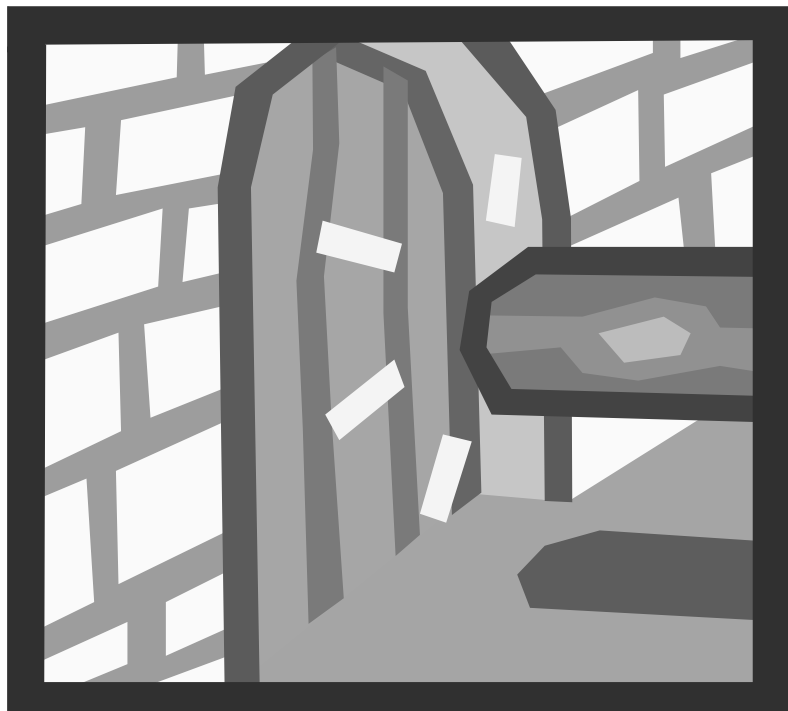
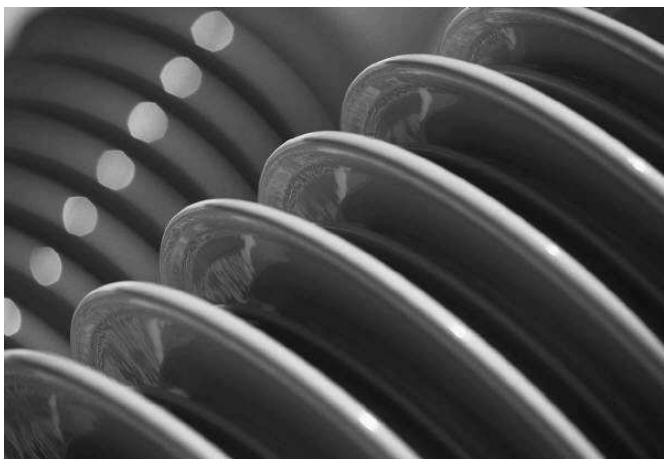
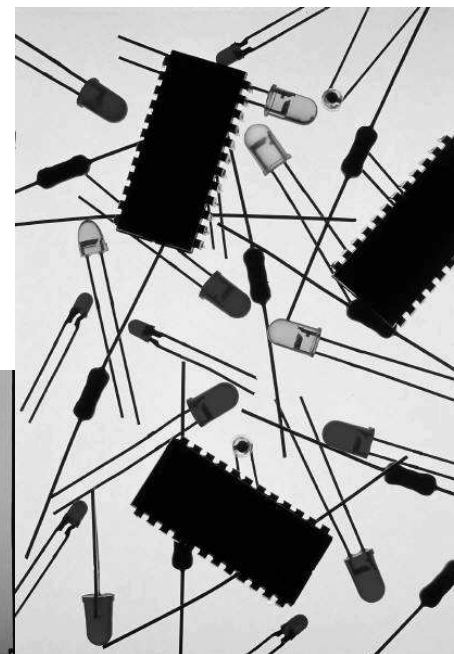


Introductory



Electronics



POWER



X. Sun

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Features of Power Electronic System

1. Function and Form

Energy Processing : altering the character of electrical energy

Interfacing : imposing relationship of voltages and currents at one port to the other
: Interacting with the external systems:

bidirectional energy flow

external determines the internal function

Form : generically referred as *converters, power processors* (ac/dc, ac/dc, dc/dc)

2. Components

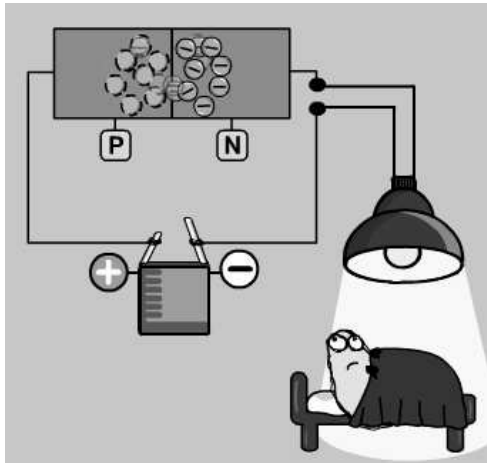
Switches : power diode (PN; Schottky), power transistor (BJT; MOSFET) , thyristor
(SCR; TRIAC; MCT; GTO)

Energy Storage Elements : capacitor, inductor

3. Dynamics and Control

Power Diode 1

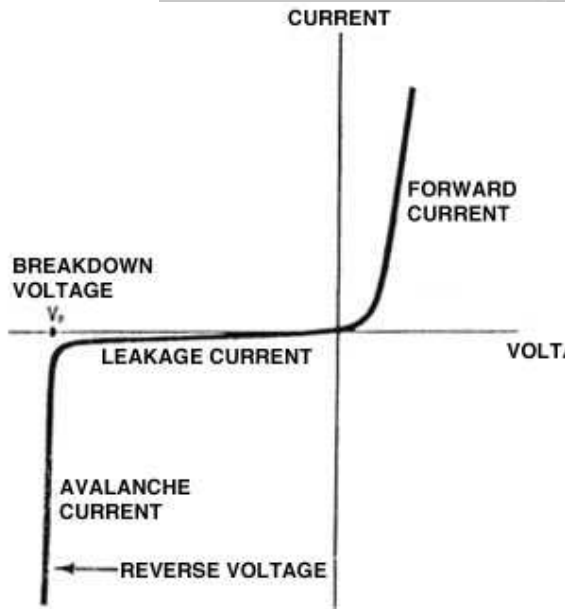
- Bipolar PN Junction



CASE 182-06, STYLE 1
TO-92 (TO-226AC)



CASE 318-08, STYLE 8
SOT-23 (TO-236AB)



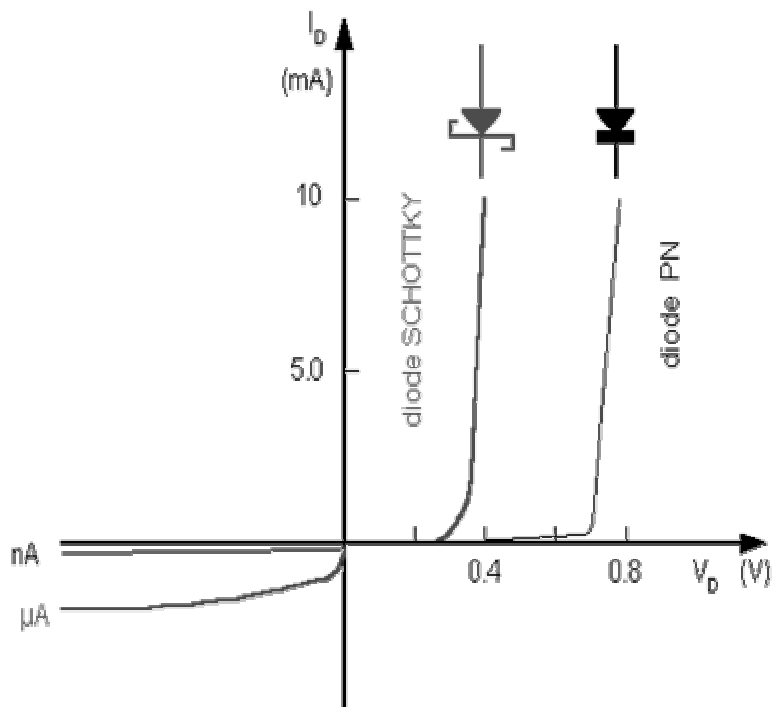
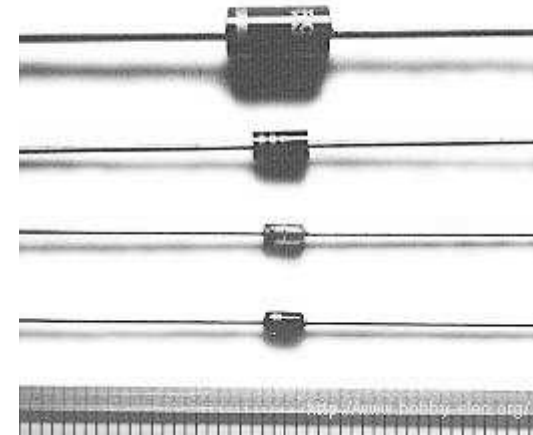
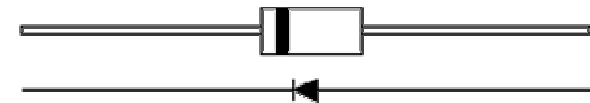
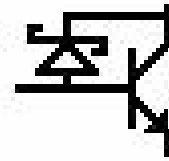
PARAMETER	SYMBOL	VALUE	UNIT
Continuous Reverse Voltage	V_R	75	V
Repetative Reverse Voltage	V_{RRM}	85	V
Repetative Peak Forward Current	I_{FRM}	250	mA
Power Dissipation at $T_{amb}=25^\circ\text{C}$	P_{tot}	330	mW
Operating and Storage Temperature Range	$T_j; T_{stg}$	-55 to +150	$^\circ\text{C}$

Power Diode 2

- Shottky Diode

Advantages:

1. Short Reverse Recovery Time
 - High speed rectifier
2. Low Voltage Drop in Forward Bias
 - High speed TTL IC 74S00 (ECL)
 - Low power TTL IC 74LS00 (TTL)



Reason for fast speed:

CHARGE STORAGE in PN diode due
To slow holes to get homes
No P-materials reduces charge storage

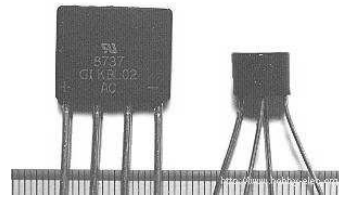
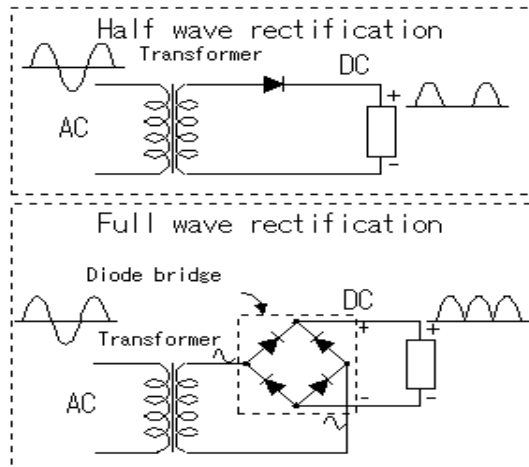
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Power Diode 3

- Diode Bridge



- Tunnel Diode 

Heavily doped, negative resistance over forward bias range, so nice for high frequency oscillator

- Varicap Diode 

PN junction cap decreases when reverse biasing voltage increases
For variable cap to eliminate the need of moving part 60pF/0v → 6pF/20v

- Zener Diode 

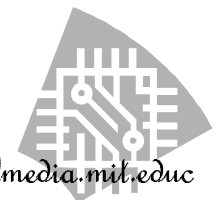
narrow junction, Zener breakdown, large change of current causes no change of voltage, voltage regulator

- LED 

III-V semiconductor, emitting photon when electron passes junction

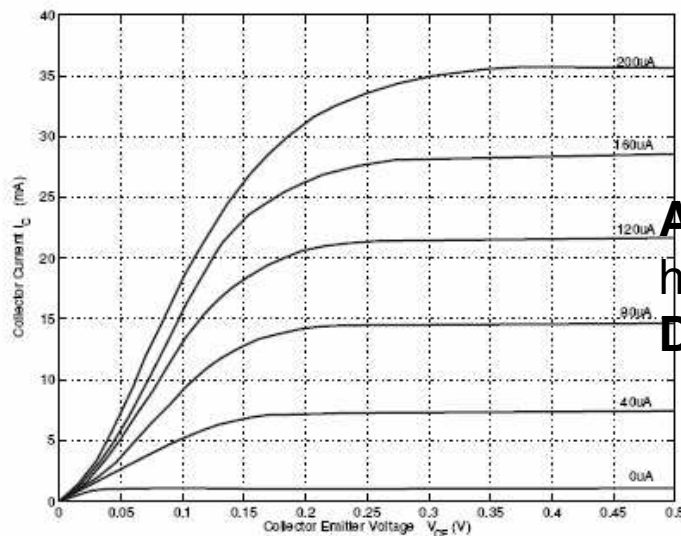
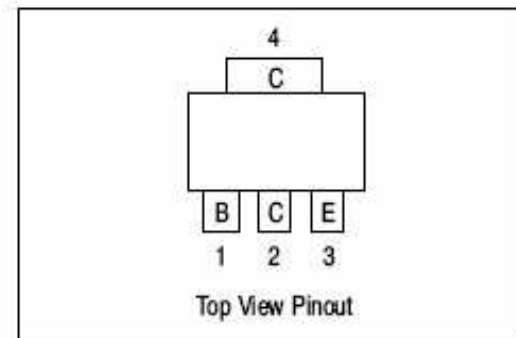
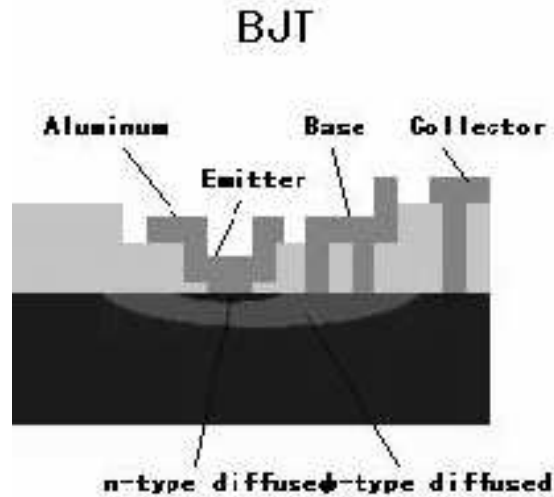
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Power Transistor 1

- Bipolar Junction Transistor (BJT)



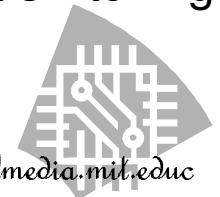
<http://jas.eng.buffalo.edu/education/fab/BjtFet/>

Advantage: High current density, medium to high Voltage operation. Low forward voltage drop.

Disadvantage: Complex base control, not fast switching

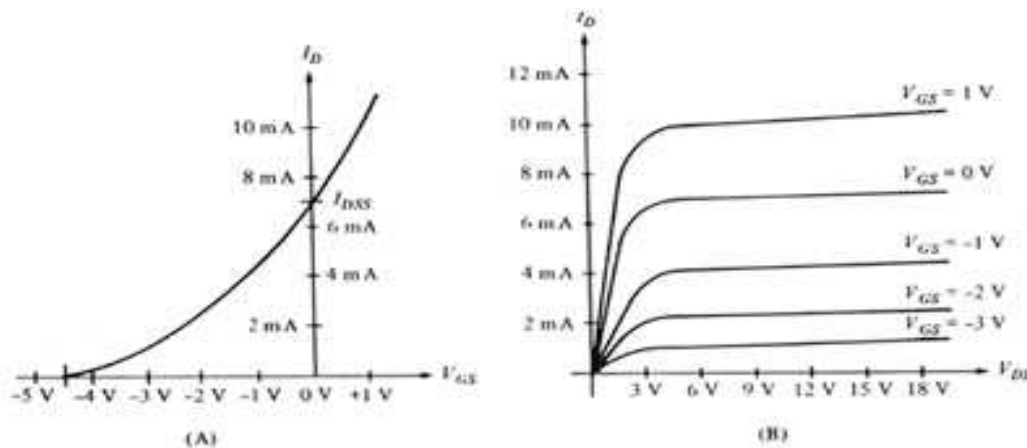
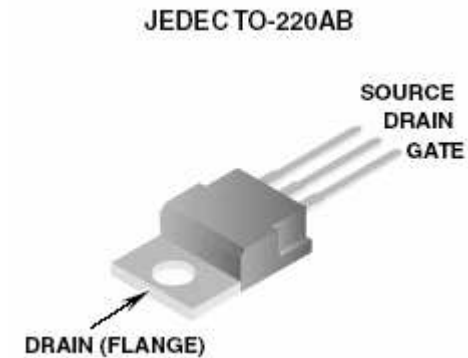
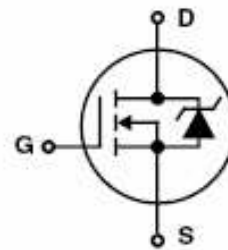
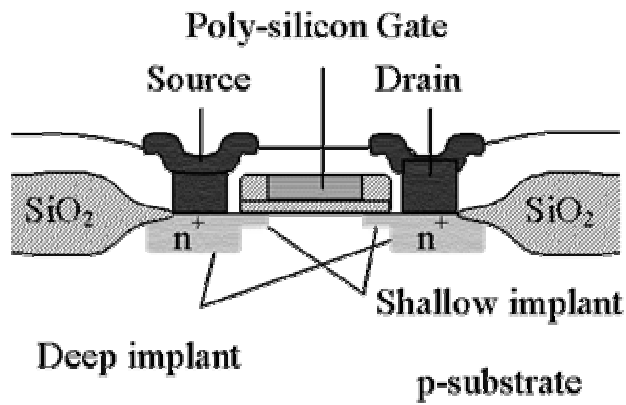
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Power Transistor 2

- Metal-Oxide-Semiconductor Field Effect Transistor (MOSFET)



Advantage: Simple gate control
Excellent fast switching
Disadvantage: Low to medium Voltage (<200V, bulk resistance)
Low current conduction capability

Power Transistor 3

- Insulated Gate Bipolar Transistor (IGBT)

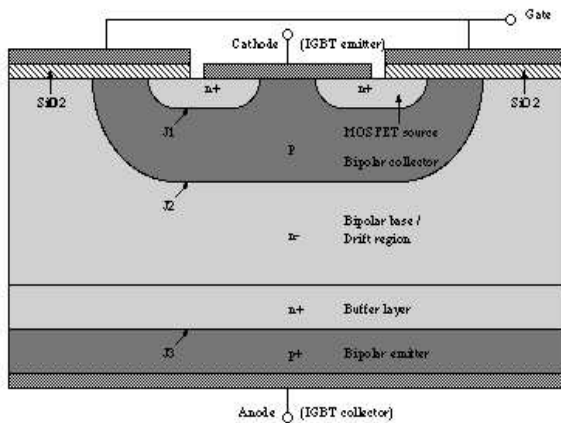
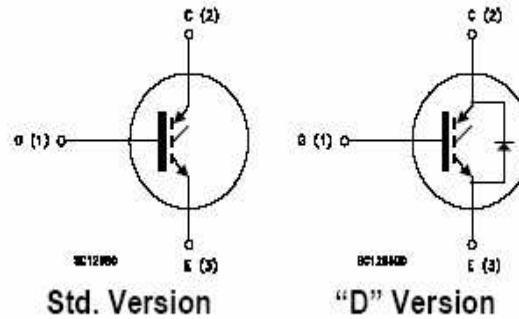


Fig.1: A typical IGBT structure

INTERNAL SCHEMATIC DIAGRAM

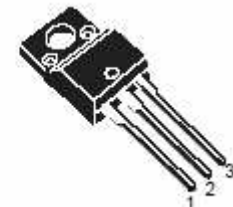


Std. Version

"D" Version



TO-220



TO-220FP



D²PAK



DPAK

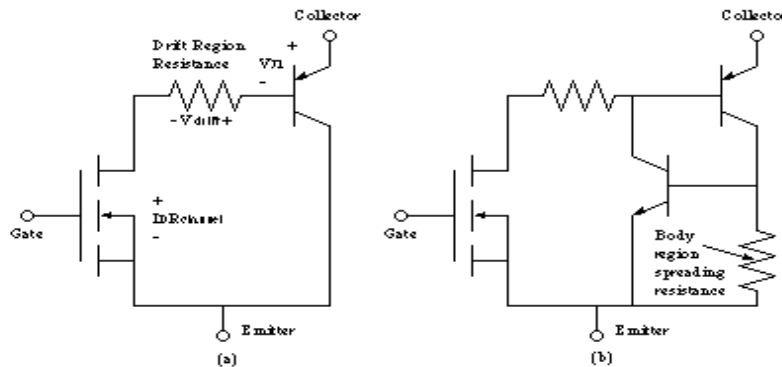
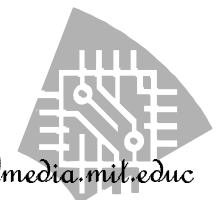


Fig 3: (a) Simple equivalent circuit for the IGBT; (b) more complete equivalent circuit showing the transistors which make up the parasitic thyristor

Combine the advantages of MOSFET and BJT.
 Gate structure like MOS
 Output structure like BJT
 High voltage 300-1700V

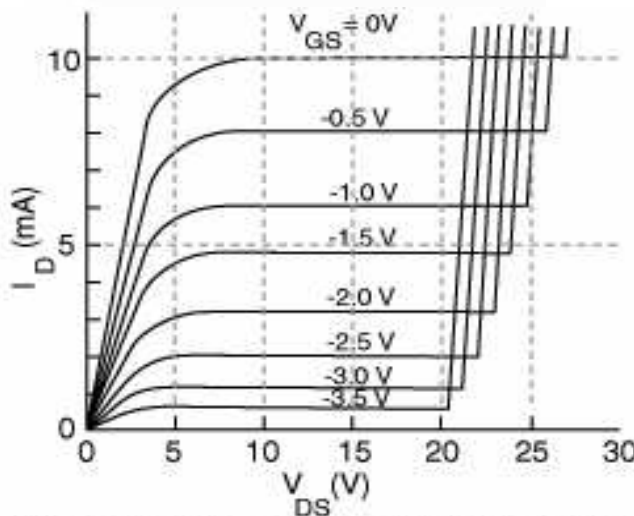
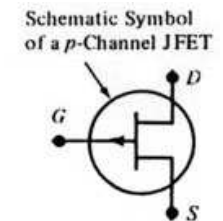
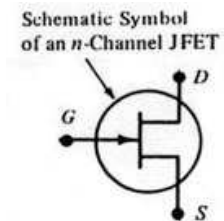
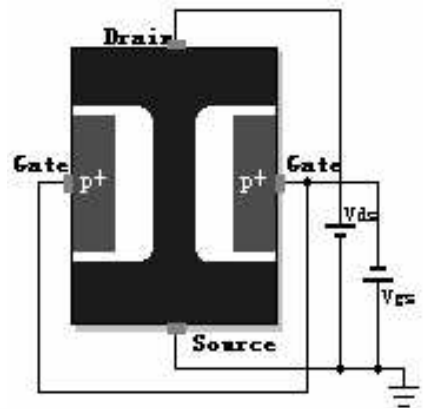
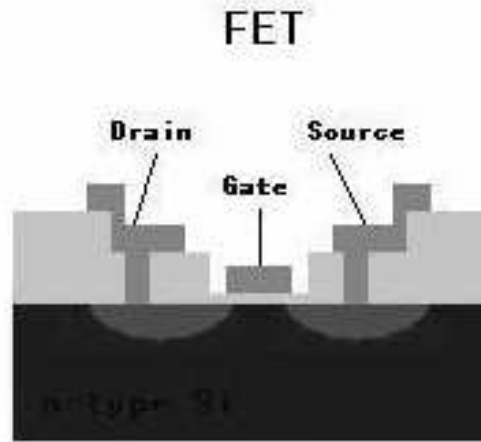
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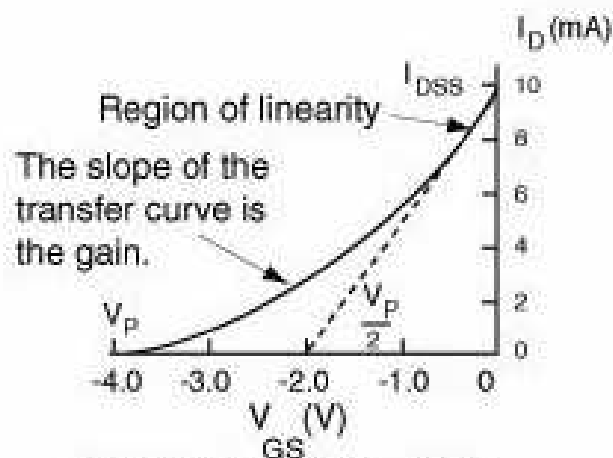


Power Transistor 4

- Junction Field Effect Transistor (JFET)



Common source JFET characteristic curves



The slope of the transfer curve is the gain.

Transfer curve for a JFET (after DiEderfer & Holton)

- Advantage:**
1. Fast Speed
 2. Low Noise

Power Transistor 5

- Darlington Transistor (Super Alfa Pair)

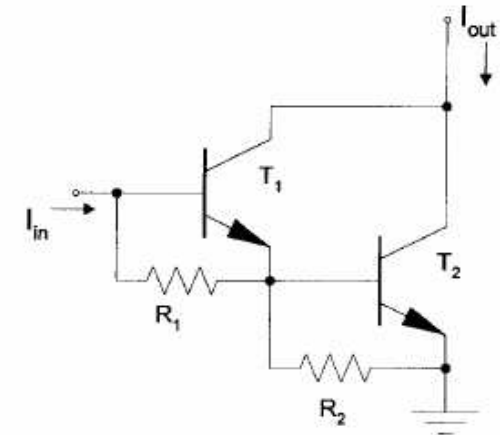
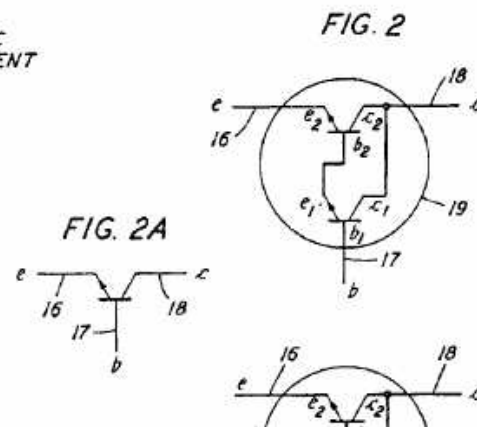
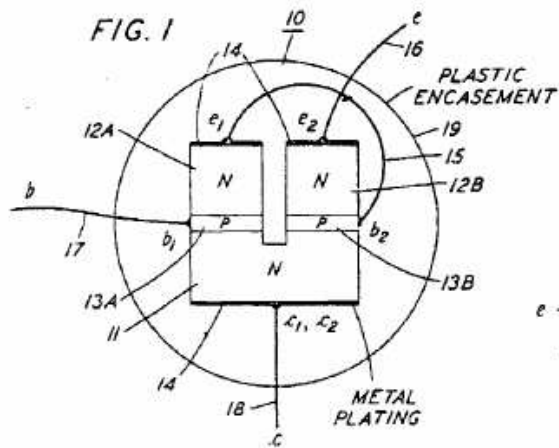
Dec. 22, 1953

S. DARLINGTON

2,663,806

SEMICONDUCTOR SIGNAL TRANSLATING DEVICE

Filed May 9, 1952



High Current Gain: $\beta = \beta_1 * \beta_2$

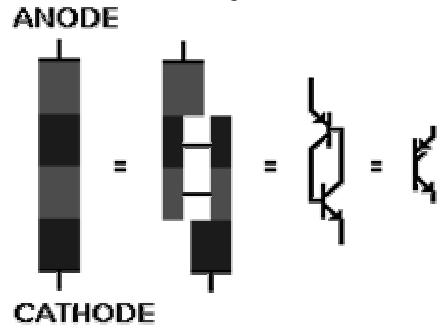
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Thyristor 1

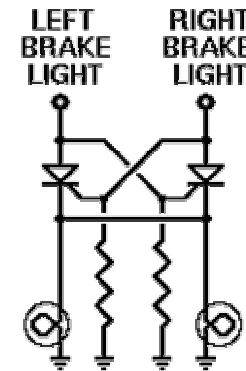
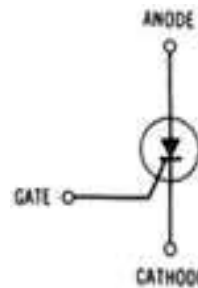
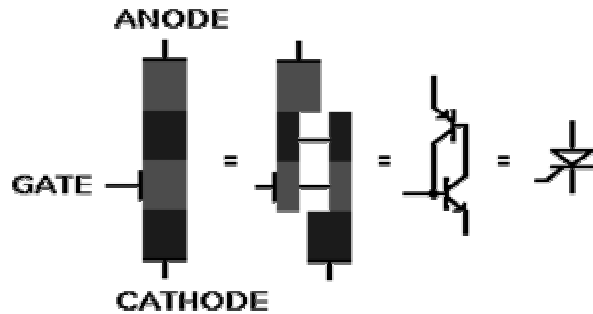
- Four Layer Diode (Triode)



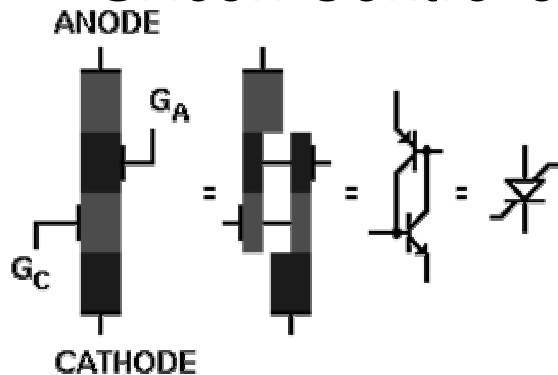
Application:

1. Sawtooth waveform generator
trigger pulse generator;
2. Protection circuit

- Silicon Controlled Rectifier (SCR)



- Silicon Controlled Switch (SCS)



Advantages:

1. Guarantee proper firing voltage dV/dt
2. Actively turn off without reducing v or i

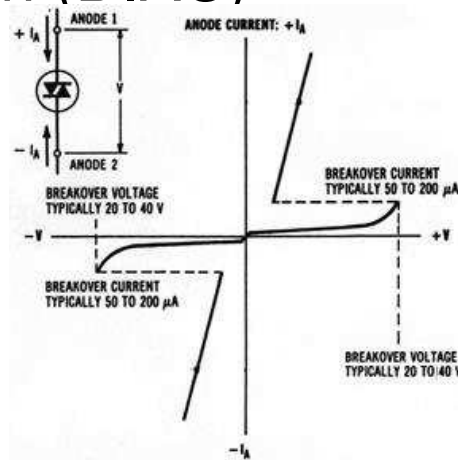
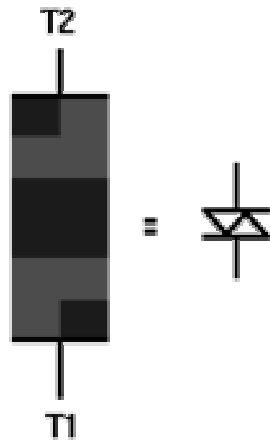
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Thyristor 2

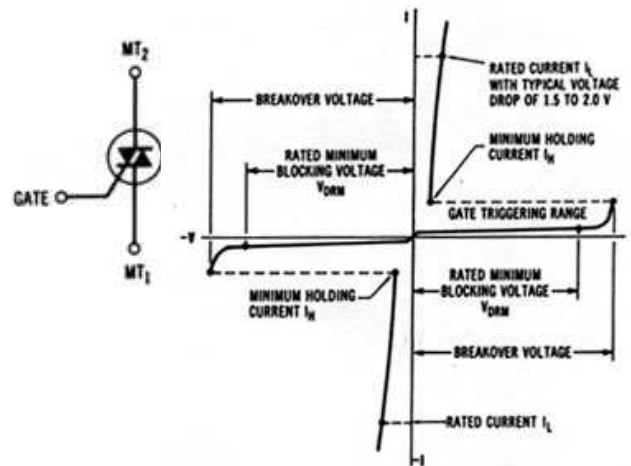
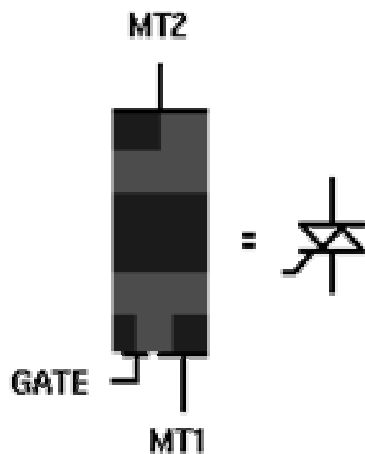
- Diode AC Switch (DIAC)



Characteristic parameters:

1. Breakover voltage
2. Breakback voltage
3. Voltage symmetry
4. Rating current
5. Power dissipation

- Triode AC Switch (TRIAC)



Typical triac VI characteristic curves.

Advantages:

1. Controllable trigger
2. Four quadrant device

Application:

1. Light dimmer control
2. Motor speed control

Reason:

Trigger pulse can control Any percentage of half cycle

A. Sar

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Relay – switches contacts when powered by a driver.

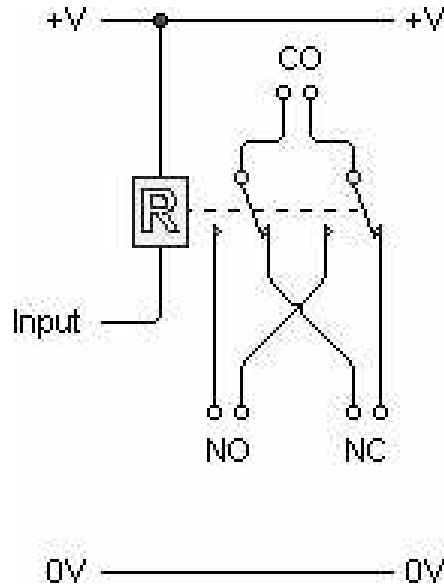
Relay



Relay not switched

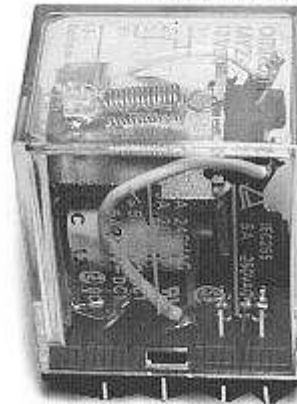


Relay switched



The Relay uses electromagnetic coil to move the poles of the switch when powered. The center terminal block is the **common** connection (CO). When not switched, CO is connect to **normal close** (NC); when switched, CO is connected to **normal open** (NO).

<http://www.hobby-elec.org/>



Driving voltage: 12V

Max Resistance voltage (AC): 240V

Permissible current limit (AC): 5A

Using Low voltage to switch high voltage

Type	PC board through hole terminal	PC board self-clinching terminal	PC board surface-mount terminal	Plug-in terminal	Quick connect terminal	Screw terminal
Typical relay type						
Terminal configuration						

Power Supply

- DC High Current Power Supply
Test Equipment



Output voltage: 0– 64V
Output current: 0– 10A
\$/W: \$2

Portable Power Supply



Output Power: 75—100W
Output Current: 0—25A
\$/W: \$1.6-\$2

Power Supply

- AC Power Supply



Output Power: 1000VA
Output Voltage: 0—110V
Output Current: 0—11A