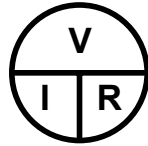


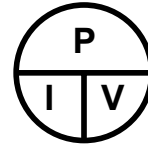
# **ANEXOS**

# ANEXO 1: FORMULARIO ELECTRÓNICA DE POTENCIA

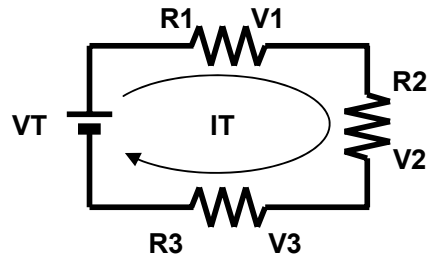
Formulas del Módulo 1:



$$\begin{aligned} V &= I \cdot R \\ I &= V / R \\ R &= V / I \end{aligned}$$



$$\begin{aligned} P &= I \cdot V \\ P &= I^2 \cdot R \\ P &= V^2 / R \end{aligned}$$



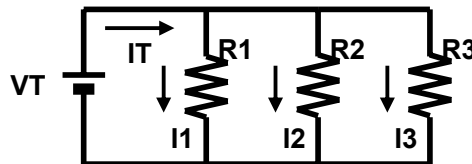
$$I_T = I_1 = I_2 = I_3$$

$$V_T = V_1 + V_2 + V_3$$

$$R_T = R_1 + R_2 + R_3$$

$$I_T = I_1 + I_2 + I_3$$

$$V_T = V_1 = V_2 = V_3$$



$$R_T = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}$$

$$F = 1 / T$$

Frecuencia

$$\begin{aligned} V_{ef} &= V_p \cdot 0.707 \\ I_{ef} &= I_p \cdot 0.707 \end{aligned}$$

Voltaje Eficaz  
Intensidad Eficaz

Formulas del Módulo 3:

$$P_d = I_d \cdot V_d$$

Potencia del Diodo

Formulas del Módulo 4:

## FORMULAS RMMO:

$V_p = VF / 0.707$	$IF = 1.57 \cdot I_m$
$V_{max} = V_p - V_d$	$P_c = V_m \cdot I_m$
$V_m = 0.318 \cdot V_{max}$	$P_c = I_m^2 \cdot R$
$V_{inv} = V_p$	$P_c = V_m^2 / R$
$I_m = V_m / R$	$P_{red} = VF \cdot IF$
$I_d = I_m$	$n = P_c / P_{red}$

## FORMULAS RMOCP:

$V_p = VF / 0.707$	$IF = 1.57 \cdot I_m$
$V_{max} = V_p - (2 \cdot V_d)$	$P_c = V_m \cdot I_m$
$V_m = 0.636 \cdot V_{max}$	$P_c = I_m^2 \cdot R$
$V_{inv} = V_p$	$P_c = V_m^2 / R$
$I_m = V_m / R$	$P_{red} = VF \cdot IF$
$I_d = I_m / 2$	$n = P_c / P_{red}$

**Formulas del Módulo 5:**

$$\begin{aligned} V_{ef} F &= VF \\ V_{ef} L &= VL \\ VPF &= VF / 0.707 \\ VPL &= VL / 0.707 \\ VPL &= 1.732 * VPF \end{aligned}$$

**FORMULAS RTMO:**

$$\begin{aligned} VPF &= VF / 0.707 \\ VPL &= 1.732 * VPF \\ V_{max} &= VPF - V_d \\ V_m &= 0.827 * V_{max} \\ V_{inv} &= VPL \\ I_m &= V_m / R \\ I_d &= I_m / 3 \\ IF &= 0.586 * I_m \\ P_c &= V_m * I_m \\ P_c &= I_m^2 * R \\ P_c &= V_m^2 / R \\ P_{red} &= 3 * VF * IF \\ n &= P_c / P_{red} \end{aligned}$$

**FORMULAS RTOCP:**

$$\begin{aligned} VPF &= VF / 0.707 \\ VPL &= 1.732 * VPF \\ VPL &= VL / 0.707 \\ V_{max} &= VPL - 2 * V_d \\ V_m &= 0.955 * V_{max} \\ V_{inv} &= VPL \\ I_m &= V_m / R \\ I_d &= I_m / 3 \\ IF &= 0.817 * I_m \\ P_c &= V_m * I_m \\ P_c &= I_m^2 * R \\ P_c &= V_m^2 / R \\ P_{red} &= 3 * VF * IF \\ n &= P_c / P_{red} \end{aligned}$$

**Formulas del Módulo 6:**

$$P_{scr} = I_{scr} * V_{fun}$$

Potencia del SCR

**Formulas del Módulo 7:**

**FORMULAS RCMO:**

$$\begin{aligned} V_p &= VF / 0.707 & IF &= 1.57 * I_m \\ V_{max} &= V_p - V_{fun} & P_c &= V_m * I_m \\ V_m &= 0.159 * V_{max} * (1 + \cos \alpha) & P_c &= I_m^2 * R \\ V_{inv} &= V_p & P_c &= V_m^2 / R \\ I_m &= V_m / R & P_{red} &= VF * IF \\ I_d &= I_m & n &= P_c / P_{red} \end{aligned}$$

**FORMULAS RMCOC:**

$$\begin{aligned} V_p &= VF / 0.707 & IF &= 1.57 * I_m \\ V_{max} &= V_p - (2 * V_d) & P_c &= V_m * I_m \\ V_m &= 0.318 * V_{max} * (1 + \cos \alpha) & P_c &= I_m^2 * R \\ V_{inv} &= V_p & P_c &= V_m^2 / R \\ I_m &= V_m / R & P_{red} &= VF * IF \\ I_d &= I_m / 2 & n &= P_c / P_{red} \end{aligned}$$

**Formulas del Módulo 8:**

**FORMULAS RTCMO:**

$$\begin{aligned} VPF &= VF / 0.707 & I_d &= I_m / 3 \\ VPL &= 1.732 * VPF & IF &= 0.586 * I_m \\ V_{max} &= VPF - V_d & P_c &= V_m * I_m \\ V_m &= 0.477 * V_{max} * (0.866 + \cos(30^\circ + \alpha)) & P_c &= I_m^2 * R \\ V_{inv} &= VPL & P_c &= V_m^2 / R \\ I_m &= V_m / R & P_{red} &= 3 * VF * IF \\ n &= P_c / P_{red} \end{aligned}$$

**FORMULAS RTCOCP:**

$V_{PF} = V_F / 0.707$	$I_d = I_m / 3$
$V_{PL} = 1.732 * V_{PF}$	$I_F = 0.817 * I_m$
$V_{PL} = V_L / 0.707$	$P_c = V_m * I_m$
$V_{max} = V_{PL} - 2 * V_d$	$P_c = I_m^2 * R$
$V_m = 0.551 * V_{max} * (0.866 + \cos(30^\circ + \alpha))$	$P_c = V_m^2 / R$
$V_{inv} = V_{PL}$	$P_{red} = 3 * V_F * I_F$
$I_m = V_m / R$	$n = P_c / P_{red}$

**Formulas del Módulo 10:**

**Voltaje de un DIMMER**

$$V_{RCeficaz} = V_{INeficaz} \sqrt{\frac{1}{\pi} \left( \pi - \alpha + \frac{\sin(2\alpha)}{2} \right)}$$

**Factor de Potencia**

$$FP \text{ ó } \cos\phi = P / S$$

$$P = I^2 * R \text{ (W)}$$

$$S = V * I \text{ (VA)}$$

**Formulas del Módulo 11:**

$$H_{FE} = I_C / I_B$$

**FORMULAS:**

$$I_{Csat} = (V_{CC} - V_{CEsat}) / R_C$$

$$I_{Bsat} = 10 * (I_C / H_{FE})$$

$$R_B = (V_{CC} - V_{BE}) / I_B$$

$$P_T = V_{CEsat} * I_{Csat}$$

**Formulas del Módulo 12:**

$$K = I_D / (V_{GS} - V_T)^2$$

**FORMULAS:**

$$I_D = V_{DD} / (R_D + r_{d\_on})$$

$$V_{GSmin} = V_T + (I_D / K)^{1/2}$$

$$V_{GG} \geq V_{GSmin}$$

$$R_G > 1M\Omega$$

$$P_T = I_D^2 * r_{d\_on}$$

**Formulas del Módulo 13:**

$$\omega \approx K * V_{a\_medio} / V_{f\_medio}$$

$$V_m = V_p * t_{on} / T$$

$$\text{Duty Cycle} = 100 * t_{on} / T$$

**Formulas del Módulo 14:**

$$P_p = P_s$$

$$V_p / V_s = N_p / N_s = I_s / I_p$$

$$S_n \approx K_1 * P_p / Q$$

$$N_p \approx K_2 * V_p / f \quad N_s \approx K_2 * V_s / f$$

**INVERTER PUSH PULL**

$$V_{ef} = 0.45 * V_{DD} * a$$

**INVERTER EN PUENTE**

$$V_{ef} = 0.9 * V_{DD} * a$$

**INVERTER TRIFÁSICO**

$$V_{efL} = 0.8165 * V_{DD}$$

**MODULACIÓN UPWM**

$$V_{ef} = V_{DD} \sqrt{\frac{\Delta}{\pi}}$$

**MODULACIÓN MPWM**

$$V_{ef} = V_{DD} \sqrt{\frac{p\Delta}{\pi}}$$

$$p = \frac{fb}{2fo}$$

**MODULACIÓN SPWM**

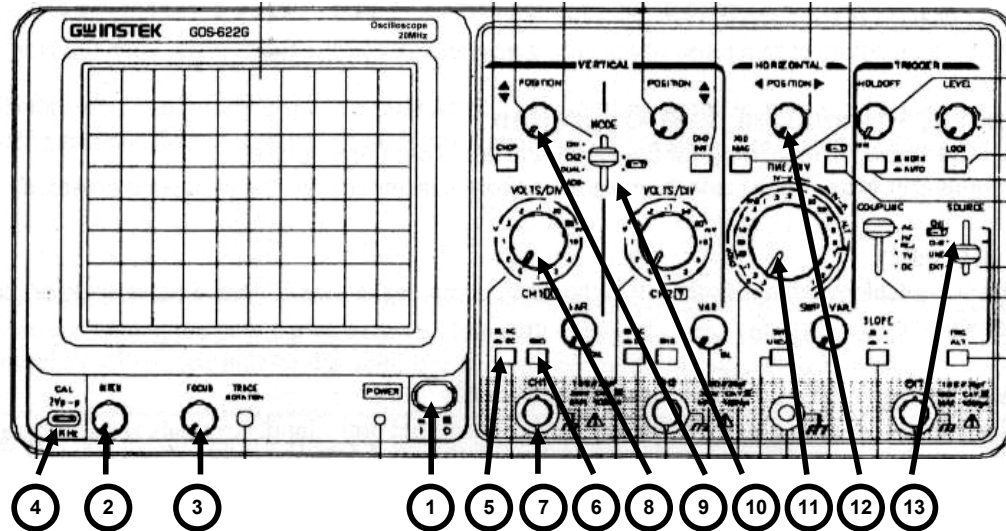
$$V_{ef} = V_{DD} \sqrt{\sum_{n=1}^p \frac{\Delta n}{\pi}}$$

$$p = \frac{fb}{2fo}$$

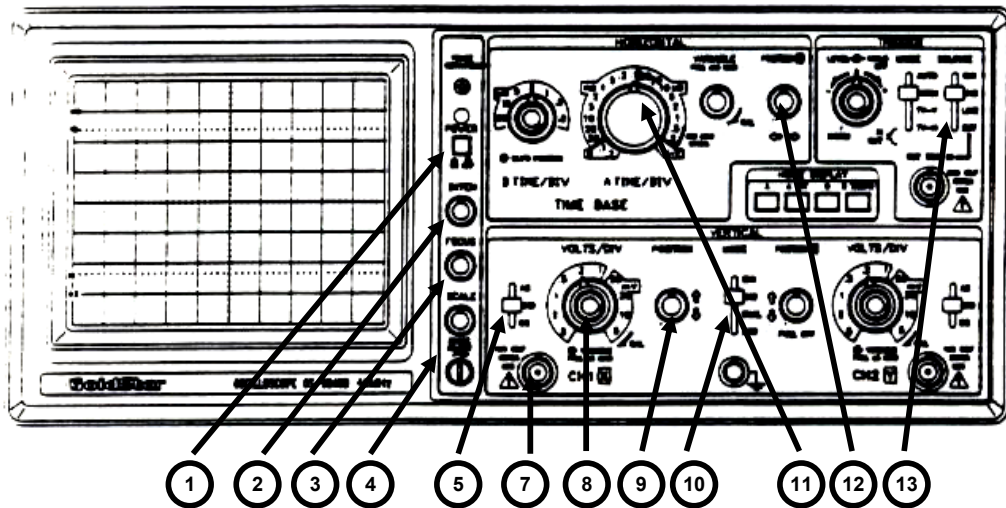
## ANEXO 2: MANEJO DEL OSCILOSCOPIO

Apariencia física y controles principales:

### OSCILOSCOPIO GWINSTEK



### OSCILOSCOPIO GOLDSTAR



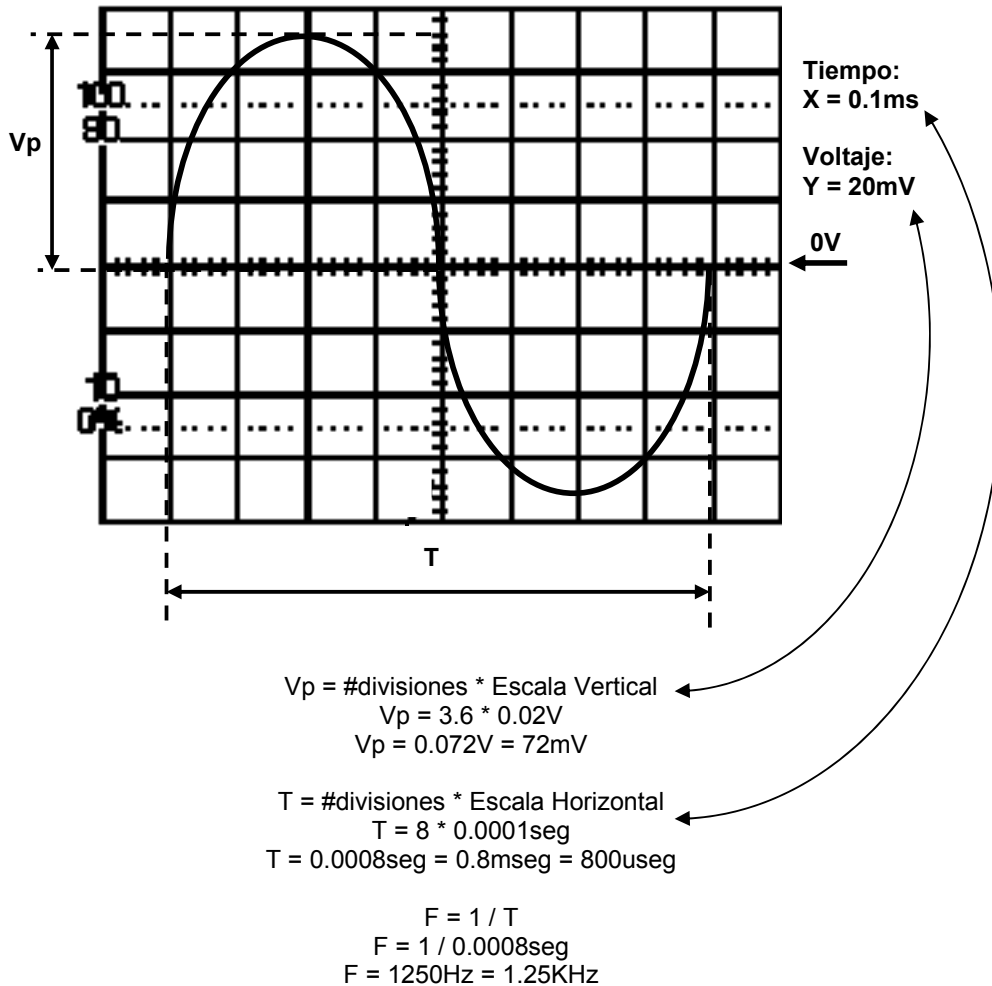
1. **Botón de Encendido:** Activa el osciloscopio. Debido a que el osciloscopio utiliza un tubo de rayos catódicos similar al de una televisión, se recomienda esperar al menos 1 minuto antes de empezar a trabajar con el mismo, a fin de estabilizar la intensidad del trazo en la pantalla.
2. **Intensidad:** Ajusta la intensidad del trazo en la pantalla. Se recomienda ajustar este control a un nivel intermedio, ya que un trazo muy intenso es perjudicial para la vista en especial al trabajar muchas horas continuas.
3. **Enfoque:** Ajusta el ancho y nitidez del trazo.

4. **Señal de Prueba:** Es una señal por lo general cuadrada de frecuencia y amplitud precisa y conocida, se utiliza para chequear el estado de las sondas y realizar calibraciones del osciloscopio.
5. **Selector DC AC:** Selecciona el tipo de señales con las que va a trabajar el osciloscopio, en el modo AC no se toma en cuenta el valor medio de las ondas, por lo que las señales aparecen como si fueran señales alternas.
6. **Selector GND:** Conecta la entrada del canal de medición a tierra. El objetivo es estabilizar el trazo en la pantalla y de esta manera ajustar el nivel de voltaje 0 a partir del cual se empezará a medir los voltajes picos tanto positivos como negativos. En el osciloscopio GOLDSTAR este control está incluido en el selector AC-DC.
7. **Conector de sonda para el canal 1:** Aquí se conecta la sonda del canal 1.
8. **Selector VOLTS / DIV del Canal 1:** Selecciona la escala de voltios por división del canal 1, es recomendable colocar esta perilla en la escala más alta antes de empezar a medir alguna señal, a fin de proteger al equipo contra voltajes muy elevados.
9. **Posición Vertical canal 1:** Ajusta la posición vertical del trazo del canal 1, se usa en conjunto con el selector GND para establecer el nivel de voltaje 0.
10. **Selector de Modo de Visualización:** Selecciona que canal se va a visualizar: canal 1, canal 2, ambos canales, la suma de las señales de ambos canales.
11. **Selector TIME / DIV:** Selecciona la escala de tiempo por división de ambos canales, se recomienda ajustar esta perilla en una escala donde se pueda apreciar la mayor parte de un ciclo de la señal de entrada, a fin de obtener información precisa sobre el período y frecuencia de la señal.
12. **Posición Horizontal:** Ajusta la posición horizontal del trazo de ambos canales, se utiliza para establecer el punto de inicio del período de una señal y de esta manera facilitar la medición del período.
13. **Selector de Modo de Sincronización:** Selecciona que canal se va a utilizar como fuente de sincronización para la medición, una mala elección de este control provoca que el osciloscopio no se sincronice y por ende la señal se esté moviendo horizontalmente sin poder realizar mediciones. Se puede tener las siguientes opciones: Canal 1, canal 2, Línea (se sincroniza a los 60Hz del tomacorriente), EXT (se sincroniza a un señal externa diferente del canal 1 o 2, para tal propósito tiene un tercer conector de sonda).

### Medición de Voltajes y Periodos:

La pantalla del osciloscopio está cuadrículada, exactamente posee 8 divisiones verticales y 10 horizontales, *el valor de las divisiones verticales depende del selector VOLTS / DIV, en cambio que el valor de las divisiones horizontales depende del selector de TIME / DIV.* Adicionalmente se dispone de 5 líneas de división secundarias por cada división principal en los ejes vertical y horizontal.

A continuación se presenta un ejemplo de medición de señales con el osciloscopio, observe que el valor de las escalas se representa como X para TIME / DIV y como Y para VOLTS / DIV:



Un detalle adicional que se debe tomar en cuenta antes de medir, es la posición del nivel de voltaje cero (ver figura anterior una flecha indicando el punto cero), ya que arriba de este punto se tienen voltajes positivos y por debajo se tiene voltajes negativos.

## ANEXO 3: HOJAS DE DATOS



## 1N4001/L - 1N4007/L

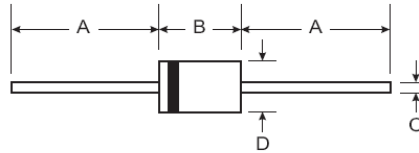
1.0A RECTIFIER

## Features

- Diffused Junction
- High Current Capability and Low Forward Voltage Drop
- Surge Overload Rating to 30A Peak
- Low Reverse Leakage Current
- Lead Free Finish, RoHS Compliant (Note 4)

## Mechanical Data

- Case: DO-41, A-405
- Case Material: Molded Plastic. UL Flammability Classification Rating 94V-0
- Moisture Sensitivity: Level 1 per J-STD-020C
- Terminals: Finish - Bright Tin. Plated Leads Solderable per MIL-STD-202, Method 208
- Polarity: Cathode Band
- Mounting Position: Any
- Ordering Information: See Last Page
- Marking: Type Number
- Weight: DO-41 0.30 grams (approximate)  
A-405 0.20 grams (approximate)



Dim	DO-41 Plastic		A-405	
	Min	Max	Min	Max
A	25.40	—	25.40	—
B	4.06	5.21	4.10	5.20
C	0.71	0.864	0.53	0.64
D	2.00	2.72	2.00	2.70

All Dimensions in mm

"L" Suffix Designates A-405 Package  
No Suffix Designates DO-41 Package

Maximum Ratings and Electrical Characteristics @ T<sub>A</sub> = 25°C unless otherwise specified

Single phase, half wave, 60Hz, resistive or inductive load.  
For capacitive load, derate current by 20%.

Characteristic	Symbol	1N 4001/L	1N 4002/L	1N 4003/L	1N 4004/L	1N 4005/L	1N 4006/L	1N 4007/L	Unit	
Peak Repetitive Reverse Voltage	V <sub>RRM</sub>	50	100	200	400	600	800	1000	V	
Working Peak Reverse Voltage	V <sub>RWM</sub>									
DC Blocking Voltage	V <sub>R</sub>									
RMS Reverse Voltage	V <sub>R(RMS)</sub>	35	70	140	280	420	560	700	V	
Average Rectified Output Current (Note 1)	I <sub>O</sub>	1.0							A	
		@ T <sub>A</sub> = 75°C								
Non-Repetitive Peak Forward Surge Current 8.3ms single half sine-wave superimposed on rated load (JEDEC Method)	I <sub>FSM</sub>	30							A	
Forward Voltage	V <sub>FM</sub>	1.0							V	
		@ I <sub>F</sub> = 1.0A								
Peak Reverse Current	I <sub>RM</sub>	5.0							μA	
		@ T <sub>A</sub> = 25°C								
		@ T <sub>A</sub> = 100°C								
Typical Junction Capacitance (Note 2)	C <sub>J</sub>	15				8				pF
Typical Thermal Resistance Junction to Ambient	R <sub>θJA</sub>	100							KW	
Maximum DC Blocking Voltage Temperature	T <sub>A</sub>	+150							°C	
Operating and Storage Temperature Range (Note 3)	T <sub>J</sub> , T <sub>STG</sub>	-65 to +150							°C	

- Notes:
1. Leads maintained at ambient temperature at a distance of 9.5mm from the case.
  2. Measured at 1. MHz and applied reverse voltage of 4.0V DC.
  3. JEDEC Value.
  4. RoHS revision 13.2.2003. Glass and High Temperature Solder Exemptions Applied, see EU Directive Annex Notes 5 and 7.

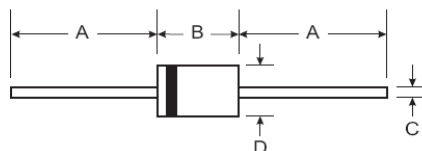


# 1N5400 - 1N5408

3.0A RECTIFIER

## Features

- Diffused Junction
- High Current Capability and Low Forward Voltage Drop
- Surge Overload Rating to 200A Peak
- Low Reverse Leakage Current
- Lead Free Finish, RoHS Compliant (Note 3)



## Mechanical Data

- Case: DO-201AD
- Case Material: Molded Plastic. UL Flammability Classification Rating 94V-0
- Moisture Sensitivity: Level 1 per J-STD-020C
- Terminals: Finish — Tin. Plated Leads Solderable per MIL-STD-202, Method 208 (3)
- Polarity: Cathode Band
- Marking: Type Number
- Weight: 1.1 grams (approximate)

DO-201AD		
Dim	Min	Max
A	25.40	—
B	7.20	9.50
C	1.20	1.30
D	4.80	5.30
All Dimensions in mm		

## Maximum Ratings and Electrical Characteristics @ T<sub>A</sub> = 25°C unless otherwise specified

Single phase, half wave, 60Hz, resistive or inductive load.  
For capacitive load, derate current by 20%.

Characteristic	Symbol	1N 5400	1N 5401	1N 5402	1N 5404	1N 5406	1N 5407	1N 5408	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V <sub>RRM</sub> V <sub>RWM</sub> V <sub>R</sub>	50	100	200	400	600	800	1000	V
RMS Reverse Voltage	V <sub>R(RMS)</sub>	35	70	140	280	420	560	700	V
Average Rectified Output Current @ T <sub>A</sub> = 105°C (Note 1)	I <sub>O</sub>	3.0							A
Non-Repetitive Peak Forward Surge Current 8.3ms Single half sine-wave superimposed on rated load	I <sub>FSM</sub>	200							A
Forward Voltage @ I <sub>F</sub> = 3.0A	V <sub>FM</sub>	1.0							V
Peak Reverse Current @ T <sub>A</sub> = 25°C at Rated DC Blocking Voltage @ T <sub>A</sub> = 150°C	I <sub>RM</sub>	10 100							μA
Typical Total Capacitance (Note 2)	C <sub>T</sub>	50				25			pF
Typical Thermal Resistance Junction to Ambient	R <sub>θJA</sub>	15							°C/W
Operating and Storage Temperature Range	T <sub>J</sub> , T <sub>STG</sub>	-65 to +150							°C

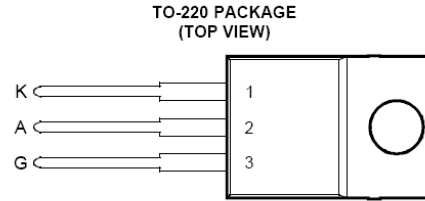
- Notes:
1. Valid provided that leads are kept at ambient temperature at a distance of 9.5mm from the case.
  2. Measured at 1.0MHz and applied reverse voltage of 4.0V DC.
  3. RoHS revision 13.2.2003. Glass and High Temperature Solder Exemptions Applied, see EU Directive Annex Notes 5 and 7.

TIC106 SERIES  
SILICON CONTROLLED RECTIFIERS

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APRIL 1971 - REVISED JULY 2000

- 5 A Continuous On-State Current
- 30 A Surge-Current
- Glass Passivated Wafer
- 400 V to 800 V Off-State Voltage
- Max  $I_{GT}$  of 200  $\mu$ A



Pin 2 is in electrical contact with the mounting base.

MDC1ACA

absolute maximum ratings over operating case temperature (unless otherwise noted)

RATING		SYMBOL	VALUE	UNIT
Repetitive peak off-state voltage (see Note 1)	TIC106D	$V_{DRM}$	400	V
	TIC106M		600	
	TIC106S		700	
	TIC106N		800	
Repetitive peak reverse voltage	TIC106D	$V_{RRM}$	400	V
	TIC106M		600	
	TIC106S		700	
	TIC106N		800	
Continuous on-state current at (or below) 80°C case temperature (see Note 2)		$I_{T(RMS)}$	5	A
Average on-state current (180° conduction angle) at (or below) 80°C case temperature (see Note 3)		$I_{T(AV)}$	3.2	A
Surge on-state current at (or below) 25°C (see Note 4)		$I_{TSM}$	30	A
Peak positive gate current (pulse width $\leq$ 300 $\mu$ s)		$I_{GM}$	0.2	A
Peak gate power dissipation (pulse width $\leq$ 300 $\mu$ s)		$P_{GM}$	1.3	W
Average gate power dissipation (see Note 5)		$P_{G(AV)}$	0.3	W
Operating case temperature range		$T_C$	-40 to +110	°C
Storage temperature range		$T_{stg}$	-40 to +125	°C
Lead temperature 1.6 mm from case for 10 seconds		$T_L$	230	°C

- NOTES: 1. These values apply when the gate-cathode resistance  $R_{GK} = 1 \text{ k}\Omega$ .  
 2. These values apply for continuous dc operation with resistive load. Above 80°C derate linearly to zero at 110°C.  
 3. This value may be applied continuously under single phase 50 Hz half-sine-wave operation with resistive load. Above 80°C derate linearly to zero at 110°C.  
 4. This value applies for one 50 Hz half-sine-wave when the device is operating at (or below) the rated value of peak reverse voltage and on-state current. Surge may be repeated after the device has returned to original thermal equilibrium.  
 5. This value applies for a maximum averaging time of 20 ms.

**PRODUCT INFORMATION**

Information is current as of publication date. Products conform to specifications in accordance with the terms of Power Innovations standard warranty. Production processing does not necessarily include testing of all parameters.



# TIC106 SERIES SILICON CONTROLLED RECTIFIERS

APRIL 1971 - REVISED JULY 2000

## electrical characteristics at 25°C case temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS			MIN	TYP	MAX	UNIT
$I_{DRM}$	Repetitive peak off-state current	$V_D = \text{rated } V_{DRM}$	$R_{GK} = 1 \text{ k}\Omega$	$T_C = 110^\circ\text{C}$			400	$\mu\text{A}$
$I_{RRM}$	Repetitive peak reverse current	$V_R = \text{rated } V_{RRM}$	$I_G = 0$	$T_C = 110^\circ\text{C}$			1	mA
$I_{GT}$	Gate trigger current	$V_{AA} = 12 \text{ V}$	$R_L = 100 \Omega$	$t_{p(g)} \geq 20 \mu\text{s}$		5	200	$\mu\text{A}$
$V_{GT}$	Gate trigger voltage	$V_{AA} = 12 \text{ V}$	$R_L = 100 \Omega$	$T_C = -40^\circ\text{C}$			1.2	V
		$t_{p(g)} \geq 20 \mu\text{s}$	$R_{GK} = 1 \text{ k}\Omega$		0.4	0.6	1	
		$V_{AA} = 12 \text{ V}$	$R_L = 100 \Omega$	$T_C = 110^\circ\text{C}$	0.2			
$I_H$	Holding current	$V_{AA} = 12 \text{ V}$	$R_{GK} = 1 \text{ k}\Omega$	$T_C = -40^\circ\text{C}$			8	mA
		Initiating $I_T = 10 \text{ mA}$					5	
$V_T$	Peak on-state voltage	$I_T = 5 \text{ A}$	(See Note 6)				1.7	V
dv/dt	Critical rate of rise of off-state voltage	$V_D = \text{rated } V_D$	$R_{GK} = 1 \text{ k}\Omega$	$T_C = 110^\circ\text{C}$		10		V/ $\mu\text{s}$

NOTE 6: This parameter must be measured using pulse techniques,  $t_p = 300 \mu\text{s}$ , duty cycle  $\leq 2\%$ . Voltage sensing-contacts, separate from the current carrying contacts, are located within 3.2 mm from the device body.

## thermal characteristics

PARAMETER		MIN	TYP	MAX	UNIT
$R_{\theta JC}$	Junction to case thermal resistance			3.5	$^\circ\text{C/W}$
$R_{\theta JA}$	Junction to free air thermal resistance			62.5	$^\circ\text{C/W}$

## PRODUCT INFORMATION



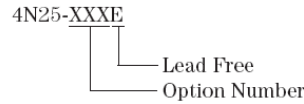
# Agilent 4N25 Phototransistor Optocoupler General Purpose Type Data Sheet

### Description

The 4N25 is an optocoupler for general purpose applications. It contains a light emitting diode optically coupled to a phototransistor. It is packaged in a 6-pin DIP package and available in wide-lead spacing option and lead bend SMD option. Response time,  $t_r$ , is typically 3  $\mu$ s and minimum CTR is 20% at input current of 10 mA.

### Ordering Information

Specify part number followed by Option Number (if desired).

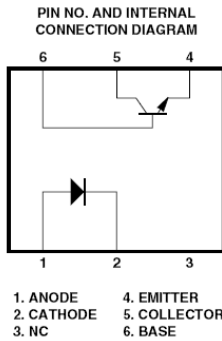


- 000 = No Options
- 060 = IEC/EN/DIN EN 60747-5-2 Option
- W00 = 0.4" Lead Spacing Option
- 300 = Lead Bend SMD Option
- 500 = Tape and Reel Packaging Option

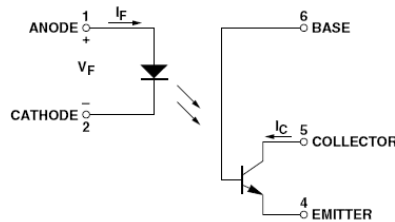
### Features

- Response time ( $t_r$ : typ., 3  $\mu$ s at  $V_{CE} = 10$  V,  $I_C = 2$  mA,  $R_L = 100 \Omega$ )
- Current Transfer Ratio (CTR: min. 20% at  $I_F = 10$  mA,  $V_{CE} = 10$  V)
- Input-output isolation voltage ( $V_{iso} = 2500$  Vrms)
- Dual-in-line package
- UL approved
- CSA approved
- IEC/EN/DIN EN 60747-5-2 approved
- Options available:
  - Leads with 0.4" (10.16 mm) spacing (W00)
  - Leads bends for surface mounting (300)
  - Tape and reel for SMD (500)
  - IEC/EN/DIN EN 60747-5-2 approvals (060)

### Functional Diagram



### Schematic



### Applications

- I/O interfaces for computers
- System appliances, measuring instruments
- Signal transmission between circuits of different potentials and impedances

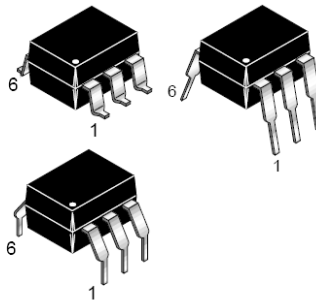
**DESCRIPTION**

The 4N39 and 4N40 have a gallium-arsenide infrared emitting diode optically coupled with a light activated silicon controlled rectifier in a dual in-line package.

**4N39 4N40**

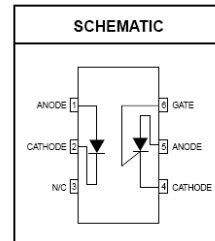
**FEATURES**

- 10 A, T<sup>2</sup>L compatible, solid state relay
- 25 W logic indicator lamp driver
- 400 V symmetrical transistor coupler
- Underwriters Laboratory (UL) recognized — File #E90700



**APPLICATIONS**

- Low power logic circuits
- Telecommunications equipment
- Portable electronics
- Solid state relays
- Interfacing coupling systems of different potentials and impedances.



Parameter	Symbol	Device	Value	Units
<b>TOTAL DEVICE</b>				
*Storage Temperature	T <sub>STG</sub>	All	-55 to +150	°C
*Operating Temperature	T <sub>OPR</sub>	All	-55 to +100	°C
*Lead Solder Temperature	T <sub>SOL</sub>	All	260 for 10 sec	°C
*Total Device Power Dissipation (-55°C to 50 °C) Derate above 50°C	P <sub>D</sub>	All	450	mW
			9.0	mW/°C
<b>EMITTER</b>				
*Continuous Forward Current	I <sub>F</sub>	All	60	mA
*Reverse Voltage	V <sub>R</sub>	All	6	V
*Forward Current - Peak (300 μs, 2% Duty Cycle)	I <sub>F(pk)</sub>	All	1.0	A
*LED Power Dissipation (-55°C to 50 °C) Derate above 50°C	P <sub>D</sub>	All	100	mW
			2.0	mW/°C
<b>DETECTOR</b>				
*Off-State And Reverse Voltage		4N39	200	V
		4N40	400	V
*Peak Reverse Gate Voltage			6	V
*Direct On-State Current			300	mA
*Surge On-State Current (100 μs)			10	A
*Peak Gate Current			10	mA
*Detector Power Dissipation (-55°C to 50°C) Derate above 50°C	P <sub>D</sub>	All	400	mW
			8.0	mW/°C



LOW COST POWER INDUCTORS  
Toroidal Inductors

Description

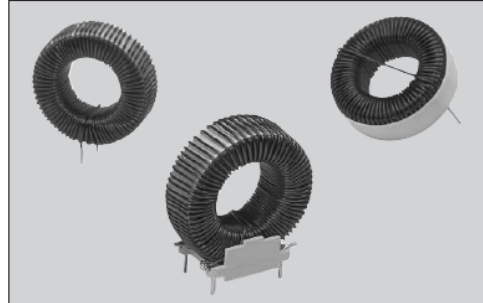
- Low loss, powdered iron cores with stable electrical operating characteristics maximize inductor efficiency by minimizing copper losses
- Available in vertical and horizontal self leaded and header mounted configurations
- Inductance values range from 10uH to 1000uH
- Current values range from 1.5 to 29.5 Amps
- Meets UL 94V-0 flammability standard

Applications

- Filters
- Buck and boost switches
- Chokes

Environmental Data

- Storage temperature range: -40C to 105C
- Operating ambient temperature range: -40C to +75C (range is application specific)



Packaging

- Supplied in bulk packaging

Family Table

Vertical Part Number	Horizontal Part Number	Header Mounted Part Number	Inductance $\mu\text{H}$ (rated)	OCL <sup>(1)</sup> $\mu\text{H} \pm 20\%$	I <sub>DC</sub> <sup>(2)</sup> Amperes	I <sub>SAT</sub> <sup>(3)</sup> Amperes	Volt- $\mu\text{Sec}$ <sup>(4)</sup> V $\mu\text{S}$	Energy <sup>(5)</sup> $\mu\text{J}$	DCR ( $\Omega$ ) <sup>(6)</sup> max
CTX10-1-52	CTX10-1-52LP	CTX10-1-52M	10	10.14	2.4	2.1	5.4	15	0.0481
CTX20-1-52	CTX20-1-52LP	CTX20-1-52M	20	20.22	1.8	2.2	7.8	36	0.0829
CTX50-1-52	CTX50-1-52LP	CTX50-1-52M	50	50.29	2.6	2.7	16.3	130	0.0715
CTX100-1-52	CTX100-1-52LP	CTX100-1-52M	100	100.40	2.5	2.4	27.5	197	0.1060
CTX150-1-52	CTX150-1-52LP	CTX150-1-52M	150	151.70	2.1	2.3	35.7	283	0.1620
CTX250-1-52	CTX250-1-52LP	CTX250-1-52M	250	250.90	1.9	2.2	47.8	421	0.2210
CTX500-1-52	CTX500-1-52LP	CTX500-1-52M	500	505.00	1.7	1.9	77.9	645	0.3610
CTX750-1-52	CTX750-1-52LP	CTX750-1-52M	750	754.40	1.8	2.4	114.3	1530	0.4340
CTX1000-1-52	CTX1000-1-52LP	CTX1000-1-52M	1000	1004.00	1.5	2.1	131.9	1530	0.6380
CTX10-2-52	CTX10-2-52LP	CTX10-2-52M	10	9.60	4.7	4.5	6.6	68	0.0183
CTX20-2-52	CTX20-2-52LP	CTX20-2-52M	20	19.60	3.2	3.2	9.4	69	0.0392
CTX50-2-52	CTX50-2-52LP	CTX50-2-52M	50	50.00	4.9	4.9	21.3	420	0.0326
CTX100-2-52	CTX100-2-52LP	CTX100-2-52M	100	101.70	4.4	4.3	35.0	643	0.0534
CTX150-2-52	CTX150-2-52LP	CTX150-2-52M	150	148.00	4.3	4.0	47.6	829	0.0719
CTX250-2-52	CTX250-2-52LP	CTX250-2-52M	250	251.10	4.2	4.2	66.0	1540	0.0833
CTX500-2-52	CTX500-2-52LP	CTX500-2-52M	500	499.40	3.1	3.3	104.0	1890	0.1830
CTX750-2-52	CTX750-2-52LP	CTX750-2-52M	750	749.30	3.4	3.4	147.3	2960	0.2080
CTX10-5-52	CTX10-5-52LP	CTX10-5-52M	10	9.68	8.7	11.1	9.4	417	0.0104
CTX20-5-52	CTX20-5-52LP	CTX20-5-52M	20	21.25	7.8	9.3	16.0	643	0.0260
CTX50-5-52	CTX50-5-52LP	CTX50-5-52M	50	49.60	7.6	9.4	29.3	1530	0.0248
CTX100-5-52	CTX100-5-52LP	CTX100-5-52M	100	97.20	8.2	7.5	45.7	1890	0.0267
CTX150-5-52	CTX150-5-52LP	CTX150-5-52M	150	150.60	7.7	7.5	66.0	2960	0.0401
CTX250-5-52	CTX250-5-52LP	CTX250-5-52M	250	254.40	9.2	8.1	102.4	5860	0.0400
CTX10-7-52	CTX10-7-52LP	CTX10-7-52M	10	10.04	11.4	13.5	11.0	640	0.0080
CTX20-7-52	CTX20-7-52LP	CTX20-7-52M	20	20.96	11.4	14.5	19.1	1540	0.0110
CTX50-7-52	CTX50-7-52LP	CTX50-7-52M	50	52.27	10.5	10.2	33.5	1900	0.0163
CTX100-7-52	CTX100-7-52LP	CTX100-7-52M	100	101.40	12.0	9.1	54.2	2960	0.0167
CTX150-7-52	CTX150-7-52LP	CTX150-7-52M	150	152.80	12.8	10.5	79.3	5900	0.0204
CTX10-10-52	CTX10-10-52LP	CTX10-10-52M	10	10.04	16.9	20.9	13.2	1530	0.0051
CTX20-10-52	CTX20-10-52LP	CTX20-10-52M	20	21.17	16.0	16.0	21.3	1900	0.0070
CTX50-10-52	CTX50-10-52LP	CTX50-10-52M	50	52.37	13.9	12.7	38.9	2960	0.0124
CTX100-10-52	CTX100-10-52LP	CTX100-10-52M	100	99.38	17.6	13.0	64.0	5880	0.0109
CTX10-16-52	CTX10-16-52LP	CTX10-16-52M	10	9.90	27.3	29.3	16.9	2970	0.0032
CTX20-16-52	CTX20-16-52LP	CTX20-16-52M	20	19.24	31.5	29.5	28.1	5860	0.0034

Notes: (1) Open circuit inductance test parameters: 100kHz, 0.250Vrms, 0 Adc.  
 (2) DC current for an approximate  $\Delta T$  of 30°C at 75°C Ambient with no core loss. See Chart 2 for derating of I<sub>DC</sub> with core loss.  
 (3) Peak current for an approximate 30% roll-off in OCL. For other current levels see Chart 1.  
 (4) Applied Volt-Time product (V $\mu\text{S}$ ) across the inductor. This value represents the V $\mu\text{S}$  at 100kHz necessary to generate a core loss equal to 10% of the total losses for 30°C rise. For other frequencies and operating levels see Chart 2. (Note: skin effect losses not included.)  
 (5) Energy storage ( $\mu\text{J}$ ) at I<sub>SAT</sub>. For other current levels see Chart 1.  
 (6) Maximum D.C. resistance at 20°C.



## BTA/BTB06 Series

SNUBBERLESS™, LOGIC LEVEL & STANDARD

6A TRIACs

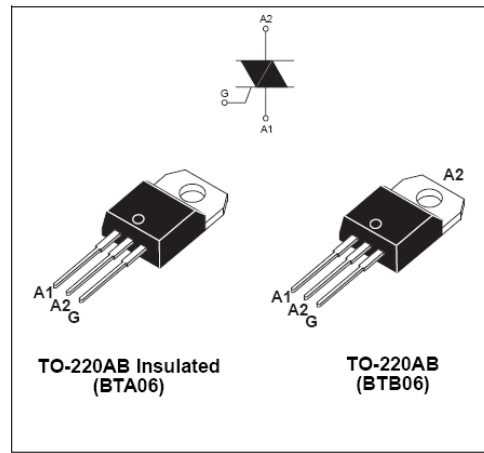
### MAIN FEATURES:

Symbol	Value	Unit
$I_{T(RMS)}$	6	A
$V_{DRM}/V_{RRM}$	600 and 800	V
$I_G (Q_1)$	5 to 50	mA

### DESCRIPTION

Suitable for AC switching operations, the BTA/BTB06 series can be used as an ON/OFF function in applications such as static relays, heating regulation, induction motor starting circuits... or for phase control in light dimmers, motor speed controllers,...

The snubberless and logic level versions (BTA/BTB...W) are specially recommended for use on inductive loads, thanks to their high commutation performances. By using an internal ceramic pad, the BTA series provides voltage insulated tab (rated at 2500V RMS) complying with UL standards (File ref.: E81734)



### ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit	
$I_{T(RMS)}$	RMS on-state current (full sine wave)	TO-220AB $T_c = 110^\circ\text{C}$	6	A
		TO-220AB Ins. $T_c = 105^\circ\text{C}$		
$I_{TSM}$	Non repetitive surge peak on-state current (full cycle, $T_j$ initial = $25^\circ\text{C}$ )	F = 50 Hz $t = 20$ ms	60	A
		F = 60 Hz $t = 16.7$ ms	63	
$I^2 t$	$I^2 t$ Value for fusing	$t_p = 10$ ms	21	$\text{A}^2\text{s}$
di/dt	Critical rate of rise of on-state current $I_G = 2 \times I_{GT}$ , $t_r \leq 100$ ns	F = 120 Hz $T_j = 125^\circ\text{C}$	50	A/ $\mu\text{s}$
$I_{GM}$	Peak gate current	$t_p = 20$ $\mu\text{s}$ $T_j = 125^\circ\text{C}$	4	A
$P_{G(AV)}$	Average gate power dissipation	$T_j = 125^\circ\text{C}$	1	W
$T_{stg}$ $T_j$	Storage junction temperature range Operating junction temperature range		- 40 to + 150 - 40 to + 125	$^\circ\text{C}$

**BTA/BTB06 Series**

**ELECTRICAL CHARACTERISTICS** (T<sub>j</sub> = 25°C, unless otherwise specified)

■ **SNUBBERLESS™ and LOGIC LEVEL (3 Quadrants)**

Symbol	Test Conditions	Quadrant		BTA/BTB06				Unit
				TW	SW	CW	BW	
I <sub>GT</sub> (1)	V <sub>D</sub> = 12 V R <sub>L</sub> = 30 Ω	I - II - III	MAX.	5	10	35	50	mA
V <sub>GT</sub>		I - II - III	MAX.	1.3				V
V <sub>GD</sub>	V <sub>D</sub> = V <sub>DRM</sub> R <sub>L</sub> = 3.3 kΩ T <sub>j</sub> = 125°C	I - II - III	MIN.	0.2				V
I <sub>H</sub> (2)	I <sub>T</sub> = 100 mA		MAX.	10	15	35	50	mA
I <sub>L</sub>	I <sub>G</sub> = 1.2 I <sub>GT</sub>	I - III	MAX.	10	25	50	70	mA
		II		15	30	60	80	
dV/dt (2)	V <sub>D</sub> = 67 %V <sub>DRM</sub> gate open T <sub>j</sub> = 125°C		MIN.	20	40	400	1000	V/μs
(di/dt) <sub>c</sub> (2)	(dV/dt) <sub>c</sub> = 0.1 V/μs T <sub>j</sub> = 125°C		MIN.	2.7	3.5	-	-	A/ms
	(dV/dt) <sub>c</sub> = 10 V/μs T <sub>j</sub> = 125°C			1.2	2.4	-	-	
	Without snubber T <sub>j</sub> = 125°C			-	-	3.5	5.3	

■ **STANDARD (4 Quadrants)**

Symbol	Test Conditions	Quadrant		BTA/BTB06		Unit
				C	B	
I <sub>G</sub> (1)	V <sub>D</sub> = 12 V R <sub>L</sub> = 30 Ω	I - II - III IV	MAX.	25 50	50 100	mA
V <sub>GT</sub>		ALL	MAX.	1.3		V
V <sub>GD</sub>	V <sub>D</sub> = V <sub>DRM</sub> R <sub>L</sub> = 3.3 kΩ T <sub>j</sub> = 125°C	ALL	MIN.	0.2		V
I <sub>H</sub> (2)	I <sub>T</sub> = 500 mA		MAX.	25	50	mA
I <sub>L</sub>	I <sub>G</sub> = 1.2 I <sub>GT</sub>	I - III - IV	MAX.	40	50	mA
		II		80	100	
dV/dt (2)	V <sub>D</sub> = 67 %V <sub>DRM</sub> gate open T <sub>j</sub> = 125°C		MIN.	200	400	V/μs
(dI/dt) <sub>c</sub> (2)	(dI/dt) <sub>c</sub> = 2.7 A/ms T <sub>j</sub> = 125°C		MIN.	5	10	V/μs

**STATIC CHARACTERISTICS**

Symbol	Test Conditions			Value	Unit
V <sub>T</sub> (2)	I <sub>TM</sub> = 5.5 A tp = 380 μs	T <sub>j</sub> = 25°C	MAX.	1.55	V
V <sub>to</sub> (2)	Threshold voltage	T <sub>j</sub> = 125°C	MAX.	0.85	V
R <sub>d</sub> (2)	Dynamic resistance	T <sub>j</sub> = 125°C	MAX.	60	mΩ
I <sub>DRM</sub> I <sub>RRM</sub>	V <sub>DRM</sub> = V <sub>R RM</sub>	T <sub>j</sub> = 25°C	MAX.	5	μA
		T <sub>j</sub> = 125°C		1	mA

**Note 1:** minimum IGT is guaranteed at 5% of IGT max.

**Note 2:** for both polarities of A2 referenced to A1

## BTA/BTB06 Series

### THERMAL RESISTANCES

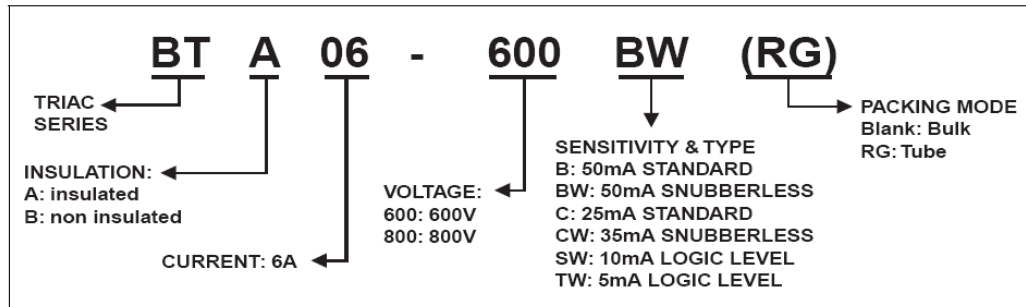
Symbol	Parameter	Value	Unit
$R_{th(j-c)}$	Junction to case (AC)	TO-220AB	1.8
		TO-220AB Insulated	2.7
$R_{th(j-a)}$	Junction to ambient	TO-220AB	60
		TO-220AB Insulated	

### PRODUCT SELECTOR

Part Number	Voltage (xxx)		Sensitivity	Type	Package
	600 V	800 V			
BTA/BTB06-xxxB	X	X	50 mA	Standard	TO-220AB
BTA/BTB06-xxxBW	X	X	50 mA	Snubberless	TO-220AB
BTA/BTB06-xxxC	X	X	25 mA	Standard	TO-220AB
BTA/BTB06-xxxCW	X	X	35 mA	Snubberless	TO-220AB
BTA/BTB06-xxcSW	X	X	10 mA	Logic level	TO-220AB
BTA/BTB06-xxcTW	X	X	5 mA	Logic level	TO-220AB

BTB: non insulated TO-220AB package

### ORDERING INFORMATION



### OTHER INFORMATION

Part Number	Marking	Weight	Base quantity	Packing mode
BTA/BTB06-xxxzy	BTA/BTB06-xxxzy	2.3 g	250	Bulk
BTA/BTB06-xxxzyRG	BTA/BTB06-xxxzy	2.3 g	50	Tube

Note: xxx = voltage, y = sensitivity, z = type

**MOTOROLA**  
SEMICONDUCTOR TECHNICAL DATA

Order this document  
by MOC3020/D



**6-Pin DIP Random-Phase  
Optoisolators Triac Driver Output  
(400 Volts Peak)**

The MOC3020 Series consists of gallium arsenide infrared emitting diodes, optically coupled to a silicon bilateral switch.

- *To order devices that are tested and marked per VDE 0884 requirements, the suffix "V" must be included at end of part number. VDE 0884 is a test option.* They are designed for applications requiring isolated triac triggering.

**Recommended for 115/240 Vac(rms) Applications:**

- Solenoid/Valve Controls
- Lamp Ballasts
- Interfacing Microprocessors to 115 Vac Peripherals
- Motor Controls
- Static ac Power Switch
- Solid State Relays
- Incandescent Lamp Dimmers

**MAXIMUM RATINGS** ( $T_A = 25^\circ\text{C}$  unless otherwise noted)

Rating	Symbol	Value	Unit
--------	--------	-------	------

**INFRARED EMITTING DIODE**

Reverse Voltage	$V_R$	3	Volts
Forward Current — Continuous	$I_F$	60	mA
Total Power Dissipation @ $T_A = 25^\circ\text{C}$ Negligible Power in Triac Driver Derate above $25^\circ\text{C}$	$P_D$	100	mW
		1.33	$\text{mW}/^\circ\text{C}$

**OUTPUT DRIVER**

Off-State Output Terminal Voltage	$V_{DRM}$	400	Volts
Peak Repetitive Surge Current ( $PW = 1 \text{ ms}$ , 120 pps)	$I_{TSM}$	1	A
Total Power Dissipation @ $T_A = 25^\circ\text{C}$ Derate above $25^\circ\text{C}$	$P_D$	300	mW
		4	$\text{mW}/^\circ\text{C}$

**TOTAL DEVICE**

Isolation Surge Voltage <sup>(1)</sup> (Peak ac Voltage, 60 Hz, 1 Second Duration)	$V_{ISO}$	7500	Vac(pk)
Total Power Dissipation @ $T_A = 25^\circ\text{C}$ Derate above $25^\circ\text{C}$	$P_D$	330	mW
		4.4	$\text{mW}/^\circ\text{C}$
Junction Temperature Range	$T_J$	-40 to +100	$^\circ\text{C}$
Ambient Operating Temperature Range <sup>(2)</sup>	$T_A$	-40 to +85	$^\circ\text{C}$
Storage Temperature Range <sup>(2)</sup>	$T_{stg}$	-40 to +150	$^\circ\text{C}$
Soldering Temperature (10 s)	$T_L$	260	$^\circ\text{C}$

1. Isolation surge voltage,  $V_{ISO}$ , is an internal device dielectric breakdown rating. For this test, Pins 1 and 2 are common, and Pins 4, 5 and 6 are common.
2. Refer to Quality and Reliability Section in Opto Data Book for information on test conditions.

**MOC3021**  
[IFT = 15 mA Max]  
**MOC3022**  
[IFT = 10 mA Max]  
**MOC3023\***  
[IFT = 5 mA Max]

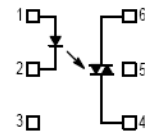
\*Motorola Preferred Device

**STYLE 6 PLASTIC**



**STANDARD THRU HOLE  
CASE 730A-04**

**SCHEMATIC**



1. ANODE
2. CATHODE
3. NC
4. MAIN TERMINAL
5. SUBSTRATE  
DO NOT CONNECT
6. MAIN TERMINAL

# TIP31, TIP31A, TIP31B, TIP31C, (NPN), TIP32, TIP32A, TIP32B, TIP32C, (PNP)

## Complementary Silicon Plastic Power Transistors

Designed for use in general purpose amplifier and switching applications.

### Features

- Collector–Emitter Saturation Voltage –  
 $V_{CE(sat)} = 1.2 \text{ Vdc (Max) @ } I_C = 3.0 \text{ Adc}$
- Collector–Emitter Sustaining Voltage –  
 $V_{CEO(sus)} = 40 \text{ Vdc (Min) – TIP31, TIP32}$   
 $= 60 \text{ Vdc (Min) – TIP31A, TIP32A}$   
 $= 80 \text{ Vdc (Min) – TIP31B, TIP32B}$   
 $= 100 \text{ Vdc (Min) – TIP31C, TIP32C}$
- High Current Gain – Bandwidth Product  
 $f_T = 3.0 \text{ MHz (Min) @ } I_C = 500 \text{ mAdc}$
- Compact TO–220 AB Package
- Pb–Free Packages are Available\*

### MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector – Emitter Voltage TIP31, TIP32 TIP31A, TIP32A TIP31B, TIP32B TIP31C, TIP32C	$V_{CEO}$	40 60 80 100	Vdc
Collector–Base Voltage TIP31, TIP32 TIP31A, TIP32A TIP31B, TIP32B TIP31C, TIP32C	$V_{CB}$	40 60 80 100	Vdc
Emitter–Base Voltage	$V_{EB}$	5.0	Vdc
Collector Current Continuous Peak	$I_C$	3.0 5.0	Adc
Base Current	$I_B$	1.0	Adc
Total Power Dissipation @ $T_C = 25^\circ\text{C}$ Derate above $25^\circ\text{C}$	$P_D$	40 0.32	W W/ $^\circ\text{C}$
Total Power Dissipation @ $T_A = 25^\circ\text{C}$ Derate above $25^\circ\text{C}$	$P_D$	2.0 0.016	W W/ $^\circ\text{C}$
Unclamped Inductive Load Energy (Note 1)	E	32	mJ
Operating and Storage Junction Temperature Range	$T_J, T_{stg}$	–65 to +150	$^\circ\text{C}$

Maximum ratings are those values beyond which device damage can occur. Maximum ratings applied to the device are individual stress limit values (not normal operating conditions) and are not valid simultaneously. If these limits are exceeded, device functional operation is not implied, damage may occur and reliability may be affected.

1.  $I_C = 1.8 \text{ A}$ ,  $L = 20 \text{ mH}$ , P.R.F. = 10 Hz,  $V_{CC} = 10 \text{ V}$ ,  $R_{BE} = 100 \Omega$

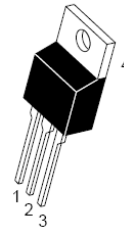
\*For additional information on our Pb–Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.



ON Semiconductor®

<http://onsemi.com>

**3 AMPERE  
POWER TRANSISTORS  
COMPLEMENTARY SILICON  
40–60–80–100 VOLTS,  
40 WATTS**



**MARKING  
DIAGRAM**

TO–220AB  
CASE 221A  
STYLE 1



TIP3xx = Device Code  
xx = 1, 1A, 1B, 1C,  
2, 2A, 2B, 2C,  
A = Assembly Location  
Y = Year  
WW = Work Week  
G = Pb–Free Package

### ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 2 of this data sheet.

TIP31, TIP31A, TIP31B, TIP31C, (NPN), TIP32, TIP32A, TIP32B, TIP32C, (PNP)

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction-to-Ambient	$R_{\theta JA}$	62.5	$^{\circ}\text{C/W}$
Thermal Resistance, Junction-to-Case	$R_{\theta JC}$	3.125	$^{\circ}\text{C/W}$

ELECTRICAL CHARACTERISTICS ( $T_C = 25^{\circ}\text{C}$  unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Sustaining Voltage (Note 2) ( $I_C = 30\text{ mAdc}$ , $I_B = 0$ )	TIP31, TIP32 TIP31A, TIP32A TIP31B, TIP32B TIP31C, TIP32C	$V_{CEO(sus)}$	40 60 80 100	- - - -	Vdc
Collector Cutoff Current ( $V_{CE} = 30\text{ Vdc}$ , $I_B = 0$ ) ( $V_{CE} = 60\text{ Vdc}$ , $I_B = 0$ )	TIP31, TIP32, TIP31A, TIP32A TIP31B, TIP31C, TIP32B, TIP32C	$I_{CEO}$	- -	0.3 0.3	mAdc
Collector Cutoff Current ( $V_{CE} = 40\text{ Vdc}$ , $V_{EB} = 0$ ) ( $V_{CE} = 60\text{ Vdc}$ , $V_{EB} = 0$ ) ( $V_{CE} = 80\text{ Vdc}$ , $V_{EB} = 0$ ) ( $V_{CE} = 100\text{ Vdc}$ , $V_{EB} = 0$ )	TIP31, TIP32 TIP31A, TIP32A TIP31B, TIP32B TIP31C, TIP32C	$I_{CES}$	- - - -	200 200 200 200	$\mu\text{Adc}$
Emitter Cutoff Current ( $V_{BE} = 5.0\text{ Vdc}$ , $I_C = 0$ )		$I_{EBO}$	-	1.0	mAdc

ON CHARACTERISTICS (Note 2)

DC Current Gain ( $I_C = 1.0\text{ Adc}$ , $V_{CE} = 4.0\text{ Vdc}$ ) ( $I_C = 3.0\text{ Adc}$ , $V_{CE} = 4.0\text{ Vdc}$ )		$h_{FE}$	25 10	- 50	-
Collector-Emitter Saturation Voltage ( $I_C = 3.0\text{ Adc}$ , $I_B = 375\text{ mAdc}$ )		$V_{CE(sat)}$	-	1.2	Vdc
Base-Emitter On Voltage ( $I_C = 3.0\text{ Adc}$ , $V_{CE} = 4.0\text{ Vdc}$ )		$V_{BE(on)}$	-	1.8	Vdc

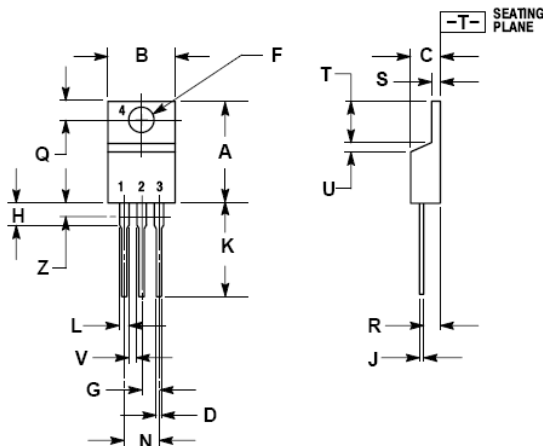
DYNAMIC CHARACTERISTICS

Current-Gain - Bandwidth Product ( $I_C = 500\text{ mAdc}$ , $V_{CE} = 10\text{ Vdc}$ , $f_{test} = 1.0\text{ MHz}$ )		$f_T$	3.0	-	MHz
Small-Signal Current Gain ( $I_C = 0.5\text{ Adc}$ , $V_{CE} = 10\text{ Vdc}$ , $f = 1.0\text{ kHz}$ )		$h_{fe}$	20	-	-

2. Pulse Test: Pulse Width  $\leq 300\ \mu\text{s}$ , Duty Cycle  $\leq 2.0\%$ .

PACKAGE DIMENSIONS

TO-220  
CASE 221A-09  
ISSUE AA



NOTES:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. DIMENSION Z DEFINES A ZONE WHERE ALL BODY AND LEAD IRREGULARITIES ARE ALLOWED.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.570	0.620	14.48	15.75
B	0.380	0.405	9.66	10.28
C	0.160	0.190	4.07	4.82
D	0.025	0.035	0.64	0.88
F	0.142	0.147	3.61	3.73
G	0.095	0.105	2.42	2.66
H	0.110	0.155	2.80	3.93
J	0.018	0.025	0.46	0.64
K	0.500	0.562	12.70	14.27
L	0.045	0.060	1.15	1.52
N	0.190	0.210	4.83	5.33
Q	0.100	0.120	2.54	3.04
R	0.080	0.110	2.04	2.79
S	0.045	0.055	1.15	1.39
T	0.235	0.255	5.97	6.47
U	0.000	0.050	0.00	1.27
V	0.045	---	1.15	---
Z	---	0.080	---	2.04

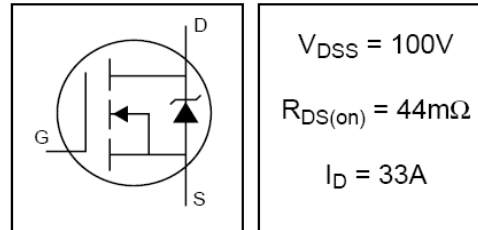
STYLE 1:

1. BASE
2. COLLECTOR
3. EMITTER
4. COLLECTOR

# IRF540N

HEXFET® Power MOSFET

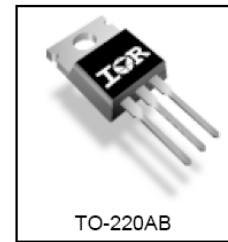
- Advanced Process Technology
- Ultra Low On-Resistance
- Dynamic dv/dt Rating
- 175°C Operating Temperature
- Fast Switching
- Fully Avalanche Rated



### Description

Advanced HEXFET® Power MOSFETs from International Rectifier utilize advanced processing techniques to achieve extremely low on-resistance per silicon area. This benefit, combined with the fast switching speed and ruggedized device design that HEXFET power MOSFETs are well known for, provides the designer with an extremely efficient and reliable device for use in a wide variety of applications.

The TO-220 package is universally preferred for all commercial-industrial applications at power dissipation levels to approximately 50 watts. The low thermal resistance and low package cost of the TO-220 contribute to its wide acceptance throughout the industry.



### Absolute Maximum Ratings

	Parameter	Max.	Units
$I_D$ @ $T_C = 25^\circ\text{C}$	Continuous Drain Current, $V_{GS}$ @ 10V	33	A
$I_D$ @ $T_C = 100^\circ\text{C}$	Continuous Drain Current, $V_{GS}$ @ 10V	23	
$I_{DM}$	Pulsed Drain Current ①	110	
$P_D$ @ $T_C = 25^\circ\text{C}$	Power Dissipation	130	W
	Linear Derating Factor	0.87	W/°C
$V_{GS}$	Gate-to-Source Voltage	$\pm 20$	V
$I_{AR}$	Avalanche Current ①	16	A
$E_{AR}$	Repetitive Avalanche Energy ①	13	mJ
dv/dt	Peak Diode Recovery dv/dt ③	7.0	V/ns
$T_J$	Operating Junction and	-55 to + 175	°C
$T_{STG}$	Storage Temperature Range		
	Soldering Temperature, for 10 seconds		
	Mounting torque, 6-32 or M3 screw	10 lbf•in (1.1N•m)	

### Thermal Resistance

	Parameter	Typ.	Max.	Units
$R_{\theta JC}$	Junction-to-Case	—	1.15	°C/W
$R_{\theta CS}$	Case-to-Sink, Flat, Greased Surface	0.50	—	
$R_{\theta JA}$	Junction-to-Ambient	—	62	

# IRF540N

International  
**IR** Rectifier

## Electrical Characteristics @ T<sub>J</sub> = 25°C (unless otherwise specified)

	Parameter	Min.	Typ.	Max.	Units	Conditions
V <sub>(BR)DSS</sub>	Drain-to-Source Breakdown Voltage	100	—	—	V	V <sub>GS</sub> = 0V, I <sub>D</sub> = 250μA
ΔV <sub>(BR)DSS/ΔT<sub>J</sub></sub>	Breakdown Voltage Temp. Coefficient	—	0.12	—	V/°C	Reference to 25°C, I <sub>D</sub> = 1mA
R <sub>DS(on)</sub>	Static Drain-to-Source On-Resistance	—	—	44	mΩ	V <sub>GS</sub> = 10V, I <sub>D</sub> = 16A ④
V <sub>GS(th)</sub>	Gate Threshold Voltage	2.0	—	4.0	V	V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = 250μA
g <sub>fs</sub>	Forward Transconductance	21	—	—	S	V <sub>DS</sub> = 50V, I <sub>D</sub> = 16A④
I <sub>DSS</sub>	Drain-to-Source Leakage Current	—	—	25	μA	V <sub>DS</sub> = 100V, V <sub>GS</sub> = 0V
		—	—	250		V <sub>DS</sub> = 80V, V <sub>GS</sub> = 0V, T <sub>J</sub> = 150°C
I <sub>GSS</sub>	Gate-to-Source Forward Leakage	—	—	100	nA	V <sub>GS</sub> = 20V
	Gate-to-Source Reverse Leakage	—	—	-100		V <sub>GS</sub> = -20V
Q <sub>g</sub>	Total Gate Charge	—	—	71	nC	I <sub>D</sub> = 16A
Q <sub>gs</sub>	Gate-to-Source Charge	—	—	14		V <sub>DS</sub> = 80V
Q <sub>gd</sub>	Gate-to-Drain ("Miller") Charge	—	—	21		V <sub>GS</sub> = 10V, See Fig. 6 and 13
t <sub>d(on)</sub>	Turn-On Delay Time	—	11	—	ns	V <sub>DD</sub> = 50V
t <sub>r</sub>	Rise Time	—	35	—		I <sub>D</sub> = 16A
t <sub>d(off)</sub>	Turn-Off Delay Time	—	39	—		R <sub>G</sub> = 5.1Ω
t <sub>f</sub>	Fall Time	—	35	—		V <sub>GS</sub> = 10V, See Fig. 10 ④
L <sub>D</sub>	Internal Drain Inductance	—	4.5	—	nH	Between lead, 6mm (0.25in.) from package and center of die contact
L <sub>S</sub>	Internal Source Inductance	—	7.5	—		
C <sub>iss</sub>	Input Capacitance	—	1960	—	pF	V <sub>GS</sub> = 0V
C <sub>oss</sub>	Output Capacitance	—	250	—		V <sub>DS</sub> = 25V
C <sub>rss</sub>	Reverse Transfer Capacitance	—	40	—		f = 1.0MHz, See Fig. 5
E <sub>AS</sub>	Single Pulse Avalanche Energy②	—	700⑤	185⑥	mJ	I <sub>AS</sub> = 16A, L = 1.5mH

## Source-Drain Ratings and Characteristics

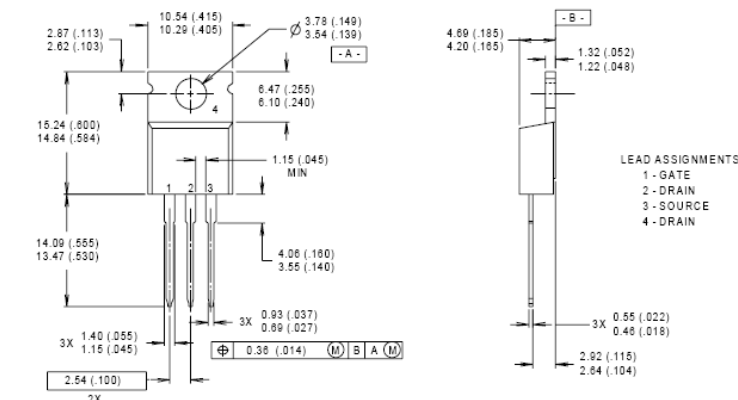
	Parameter	Min.	Typ.	Max.	Units	Conditions
I <sub>S</sub>	Continuous Source Current (Body Diode)	—	—	33	A	MOSFET symbol showing the integral reverse p-n junction diode.
I <sub>SM</sub>	Pulsed Source Current (Body Diode)①	—	—	110		
V <sub>SD</sub>	Diode Forward Voltage	—	—	1.2	V	T <sub>J</sub> = 25°C, I <sub>S</sub> = 16A, V <sub>GS</sub> = 0V ④
t <sub>rr</sub>	Reverse Recovery Time	—	115	170	ns	T <sub>J</sub> = 25°C, I <sub>F</sub> = 16A
Q <sub>rr</sub>	Reverse Recovery Charge	—	505	760	nC	di/dt = 100A/μs ④
t <sub>on</sub>	Forward Turn-On Time	Intrinsic turn-on time is negligible (turn-on is dominated by L <sub>S</sub> +L <sub>D</sub> )				

### Notes:

- ① Repetitive rating; pulse width limited by max. junction temperature. (See fig. 11)
- ② Starting T<sub>J</sub> = 25°C, L = 1.5mH  
R<sub>G</sub> = 25Ω, I<sub>AS</sub> = 16A. (See Figure 12)
- ③ I<sub>SD</sub> ≤ 16A, di/dt ≤ 340A/μs, V<sub>DD</sub> ≤ V<sub>(BR)DSS</sub>, T<sub>J</sub> ≤ 175°C
- ④ Pulse width ≤ 400μs; duty cycle ≤ 2%.
- ⑤ This is a typical value at device destruction and represents operation outside rated limits.
- ⑥ This is a calculated value limited to T<sub>J</sub> = 175°C .

### TO-220AB

Dimensions are shown in millimeters (inches)



- NOTES:
- 1 DIMENSIONING & TOLERANCING PER ANSI Y14.5M, 1982.
  - 2 CONTROLLING DIMENSION - INCH
  - 3 OUTLINE CONFORMS TO JEDEC OUTLINE TO-220AB.
  - 4 HEATSINK & LEAD MEASUREMENTS DO NOT INCLUDE BURRS.