

## Projet 11 - HS04 / Hacheur symétrique pour train.

Projet : TRAIN2

Info : [DIV223], sujet de formation 2001/2002.

Révision : 3 du 27 août 2001

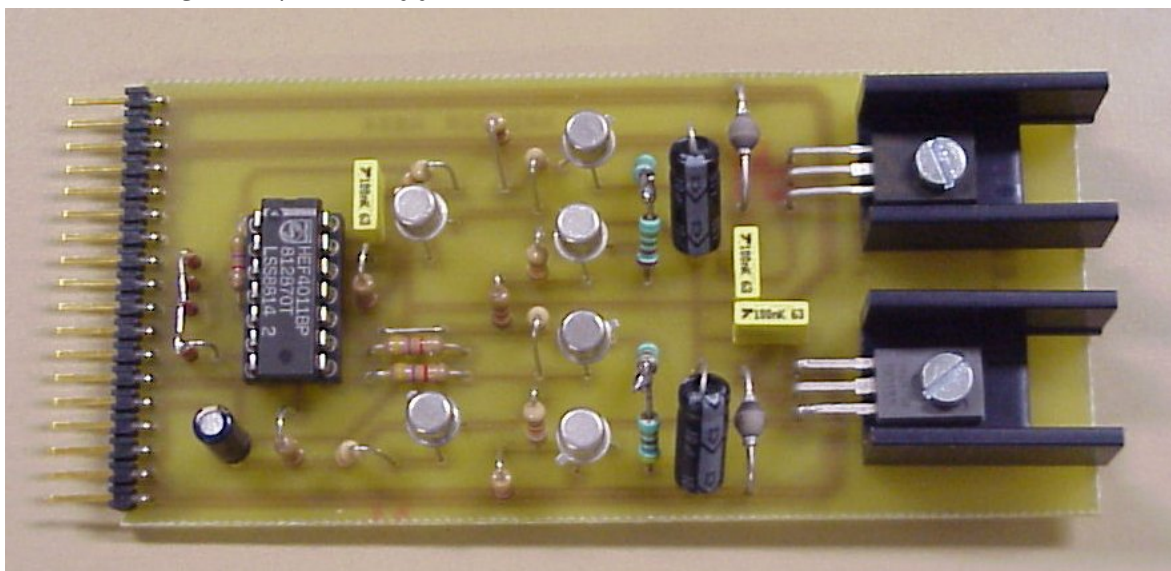


Figure 11.1. Hacheur symétrique pour train (images\_maquettes\hs04-1.jpg).

### 11.1 Liste des documents

- Calculs des résistances
- Implantation du connecteur HE13 - 18 points.
- Contraintes mécaniques.
- Liste des composants.
- Implantation des composants et circuit imprimé coté cuivre.
- Schéma électronique de la partie commande.
- Schéma électronique de la partie puissance.
- Documentations : HEF4011B, BD135, BD136, BYV95A, 2N2222A, 2N2907A.

### 11.2 Fonctionnement du montage

Tableau 11.1. Table de vérité du montage.

$\overline{\text{STOP}}$	AVAR	T1	T2	Q1	Q6	Q4	Q2	Q5	Q3	Vout
0	X	+5V	0V	ON	ON	ON	ON	OFF	OFF	HZ
1	0	0V	0V	OFF	ON	OFF	ON	ON	OFF	+E
1	1	+5V	+5V	ON	OFF	ON	OFF	OFF	ON	-E

### 11.3 Calculs des résistances

Soit I le courant maximal dans la charge. Soient  $\beta_3$  et  $\beta_2$  les gains en régime de saturation respectifs des transistors Q3 et Q2. La résistance R4 est donnée par

$$R_4 \approx \frac{+E}{ib_3} = \frac{\beta_3 \cdot E}{I}$$

La puissance dissipée dans R4 vaut

$$P_{R_4} = R_4 \cdot (ib_3)^2 = R_4 \cdot \left(\frac{\beta_3}{I}\right)^2$$

La résistance R5 est

$$\text{donnée par } R_5 \approx \frac{+E}{ib_2} = \frac{\beta_2 \cdot E}{ib_3} = \frac{\beta_2 \cdot \beta_3 \cdot E}{I}$$

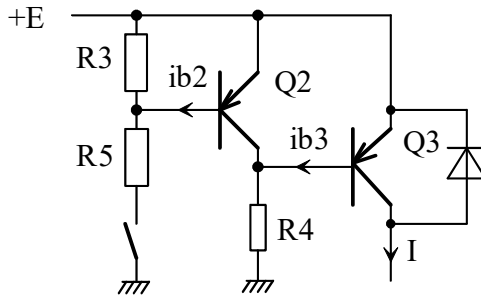


Figure 11.2. (orcad\train\hs03.drw).

R3 est prise 10 fois plus faible que R5.

Tableau 11.2. Calcul des résistances pour 3A – TIP41C et TIP42C (projets-train.xls / HS04).

Tension E (en V)	5	9	12	15	16	18	24
Beta Q3 Q5	40	40	40	40	40	40	40
Beta Q2 Q4	80	80	80	80	80	80	80
I Q3 Q5 max (en A)	3	3	3	3	3	3	3
R4 (en ohms)	57,3	111	151	191	204	231	311
P dans R4 en W	0,323	0,623	0,848	1,07	1,15	1,30	1,75
R12 (en ohms)	124	177	217	257	271	297	377
P dans R12 en W	0,698	0,998	1,22	1,45	1,52	1,67	2,12
R5 (en ohms)	4587	8853	12053	15253	16320	18453	24853
R3 (en ohms)	459	885	1205	1525	1632	1845	2485
R10 (en ohms)	9920	14187	17387	20587	21653	23787	30187
R11 (en ohms)	992	1419	1739	2059	2165	2379	3019

Remarque : Les transistors TIP41C et TIP42C sont capable de conduire 6A pour une tension de 100V.

Tableau 11.3. Calcul des résistances pour 1A – BD135 et BD136 (projets-train.xls / HS04).

Tension E (en V)	5	9	12	15	16	18	24
Beta Q3 Q5	40	40	40	40	40	40	40
Beta Q2 Q4	80	80	80	80	80	80	80
I Q3 Q5 max (en A)	1	1	1	1	1	1	1
R4 (en ohms)	172	332	452	572	612	692	932
P dans R4 en W	0,108	0,208	0,283	0,36	0,38	0,43	0,58
R12 (en ohms)	372	532	652	772	812	892	1132
P dans R12 en W	0,233	0,333	0,41	0,48	0,51	0,56	0,71
R5 (en ohms)	13760	26560	36160	45760	48960	55360	74560
R3 (en ohms)	1376	2656	3616	4576	4896	5536	7456
R10 (en ohms)	29760	42560	52160	61760	64960	71360	90560
R11 (en ohms)	2976	4256	5216	6176	6496	7136	9056

Remarque : Les transistors BD135 et BD136 sont capable de conduire 1,5A pour une tension de 45V.

Remarque : Les transistors BD139 et BD140 sont capable de conduire 1,5A pour une tension de 80V.

## 11.4 Implantation du connecteur HE13 - 18 points

Tableau 11.4. Implantation du connecteur HS04.

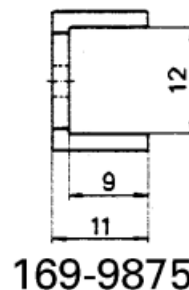
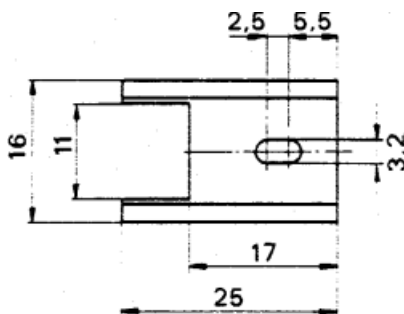
N° de broche :	Désignation :	MUX_HS04
1	OUT	IN3
2	OUT	IN4
3	+E (+14V → +20V)	IN2
4	+E (+14V → +20V)	IN5
5	+E (+14V → +20V)	IN1
6	GND	IN6
7	$\overline{\text{STOP4}}$ : general	IN0
8	$\overline{\text{STOP3}}$ : voie III	IN7
9	$\overline{\text{STOP2}}$ : voie II	
10	$\overline{\text{STOP1}}$ : voie I	
11	AVAR	OUT
12	$\overline{\text{STOP0}}$	$\overline{\text{STOP}}$
13	GND	GND
14	+5V	+5V
15	GND	
16	-E (-14V → -20V)	
17	-E (-14V → -20V)	
18	-E (-14V → -20V)	

### 11.5 Contraintes mécaniques

Les transistors de puissance seront montés sur des radiateurs de type RAWA 400 :



Figure 11.3. (images-composants\rawa400a.jpg).



169-9875

Figure 11.4. (images-composants\rawa400b.gif).

La carte électronique fait 50 mm x 100 mm, afin d'avoir 12 circuits dans une plaque du commerce de 200 mm x 300 mm (référence 292-6932, Radiospares, 87<sup>F</sup>40 HT, septembre 1999 - janvier 2000).

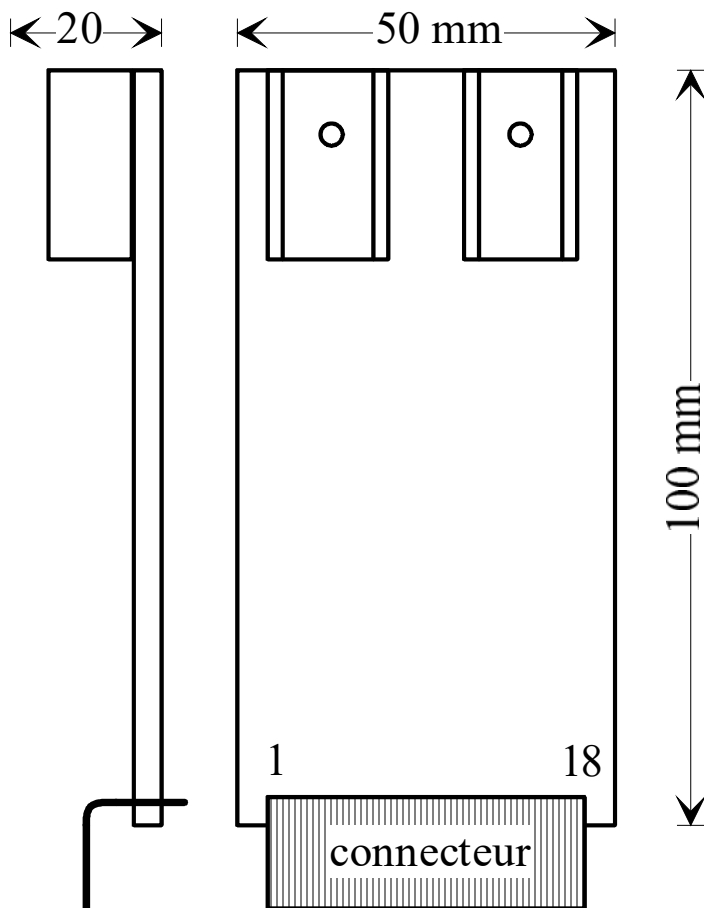
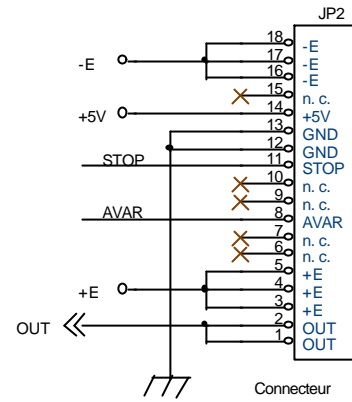
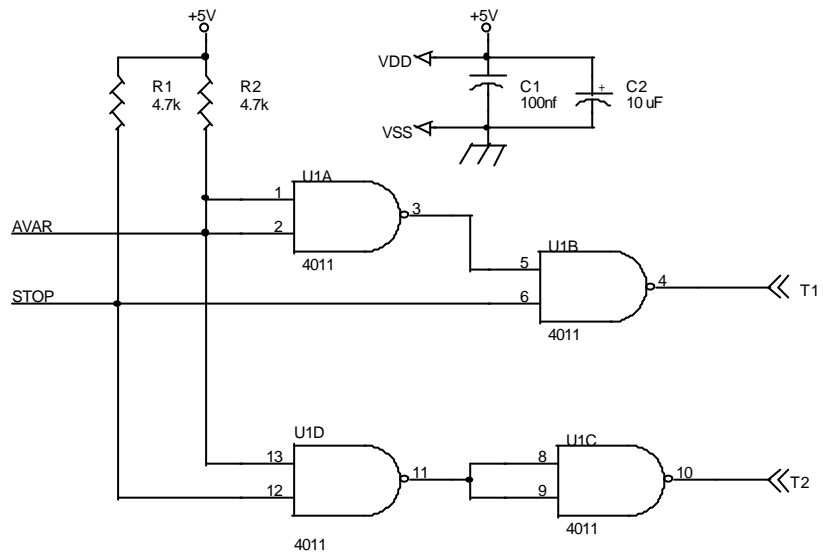


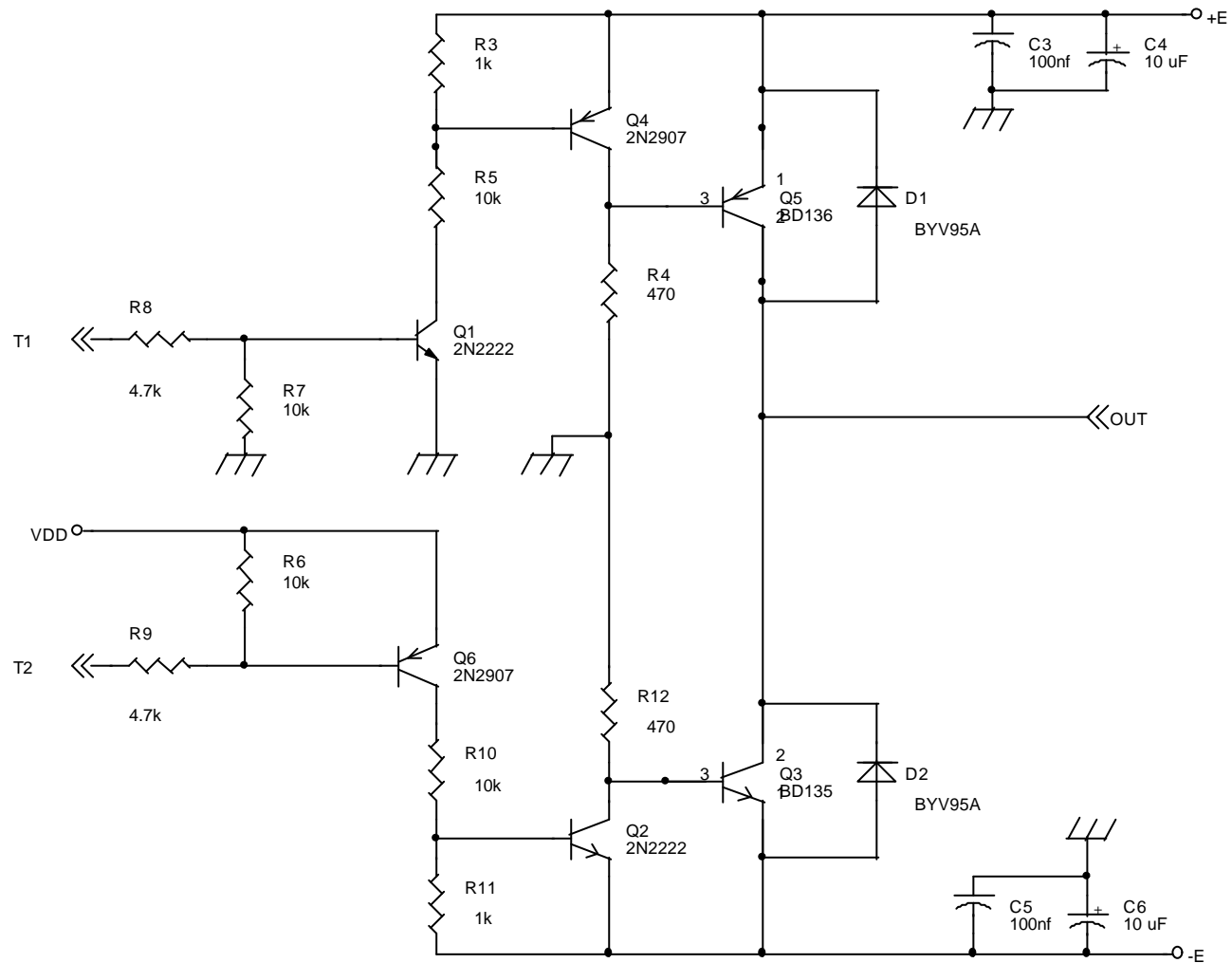
Figure 11.5. Dimensions de la carte (orcad\train2\hs04.drw).

Référence	Qu.	Désignation	Fournisseur	Code Cde.	Page :	U.D.V.	Prix	Prix U.	Prix T.
JP1	0.5	Connecteur en barrette HE13 36 pts	Radiospare 2000	189-9665	1-289	1	49.06 F	49.06 F	24.53 F
C1,C3,C5	3	100nF MKT 63V	Radiospare 2000	166-8348	1-755	10	13.90 F	1.39 F	4.17 F
C2	1	10 uF 25V radial chimique	Radiospare 2000			5	7.00 F	1.40 F	1.40 F
C4,C6	2	10 uF 25V axial chimique	Radiospare 2000	108-5254	1-742	5	7.00 F	1.40 F	2.80 F
D1,D2	2	BYV95A	Radiospare 2000	196-1007	1-937	5	11.50 F	2.30 F	4.60 F
Q2,Q1	2	2N2222A	Radiospare 2000	295-028	1-957	1	3.00 F	3.00 F	6.00 F
Q3	1	BD135				1	7.50 F	7.50 F	7.50 F
Q4,Q6	2	2N2907A	Radiospare 2000	296-166	1-957	1	4.50 F	4.50 F	9.00 F
Q5	1	BD136				1	7.30 F	7.30 F	7.30 F
R1,R2,R8,R9	4	4.7k	IUT GEII			1	0.20 F	0.20 F	0.80 F
R3, R11	2	1k	IUT GEII			1	0.20 F	0.20 F	0.40 F
R4,R12	2	470	IUT GEII			1	0.20 F	0.20 F	0.40 F
R5,R6,R7,R10	4	10k	IUT GEII			1	0.20 F	0.20 F	0.80 F
U1	1	HEF4011BP	Radiospare 2000	306-544	1-1091	5	21.06 F	4.21 F	4.21 F
Divers	2	Dissipateur RAWA 400 11P	Radiospare 2000	169-9875		1	5.25 F	5.25 F	10.50 F
Divers	1	Support 14 broches tulipe	Radiospare 2000	100-9941	1-396	10	48.45 F	4.85 F	4.85 F
Divers	50	Circuit imprimé SF50x100 mm	IUT GEII			1	0.20 F	0.20 F	10.00 F

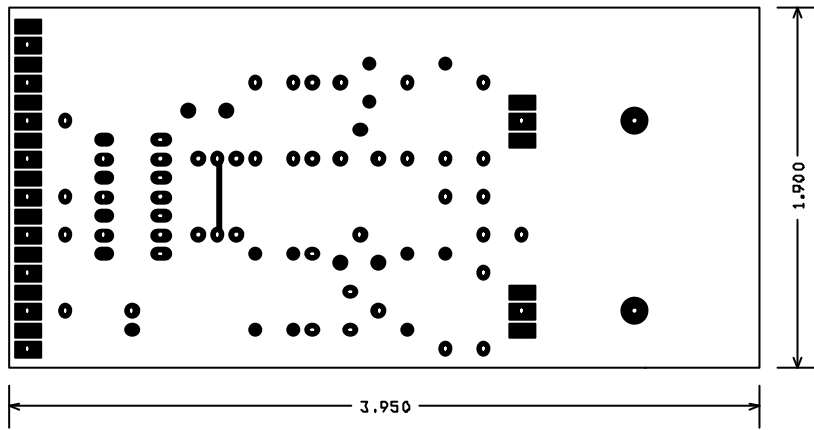
TOTAL H.T. :	99.26 F
dont TVA : 20.60%	20.45 F
<b>TOTAL T.T.C. :</b>	<b>119.70 F</b>



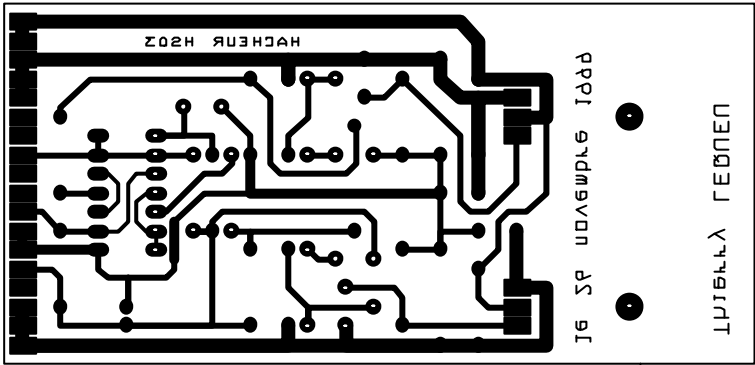
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Thierry LEQUEU		
Size	Document Number	Rev
A4	EEP - TL - HACHEUR SYMETRIQUE	1
Date:	Friday, November 26, 1999	Sheet 1 of 2

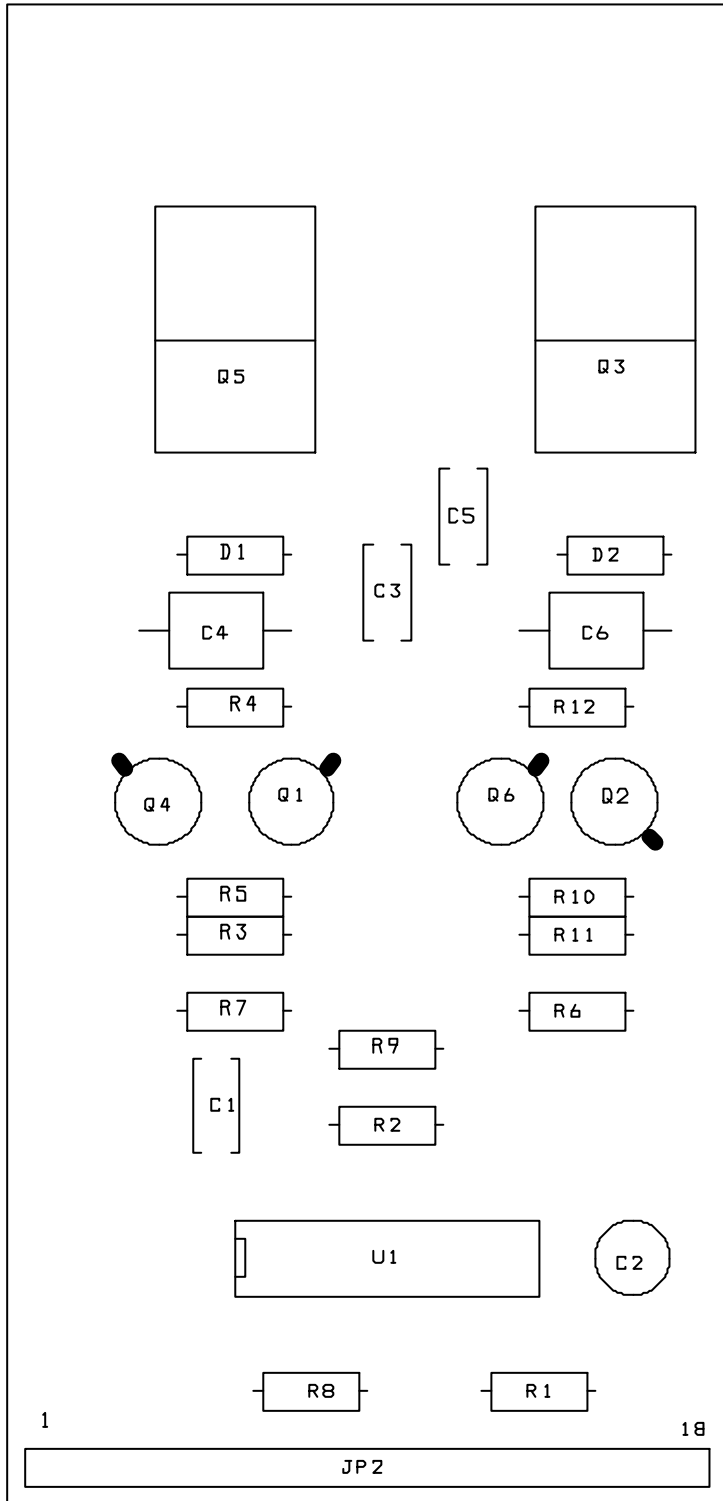


Title		
Thierry LEQUEU		
Size	Document Number	Rev
A	EEP - TL - HACHEUR SYMETRIQUE	1
Date:	Friday, November 26, 1999	Sheet 2 of 2

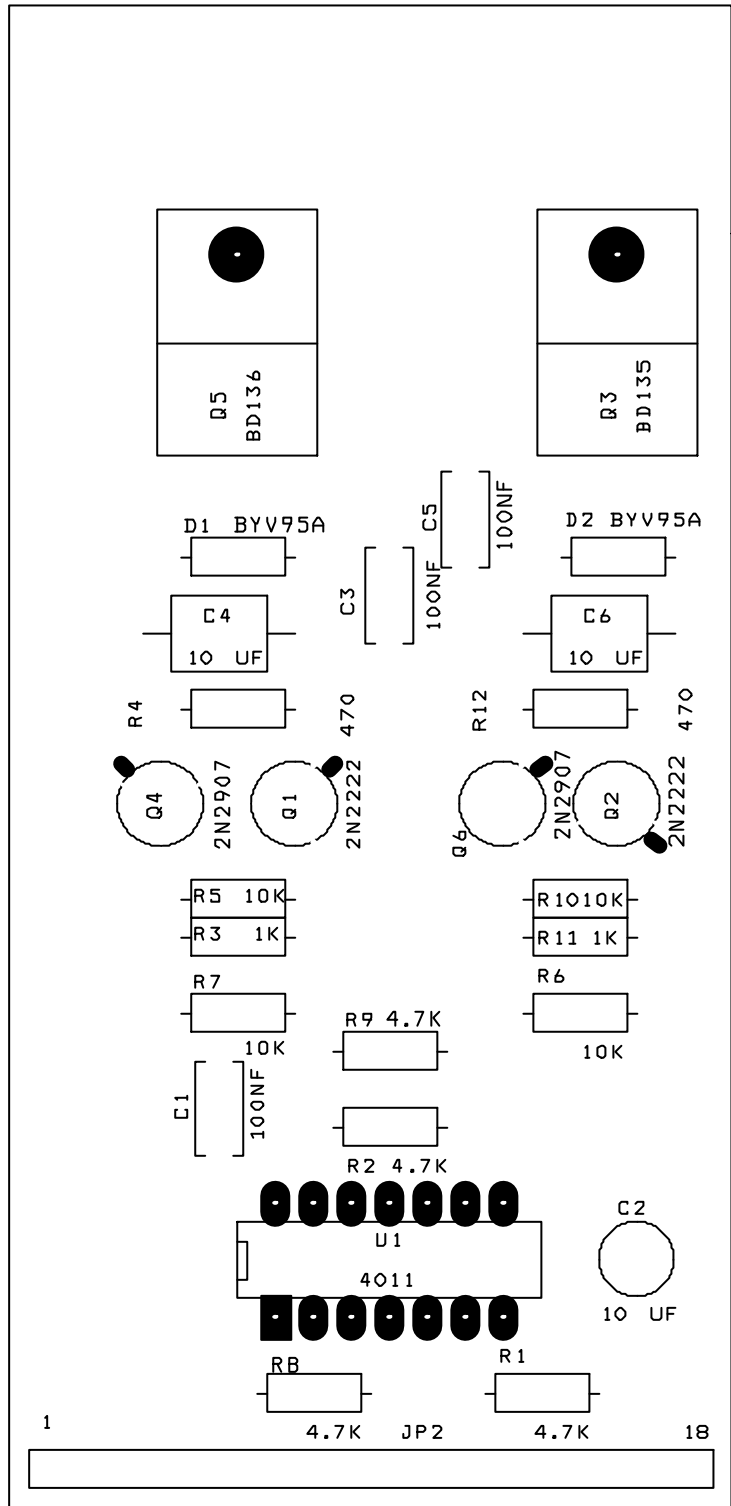




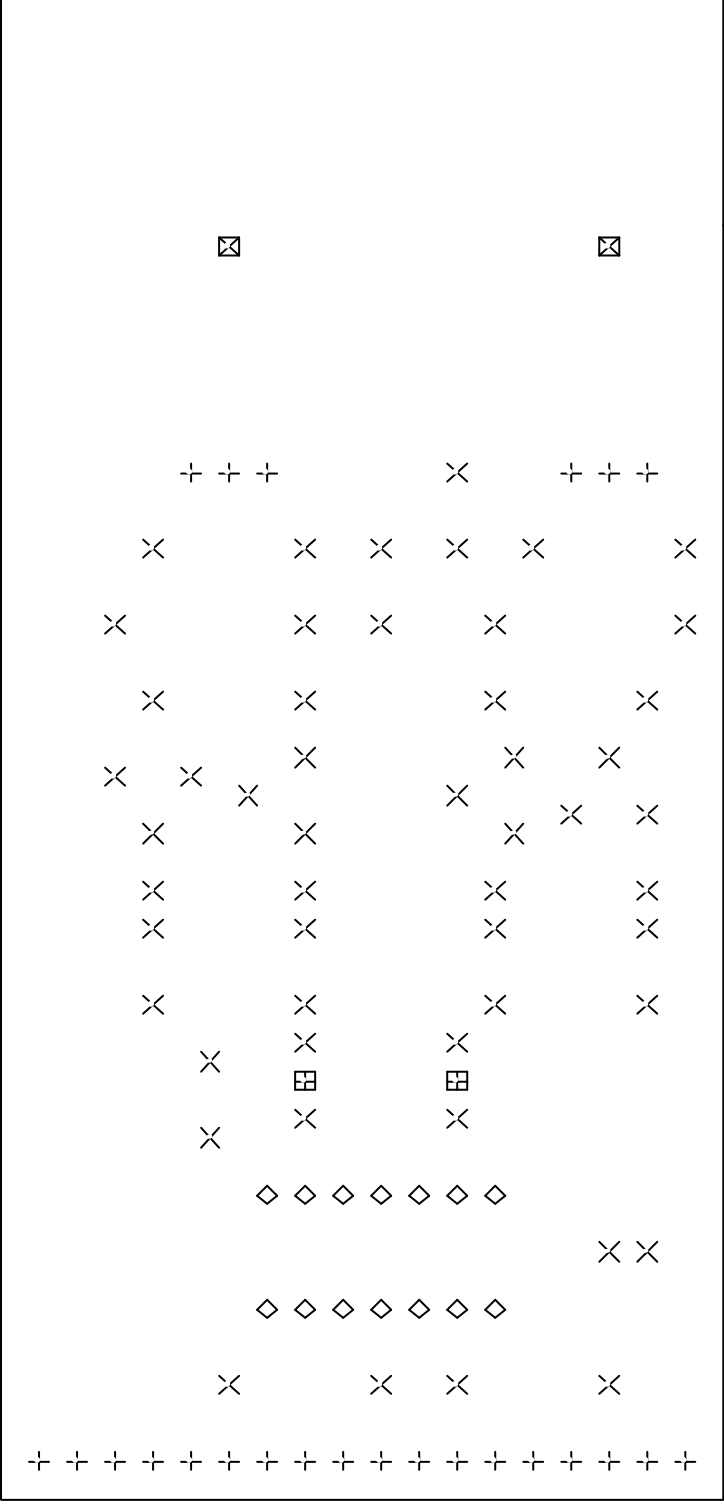




48.26



100.33



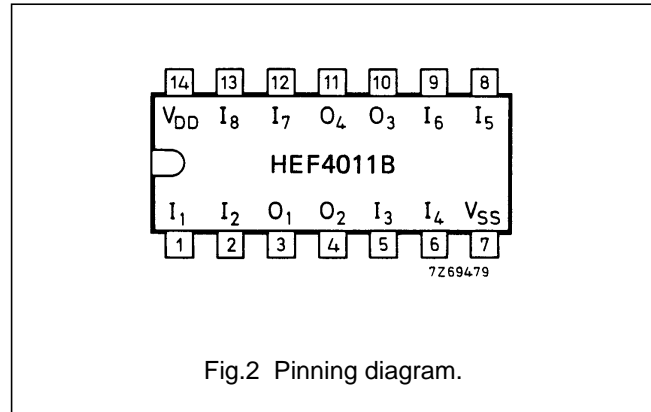
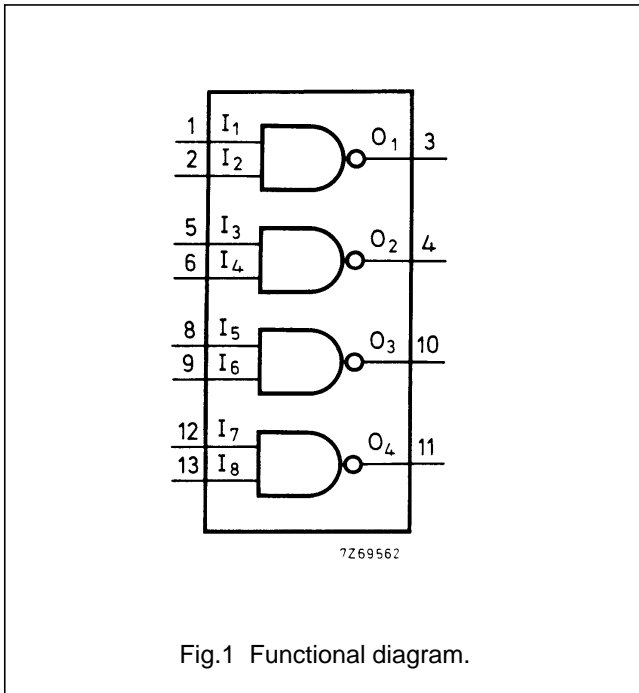
DRILL CHART				
SYM	DIAM	TOL	QTY	NOTE
+	0.010		24	NON-PLATED
x	0.020		52	NON-PLATED
◇	0.020		14	
⊕	0.028		2	
⊠	0.147		2	
TOTAL			94	

# Quadruple 2-input NAND gate

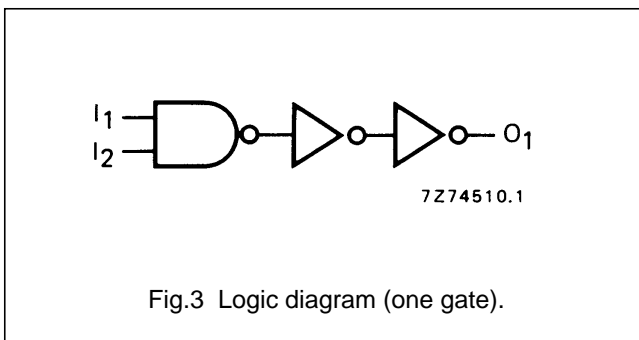
# HEF4011B gates

### DESCRIPTION

The HEF4011B provides the positive quadruple 2-input NAND function. The outputs are fully buffered for highest noise immunity and pattern insensitivity of output impedance.



- HEF4011BP(N): 14-lead DIL; plastic (SOT27-1)
  - HEF4011BD(F): 14-lead DIL; ceramic (cerdip) (SOT73)
  - HEF4011BT(D): 14-lead SO; plastic (SOT108-1)
- ( ): Package Designator North America



### FAMILY DATA, I<sub>DD</sub> LIMITS category GATES

See Family Specifications

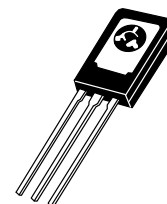
# Plastic Medium Power Silicon NPN Transistor

**BD135**  
**BD137**  
**BD139**

... designed for use as audio amplifiers and drivers utilizing complementary or quasi complementary circuits.

- DC Current Gain —  $h_{FE} = 40$  (Min) @  $I_C = 0.15$  Adc
- BD 135, 137, 139 are complementary with BD 136, 138, 140

**1.5 AMPERE**  
**POWER TRANSISTORS**  
**NPN SILICON**  
**45, 60, 80 VOLTS**  
**10 WATTS**



**CASE 77-08**  
**TO-225AA TYPE**

## MAXIMUM RATINGS

Rating	Symbol	Type	Value	Unit
Collector-Emitter Voltage	$V_{CEO}$	BD 135 BD 137 BD 139	45 60 80	Vdc
Collector-Base Voltage	$V_{CBO}$	BD 135 BD 137 BD 139	45 60 100	Vdc
Emitter-Base Voltage	$V_{EBO}$		5	Vdc
Collector Current	$I_C$		1.5	Adc
Base Current	$I_B$		0.5	Adc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above $25^\circ\text{C}$	$P_D$		1.25 10	Watts mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above $25^\circ\text{C}$	$P_D$		12.5 100	Watt mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	$T_J, T_{stg}$		-55 to +150	$^\circ\text{C}$

## THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$\theta_{JC}$	10	$^\circ\text{C/W}$
Thermal Resistance, Junction to Ambient	$\theta_{JA}$	100	$^\circ\text{C/W}$

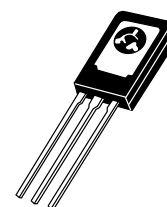
# Plastic Medium Power Silicon PNP Transistor

... designed for use as audio amplifiers and drivers utilizing complementary or quasi complementary circuits.

- DC Current Gain —  $h_{FE} = 40$  (Min) @  $I_C = 0.15$  Adc
- BD 136, 138, 140 are complementary with BD 135, 137, 139

**BD136**  
**BD138**  
**BD140**  
**BD140-10**

**1.5 AMPERE**  
**POWER TRANSISTORS**  
**PNP SILICON**  
**45, 60, 80 VOLTS**  
**10 WATTS**



**CASE 77-08**  
**TO-225AA TYPE**

## MAXIMUM RATINGS

Rating	Symbol	Type	Value	Unit
Collector-Emitter Voltage	$V_{CEO}$	BD 136 BD 138 BD 140	45 60 80	Vdc
Collector-Base Voltage	$V_{CBO}$	BD 136 BD 138 BD 140	45 60 100	Vdc
Emitter-Base Voltage	$V_{EBO}$		5	Vdc
Collector Current	$I_C$		1.5	Adc
Base Current	$I_B$		0.5	Adc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above $25^\circ\text{C}$	$P_D$		1.25 10	Watts mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above $25^\circ\text{C}$	$P_D$		12.5 100	Watt mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	$T_J, T_{stg}$		-55 to +150	$^\circ\text{C}$

## THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$\theta_{JC}$	10	$^\circ\text{C}/\text{W}$
Thermal Resistance, Junction to Ambient	$\theta_{JA}$	100	$^\circ\text{C}/\text{W}$

## Fast soft-recovery controlled avalanche rectifiers

## BYV95 series

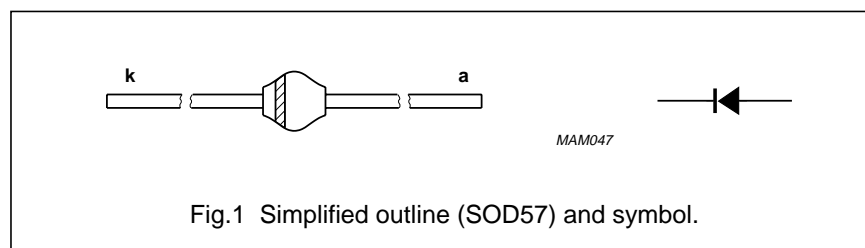
### FEATURES

- Glass passivated
- High maximum operating temperature
- Low leakage current
- Excellent stability
- Guaranteed avalanche energy absorption capability
- Available in ammo-pack.

### DESCRIPTION

Rugged glass SOD57 package, using a high temperature alloyed construction. This package is

hermetically sealed and fatigue free as coefficients of expansion of all used parts are matched.



### LIMITING VALUES

In accordance with the Absolute Maximum Rating System (IEC 134).


SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
$V_{RRM}$	repetitive peak reverse voltage				
	BYV95A		–	200	V
	BYV95B		–	400	V
	BYV95C		–	600	V
$V_R$	continuous reverse voltage				
	BYV95A		–	200	V
	BYV95B		–	400	V
	BYV95C		–	600	V
$I_{F(AV)}$	average forward current	$T_{tp} = 65\text{ °C}$ ; lead length = 10 mm see Fig. 2; averaged over any 20 ms period; see also Fig. 6	–	1.5	A
		$T_{amb} = 65\text{ °C}$ ; PCB mounting (see Fig.11); see Fig. 3; averaged over any 20 ms period; see also Fig. 6	–	0.8	A
$I_{FRM}$	repetitive peak forward current	$T_{tp} = 65\text{ °C}$ ; see Fig. 4	–	17	A
		$T_{amb} = 65\text{ °C}$ ; see Fig. 5	–	9	A
$I_{FSM}$	non-repetitive peak forward current	$t = 10\text{ ms}$ half sine wave; $T_j = T_{j\text{ max}}$ prior to surge; $V_R = V_{RRM\text{ max}}$	–	35	A
$E_{RSM}$	non-repetitive peak reverse avalanche energy	$L = 120\text{ mH}$ ; $T_j = T_{j\text{ max}}$ prior to surge; inductive load switched off	–	10	mJ
$T_{stg}$	storage temperature		–65	+175	°C
$T_j$	junction temperature	see Fig. 7	–65	+175	°C

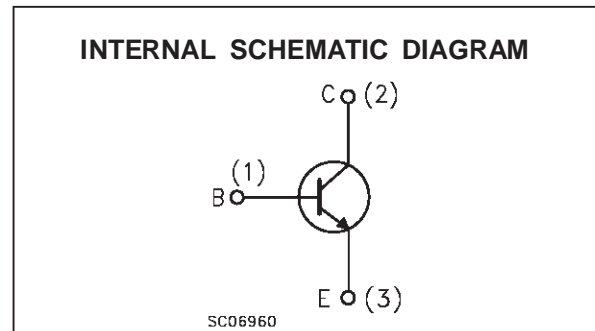
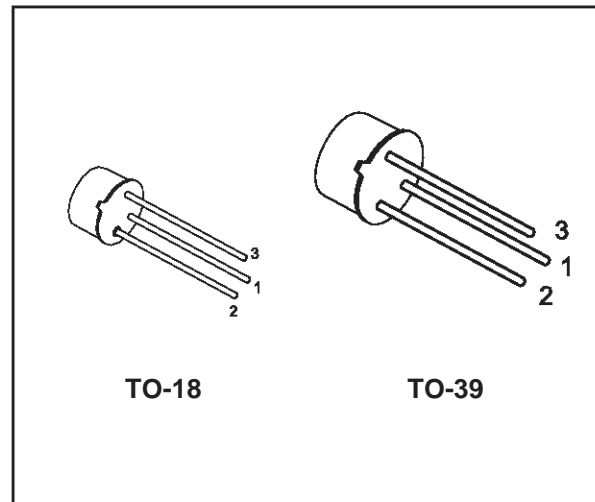


## HIGH SPEED SWITCHES

### DESCRIPTION

The 2N2219A and 2N2222A are silicon planar epitaxial NPN transistors in Jedec TO-39 (for 2N2219A) and in Jedec TO-18 (for 2N2222A) metal case. They are designed for high speed switching application at collector current up to 500mA, and feature useful current gain over a wide range of collector current, low leakage currents and low saturation voltage.

 2N2219A approved to CECC 50002-100,  
2N2222A approved to CECC 50002-101  
available on request.



### ABSOLUTE MAXIMUM RATINGS

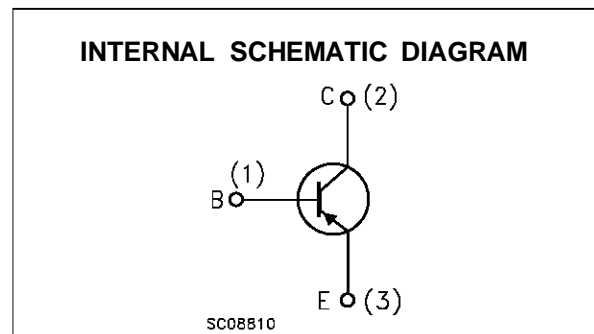
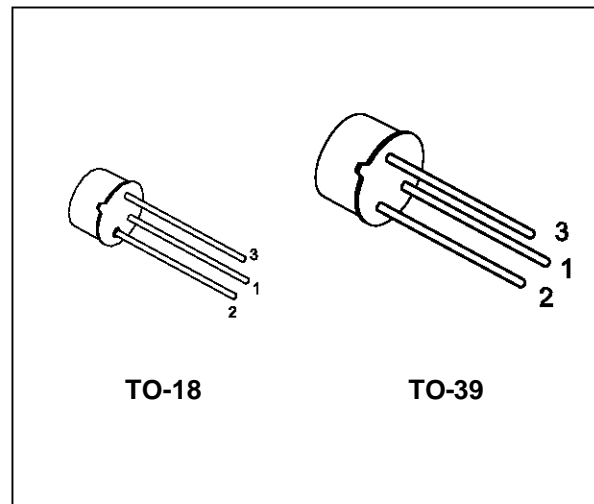
Symbol	Parameter	Value	Unit
$V_{CBO}$	Collector-Base Voltage ( $I_E = 0$ )	75	V
$V_{CEO}$	Collector-Emmitter Voltage ( $I_B = 0$ )	40	V
$V_{EBO}$	Emitter-Base Voltage ( $I_C = 0$ )	6	V
$I_C$	Collector Current	0.8	A
$P_{tot}$	Total Dissipation at $T_{amb} \leq 25^\circ C$ for <b>2N2219A</b> for <b>2N2222A</b> at $T_{case} \leq 25^\circ C$ for <b>2N2219A</b> for <b>2N2222A</b>	0.8	W
		0.5	W
		3	W
		1.8	W
$T_{stg}$	Storage Temperature	-65 to 200	$^\circ C$
$T_j$	Max. Operating Junction Temperature	175	$^\circ C$

## GENERAL PURPOSE AMPLIFIERS AND SWITCHES

### DESCRIPTION

The 2N2905A and 2N2907A are silicon planar epitaxial PNP transistors in Jedec TO-39 (for 2N2905A) and in Jedec TO-18 (for 2N2907A) metal case. They are designed for high speed saturated switching and general purpose applications.

- ☰ 2N2905A approved to CECC 50002-100, 2N2906A approved to CECC 50002-103 available on request.

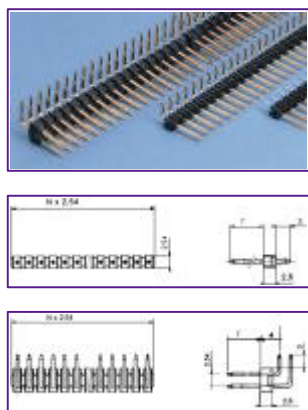


### ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
$V_{CBO}$	Collector-Base Voltage ( $I_E = 0$ )	-60	V
$V_{CEO}$	Collector-Emitter Voltage ( $I_B = 0$ )	-60	V
$V_{EBO}$	Emitter-Base Voltage ( $I_C = 0$ )	-5	V
$I_C$	Collector Current	-0.6	A
$P_{tot}$	Total Dissipation at $T_{amb} \leq 25^\circ\text{C}$ for <b>2N2905A</b> for <b>2N2907A</b> at $T_{case} \leq 25^\circ\text{C}$ for <b>2N2905A</b> for <b>2N2907A</b>	0.6	W
		0.4	W
		3	W
		1.8	W
$T_{stg}$	Storage Temperature	-65 to 200	$^\circ\text{C}$
$T_j$	Max. Operating Junction Temperature	200	$^\circ\text{C}$

## Barrettes simple et double rangée au pas de 2,54 mm

FCI



- Embases mâles HE 13 destinées au raccordement carte à carte, compatibles avec les fiches femelles de la série 6160 et toute autre fiche HE 13/HE 14.
- Ces connecteurs sont équipés de 1 ou 2 rangées de 36 contacts chacune qui peuvent être sectionnées manuellement. Un pied de lavage permet le nettoyage après soudure.
- Cette série est conforme à la norme NFC 93401, les contacts sont dorés.

### Spécifications techniques

Pas: 2,54 mm

Section des broches: 0,63 x 0,63 mm

Résistance d'isolement:  $\geq 10^3 M\Omega$

Résistance de contact:  $\leq 20 m\Omega$

Intensité admissible: 3 A à 20°C

Tension de tenue: 1000 V eff.

Tenue en température: -55°C à +125°C

Endurance mécanique: 400 cycles

Isolant auto-extinguible: UL 94-V0

Matière des contacts: laiton

Revêtement des contacts: dorure sur nickel

réf. nombre  
FCI de rangées

#### Version droite Version coudée

6170 36 1D1201 6170 36 1C1201 1

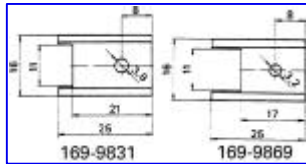
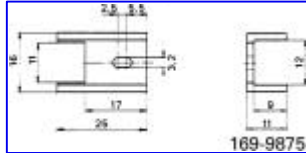
6170 36 2D1201 6170 36 2C1201 2

U.D.V.=5

réf. FCI	code commande	prix de l'U.D.V.		
		1-9	10-24	25+
Version droite				
6170 36 1D1201	<a href="#">189-9643</a>	45.67 Fr	43.39 Fr	38.82 Fr
6170 36 2D1201	<a href="#">189-9659</a>	88.39 Fr	83.97 Fr	75.13 Fr
Version coudée				
6170 36 1C1201	<a href="#">189-9665</a>	49.06 Fr	46.61 Fr	41.70 Fr
6170 36 2C1201	<a href="#">189-9687</a>	97.37 Fr	92.50 Fr	82.76 Fr

## Dissipateurs thermiques type RAWA 400

Seifert



- Dissipateurs pour moyennes puissances.

### Spécifications techniques

Résistance thermique: 18°C / W

U.D.V.=1

réf. Seifert	code commande	prix de l'U.D.V.		
		1-99	100-249	250+
RAWA 400 8P	<a href="#">169-9831</a>	5.25 Fr	4.73 Fr	4.20 Fr
RAWA 400 9P	<a href="#">169-9869</a>	5.25 Fr	4.73 Fr	4.20 Fr
RAWA 400 11P	<a href="#">169-9875</a>	5.25 Fr	4.73 Fr	4.20 Fr