	300	ns
Load	Rise Time	t_r	$V_{GE1} = V_{GE2}$ = 15V, R_G = 2.1Ω	–	–	700	ns
Switching	Turn-off Delay Time	$t_{d(off)}$		–	–	450	ns
Times	Fall Time	t_f		–	–	350	ns
Diode Reverse Recovery Time		t_{rr}	I_E = 600A, di_E/dt = –1200A/µs	–	–	250	ns
Diode Reverse Recovery Charge		Q_{rr}	I_E = 600A, di_E/dt = –1200A/µs	–	4.46	–	µC

Thermal and Mechanical Characteristics, T_j = 25 °C unless otherwise specified

Characteristics	Symbol	Test Conditions	Min.	Typ.	Max.	Units
Thermal Resistance, Junction to Case	$R_{th(j-c)}$	Per IGBT	–	–	0.035	°C/W
Thermal Resistance, Junction to Case	$R_{th(j-c)}$	Per FWDi	–	–	0.06	°C/W
Contact Thermal Resistance	$R_{th(c-f)}$	Per Module, Thermal Grease Applied	–	–	0.035	°C/W

XC9536XL High Performance CPLD

DS058 (v1.9) April 3, 2007

Product Specification

Features

- 5 ns pin-to-pin logic delays
- System frequency up to 178 MHz
- 36 macrocells with 800 usable gates
- Available in small footprint packages
  - 44-pin PLCC (34 user I/O pins)
  - 44-pin VQFP (34 user I/O pins)
  - 48-pin CSP (36 user I/O pins)
  - 64-pin VQFP (36 user I/O pins)
  - Pb-free available for all packages
- Optimized for high-performance 3.3V systems
  - Low power operation
  - 5V tolerant I/O pins accept 5 V, 3.3V, and 2.5V signals
  - 3.3V or 2.5V output capability
  - Advanced 0.35 micron feature size CMOS Fast FLASH™ technology
- Advanced system features
  - In-system programmable
  - Superior pin-locking and routability with Fast CONNECT™ II switch matrix
  - Extra wide 54-input Function Blocks
  - Up to 90 product-terms per macrocell with individual product-term allocation
  - Local clock inversion with three global and one product-term clocks
  - Individual output enable per output pin
  - Input hysteresis on all user and boundary-scan pin inputs
  - Bus-hold circuitry on all user pin inputs
  - Full IEEE Standard 1149.1 boundary-scan (JTAG)
- Fast concurrent programming
- Slew rate control on individual outputs
- Enhanced data security features
- Excellent quality and reliability
  - Endurance exceeding 10,000 program/erase cycles
  - 20 year data retention
  - ESD protection exceeding 2,000V
- Pin-compatible with 5V-core XC9536 device in the 44-pin PLCC package and the 48-pin CSP package

WARNING: Programming temperature range of T_A = 0° C to +70° C

Description

The XC9536XL is a 3.3V CPLD targeted for high-performance, low-voltage applications in leading-edge communications and computing systems. It is comprised of two 54V18 Function Blocks, providing 800 usable gates with propagation delays of 5 ns. See Figure 2 for architecture overview.

Power Estimation

Power dissipation in CPLDs can vary substantially depending on the system frequency, design application and output loading. To help reduce power dissipation, each macrocell in a XC9500XL device may be configured for low-power mode (from the default high-performance mode). In addition, unused product-terms and macrocells are automatically deactivated by the software to further conserve power.

For a general estimate of I_{CC}, the following equation may be used:

$$I_{CC}(mA) = MC_{HS}(0.175*PT_{HS} + 0.345) + MC_{LP}(0.052*PT_{LP} + 0.272) + 0.04 * MC_{TOG}(MC_{HS} + MC_{LP})* f$$

where:

MC_{HS} = # macrocells in high-speed configuration

PT_{HS} = average number of high-speed product terms per macrocell

MC_{LP} = # macrocells in low power configuration

PT_{LP} = average number of low power product terms per macrocell

f = maximum clock frequency

MCTOG = average % of flip-flops toggling per clock (~12%)

This calculation was derived from laboratory measurements of an XC9500XL part filled with 16-bit counters and allowing a single output (the LSB) to be enabled. The actual I_{CC} value varies with the design application and should be verified during normal system operation. Figure 1 shows the above estimation in a graphical form. For a more detailed discussion of power consumption in this device, see Xilinx application note [XAPP114, "Understanding XC9500XL CPLD Power."](#)

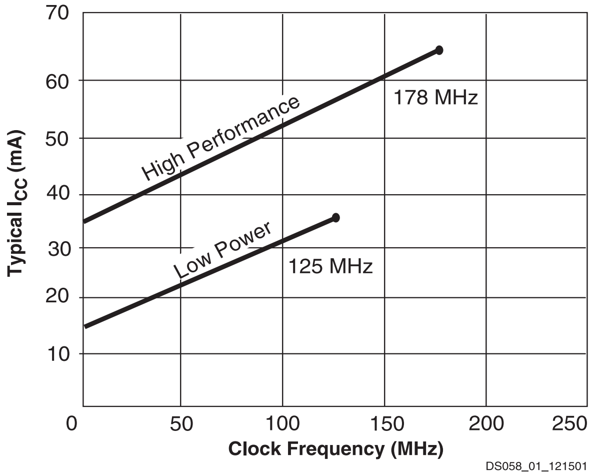


Figure 1: **Typical I_{CC} vs. Frequency for XC9536XL**

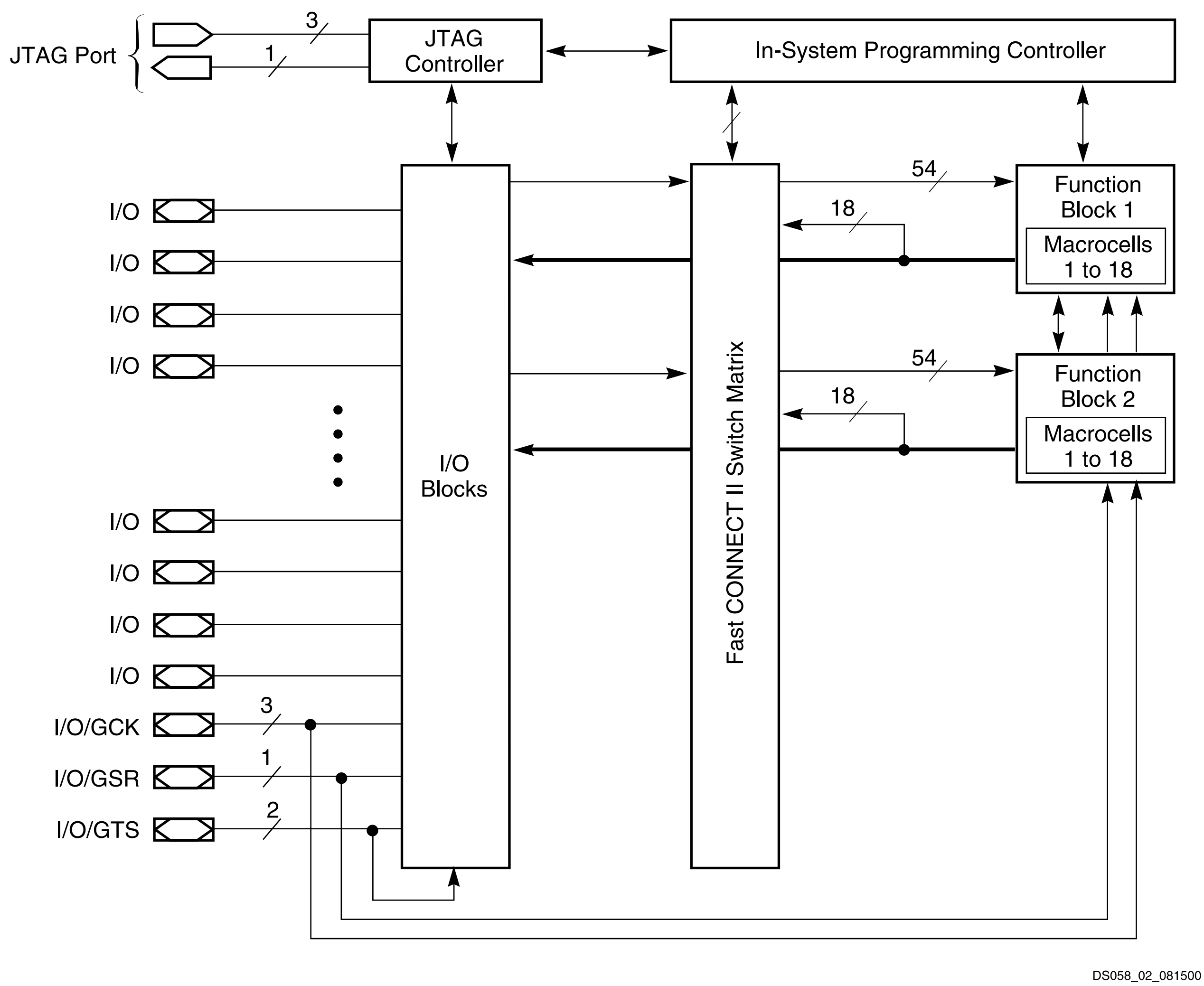


Figure 2: **XC9536XL Architecture**

Function Block outputs (indicated by the bold line) drive the I/O Blocks directly.

Absolute Maximum Ratings[2]

Symbol	Description	Value	Units
V_{CC}	Supply voltage relative to GND	–0.5 to 4.0	V
V_{IN}	Input voltage relative to GND[1]	–0.5 to 5.5	V
V_{TS}	Voltage applied to 3-state output[1]	–0.5 to 5.5	V
T_{STG}	Storage temperature (ambient)[3]	–65 to +150	°C
T_J	Junction temperature	+150	°C

Notes:

1. Maximum DC undershoot below GND must be limited to either 0.5V or 10 mA, whichever is easier to achieve. During transitions, the device pins may undershoot to –2.0 V or overshoot to +7.0V, provided this over- or undershoot lasts less than 10 ns and with the forcing current being limited to 200 mA. External I/O voltage may not exceed V_{CCINT} by 4.0V.
2. Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those listed under Operating Conditions is not implied. Exposure to Absolute Maximum Ratings conditions for extended periods of time may affect device reliability.
3. For soldering guidelines and thermal considerations, see the Device Packaging information on the Xilinx website. For Pb-free packages, see XAPP427.

Recommended Operation Conditions

Symbol	Parameter		Min	Max	Units
V_{CCINT}	Supply voltage for internal logic and input buffers	Commercial T_A = 0°C to 70°C	3.0	3.6	V
		Industrial T_A = –40°C to +85°C	3.0	3.6	V
V_{CCIO}	Supply voltage for output drivers for 3.3V operation		3.0	3.6	V
	Supply voltage for output drivers for 2.5V operation		2.3	2.7	V
V_{IL}	Low-level input voltage		0	0.80	V
V_{IH}	High-level input voltage		2.0	5.5	V
V_O	Output voltage		0	V_{CCIO}	V

Quality and Reliability Characteristics

Symbol	Parameter	Min	Max	Units
T_{DR}	Data Retention	20	-	Years
N_{PE}	Program/Erase Cycles (Endurance)	10,000	-	Cycles
V_{ESD}	Electrostatic Discharge (ESD)	2,000	-	Volts

DC Characteristic Over Recommended Operating Conditions

Symbol	Parameter	Test Conditions	Min	Max	Units
V_{OH}	Output high voltage for 3.3V outputs	I_{OH} = –4.0 mA	2.4	-	V
	Output high voltage for 2.5V outputs	I_{OH} = –500 µA	90% V_{CCIO}	-	V
V_{OL}	Output low voltage for 3.3V outputs	I_{OL} = 8.0 mA	-	0.4	V
	Output low voltage for 2.5V outputs	I_{OL} = 500 µA	-	0.4	V
I_{IL}	Input leakage current	V_{CC} = Max; V_{IN} = GND or V_{CC}	-	±10	µA
I_{IH}	I/O high-Z leakage current	V_{CC} = Max; V_{IN} = GND or V_{CC}	-	±10	µA
I_{IH}	I/O high-Z leakage current	V_{CC} = Max; V_{CCIO} = Max; V_{IN} = GND or 3.6V	-	±10	µA
		V_{CC} Min < V_{IN} < 5.5V	-	±50	µA
C_{IN}	I/O capacitance	V_{IN} = GND; f = 1.0 MHz	-	10	pF
I_{CC}	Operating supply current (low power mode, active)	V_{IN} = GND, No load; f = 1.0 MHz	10 (Typical)		mA

XC9536XL I/O Pins(2)

Function Block	Macro-cell	PC44	VQ44	CS48	VQ64	BScan Order	Function Block	Macro-cell	PC44	VQ44	CS48	VQ64	BScan Order
1	1	2	40	D6	9	105	2	1	1	39	D7	8	51
1	2	3	41	C7	10	102	2	2	44	38	E5	7	48
1	3	5(1)	43(1)	B7(1)	15(1)	99	2	3	42(1)	36(1)	E6(1)	5(1)	45
1	4	4	42	C6	11	96	2	4	43	37	E7	6	42
1	5	6(1)	44(1)	B6(1)	16(1)	93	2	5	40(1)	34(1)	F6(1)	2(1)	39
1	6	8	2	A6	19	90	2	6	39(1)	33(1)	G7(1)	64(1)	36
1	7	7(1)	1(1)	A7(1)	17(1)	87	2	7	38	32	G6	63	33
1	8	9	3	C5	20	84	2	8	37	31	F5	62	30
1	9	11	5	B5	22	81	2	9	36	30	G5	61	27
1	10	12	6	A4	24	78	2	10	35	29	F4	60	24
1	11	13	7	B4	25	75	2	11	34	28	G4	57	21
1	12	14	8	A3	27	72	2	12	33	27	E3	56	18
1	13	18	12	B2	33	69	2	13	29	23	F2	50	15
1	14	19	13	B1	35	66	2	14	28	22	G1	48	12
1	15	20	14	C2	36	63	2	15	27	21	F1	45	9
1	16	22	16	C3	38	60	2	16	26	20	E2	44	6
1	17	24	18	D2	42	57	2	17	25	19	E1	43	3
1	18	-	-	D3	39	54	2	18	-	-	E4	49	0

Notes:
1. Global control pin.
2. The pin-outs are the same for Pb-free versions of packages.

XC9536XL Global, JTAG and Power Pins(1)

Pin Type	PC44	VQ44	CS48	VQ64
I/O/GCK1	5	43	B7	15
I/O/GCK2	6	44	B6	16
I/O/GCK3	7	1	A7	17
I/O/GTS1	42	36	E6	5
I/O/GTS2	40	34	F6	2
I/O/GSR	39	33	G7	64
TCK	17	11	A1	30
TDI	15	9	B3	28
TDO	30	24	G2	53
TMS	16	10	A2	29
V_{CCINT} 3.3V	21, 41	15, 35	C1, F7	3, 37
V_{CCIO} 2.5V/3.3V	32	26	G3	55
GND	10, 23, 31	4, 17, 25	A5, D1, F3	21, 41, 54
No Connects	-	-	C4, D4	1, 4, 12, 13, 14, 18, 23, 26, 31, 32, 34, 40, 46, 47, 51, 52, 58, 59

Notes:
1. The pin-outs are the same for Pb-free versions of packages.

ANALOG DEVICES

2-Terminal IC Temperature Transducer

Data Sheet **AD590**

FEATURES

Linear current output: 1 μA/K
Wide temperature range: −55°C to +150°C
Probe-compatible ceramic sensor package
2-terminal device: voltage in/current out
Laser trimmed to ±0.5°C calibration accuracy (AD590M)
Excellent linearity: ±0.3°C over full range (AD590M)
Wide power supply range: 4 V to 30 V
Sensor isolation from case
Available in 2-lead FLATPACK, 4-lead LFCSP, 3-pin TO-52, 8-lead SOIC, and die form

GENERAL DESCRIPTION

The AD590 is a 2-terminal integrated circuit temperature transducer that produces an output current proportional to absolute temperature. For supply voltages between 4 V and 30 V, the device acts as a high impedance, constant current regulator passing 1 μA/K. Laser trimming of the chip's thin-film resistors is used to calibrate the device to 298.2 μA output at 298.2 K (25°C).

The AD590 should be used in any temperature-sensing application below 150°C in which conventional electrical temperature sensors are currently employed. The inherent low cost of a monolithic integrated circuit combined with the elimination of support circuitry makes the AD590 an attractive alternative for many temperature measurement situations. Linearization circuitry, precision voltage amplifiers, resistance measuring circuitry, and cold junction compensation are not needed in applying the AD590.

In addition to temperature measurement, applications include temperature compensation or correction of discrete components, biasing proportional to absolute temperature, flow rate measurement, level detection of fluids and anemometry. The AD590 is available in die form, making it suitable for hybrid circuits and fast temperature measurements in protected environments.

The AD590 is particularly useful in remote sensing applications. The device is insensitive to voltage drops over long lines due to its high impedance current output. Any well-insulated twisted pair is sufficient for operation at hundreds of feet from the receiving circuitry. The output characteristics also make the AD590 easy to multiplex: the current can be switched by a CMOS multiplexer, or the supply voltage can be switched by a logic gate output.

PIN CONFIGURATIONS

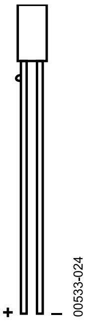


Figure 1. 2-Lead FLATPACK

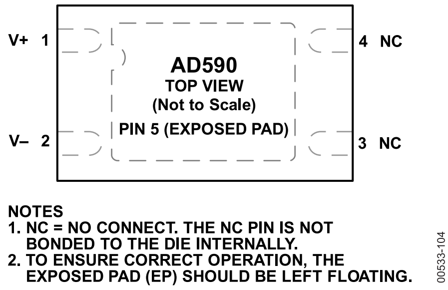


Figure 2. 4-Lead LFCSP

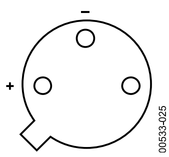


Figure 3. 3-Pin TO-52

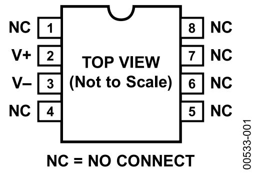


Figure 4. 8-Lead SOIC

PRODUCT HIGHLIGHTS

1. The AD590 is a calibrated, 2-terminal temperature sensor requiring only a dc voltage supply (4 V to 30 V). Costly transmitters, filters, lead wire compensation, and linearization circuits are all unnecessary in applying the device.
2. State-of-the-art laser trimming at the wafer level in conjunction with extensive final testing ensures that AD590 units are easily interchangeable.
3. Superior interface rejection occurs because the output is a current rather than a voltage. In addition, power requirements are low (1.5 mW @ 5 V @ 25°C). These features make the AD590 easy to apply as a remote sensor.
4. The high output impedance (>10 MΩ) provides excellent rejection of supply voltage drift. For instance, changing the power supply from 5 V to 10 V results in only a 1 μA maximum current change, or 1°C equivalent error.
5. The AD590 is electrically durable: it withstands a forward voltage of up to 44 V and a reverse voltage of 20 V. Therefore, supply irregularities or pin reversal does not damage the device.

Rev. G Document Feedback

One Technology Way, P.O. Box 9106, Norwood, MA 02062-9106, U.S.A.
Tel: 781.329.4700

Technical Support **www.analog.com**

GENERAL APPLICATIONS

Figure 17 shows a typical use of the AD590 in a remote temperature sensing application. The AD590 is used as a thermometer circuit that measures temperature from −55°C to +150°C, with an output voltage of 1 mV/°K. Because the AD590 measures absolute temperature (its nominal output is 1 mA/K), the output must be offset by 273.2 mA to read out in degrees Celsius.

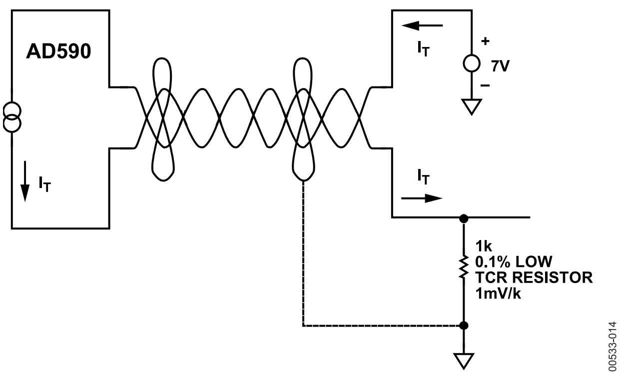


Figure 17. Variable Scale Display

Connecting several AD590 units in series, as shown in Figure 18, allows the minimum of all the sensed temperatures to be indicated. In contrast, using the sensors in parallel yields the average of the sensed temperatures.

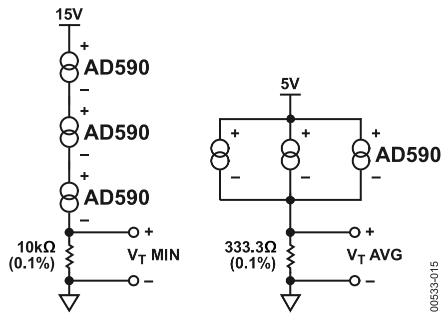


Figure 18. Series and Parallel Connection

The circuit in Figure 19 demonstrates one method by which differential temperature measurements can be made. R1 and R2 can be used to trim the output of the op amp to indicate a desired temperature difference. For example, the inherent offset between the two devices can be trimmed in. If V+ and V− are radically different, then the difference in internal dissipation causes a differential internal temperature rise. This effect can be used to measure the ambient thermal resistance seen by the sensors in applications such as fluid-level detectors or anemometry.

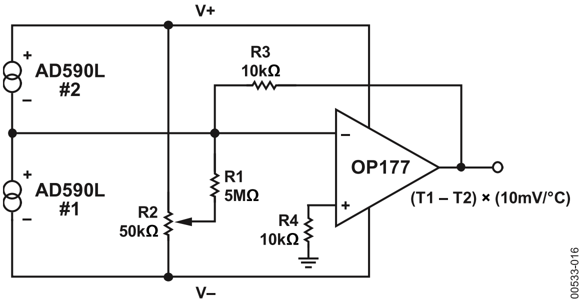


Figure 19. Differential Measurements

Figure 20 is an example of a cold junction compensation circuit for a Type J thermocouple using the AD590 to monitor the reference junction temperature. This circuit replaces an ice-bath as the thermocouple reference for ambient temperatures between 15°C and 35°C. The circuit is calibrated by adjusting R_T for a proper meter reading with the measuring junction at a known reference temperature and the circuit near 25°C. Using components with the TCs as specified in Figure 20, compensation accuracy is within ±0.5°C for circuit temperatures between 15°C and 35°C. Other thermocouple types can be accommodated with different resistor values. Note that the TCs of the voltage reference and the resistors are the primary contributors to error.

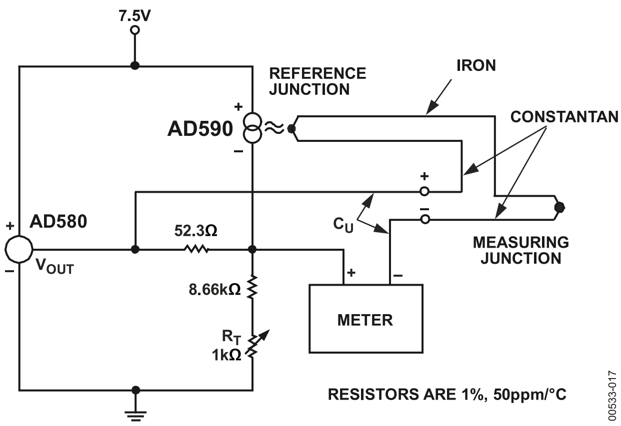


Figure 20. Cold Junction Compensation Circuit for Type J Thermocouple

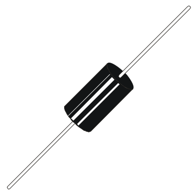
BZW50

Transil™, transient voltage surge suppressor (TVS)

Datasheet — production data

Features

- Peak pulse power: 5000 W (10/1000 µs)
- Stand-off voltage range from 10 V to 180 V
- Unidirectional and bidirectional types
- Low clamping factor
- Fast response time
- UL497B, file number: QVGQ2.E136224



R6

Description

Transil diodes provide high overvoltage protection by clamping action. Their instantaneous response to transient overvoltages makes them particularly suited to protect voltage sensitive devices such as MOS Technology and low voltage supplied ICs.

TM:Transil is a trademarks of STMicroelectronics.

1 Characteristics

Table 1. Absolute maximum ratings (T_{amb} = 25 °C)

Symbol	Parameter		Value	Unit
P_{PP}	Peak pulse power dissipation[(1)]	$T_{j\ initial} = T_{amb}$	5000	W
P	Power dissipation on infinite heatsink	T_{amb} = 75 °C	6.5	W
I_{FSM}	Non repetitive surge peak forward current for unidirectional types	t_p = 10 ms $T_{j\ initial} = T_{amb}$	500	A
T_{stg}	Storage temperature range		-65 to + 175	°C
T_j	Maximum operating junction temperature		175	°C
T_L	Maximum lead temperature for soldering during 10 s at 5 mm from case.		260	°C

1. For a surge greater than the maximum values, the diode will fail in short-circuit.

Table 2. Thermal resistances

Symbol	Parameter	Value	Unit
$R_{th(j-l)}$	Junction to leads	15	°C/W
$R_{th(j-a)}$	Junction to ambient on printed circuit. L_{lead} = 10 mm	65	

Figure 1. Electrical characteristics - definitions

Symbol	Parameter
V_{RM}	Stand-off voltage
V_{BR}	Breakdown voltage
V_{CL}	Clamping voltage
I_{RM}	Leakage current @ V_{RM}
I_{PP}	Peak pulse current
αT	Voltage temperature coefficient
V_F	Forward voltage drop
R_D	Dynamic resistance

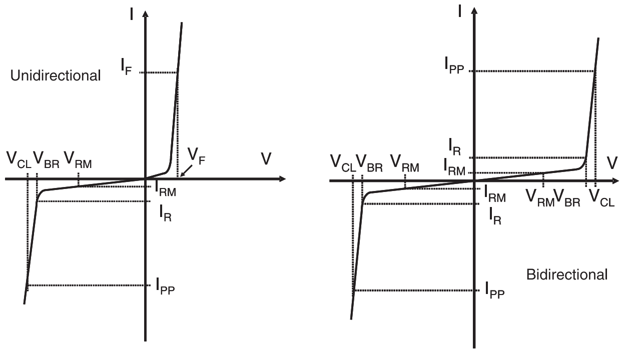


Figure 2. Pulse definition for electrical characteristics

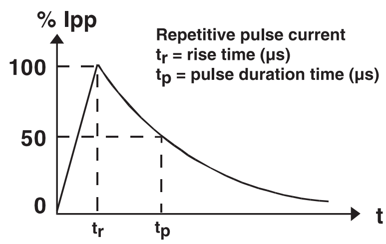


Table 3. Electrical characteristics - values (T_{amb} = 25 °C)

Order code		I_{RM} @ V_{RM} max		V_{BR} @ I_R (1) min		V_{CL} @ I_{PP} 10/1000 µs max		V_{CL} @ I_{PP} 8/20µs max		αT (2) max	C (3) typ
Unidirectional	Bidirectional	µA	V	V	mA	V	A	V	A	10^{-4}/ °C	pF
BZW50-10	BZW50-10B	5	10	11.1	1	18.8	266	23.4	2564	7.8	24000
BZW50-12	BZW50-12B	5	12	13.3	1	22	227	28	2143	8.4	18500
BZW50-15	BZW50-15B	5	15	16.6	1	26.9	186	35	1714	8.8	13500
BZW50-18	BZW50-18B	5	18	20	1	32.2	155	41.5	1446	9.2	11500
BZW50-22	BZW50-22B	5	22	24.4	1	39.4	127	51	1177	9.6	8500
BZW50-27	BZW50-27B	5	27	30	1	48.3	103	62	968	9.8	7000
BZW50-33	BZW50-33B	5	33	36.6	1	59	85	76	789	10	5750
BZW50-39	BZW50-39B	5	39	43.3	1	69.4	72	90	667	10.1	4800
BZW50-47	BZW50-47B	5	47	52	1	83.2	60.1	108	556	10.3	4100
BZW50-56	BZW50-56B	5	56	62.2	1	99.6	50	129	465	10.4	3400
BZW50-68	BZW50-68B	5	68	75.6	1	121	41	157	382	10.5	3000
BZW50-82	BZW50-82B	5	82	91	1	145	34	189	317	10.6	2600
BZW50-100	BZW50-100B	5	100	111	1	179	28	228	263	10.7	2300
BZW50-120	BZW50-120B	5	120	133	1	215	23	274	219	10.8	1900
BZW50-150	BZW50-150B	5	150	166	1	269	19	343	175	10.8	1700
BZW50-180	BZW50-180B	5	180	200	1	322	16	410	146	10.8	1500

1. Pulse test: t_p < 50 ms.
2. $\Delta V_{BR} = \alpha T \cdot (T_{amb} - 25) \cdot V_{BR}(25°C)$.
3. V_R = 0 V, F = 1 MHz. For bidirectional types, capacitance value is divided by 2.

NTE ELECTRONICS, INC.
44 FARRAND STREET
BLOOMFIELD, NJ 07003
(973) 748–5089

NTE577
Silicon Diode
General Purpose, Fast Recovery Switch

Electrical Characteristics:

Maximum Peak Reverse Voltage, P_{RV} 1000V
Maximum Average Rectified Current (T_A = +50°, half–wave, resistive load 60Hz), I_O 5A
Maximum Forward Peak Surge Current (8.3ms superimposed), I_{FSM} 200A
Maximum Reverse Current (T_A = +25°C, P_{RV} = 1000V), I_R 10μA
Maximum Forward Voltage (T_A = +25°C, I_F = 5A), V_{FM} 1.7V
Maximum Reverse Recovery Time, t_{rr} 70ns
Operating Temperature Range, T_{opr} . . . . –65° to +150°C
Storage Temperature Range, T_{stg} . . . . –65° to +150°C