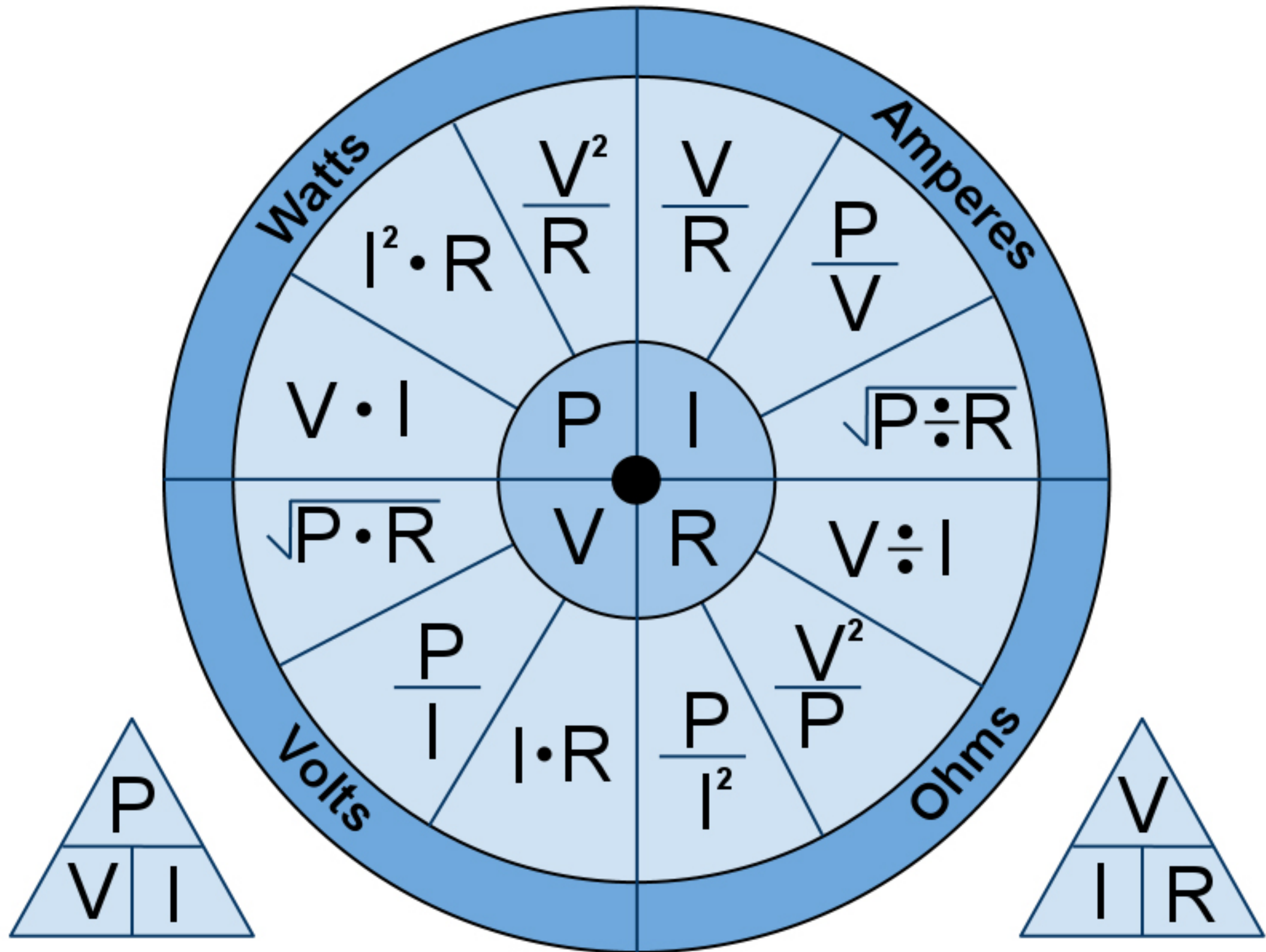


Ohm's & Watt's Laws



RESISTOR COLOR CODES

STANDARD FOUR
BAND RESISTOR



	A	B	C	D	E	F
COLOR	1ST	2ND	3RD	MULTIPLIER	TOLERANCE	RELIABILITY
BLACK		0	0	1		
BROWN	1	1	1	10	± 1%	1%
RED	2	2	2	10 ²	± 2%	0.1%
ORANGE	3	3	3	10 ³	± 3%	0.01%
YELLOW	4	4	4	10 ⁴	± 4%	0.001%
GREEN	5	5	5	10 ⁵	± 0.5%	
BLUE	6	6	6	10 ⁶	± 0.25%	
VIOLET	7	7	7	10 ⁷	± 0.1%	
GREY	8	8	8	10 ⁸		
WHITE	9	9	9	10 ⁹		
GOLD					± 5%	
SILVER					± 10%	
NONE					± 20%	
	A	B	C	D	E	F

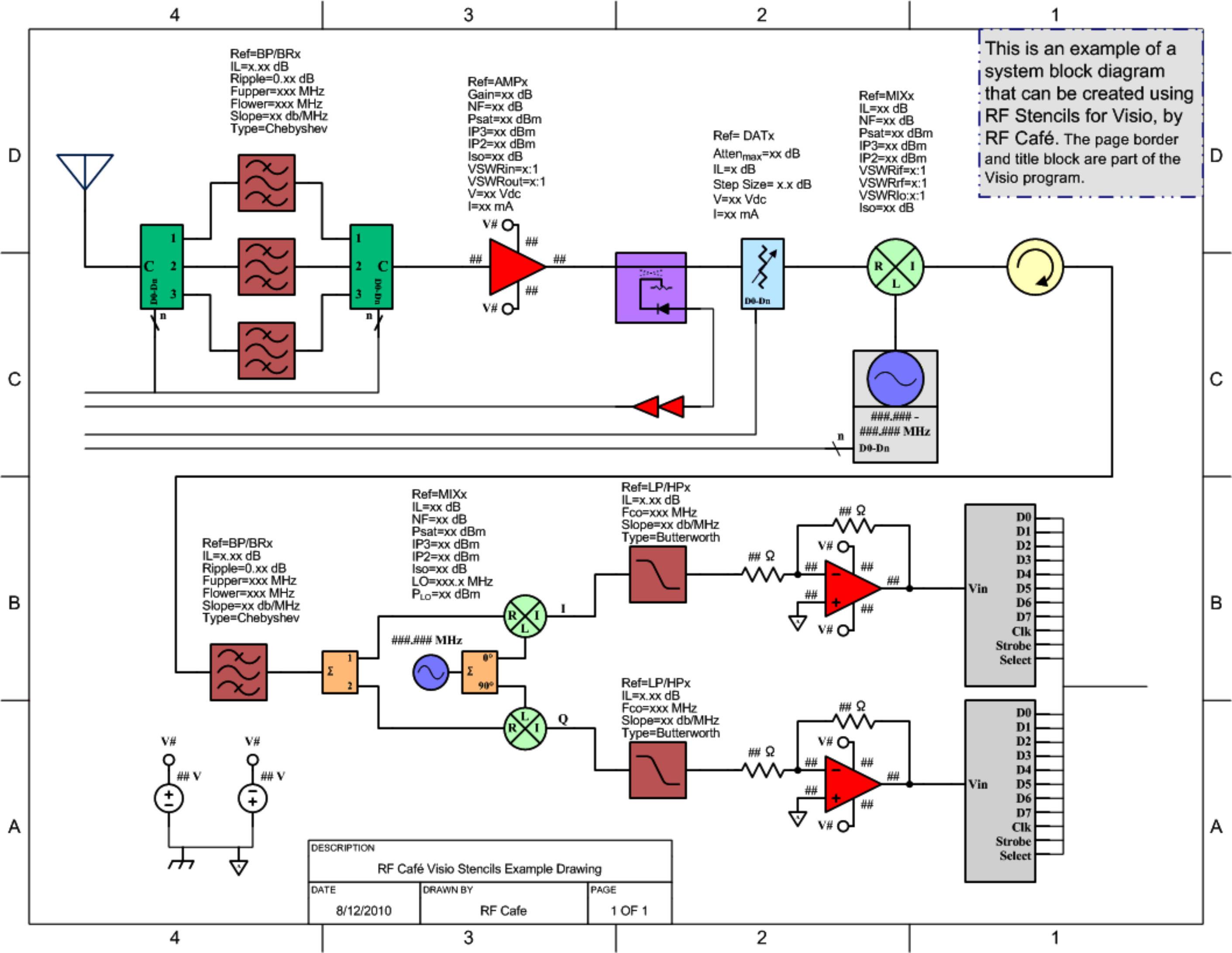
FIVE BAND
(PRECISION) RESISTOR



FIVE BAND
(RELIABILITY)
RESISTOR*



*Found in military electronics





Diode



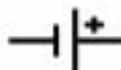
Capacitor



Inductor



Resistor



DC voltage
source



AC voltage
source



And gate



Nand gate



Or gate



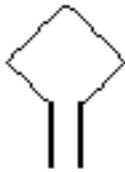
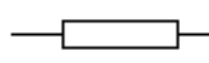
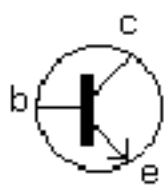
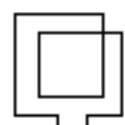
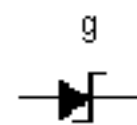
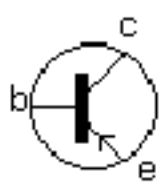
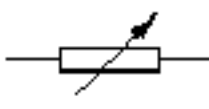
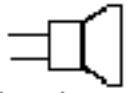
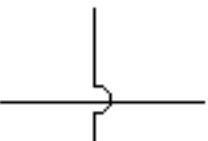
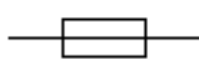
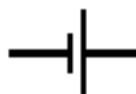
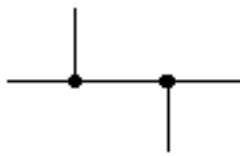
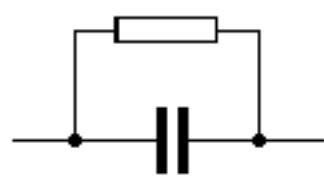
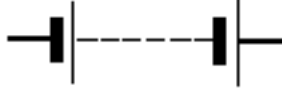
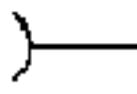
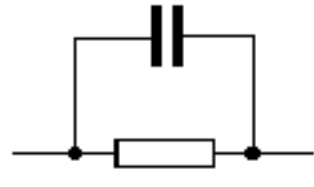
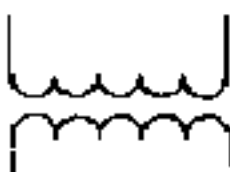
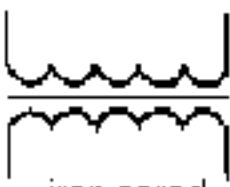
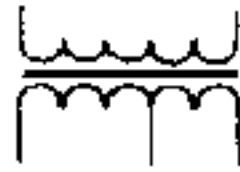
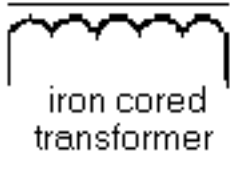
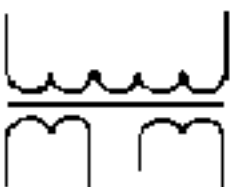
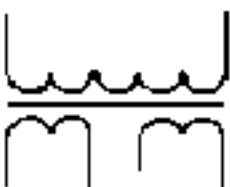
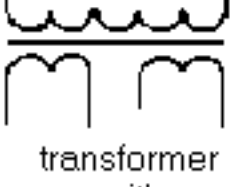
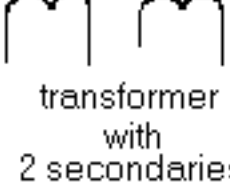
Nor gate

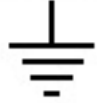
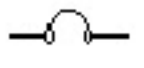
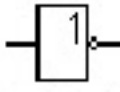
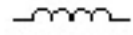
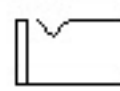
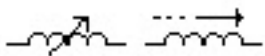
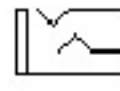
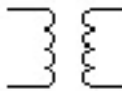
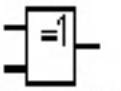


Xor gate



Inverter
(Not gate)

					
aerial (antenna)	milliammeter	preset	p-n diode	varicap diode	L.E.D.
					
loop aerial	voltmeter	resistor	zener diode	npn transistor	thyristor
					
frame aerial	wattmeter	resistor (alt)	zener (alt)	pnp transistor	
					
dipole	bell	variable	loudspeaker	wires crossing	
					
earth	filament lamp	tapped	microphone	wires crossing (alt)	
					
chassis	fuse	inductor	microphone (alt)	wires joining	
					
cell	fuse (alt)	inductor (alt)	microphone (alt)	two junctions	
					
battery	plug	tapped	earpiece	C more important than R	
					
battery (alt)	socket	with core	headset	R more important than C	
					
AC supply	polarised	air cored transformer	transformer with 2 secondaries	transformer with tapped secondary	
					
ammeter	electrolytic	iron cored transformer	transformer with 2 secondaries	transformer with tapped secondary	
					
microammeter	variable	transformer with 2 secondaries	transformer with 2 secondaries	transformer with 2 secondaries	

دايود نفقي	Tunnel Diode		أرضي	Ground Earth	
عاكس	Inverter (NOT Gate)		سماعة رأس	Headphone	
عاكس	INVERTER (NOT Gate)		ملف بقلب هوائي	Inductor Air Core	
قابس	Jack Co-axial		ملف بقلب حديدي	Inductor Iron Core or ferrite core	
قابس تليفون	Jack Phone (Phone Jack)		ملف ذاتي	Inductor Tapped	
قابس تليفون	Jack Phone (Switched)		ملف متغير	Inductor Variable	
قابس تليفون	Jack Phone (3 conductor)		دائرة متكاملة	Integrated Circuit	
Transformer Air Core			Transformer Iron Core		
Transistor Bipolar - NPN			Transistor Bipolar - PNP		
Transistor n-channel Field Effect			Transistor p-channel Field Effect		
Transistor Metal Oxide Single Gate			Transistor Metal Oxide Dual Gate		
Transistor Photosensitive			Transistor Schottky - NPN		
XOR Gate (exclusive OR)			XOR Gate (exclusive OR)		
Thyristors: Main Terminal 1			Transistor Unijunction - UJT		
DIAC	SCR	TRIAC	TRIAC	Base 1 Base 2	

Overloads

Thermal



Contacts

Normally Closed



Normally Open

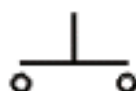


Push Buttons

Normally Closed



Normally Open



Switches

Timing Closed NC



Timing Closed NO



Timing Open NC



Timing Open NO



Switches

Flow NC



Flow NO



Normally Closed



Normally Open



Limit NC



Limit NO



Temperature NC



Temperature NO



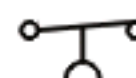
Pressure NC



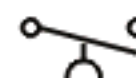
Pressure NO



Liquid NC

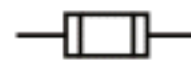


Liquid NO



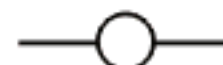
Fuse

Generic



Coil

Generic



Circuit Breaker

Generic



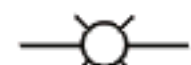
Motor

Three Phase



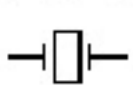
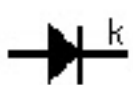
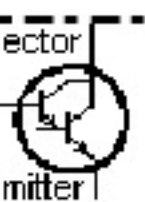
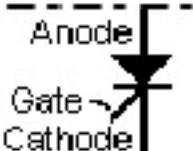
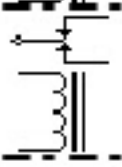
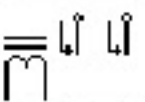
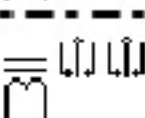
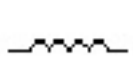
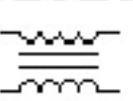
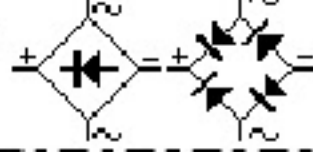
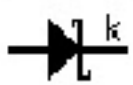
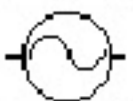
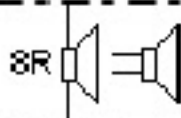
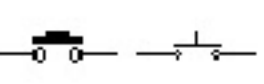
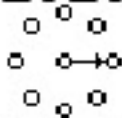
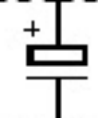
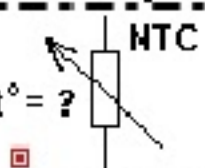
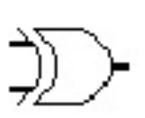
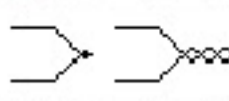
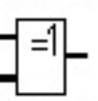
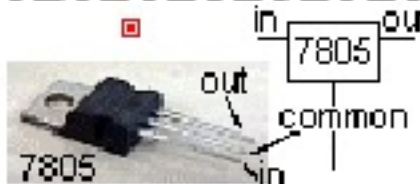
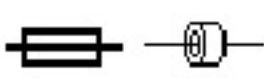
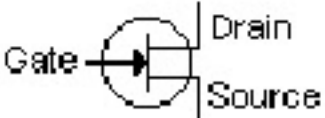
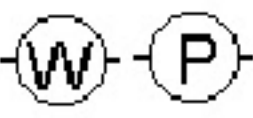
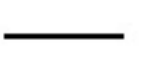
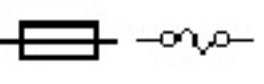
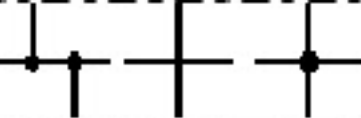
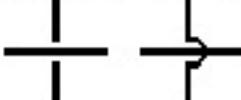
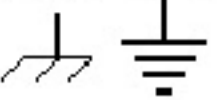
Indicator Light

Generic



Transformer



مقاومة متغيرة	Potentiometer (variable resistor)		هزاز كريستالي	Crystal Piezoelectric	
ثنائي مقوم	Rectifier Semiconductor		ترانزستور دارلنكتون	Darlington Transistor	
ثايرستور	Rectifier Silicon Controlled (SCR)		خط تأخير	Delay Line	
ريلية	Relay - spst		دياك	DIAC (Bilateral Switch)	
ريلية	Relay - spdt		ديود	Diode	
ريلية	Relay - dpst		ديود غن	Diode - Gunn	
ريلية	Relay - dpdt		ديود ضوئي	Diode - Light Emitting (LED)	
ملف راديوي	RFC Radio Frequency Choke		ديود مستقبل للضوء	Diode Photo Sensitive	
	Saturable Reactor			Diode Photovoltaic	
قادح شميث	Schmitt Trigger (Inverter Gate)		جسر تقويم	Diode Bridge (Bridge Rectifier)	
ثنائي شوتكي	Schottky Diode		ثنائي بن	Diode - Pin	
مولد إشارة متناوبة	Signal Generator		ثنائي الفاراكتور	Diode - Varactor	
بفلات	Speaker		ثنائي زينر	Diode - Zener	
مفتاح ضاغط	Switch - push (Push Button)		ميكرفون	Electret Microphone (Condenser mic)	
مفتاح دوار	Switch - Rotary		مكثف إلكتروني	Electrolytic (Polarised Capacitor)	
مقاومة NTC	Thermal Probe NTC: as temp rises, resistance decreases		بوابة OR	Exclusive-OR Gate (XOR Gate)	
مزدوجة حرارية	Thermocouple		بوابة OR	Exclusive-OR Gate (XOR Gate)	
منظم جهد	Voltage Regulator (7805 etc)		فاصمة حرارية	Ferrite Bead	
جهاز قياس الجهد	Voltmeter		ترانزستور حقلي سالب القناة	Field Effect Transistor (FET) n-channel	
جهاز قياس القدرة	Wattmeter		ترانزستور حقلي موجب القناة	Field Effect Transistor (FET) p-channel	
أسلاك	Wires		فيوز حراري	Fuse	
أسلاك متصلة	Wires Connected		غلغانومتر	Galvanometer	
أسلاك غير متصلة	Wires Not Connected		أرضي	Ground Chassis	



FLOOR
PUSH



CONTACTS ON ELECTRIC
SWITCH LOCK OPERATED
BY CAM WHEN PADLOCK
IS REMOVED.

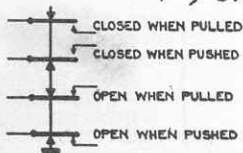
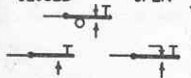


BRIDGE
CIRCUIT
CONTROLLER
PUSH
BUTTON
OR
STRAP KEY

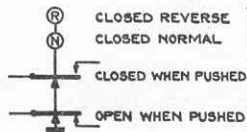


MULTICONTACT

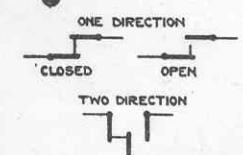
SPECIAL CONTROLLER
USE AND OPERATION
TO BE NOTED.



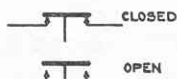
PUSH-PULL
BUTTON



PUSH-TURN
BUTTON



TRACK
INSTRUMENT



DOOR
CONTACT



AUTOMATIC
LEVER OPERATED



CLOCKWORK
MANUALLY OPERATED
NORMALLY LATCHED UP.



CLOCKWORK
MANUALLY OPERATED
NORMALLY RUN DOWN.



SCREW
MANUALLY OPERATED



INTERMEDIATE



LEVER LATCH



ELECTRIC LOCK
ARMATURE



KEY OPERATION



TEST CLIP OR
SWITCH

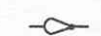
TRAIN STOP
TRIP TYPE

TRIPPING
POSITION

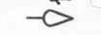
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POSITION



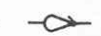
CONTACT CLOSED IN
TRIPPING
POSITION.



CONTACT CLOSED
IN NON-TRIPPING
POSITION.



CONTACT OPEN
IN NON-TRIPPING
POSITION.



CONTACT OPEN
IN TRIPPING
POSITION.



DEPENDENT
CONTACTS



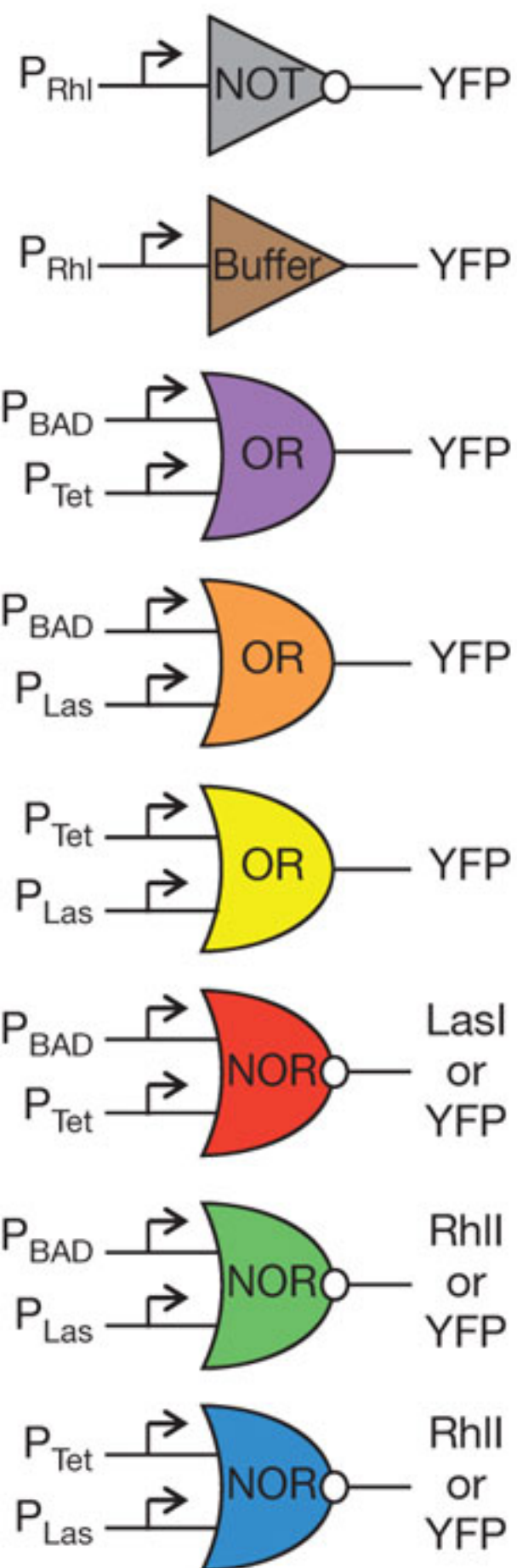
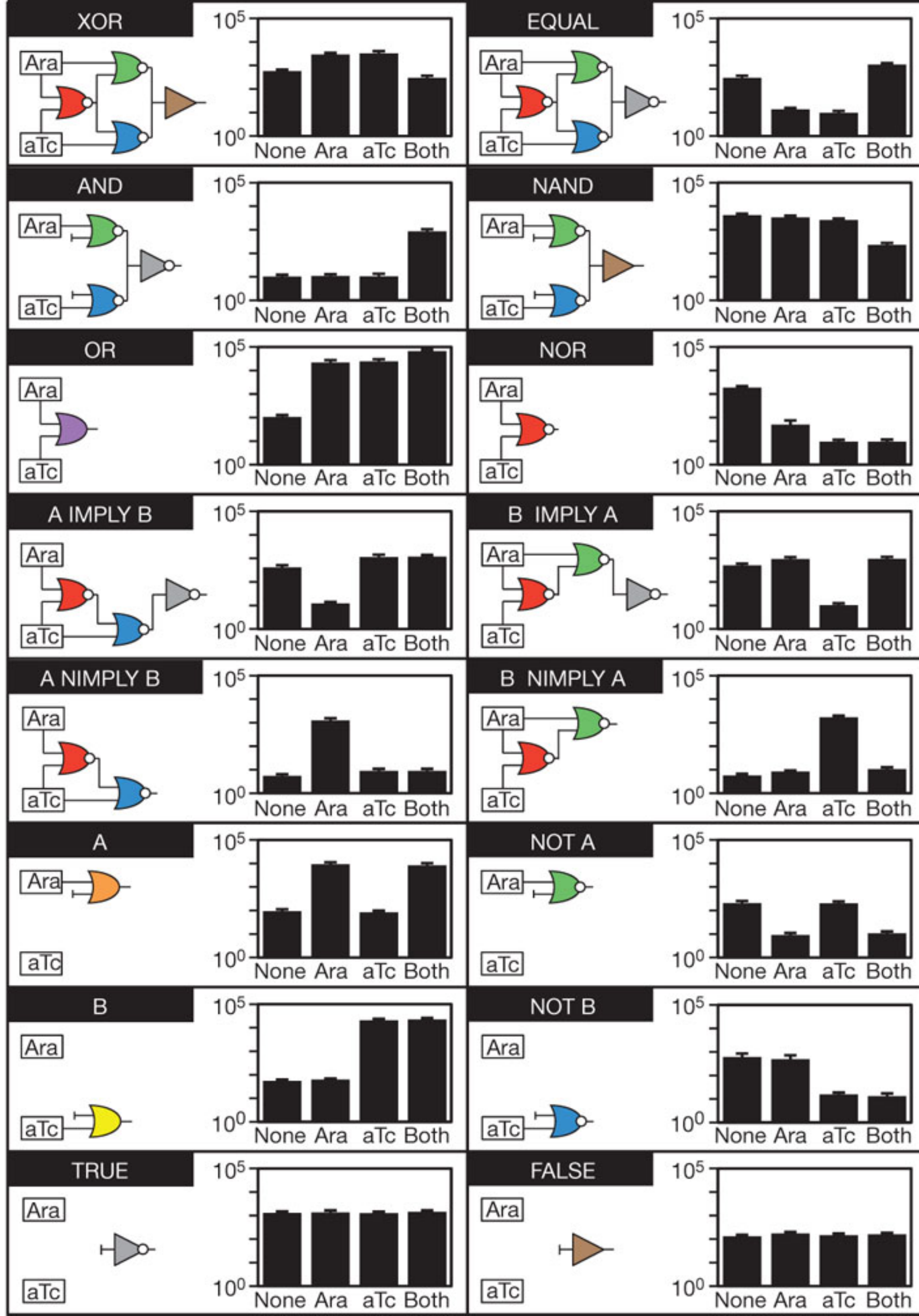
CONTACT CLOSED
BY HOLD CLEAR
MECHANISM
WHEN HOLD CLEAR
IS ENERGIZED.

AUTOMATIC TRAIN STOP
INDUCTIVE TYPE

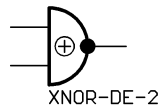
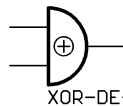
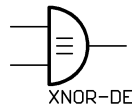
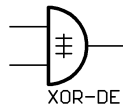
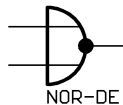
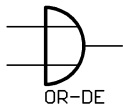
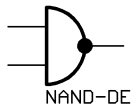
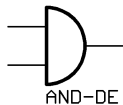
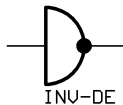
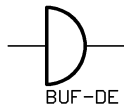
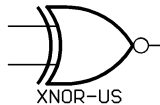
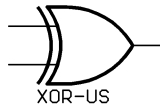
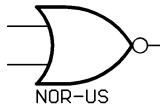
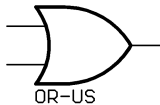
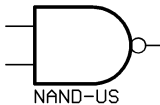
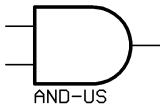
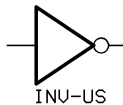
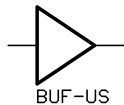
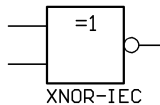
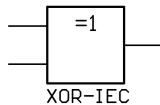
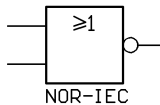
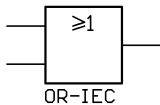
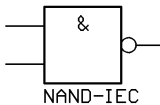
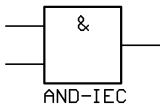
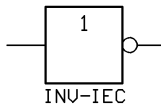
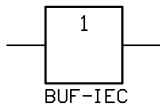


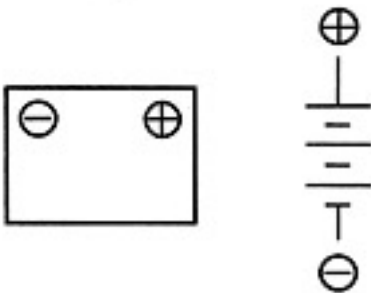
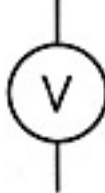
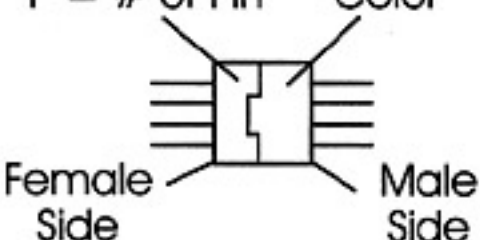
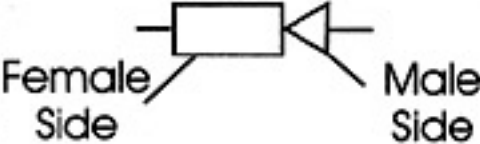
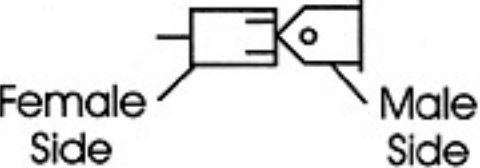
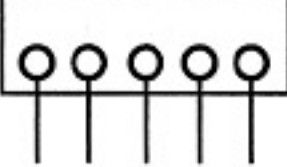
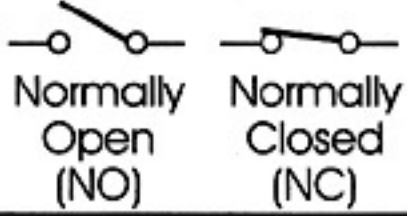
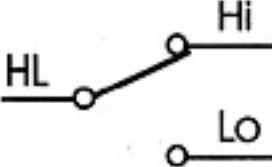
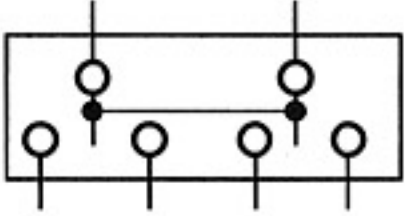
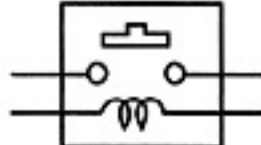
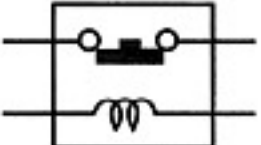
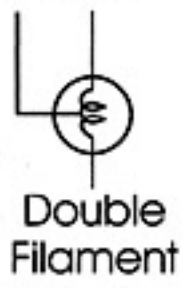
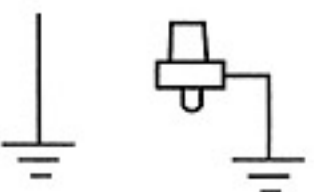
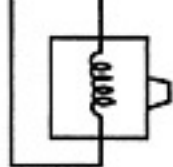
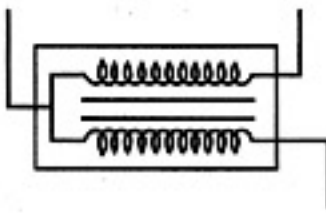
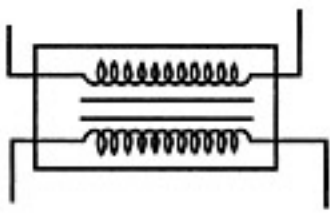
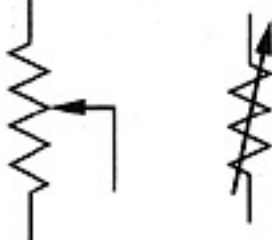
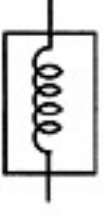
GRAPHICAL SYMBOLS CIRCUIT CONTROLLER CONTACTS MISCELLANEOUS

AAR
SIG. SEC.
16758

a Logic gate library**b**

VALVE SYMBOLS	PIPING SYMBOLS	INSTRUMENTATION SYMBOLS	MISCELLANEOUS SYMBOLS	LINE SYMBOLS	ABBREVIATION
BALL VALVE F = FULL PORT BALL R = REDUCED PORT BALL BUTTERFLY VALVE CHECK VALVE D = WITH DASHPOT GATE VALVE OR MISCELLANEOUS VALVE GLOBE VALVE NEEDLE VALVE PLUG VALVE ANGLE VALVE (UNDEFINED) THREE WAY VALVE FOUR WAY VALVE ANGLE CHOKE VALVE CHOKE VALVE PRESSURE OR SAFETY RELIEF VALVE—PILOT OPERATED TYPE RUPTURE DISC OR PIN PRESSURE OR SAFETY RELIEF VALVE—CONVENTIONAL OR BALANCED BELLOWS TYPE DIAPHRAGM OPERATED CONTROL VALVE (GLOBE BODY) SELF-CONTAINED REGULATING VALVE DIAPHRAGM OPERATED CONTROL VALVE WITH HANDWHEEL DIAPHRAGM OPERATED CONTROL VALVE (BUTTERFLY TYPE) DIAPHRAGM OPERATED CONTROL VALVE (VEE BALL TYPE) DIAPHRAGM OPERATED CONTROL VALVE (CAMFLEX TYPE) FLOAT OPERATED VALVE (LOV) HAND CONTROL VALVE / IN-LINE CHOKE VALVE DOUBLE DIAPHRAGM CONTROL VALVE MOTOR OPERATED VALVE (MOV) 2 WAY SOLENOID VALVE THREE WAY SOLENOID VALVE WITH MANUAL RESET FAIL OPEN A TO C HYDRAULIC OR PNEUMATIC PISTON OPERATED CONTROL VALVE OR SHUTDOWN VALVE (BALL TYPE VALVE) WELLHEAD WING VALVE (SSV)	LINE NUMBER CHANGE LINE SIZE CHANGE SPECIFICATION BREAK HOSE CONNECTION SPECTACLE BLIND (OPEN OR CLOSED) PADDLE BLIND (SPACER) (OPEN OR CLOSED) HAMER BLIND (OPEN OR CLOSED) SPECIALTY ITEM FLAT STRAINER Y-TYPE STRAINER T-TYPE STRAINER BASKET STRAINER DUPLEX STRAINER CONE STRAINER (APEX DOWNSTREAM) TUNDISH TO OPEN DRAIN SYSTEM CLOSED DRAIN OPEN DRAIN SYSTEM (WITH LIQUID SEAL) TRAP—STEAM, AIR OR LIQUID SWIVEL JOINT CHAMFERED TERMINATING LINE BETE FOG NOZZLE TYPE N2W, N2, N1, N1W, N3, N3 DELETED CLAMP CONNECTOR TECHLOK TYPE CONNECTOR EXTRUDED HEADER PULSATION DAMPENER / STABILIZER	FLOW ELEMENT (VENTURI OR NOZZLE) FLOW ELEMENT (TURBINE) FLOW ELEMENT (ORIFICE PLATE) FLOW ELEMENT (ANNUBAR) FLOW ELEMENT (QUICK CHANGE ORIFICE PLATE) FLOW ELEMENT UNCLASSIFIED FLOW STRAIGHTENING VANES POSITIVE DISPLACEMENT METER (LOCAL TOTALIZING) ROTAMETER ROTAMETER WITH INTEGRAL THROTTLE VALVE SIGHT GLASS LOCALLY MOUNTED INSTRUMENT CENTRAL CONTROL PANEL MOUNTED INSTRUMENT, HARDWIRED INDIVIDUAL INSTRUMENT LOCAL PANEL MOUNTED INSTRUMENT (LOCAL PANEL 4) REAR OR PANEL MOUNTED INSTRUMENT (SINGLE LINE - CENTRAL C.P., DOUBLE LINE - LOCAL C.P.) INSTRUMENT FUNCTION WITH SHARED DISPLAY/CONTROL (VIDEO OR KEYBOARD) ACCESSIBLE TO OPERATOR AT MASTER CONTROL (D.C.S) SYSTEM SHARED INSTRUMENT FUNCTION NOT ACCESSIBLE TO OPERATOR AT MASTER CONTROL (D.C.S) SYSTEM INSTRUMENT WITH TWO FUNCTIONS IN THE SAME CASE HEAT TRACED INSTRUMENT PILOT LIGHT (LOCAL) CURRENT TO PNEUMATIC TRANSDUCER RESET (LOCAL OR REMOTE) INSTRUMENT TUBING CHECK VALVE HAND VALVE - MANUALLY OPERATED VALVE UNIT SWITCH	(E) (O) (S) E = ELECTRIC O = OIL S = STEAM VESSEL INSULATION TYPE & THICKNESS INSULATED LINE FLEXIBLE CONNECTOR EXPANSION BELLOWS FURNISHED WITH EQUIPMENT VANE TYPE MIST EXTRACTOR (INTERNAL TO VESSEL) MESH TYPE MIST EXTRACTOR (INTERNAL TO VESSEL) VORTEX BREAKER (INTERNAL TO VESSEL) HALF OPEN PIPE INLET DISTRIBUTOR (INTERNAL TO VESSEL) LEVEL ELEVATION ABOVE TAN. LINE OR INSIDE BOTTOM OF HORIZONTAL VESSEL OR TANK MINIMUM ELEVATION ABOVE CENTERLINE OF PUMP OR SPECIFIED EQUIPMENT FIRE MONITOR HOSE REEL FILTER FLAME ARRESTOR FLUIDIC VENT TIP SILENCER WELLHEAD CHRISTMAS TREE (SINGLE OR DUAL COMPLETION) CHEMICAL INJECTION SHOWER RAIN CAP LINE END CLOSURE STATIC MIXER INSTALLED OFFSHORE BY UNOCAL INSTALLED OFFSHORE BY CONTRACTOR	MAJOR PROCESS LINE MINOR PROCESS LINE OR UTILITY LINE FUTURE PROCESS LINE FUTURE EQUIPMENT SKID OR PACKAGE LIMIT ELECTRICAL/ELECTRONIC SIGNAL PNEUMATIC SIGNAL (GAS OR AIR) HYDRAULIC SIGNAL INSTRUMENT CAPILLARY TUBING COMMUNICATION LINK COMPUTER OR MICROPROCESSOR SYSTEM NEXT DRAWING (NOT TERMINATING AT BORDER) LINE FROM DRAWING TO NEXT DRAWING (REF. NO. OPTIONAL) CONTINUATION OF INSTRUMENT OR ELECTRICAL SIGNALS LINE WITH CONTRAFLOW (NOT TERMINATING AT BORDER)	AC AIR TO CLOSE AO AIR TO OPEN AS AIR SUPPLY A/M AUTO/MANUAL CAM COMPUTER AUTO/MANUAL CC CORROSION COUPON CF CUSTOMER FURNISHED CI CHEMICAL INJECTION CO CLEAN OUT CRL COMPUTER REMOTE LOCAL CSC CAR SEALED CLOSED CSO CAR SEALED OPEN ELEV ELEVATION ERP ELECTRIC RESISTANCE PROBE (CORROSION MONITORING PROBE) ESD EMERGENCY SHUTDOWN FC FAIL CLOSE F & G FIRE AND GAS MONITORING PANEL FO FAIL OPEN GS GAS SUPPLY HH HAND HOLE HDA HAND / OFF / AUTO HS HYDRAULIC SUPPLY IAS INSTRUMENT AIR SUPPLY LAT LOWEST ASTRONOMICAL TIDE LC LOCK CLOSED LG LENGTH LO LOCK OPEN LS LIQUID SEAL MW MANWAY MWL MEAN WATER LEVEL MWP MAXIMUM WORKING PRESSURE MWT MAXIMUM WORKING TEMPERATURE NC NORMALLY CLOSED NO NORMALLY OPEN NMF NORMALLY NO FLOW PP PERSONNEL PROTECTION R-S RUN / STOP RTD RESISTANCE TEMPERATURE DETECTOR SC SAMPLE CONNECTION SDA SDV, DELUGE AND ANNUNCIATOR SDV SHUTDOWN VALVE SO STEAM OUT SSV SURFACE SAFETY VALVE SSSV SUB-SURFACE SAFETY VALVE S/S SEAM TO SEAM TC TURBINE CONTROL TSO TIGHT SHUT OFF T/L TANGENT LENGTH T/T TANGENT TO TANGENT VB VACUUM BREAKER VF VENDOR FURNISHED WC WATER COLUMN WCP WELL CONTROL PANEL
FIRE & GAS MONITORING SYMBOLS					
HEAT SENSOR/FUSIBLE PLUG GAS DETECTOR OXYGEN DETECTOR SMOKE DETECTOR FIRE DETECTOR					
ANNUNCIATOR, ESD AND FLOW COMPUTATION SYMBOLS					
ELECTRIC TO ESD PANEL IN CONTROL ROOM ELECTRIC SIGNAL FROM ESD PANEL IN CONTROL ROOM ELECTRONIC SIGNAL TO FLOW COMPUTER IN CONTROL ROOM PNEUMATIC SIGNAL TO SDV, DELUGE AND ANNUNCIATOR PANEL IN CONTROL ROOM ELECTRIC/ELECTRONIC SIGNAL TO SDV, DELUGE AND ANNUNCIATOR PANEL IN CONTROL ROOM					



BATTERY	CONNECTION		MULTI-TESTER			MOTOR		
	Connected	No Connection	Voltmeter	Ohmmeter	Ammeter			
								
PUMP	CONNECTOR P = # of Pin Color		CONNECTOR (Round Type)	CONNECTOR (Flat Type)		EYELET TERMINAL		
								
IGNITION SWITCH (Circuit Symbol)	IGNITION SWITCH (Wiring Symbol)		SWITCH (Two Terminal)		SWITCH (Three Terminal Type)	SWITCH (Combination Type)		
								
FUSE	RELAY (Normally Open Type)		RELAY (Normally Closed Type)		LIGHT BULB Double Filament	GROUND		
								
THREE-PHASE ALTERNATOR	SINGLE-PHASE ALTERNATOR		PULSE GENERATOR		IGNITION COIL (Single Type)	IGNITION COIL (Dual Type)		
								
SPARK PLUG	RESISTOR		VARIABLE RESISTOR		COIL	SOLENOID	LED	CAPACITOR
								

SYMBOL	NAME	PART
	ANTENNA	
	GROUND	
	FIXED CONDENSER	
	VARIABLE CONDENSER	
	GANG CONDENSER	
	ELECTRO- LYTRIC CONDENSER	
	FIXED RESISTANCE	
	VARIABLE RESISTANCE	
	VOLTAGE DIVIDER RESISTANCE	
	3-ELEMENT VACUUM TUBE	
	R.F. PENTODE VACUUM TUBE	
	HEATER TYPE TUBE	
	COIL	
	RADIO FREQUENCY CHOKE	
	FILTER CHOKE	
	AUDIO TRANSFORMER	
	PUSH-PULL AUDIO TRANSFORMER	
	POWER TRANSFORMER	

FIG.
17

SYMBOL	NAME	PART
	VOLTMETER	
	AMMETER	
	MILLIAMMETER	
	IRON CORE COILS	
	I. F. TRANSFORMER	
	TRANSMITTING CRYSTAL	
	WIRES CROSS	
	WIRES JOIN	
	EARPHONES	
	MAGNETIC LOUDSPEAKER	
	DYNAMIC LOUDSPEAKER	
	SWITCH	
	KEY	
	MICROPHONE	
	PHONOGRAPH PICK-UP	
	BATTERY	
	CONDENSER AND GRID LEAK	
	BINDING POSTS	

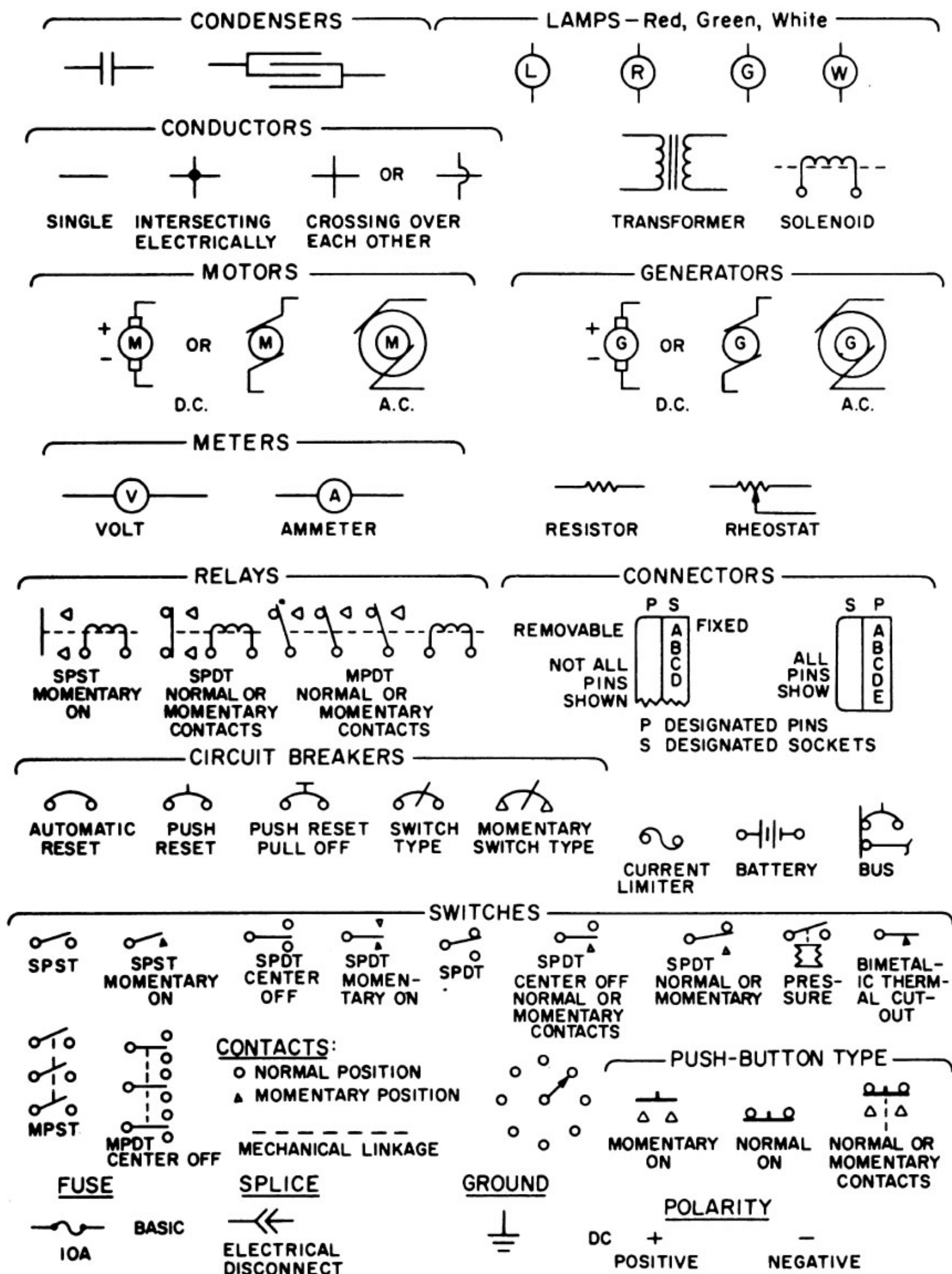
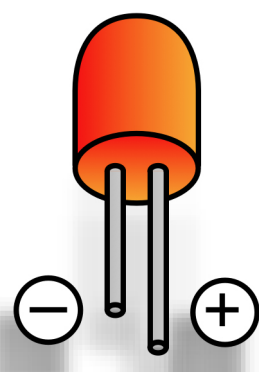


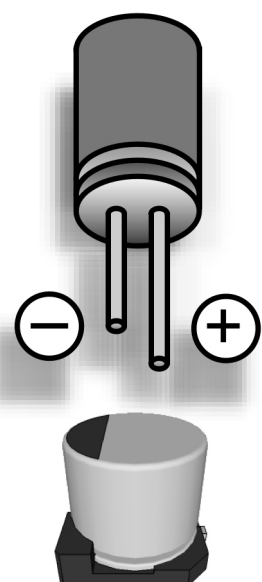
Figure 2-28. Electrical symbols.

Cathode -
Anode +

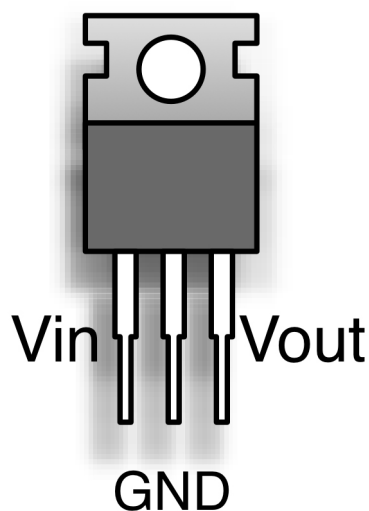
LED



CAPACITOR



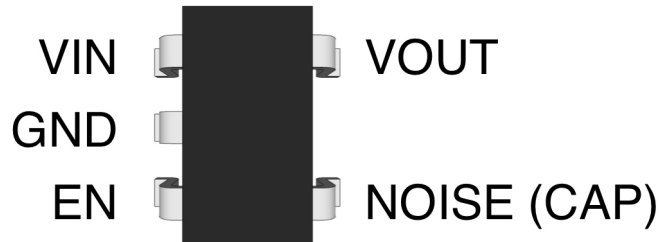
REGULATOR
(e.g. LM78xx)



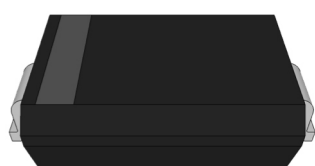
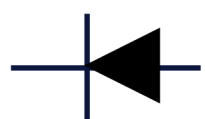
Resistor

	Digit	Multiplier	Tolerance
Silver	-	0.01	±10%
Gold	-	0.1	±5%
Black	0	1	-
Brown	1	10	±1%
Red	2	100	±2%
Orange	3	1k	-
Yellow	4	10k	-
Green	5	100k	±0.5%
Blue	6	1M	±0.25%
Violet	7	10M	±0.1%
Gray	8	-	-
White	9	-	-

Marked by
color or
dot

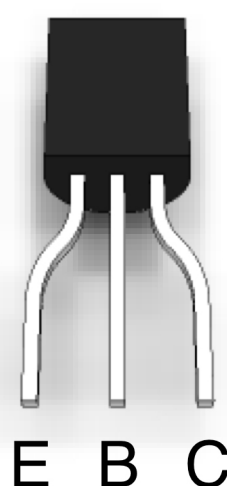


DIODE

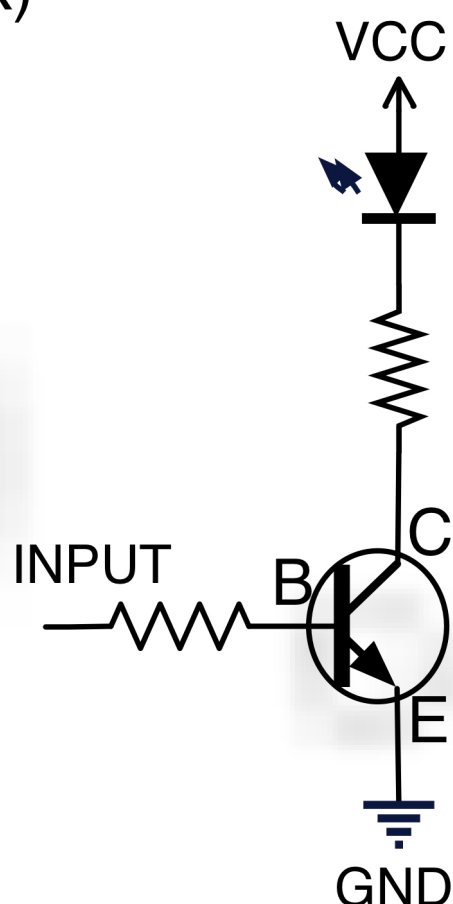
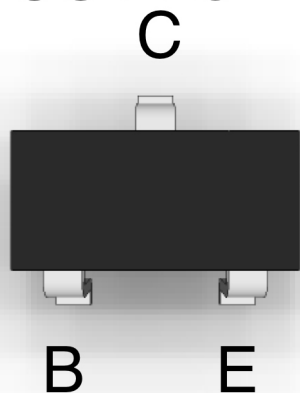


NPN transistor (Current sink)
(e.g. PN2222)

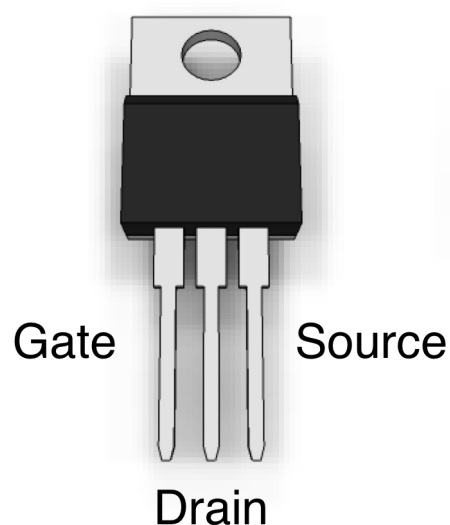
TO-92



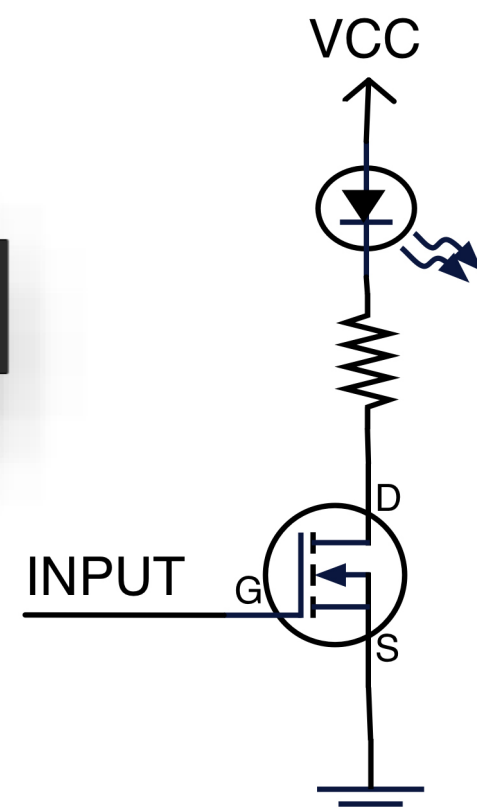
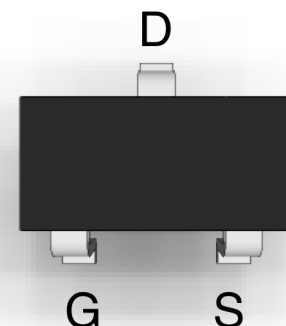
SOT-23



N-channel MOSFET

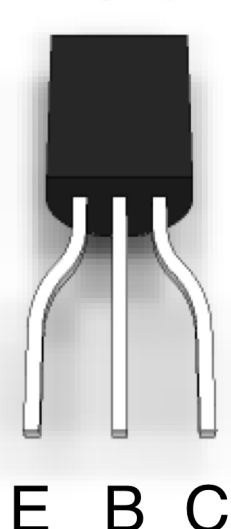


SOT-23

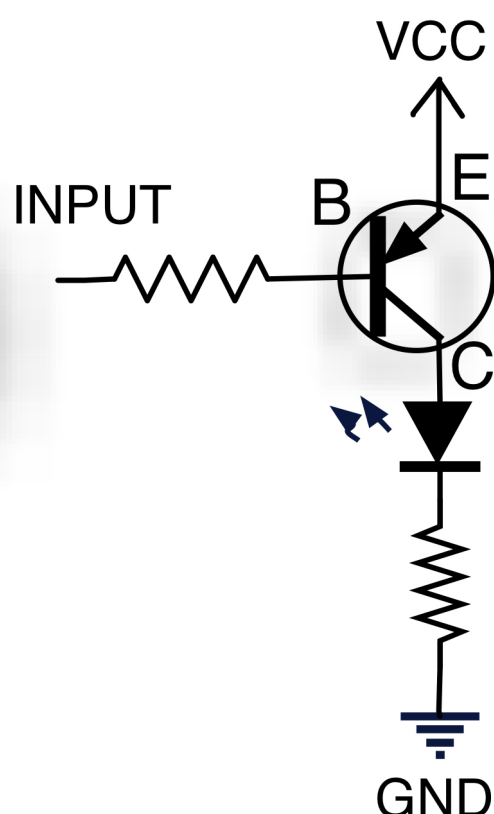
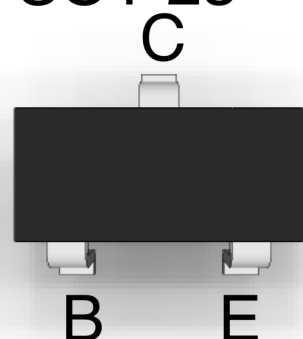


PNP transistor (Current source)
(e.g. PN2907)

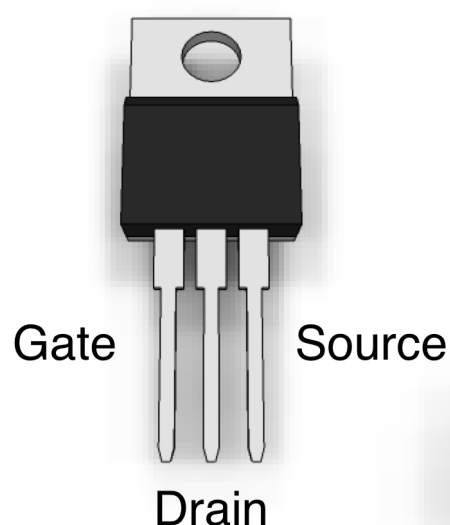
TO-92



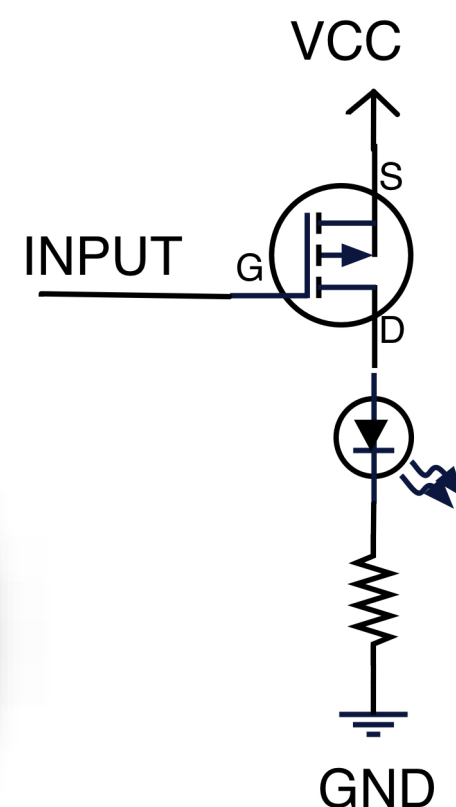
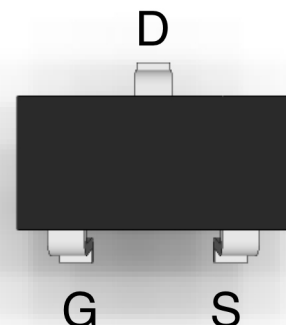
SOT-23



P-channel MOSFET



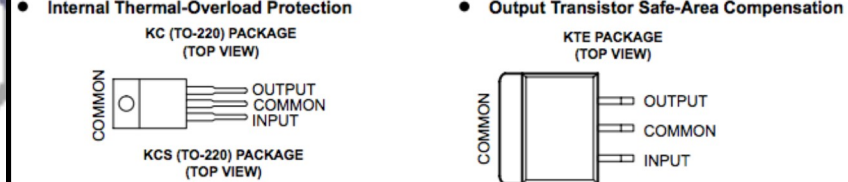
SOT-23



* Please note that some components may have a different pinout than the one showed above, you should always check the data sheet before using a new component.

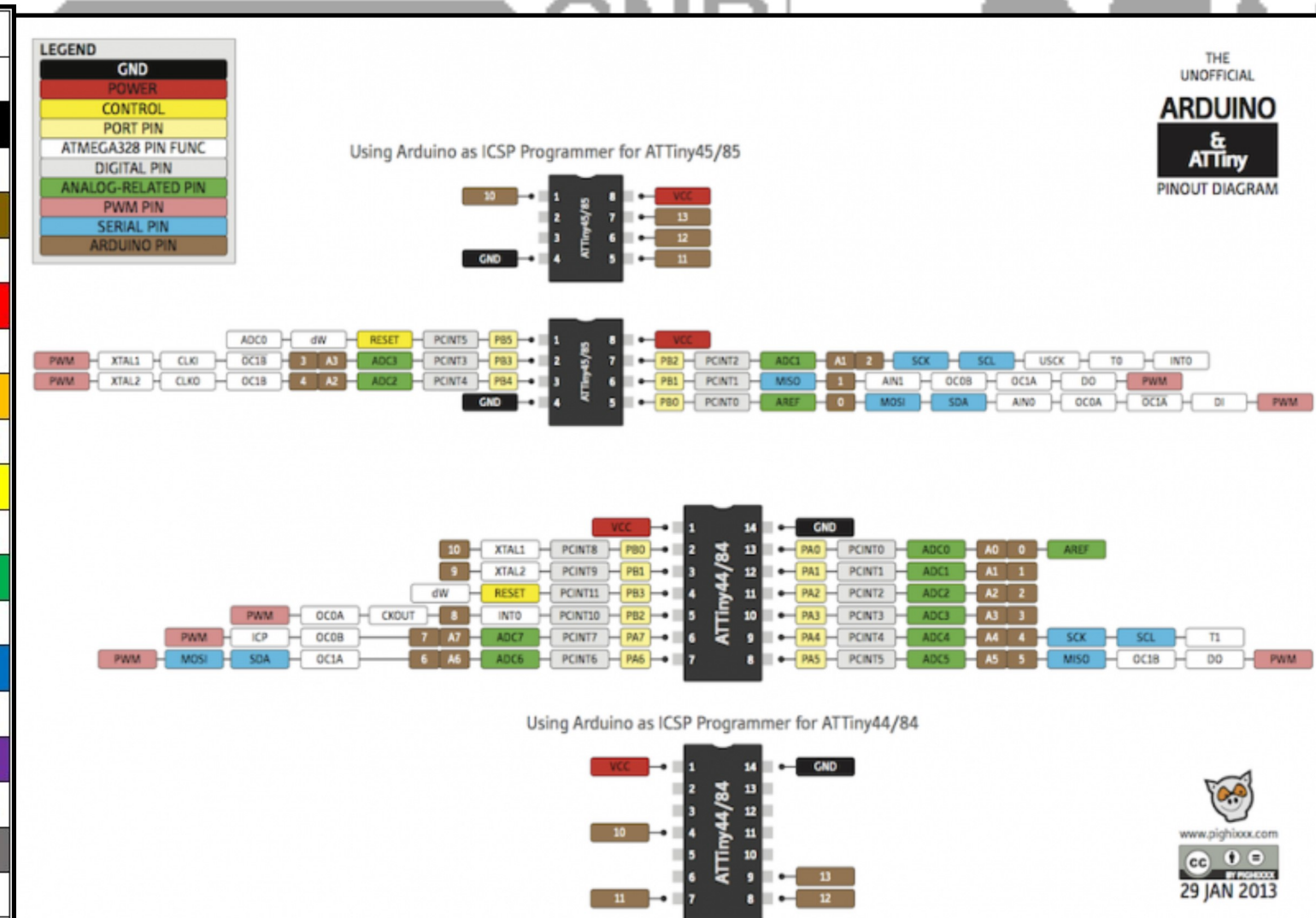
Color	Band 1	Band 2	Band 3	Multiplier	Tolerance
Black	0	0	0	10e0	
Brown	1	1	1	10e1	1.00%
Red	2	2	2	10e2	2.00%
Orange	3	3	3	10e3	3.00%
Yellow	4	4	4	10e4	4.00%
Green	5	5	5	10e5	0.50%
Blue	6	6	6	10e6	0.25%
Violet	7	7	7	10e7	0.10%
Grey	8	8	8	10e8	0.05%
White	9	9	9	10e9	
Gold				10e-1	5.00%
Silver				10e-2	10.00%
No band					20.00%

- 3-Terminal Regulators
- Output Current up to 1.5 A
- Internal Thermal-Overload Protection
- High Power-Dissipation Capability
- Internal Short-Circuit Current Limiting
- Output Transistor Safe-Area Compensation



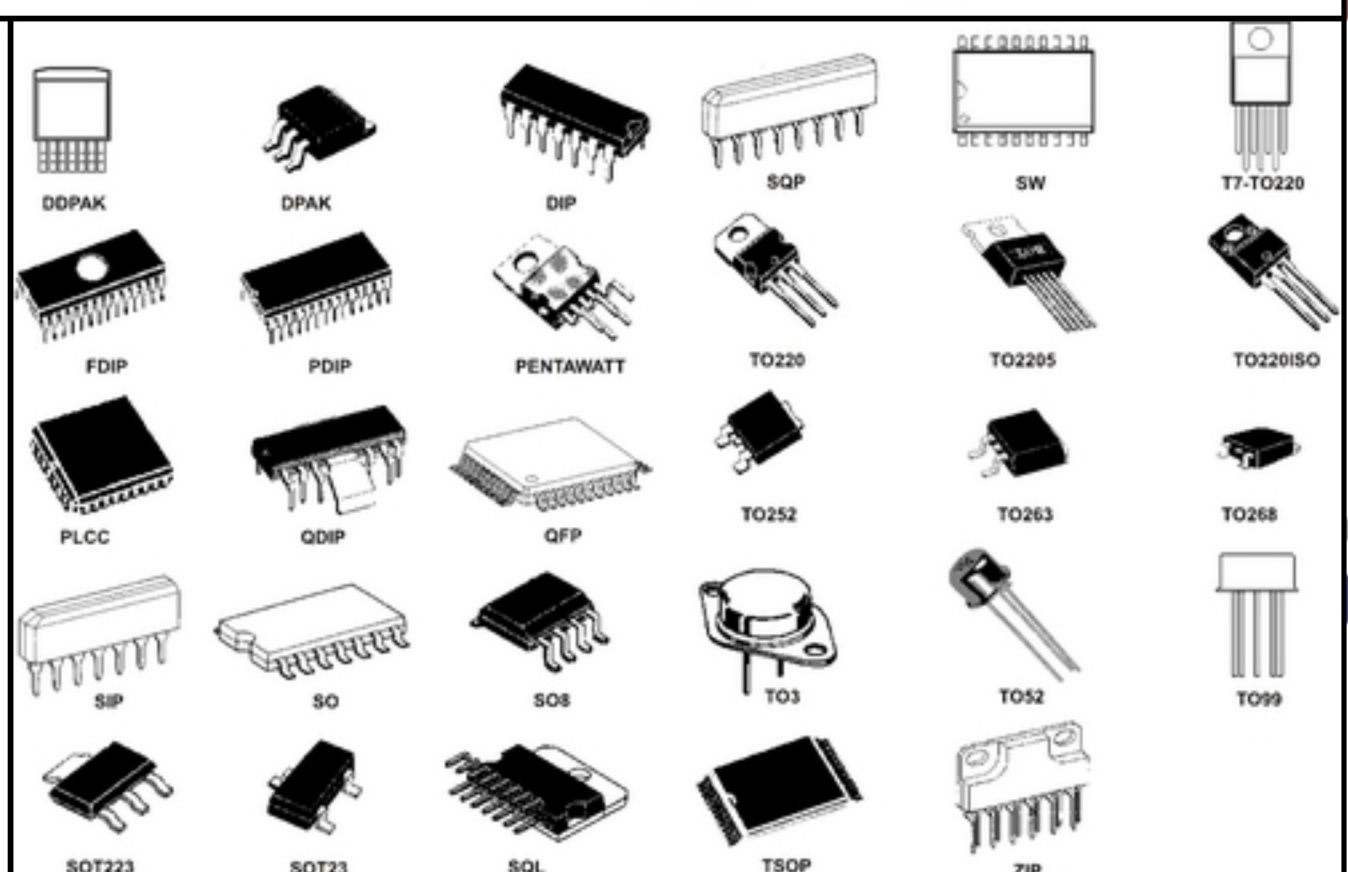
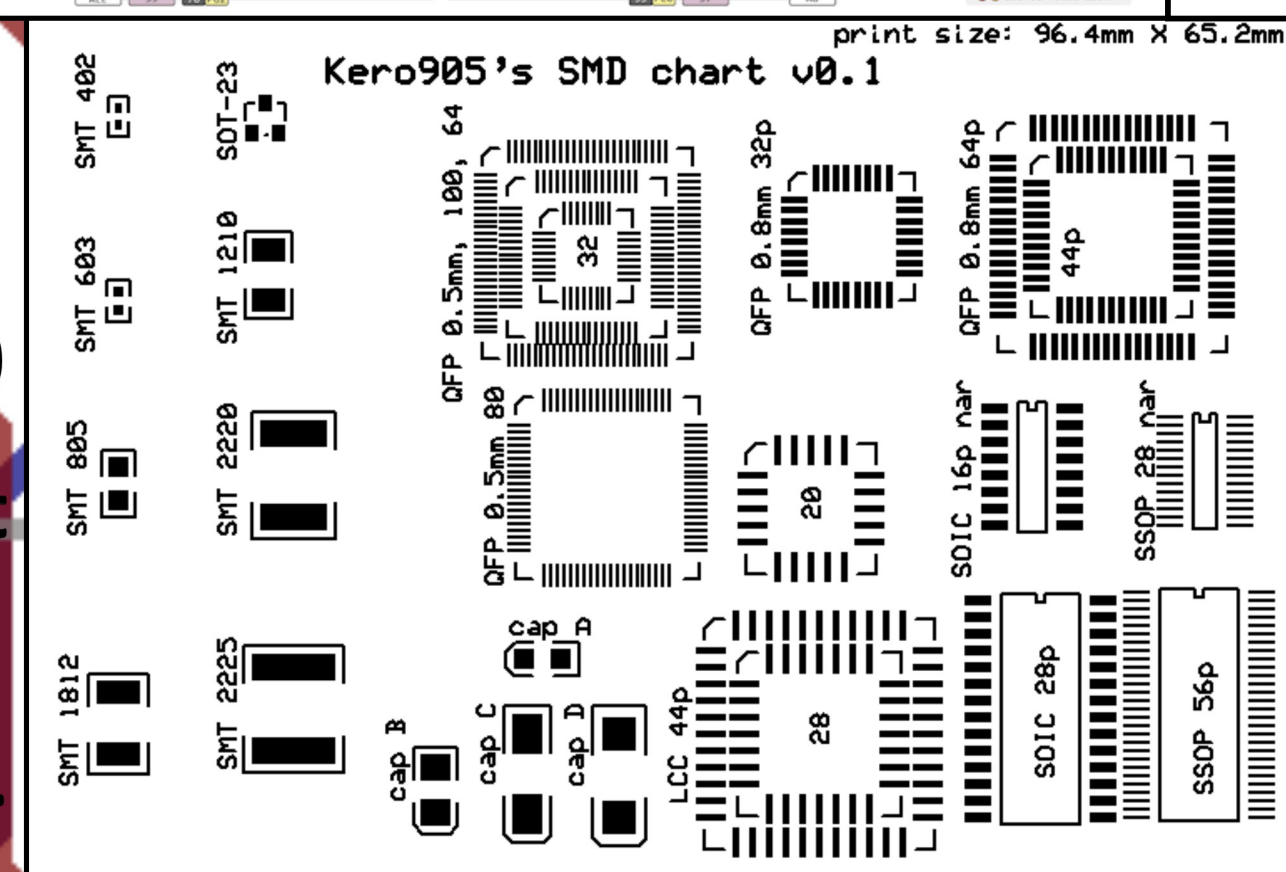
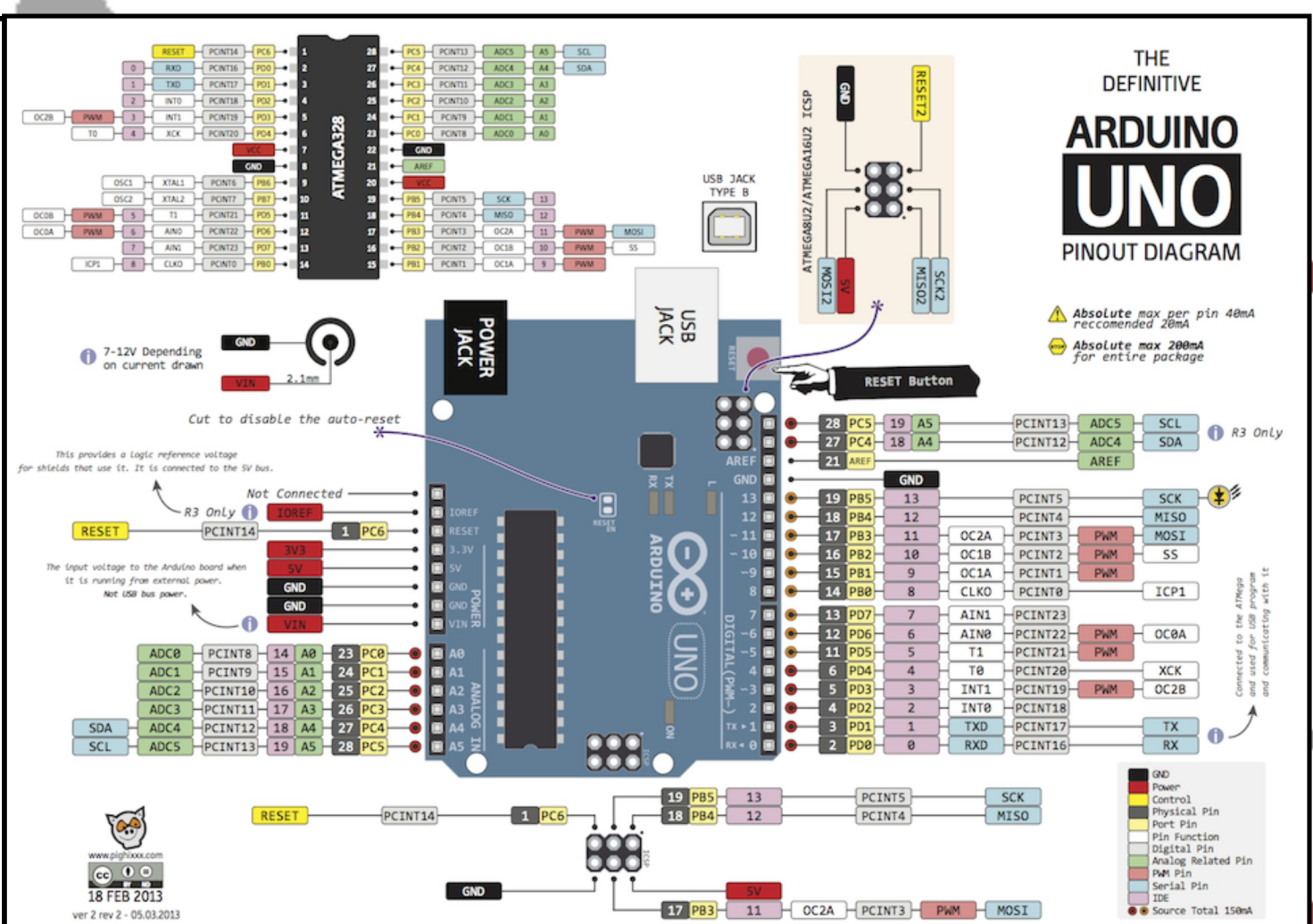
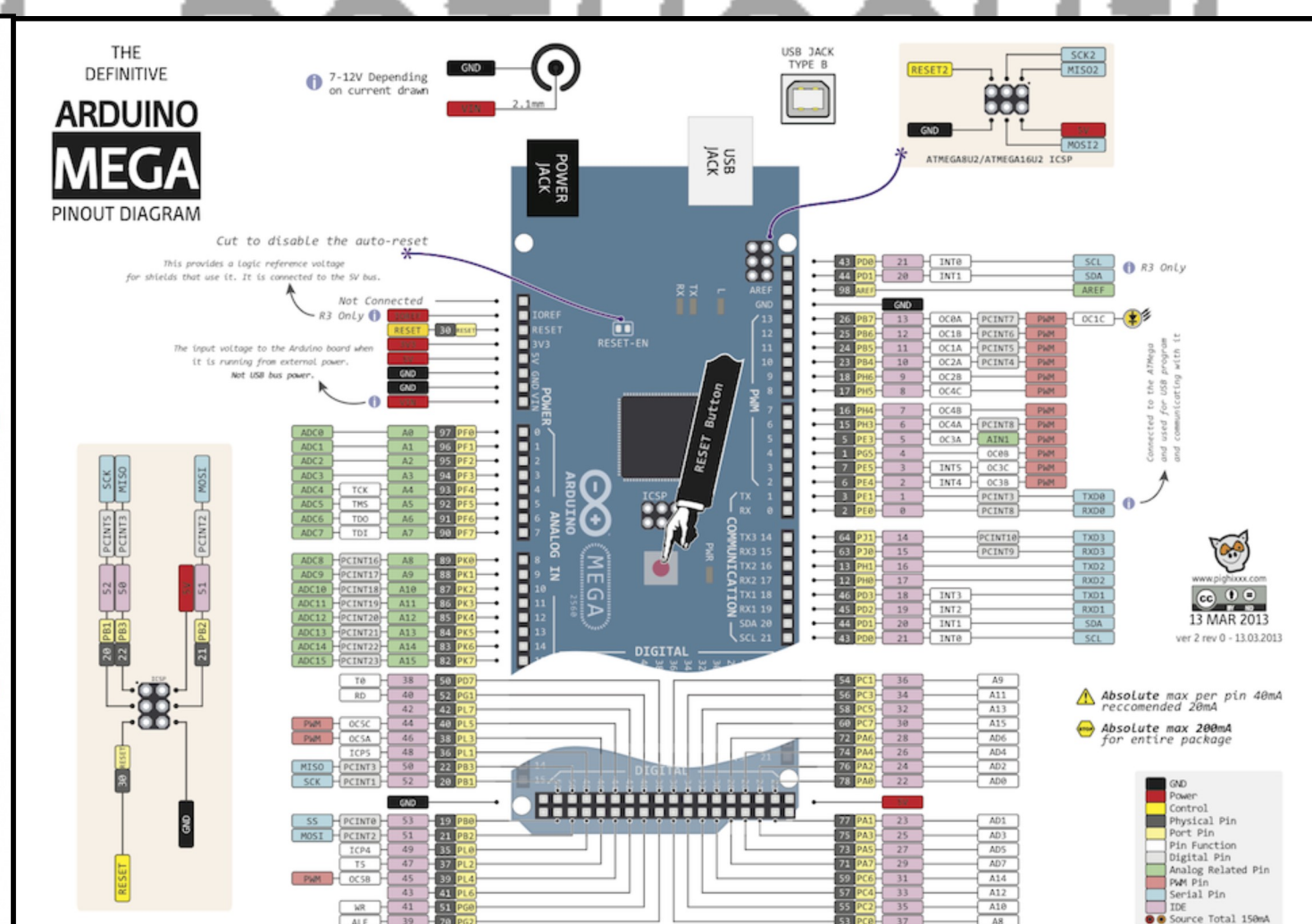
PARAMETER	TEST CONDITIONS	T _J	MIN	TYP	MAX	UNIT
Output voltage	I _Q = 5 mA to 1 A P _D ≤ 15 W V _I = 7 V to 20 V	25°C	4.8	5	5.2	V
Input voltage regulation	V _I = 7 V to 25 V V _O = 5 V to 15 V f = 120 Hz	25°C		3	100	mV
Ripple rejection	I _Q = 5 mA to 1.5 A f = 1 kHz	25°C	62	76		dB
Output voltage regulation	I _Q = 5 mA to 1.5 A f = 1 kHz	25°C		15	100	mV
Output resistance	I _Q = 5 mA f = 1 kHz	25°C		0.017		Ω
Temperature coefficient of output voltage	I _Q = 5 mA f = 10 Hz to 100 kHz	25°C		-1.1		mV/°C
Output noise voltage	I _Q = 1 A f = 10 Hz to 100 kHz	25°C		2		μV
Dropout voltage	V _I = 7 V to 25 V I _Q = 5 mA to 1 A	25°C		4.2		V
Standby current	V _I = 7 V to 25 V I _Q = 5 mA to 1 A	25°C		1.3		mA
Short-circuit output current	I _Q = 5 mA to 1 A	25°C		750		mA
Peak output current		25°C		2.2		A

Structure	Variables	Functions
setup()	Constants	Digital I/O
loop()	LOW	digitalWrite()
Control Structures	INPUT OUTPUT INPUT_PULLUP	true false
if...else	integer constants	digitalRead()
for	floating point constants	Analog I/O
while	Data Types	analogReference()
do...while	void	analogRead()
break	boolean	analogWrite() - PWM
continue	char	Due only
return	unsigned char	analogReadResolution()
goto	byte	analogWriteResolution()
Further Syntax	int	Advanced I/O
() (semicolon)	unsigned int	tone()
() (curly braces)	word	noTone()
// (single line comment)	long	shiftOut()
/* */ (multi-line comment)	float	shiftIn()
#define	unsigned long	pulseIn()
#include	float	Time
Arithmetic Operators	double	micros()
= (assignment operator)	string - char array	delay()
+ (addition)	String - object array	delayMicroseconds()
- (subtraction)	Conversion	Math
* (multiplication)	char()	min()
/ (division)	max()	
% (modulo)	abs()	
Comparison Operators	int()	
== (equal to)	word()	map()
!= (not equal to)	long()	pow()
< (less than)	float()	sqrt()
<= (less than or equal to)	Variable Scope & Qualifiers	Trigonometry
> (greater than)	variable scope	sin()
>= (greater than or equal to)	static	cos()
Boolean Operators	volatile	tan()
&& (and)	const	Random Numbers
(or)	Utilities	randomSeed()
! (not)	sizeof()	random()
Pointer Access Operators		Bits and Bytes
* (dereference operator)		lowByte()
& (reference operator)		highByte()
Bitwise Operators		bitRead()
& (bitwise and)		bitWrite()
(bitwise or)		bitSet()
^ (bitwise xor)		bitClear()
~ (bitwise not)		bit()
<< (bitshift left)	External Interrupts	attachInterrupt()
>> (bitshift right)	detachInterrupt()	detachInterrupt()
Compound Operators	Interrupts	interrupts()
++ (increment)	noInterrupts()	noInterrupts()
+= (compound addition)	Communication	Serial
-= (compound subtraction)	Stream	Stream
*= (compound multiplication)	USB (Leonardo and Due only)	USB (Leonardo and Due only)
/= (compound division)	Keyboard	Keyboard
&= (compound bitwise and)	Mouse	Mouse
= (compound bitwise or)		

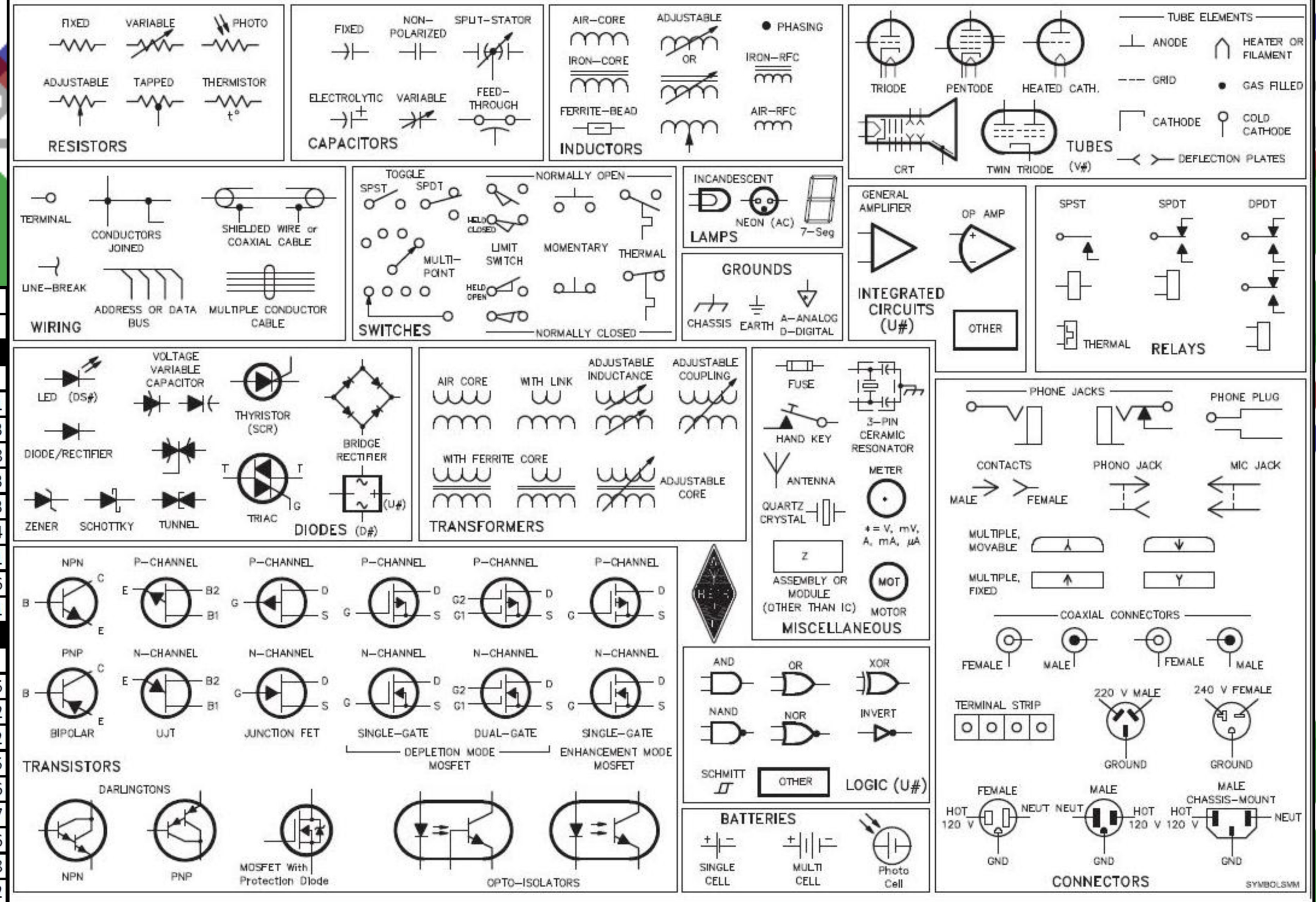


Part Name	Manufacturer	Package	Pin Count	Notes
LM7805	ON Semiconductor	TO-18	3	5V Regulator
LM7809	ON Semiconductor	TO-18	3	9V Regulator
LM7812	ON Semiconductor	TO-18	3	12V Regulator
LM7815	ON Semiconductor	TO-18	3	15V Regulator
LM7818	ON Semiconductor	TO-18	3	18V Regulator
LM7820	ON Semiconductor	TO-18	3	20V Regulator
LM7824	ON Semiconductor	TO-18	3	24V Regulator
LM7828	ON Semiconductor	TO-18	3	28V Regulator
LM7830	ON Semiconductor	TO-18	3	30V Regulator
LM7835	ON Semiconductor	TO-18	3	35V Regulator
LM7805C	ON Semiconductor	TO-18	3	5V Regulator
LM7809C	ON Semiconductor	TO-18	3	9V Regulator
LM7812C	ON Semiconductor	TO-18	3	12V Regulator
LM7815C	ON Semiconductor	TO-18	3	15V Regulator
LM7818C	ON Semiconductor	TO-18	3	18V Regulator
LM7820C	ON Semiconductor	TO-18	3	20V Regulator
LM7824C	ON Semiconductor	TO-18	3	24V Regulator
LM7828C	ON Semiconductor	TO-18	3	28V Regulator
LM7830C	ON Semiconductor	TO-18	3	30V Regulator
LM7835C	ON Semiconductor	TO-18	3	35V Regulator

Electronics Reference v1.0
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Schematic Symbols for Common Electronics and Electrical Components



PCB Trace Width		Temperature Rise = 10 deg C	
Thickness = 1 oz/ft^2		Trace Length = 1 inch	
Current	Trace Width(mil)	Resistance	Vdrop
0.01	0.0536	9.41	0.0941
0.1	1.28	0.393	0.0393
0.25	4.55	0.111	0.0278
0.5	11.8	0.0427	0.0213
0.75	20.7	0.0244	0.0183
1	30.8	0.0164	0.0164
2	80	0.00631	0.0126
5	283	0.00178	0.00891
External Layer			
Current	Trace Width(mil)	Resistance	Vdrop
0.01	0.0206	24.5	0.245
0.1	0.494	1.02	0.102
0.25	1.75	0.289	0.0722
0.5	4.55	0.111	0.0555
0.75	7.95	0.0635	0.0476
1	11.8	0.0427	0.0427
1.5	20.7	0.0244	0.0366
2	30.8	0.0164	0.0328
5	109	0.00464	0.0232

PLAN AND DETAIL LEGEND

	P.A. SPEAKER WITH DRIVER
	P.A. SPEAKER
	TELEPHONE
	HAZARDOUS TELEPHONE
	TELEPHONE JACK OUTLET
	MICROWAVE ANTENNA
	OMNI ANTENNA
	FLASHING LIGHT
MISC. ABBREVIATIONS	
	B.O.T. BOTTOM OF TRAY / LADDER
	AUDIBLE ALARM BELL
	BEACON LIGHT
	ISR - INTRUSION DETECTION RECEIVER
	ISE - INTRUSION DETECTION EMITTER

ELECTRONIC CIRCUIT SYMBOLS

WIRE	WIRE		TRANSISTORS	NPN BJT		DIODES	DIODE		SWITCHES	PUSH TO BREAK		INPUT DEVICES	MICROPHONE		LOGIC GATES	NOT	
	JOINED WIRE			PNP BJT			LED			PUSH TO MAKE			THERMISTOR			AND	
	WIRE NOT JOINED			PNP JFET			ZENER DIODE			SPST			LDR			OR	
	CELL			NPN JFET			PHOTO DIODE			SPDT			PHONE JACK			NAND	
	BATTERY			N CHANNEL MOSFET enh			SCR			DPST			TRANSFORMER			EX-OR	
	DC SUPPLY			P CHANNEL MOSFET enh			TUNNEL DIODE			DPDT			TRANSFORMER WITH CENTRE TAP			EX-NOR	
	AC SUPPLY			N CHANNEL MOSFET dep			SCHOTTKY DIODE			BELL			AMPLIFIER				
	EARTH/ GROUND			P CHANNEL MOSFET dep			CAPACITOR			BUZZER			ANTENNAE				
	FUSE			PHOTO-TRANSISTOR			CAPACITOR POLARISED			EARPHONE			RELAY				
				AMMETER			VARIABLE CAPACITOR			SPEAKER							
POWER SUPPLY			METERS	GALVANOMETER		CAPACITORS	TRIMMER CAPACITOR		OUTPUT DEVICES	LAMP		MISCELLANEOUS	INTEGRATED CIRCUIT				
				OHMMETER			RESISTOR			LAMP							
				OSCILLOSCOPE			RHEOSTAT			HEATER							
							POTENTIOMETER			INDUCTOR							
							PRESET			PIEZO TRANSDUCER							

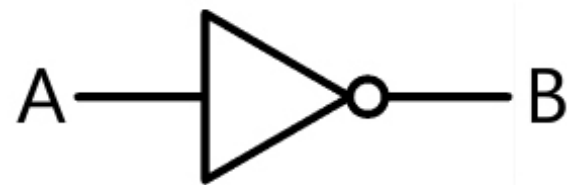
RESISTOR CODES

0	1	2	3	4	5	6	7	8	9	x0.01	x0.1	±10%	±5%	±2%	±1%
BLACK	BROWN	RED	ORANGE	YELLOW	GREEN	BLUE	VIOLET	GREY	WHITE	SILVER	GOLD	SILVER	GOLD	RED	BROWN

7 LOGIC GATES & 4 USEFUL COMBINATIONS

Standard Logic Gates

NOT



A	B
1	0
0	1

AND



A	B	C
1	1	1
1	0	0
0	1	0
0	0	0

NAND



A	B	C
1	1	0
1	0	1
0	1	1
0	0	1

OR



A	B	C
1	1	1
1	0	1
0	1	1
0	0	0

NOR



A	B	C
1	1	0
1	0	0
0	1	0
0	0	1

XOR



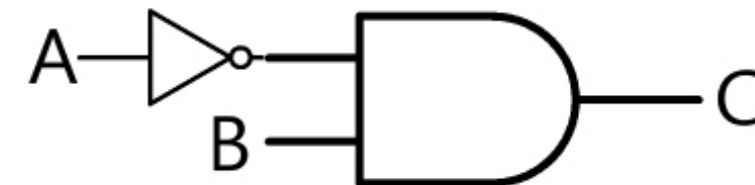
A	B	C
1	1	0
1	0	1
0	1	1
0	0	0

XNOR

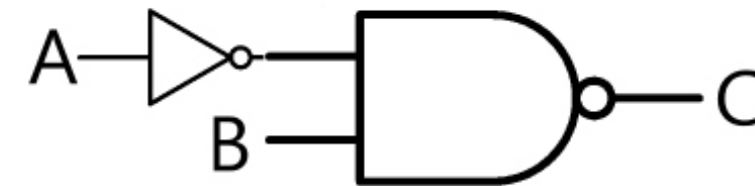


A	B	C
1	1	1
1	0	0
0	1	0
0	0	1

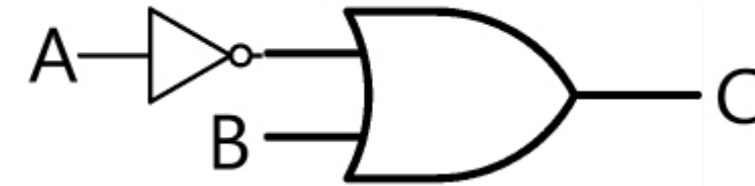
Preceding NOT Gate on One Input for AND, NAND, OR, NOR Gates



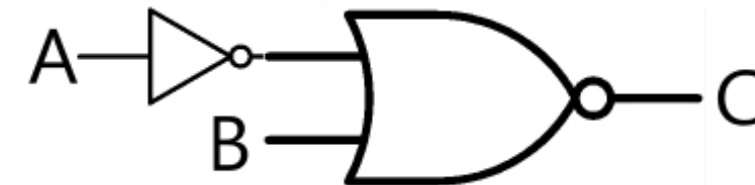
A	B	C
1	1	0
1	0	0
0	1	1
0	0	0



A	B	C
1	1	1
1	0	1
0	1	0
0	0	1



A	B	C
1	1	1
1	0	0
0	1	1
0	0	1



A	B	C
1	1	0
1	0	1
0	1	0
0	0	0



A	B	C
1	1	1
1	0	0
0	1	0
0	0	1

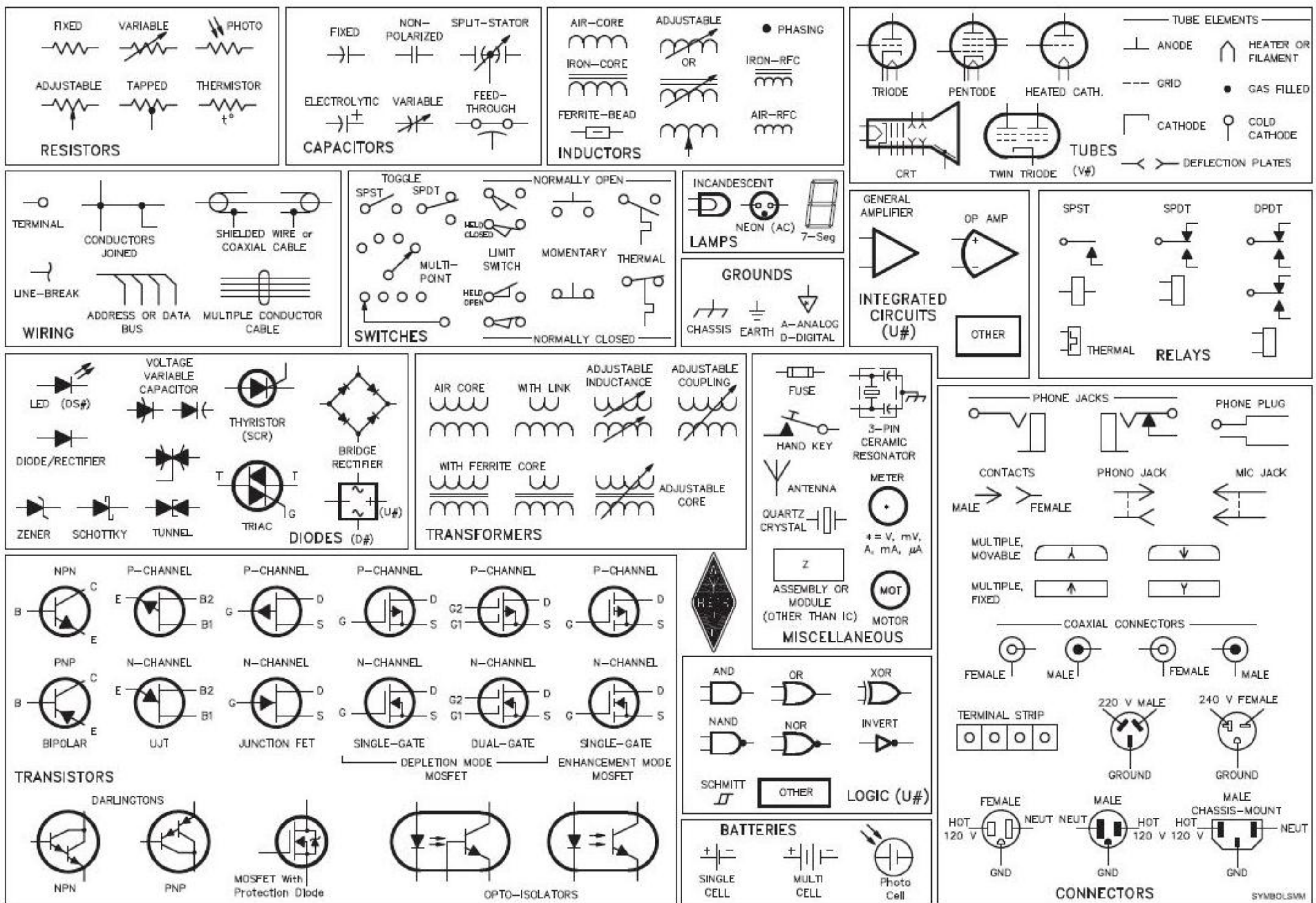


A	B	C
1	1	0
1	0	1
0	1	1
0	0	0

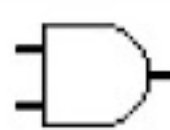
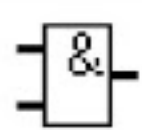
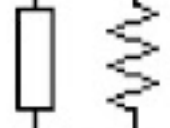
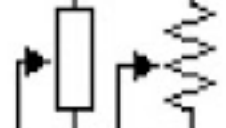
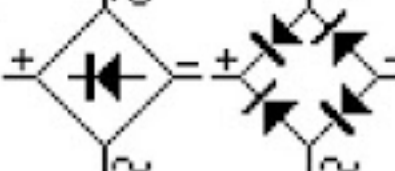
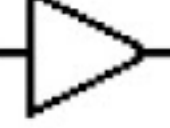
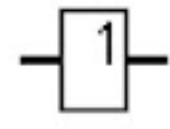
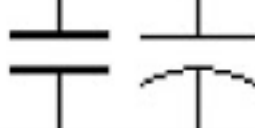
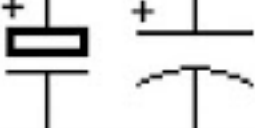
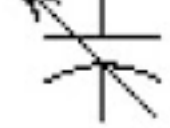
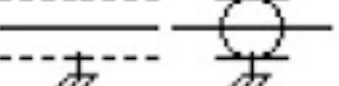
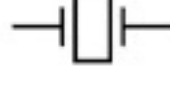
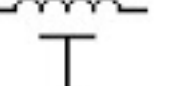
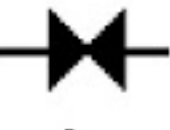
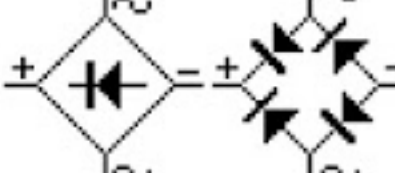
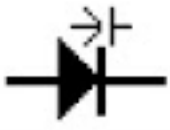
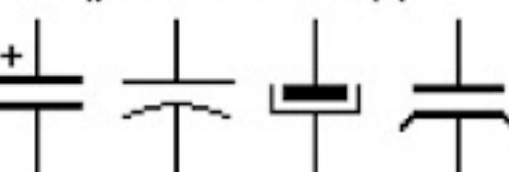
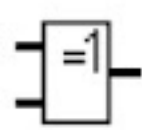
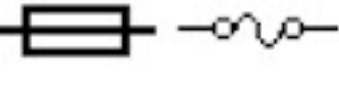
Use XNOR

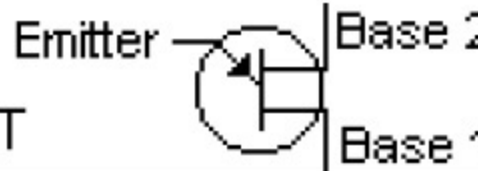
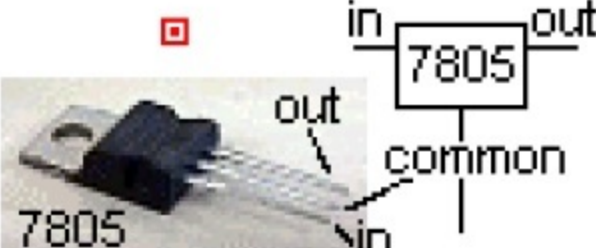
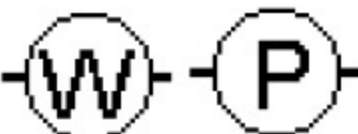
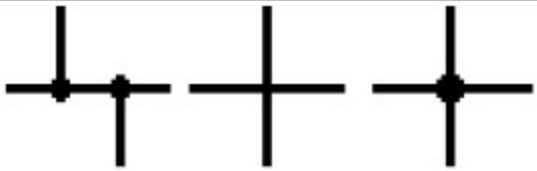
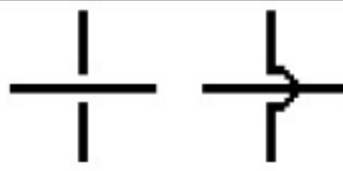
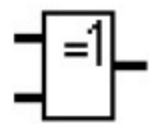
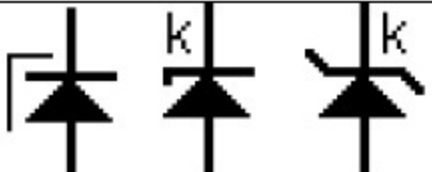
Use XOR

Schematic Symbols for Common Electronics and Electrical Components

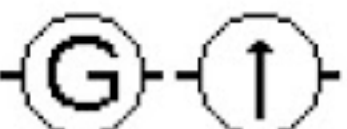
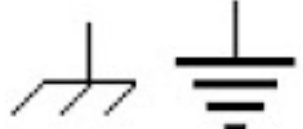
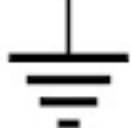
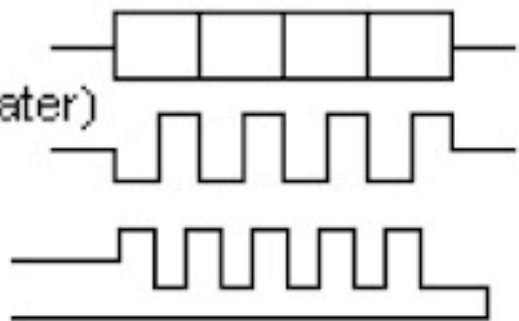
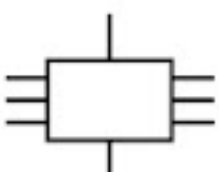
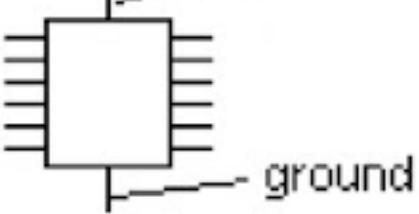
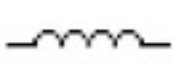
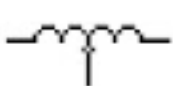
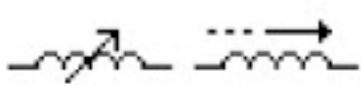
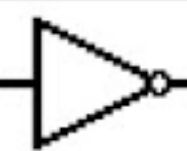
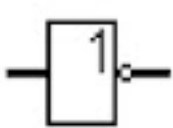
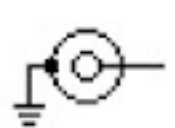
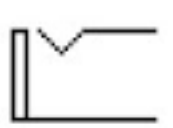
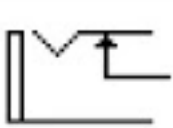
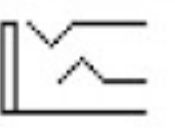
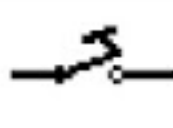
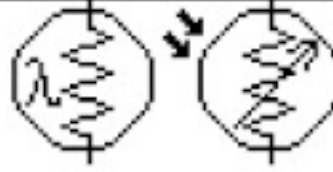
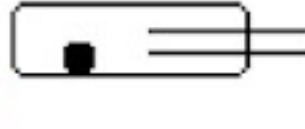
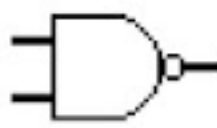
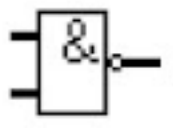
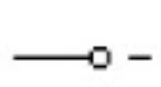
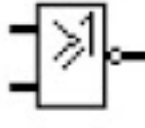
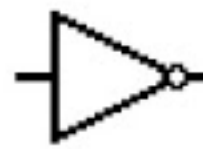
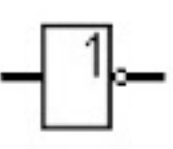
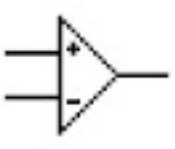
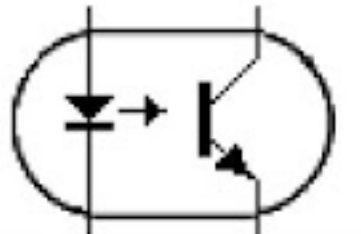
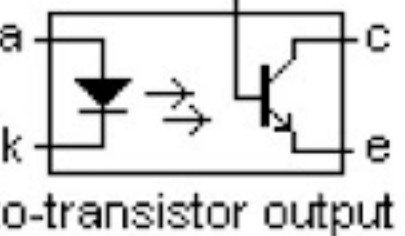
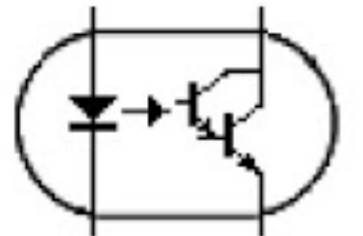
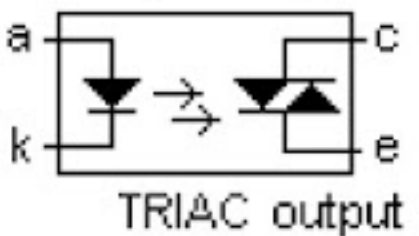
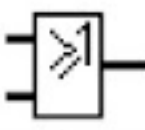
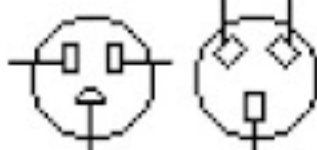
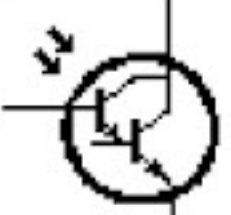
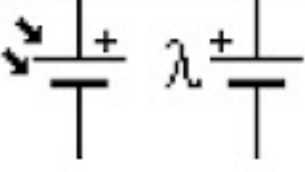
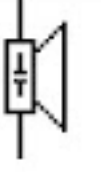


circuit symbols

AC current:  voltage: 	ALTERNISTOR TRIAC A TRIAC and 33 - 43v DIAC Main Terminal 1 Gate Main Terminal 2 	Ammeter (amp meter) 
AND Gate 	AND Gate 	Antenna balanced 
Antenna Loop, Shielded 	Antenna Loop, Unshielded 	Antenna unbalanced 
Attenuator, fixed (see Resistor) 	Attenuator, variable (see Resistor) 	Battery 
Bilateral Switch (DIAC) 	Bridge Rectifier (Diode Bridge) 	BUFFER (Amplifier Gate) 
BUFFER (Amplifier Gate) 	Buzzer 	Capacitor feedthrough 
Capacitor non-polarised 	Capacitor polarised (see electrolytic) 	Capacitor Variable 
Cavity Resonator 	Cell 	Circuit Breaker 
Coaxial Cable  Connectors Plug (male) Jack (female) connected Plug (male) (female)	Crystal Microphone (Piezoelectric)  Crystal Piezoelectric  Darlington Transistor  DC current:  voltage: 	Delay Line  DIAC (Bilateral Switch)  Diode  Diode - Gunn  Diode - Light Emitting (LED) 
Diode Photo Sensitive 	Diode Photovoltaic 	Diode Bridge (Bridge Rectifier) 
Diode - Pin 	Diode - Varactor 	Diode - Zener 
Earpiece (earphone, crystal earpiece) 	Earth Ground 	Electroluminescence 
Electret Microphone (Condenser mic)  Electrolytic (Polarised Capacitor)  alternate symbols: (positive on top) 	Electrolytic - Tanatalum positive end black band or chamfer  10u tantalum Exclusive-OR Gate (XOR Gate) 	Exclusive-OR Gate (XOR Gate)  Field Effect Transistor (FET) n-channel also: N-Channel J FET 
Field Effect Transistor (FET) p-channel also: P-Channel J FET 	Flashing LED (Light Emitting Diode)  (Indicates chip inside LED)	Fuse 

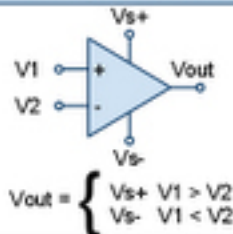
Transistor Bipolar - PNP 	Transistor n-channel Field Effect 	Transistor p-channel Field Effect 
Transistor Metal Oxide Single Gate 	Transistor Metal Oxide Dual Gate 	Transistor Photosensitive 
Transistor Schottky - NPN 	Transistor Unijunction - UJT Unijunction Transistor (UJT) N-type 	Transistor Unijunction - UJT Unijunction Transistor (UJT) P-type 
TRIAC 	Tunnel Diode  Unijunction Transistor - UJT 	Varactor varactor diode   Voltmeter 
Voltage Regulator (7805 etc) 	Wattmeter 	Wires 
Wires Connected 	Wires Not Connected 	XOR Gate (exclusive OR) 
XOR Gate (exclusive OR) 	Zener Diode 	Learn BASIC ELECTRONICS Go to: www.edatasl.blogspot.com

Positive Voltage Connection 	Potentiometer (variable resistor) 	Programmable Unijunction Transistor PUT
Rectifier Semiconductor 	Rectifier Silicon Controlled (SCR) 	Reed Switch
Relay - spst 	Relay - spdt 	Relay - dpst
Relay - dpdt 	Resistor Fixed 	Resistor Non Inductive
Resistor preset 	Resistor variable 	Resonator 3-pin
RFC Radio Frequency Choke 	Rheostat (Variable Resistor) 	Saturable Reactor
Schmitt Trigger (Inverter Gate) 	Schottky Diode (also Schottky) Low forward voltage 0.3v Fast switching also called Schottky Barrier Diode 	Shockley Diode 4-layer PNP device Remains off until forward current reaches the forward break-over voltage.
Shielding 	Silicon Bilateral Switch (SBS) 	Silicon Unilateral Switch (SUS)
Signal Generator 	Silicon Controlled Rectifier (SCR) 	Switch - process activated normally open: normally closed:
Solar Cell 	Surface Mount 	Flow
Spark Gap 	Switch - push (Push Button) 	Level
Speaker 	Switch - dpst 	Pressure
Switch - mercury tilt switch 	Switch - spst 	Temperature
Switch - spdt 	Switch - push off (Push Button) 	Switch - dpst
Switch - dpdt 	Switch - push (Push Button) 	Switch - push off (used in alarms etc)
Switch - Rotary 	Test Point 	Thermal Probe NTC: as temp rises, resistance decreases
Thermocouple 	Thyristors: Main Terminal1 Bilateral Switch 	Touch Sensor
Tilt switch mercury 	Transformer (Tapped Primary/Sec) 	Transformer Air Core
Transformer Iron Core 	Transformer (Tapped Primary/Sec) 	Transistor Bipolar - NPN

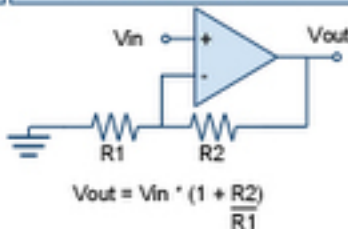
Galvanometer 	Globe 	Ground Chassis 
Ground Earth  Headphone 	Heater (immersion heater) (cooker etc) 	IC Integrated Circuit  
Inductor Air Core 	Inductor Iron Core or ferrite core  	Inductor Tapped 
Inductor Variable 	Integrated Circuit  	Inverter (NOT Gate) 
INVERTER (NOT Gate) 	Jack Co-axial 	Jack Phone (Phone Jack) 
Jack Phone (Switched) 	Jack Phone (3 conductor) 	Key Telegraph (Morse Key) 
Lamp Incandescent 	Lamp - Neon 	LASCR (Light Activated Silicon Controlled Rectifier) 
LASER diode  laser diode photo diode	LDR (Light Dependent Resistor) 	Light Emitting Diode (LED)  
Light Emitting Diode (LED - flashing)  (Indicates chip inside LED)	Mercury Switch 	Micro-amp meter (micro-ammeter) 
Microphone (see Electret Mic) 	Microphone (Crystal - piezoelectric) 	Milliamp meter (milli-ammeter) 
Motor 	NAND Gate 	NAND Gate 
Nitinol wire "Muscle wire" 	Negative Voltage Connection 	NOR Gate 
NOR Gate 	NOT Gate Inverter 	NOT Gate Inverter 
Ohm meter 	Operational Amplifier (Op Amp) 	Optocoupler (Transistor output) 
Opto Coupler (Opto-isolator)  a k c Photo-transistor output	Optocoupler (Darlington output) 	Opto Coupler (Opto-isolator)  a k c TRIAC output
OR Gate 	OR Gate 	Oscilloscope see CRO 
Outlet (Power Outlet) 	Piezo Diaphragm 	Photo Cell (photo sensitive resistor) 
Photo Darlington Transistor 	Photo Diode 	Photo FET (Field Effect Transistor)  Gate Drain Source
Photo Transistor 	Photovoltaic Cell (Solar Cell) 	Piezo Tweeter (Piezo Speaker) 

Basic Operational Amplifier Configurations

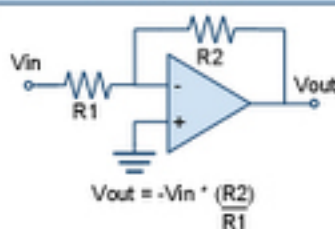
Voltage Comparator



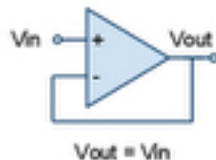
Non-Inverting Amplifier



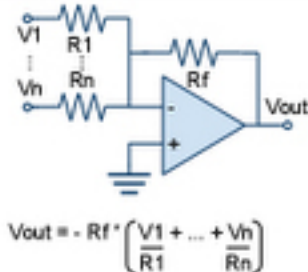
Inverting Amplifier



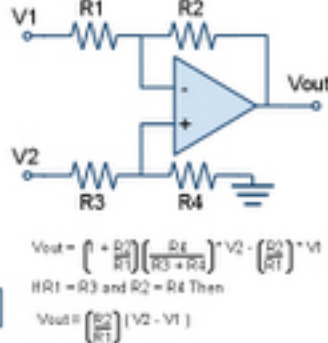
Voltage Follower



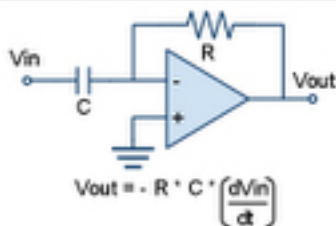
Inverting Summing Amplifier



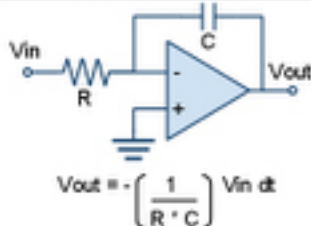
Differential Amplifier



Differentiator Amplifier



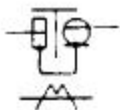
Integrator Amplifier



MODE TRANSDUCER (53)

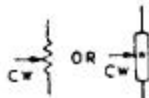
(common coaxial/waveguide usage)

TRANSDUCER FROM RECTANGULAR WAVEGUIDE TO COAXIAL WITH MODE SUPPRESSION, DIRECT-CURRENT GROUNDS CONNECTED



MOTION, MECHANICAL (54)

ROTATION APPLIED TO A RESISTOR



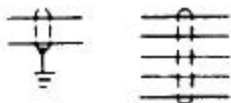
(identification replaces (*) asterisk)

NUCLEAR-RADIATION DETECTOR, GAS FILLED: IONIZATION CHAMBER; PROPORTIONAL COUNTER TUBE; GEIGER-MULLER COUNTER TUBE (50) (see RADIATION-SENSITIVITY INDICATOR)



PATH, TRANSMISSION (58)

CABLE: 2-CONDUCTOR, SHIELD GROUNDED AND 5-CONDUCTOR SHIELDED



PICKUP HEAD (61)

GENERAL



WRITING, RECORDING



READING, PLAYBACK



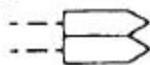
ERASING



WRITING, READING, AND ERASING



STEREO



RECTIFIER (65)

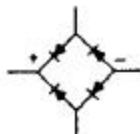
SEMICONDUCTOR DIODE, METALLIC RECTIFIER, ELECTROLYTIC RECTIFIER, ASYMMETRICAL VARISTOR



MERCURY-POL TUBE POWER RECTIFIER



FULLWAVE BRIDGE-TYPE

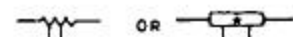


RESISTOR (68)

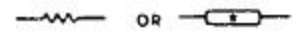
GENERAL



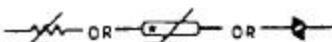
TAPPED



HEATING



SYMMETRICAL VARISTOR RESISTOR, VOLTAGE SENSITIVE (silicon carbide, etc.)



(identification marks replace (*) asterisk)

WITH ADJUSTABLE CONTACT



ADJUSTABLE OR CONTINUOUSLY ADJUSTABLE (variable)

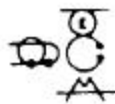


(identification replaces (*) asterisk)

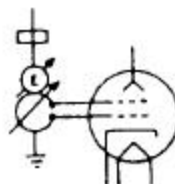
RESONATOR, TUNED CAVITY (71)

(common coaxial/waveguide usage)

RESONATOR WITH MODE SUPPRESSION COUPLED BY AN E-PLANE APERTURE TO A GUIDED TRANSMISSION PATH AND BY A LOOP TO A COAXIAL PATH



TUNABLE RESONATOR WITH DIRECT-CURRENT GROUND CONNECTED TO AN ELECTRON DEVICE AND ADJUSTABLY COUPLED BY AN E-PLANE APERTURE TO A RECTANGULAR WAVEGUIDE



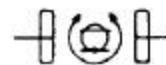
ROTARY JOINT, RF (COUPLER) (72)

GENERAL, WITH RECTANGULAR WAVEGUIDE



(transmission path recognition symbol replaces (*) asterisk)

COAXIAL TYPE IN RECTANGULAR WAVEGUIDE



CIRCULAR WAVEGUIDE TYPE IN RECTANGULAR WAVEGUIDE



SEMICONDUCTOR DEVICE (73) (Two Terminal, diode)

SEMICONDUCTOR DIODE, RECTIFIER



CAPACITIVE DIODE (also Varicap, Varactor, reactance diode, parametric diode)



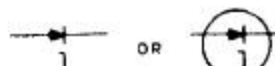
BREAKDOWN DIODE, UNIDIRECTIONAL (also backward diode, avalanche diode, voltage regulator diode, Zener diode, voltage reference diode)



BREAKDOWN DIODE, BIDIRECTIONAL AND BACKWARD DIODE (also bipolar voltage limiter)



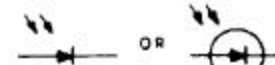
TUNNEL DIODE (also Esaki diode)



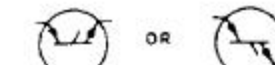
TEMPERATURE-DEPENDENT DIODE



PHOTODIODE (also solar cell)



SEMICONDUCTOR DIODE, PNPN SWITCH (also Shockley diode, four-layer diode and SCR)



(Multi-Terminal, transistor, etc.)

PNP TRANSISTOR



NPN TRANSISTOR

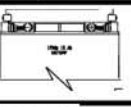
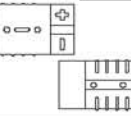
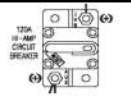
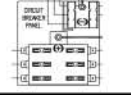
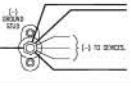
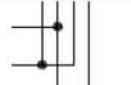
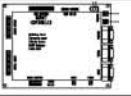
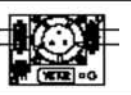
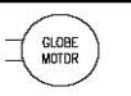
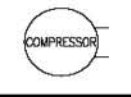
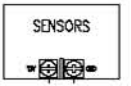


UNIJUNCTION TRANSISTOR, N-TYPE BASE



2006 FIRST Robotics - Basic Electronics

The Robot - Quick Reference Sheet 1

Item	Use	Notes	Photo	Symbol
12V Battery	Supplies most of the power to the robot. Dangerous - 200Amps possible during short circuit. Connected only to the Anderson Connector.	Only one allowed per robot. Keep it charged. Locate it for easy access.		
Anderson Connector	Only item connected to 12V battery. Keep as close to 12V battery as possible.	6 AWG Wire. Don't use to carry 12V battery. Locate it for easy access.		
7.2V Battery	Supplies robot controller with power to run micro. Only other battery allowed to power robot.	Only one allowed per robot. Keep it charged. Locate it for easy access.		
Main Breaker	Protects all of the robot electronics from the 12V battery.	Only one allowed per robot. Protect it from other robots. Locate it for easy access.		
Breaker Panels	Protects each electrical device used on robot. Ratings 20Amp, 30Amp and 40Amp. Self resetting.	Protect it from other robots. Locate it for easy access.		
Ground Stud	Used for distribution of battery ground when multiple breaker panels are used.	Do not ground to any part of robot.		
Wires	Transports power from batteries to electrical devices. Color Coded. Higher correct required - thicker wire needed.	Keep as short as possible. Follow color coding. Use correct gauge.		
Terminal Crimps	Used to connect wires to electrical devices. Color coded per wire size. Easy connect - disconnect.	Use fully insulated terminals. Check crimps often. Use right size per wire gauge.		
Robot Controller	The computer/brains of the robot. Stores and executes the software program. Gives feedback on robot status.	Locate it for easy viewing. Protect it from other robots. Locate it for easy access.		
Radio	Transmits data back and forth between the Robot and Driver Board.	Do not bury in inside robot. Protect it from other robots.		
Team Color Leds	Distinguishes alliances by flashing alliances color. Flashes status codes of robot.	Locate it for easy viewing. Protect it from other robots.		
Software	Controls robot during autonomous and driver mode. Default and user software available.		1100111	C Basic
Victor Speed Controller	Used to control a high current such as a motor by the RC. Off & On - Forward & Reverse - Variable speed. Used for 30amp and 40amp devices.	Locate it for easy viewing. LED indicates status. Keep airflow to fan unrestricted.		
Spike Relay	Used to control a high current such as a motor by the RC. Forward & Reverse only. Used for 20amp max devices.	Locate it for easy viewing. LED indicates status.		
Motors	Does most of the work on the robot. Used for drive trains, arms, lifters, shifters, etc.	Do not overdrive. Watch for overheating.		
Pneumatics	Used to do some of the work on the robot. Used for arms, lifters, shifters, etc. Can be faster than motors.	120 psi used for storage. 60 psi max used for work.		
Sensors	Allows feedback to Robot Controller of robot's status. Can be kit supplied or custom made. Very helpful in autonomous mode.			

COMMON THREE-TERMINAL SEMICONDUCTORS: BASIC DATA & CONNECTIONS

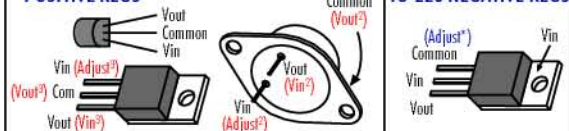
I. Bipolar Transistors

TYPE	POL	CASE, Conn's	V _{ceo}	V _{ceo}	I _c max	h _{FE} @ I _c (mA)	F _T (MHz) @ I _c (mA)	P _{tot}	R _{th(j-a)} (°C/W)	Application	Packages & Pinouts
BC327	PNP	TO-92 (17)	-45	-50	-800mA	100 min -100mA	260 typ -10mA	625mW	83.3	Amplifier; low power output	 TO-92 (17) TO-92 (14)
BC328	PNP	TO-92 (17)	-25	-30	-800mA	100 min -100mA	260 typ -10mA	625mW	83.3	Amplifier; low power output	
BC337	NPN	TO-92 (17)	45	50	800mA	100 min 100mA	210 typ 10mA	625mW	83.3	Amplifier; low power output	
BC338	NPN	TO-92 (17)	25	30	800mA	100 min 100mA	210 typ 10mA	625mW	83.3	Amplifier; low power output	
BC546	NPN	TO-92 (17)	65	80	100mA	125 min 2mA	300 typ 10mA	625mW	83.3	Small signal amplifier	 TO-92 (72) TO-5
BC547	NPN	TO-92 (17)	45	50	100mA	125 min 2mA	300 typ 10mA	625mW	83.3	Small signal amplifier	
BC548	NPN	TO-92 (17)	30	30	100mA	125 min 2mA	300 typ 10mA	625mW	83.3	Small signal amplifier	
BC549	NPN	TO-92 (17)	30	30	100mA	125 min 2mA	300 typ 10mA	500mW	150	Low noise audio preamplifier	
BC550	NPN	TO-92 (17)	45	50	100mA	125 min 2mA	300 typ 10mA	500mW	150	Low noise audio preamplifier	 TO-225 TO-220
BC556	PNP	TO-92 (17)	-65	-80	-100mA	75 min -2mA	200 typ -10mA	500mW	150	Small signal amplifier	
BC557	PNP	TO-92 (17)	-45	-50	-100mA	75 min -2mA	200 typ -10mA	500mW	150	Small signal amplifier	
BC558	PNP	TO-92 (17)	-30	-30	-100mA	75 min -2mA	200 typ -10mA	500mW	150	Small signal amplifier	
BC559	PNP	TO-92 (17)	-30	-30	-100mA	125 min -2mA	200 typ -10mA	500mW	150	Low noise audio preamplifier	 TO-218 TO-264
BC639	NPN	TO-92 (14)	80	100	1A	40 min 150mA	130 typ 10mA	1W	60	Audio driver; low power output	
BC640	PNP	TO-92 (14)	-80	-100	-1A	40 min -150mA	50 typ -10mA	1W	60	Audio driver; low power output	
BD135	NPN	TO-225	45	45	1.5A	40 min 150mA	(not specified)	1.25W	10	Audio driver; low power output	
BD136	PNP	TO-225	-45	-45	-1.5A	40 min -150mA	(not specified)	1.25W	10	Audio driver; low power output	 TO-3
BD139	NPN	TO-225	80	100	1.5A	40 min 150mA	(not specified)	1.25W	10	Audio driver; low power output	
BD140	PNP	TO-225	-80	-100	-1.5A	40 min -150mA	(not specified)	1.25W	10	Audio driver; low power output	
BD649	NPN	TO-220	100	100	8A	750 min 6A	5.0 typ 6A	62W	3.13	NPN Darlington; medium power	
BD650	PNP	TO-220	-100	-100	-8A	750 min -6A	5.0 typ -6A	62W	3.13	PNP Darlington; medium power	 TO-3
BD681	NPN	TO-225	100	100	4A	750 min 1.5A	(not specified)	40W	3.13	NPN Darlington; medium power	
BD682	PNP	TO-225	-100	-100	-4A	750 min -1.5A	(not specified)	40W	3.13	PNP Darlington; medium power	
HJ2955	PNP	TO-3	-60	-70	-1.5A	20 min -4A	2.5 min -4A	115W	1.5	PNP Power amp & switch	
HJ10012	NPN	TO-3	400	600	10A	300 min 3A	(not specified)	175W	1.0	HV NPN Darlington; switch	 TO-3
HJ121193	NPN	TO-264	250	400	16A	25 min 8A	4.0 min 1A	200W	0.7	NPN Power amp & switch	
HJ121194	PNP	TO-264	-250	-400	-16A	25 min -8A	4.0 min -1A	200W	0.7	PNP Power amp & switch	
HJ15003	NPN	TO-3	140	140	20A	25 min 5A	2.0 min 500mA	250W	0.7	NPN Power amp & switch	
HJ15004	PNP	TO-3	-140	-140	-20A	25 min -5A	2.0 min -500mA	250W	0.7	PNP Power amp & switch	 TO-3
HJE340	NPN	TO-225	300	300	500mA	30 min 50mA	(not specified)	20W	6.25	HV NPN medium power	
HJE350	PNP	TO-225	-300	-300	-500mA	30 min -50mA	(not specified)	20W	6.25	HV PNP medium power	
HJE3055	NPN	TO-220	60	70	10A	20 min 4A	2.0 min 500mA	75W	1.67	NPN Power amp & switch	
HJE2955	PNP	TO-220	-60	-70	-10A	20 min -4A	2.0 min -500mA	75W	1.67	PNP Power amp & switch	 TO-3
TIP31	NPN	TO-220	40	40	3A	25 min 1A	3.0 min 500mA	40W	3.13	NPN Power amp & switch	
TIP32	PNP	TO-220	-40	-40	-3A	25 min -1A	3.0 min -500mA	40W	3.13	PNP Power amp & switch	
TIP35C	NPN	TO-218	100	100	25A	25 min 1A	3.0 min 1A	125W	1.0	NPN Power amp & switch	
TIP36C	PNP	TO-218	-100	-100	-25A	25 min -1A	3.0 min -1A	125W	1.0	PNP Power amp & switch	 TO-3
TIP41C	NPN	TO-220	100	100	6A	30 min 300mA	3.0 min 500mA	65W	1.92	NPN Power amp & switch	
TIP122	NPN	TO-220	100	100	5A	1000 min 3A	(not specified)	65W	1.92	NPN Darlington; medium power	
TIP3055	NPN	TO-218	60	100	15A	20 min 4A	2.5 min 500mA	90W	1.39	NPN Power amp & switch	
TIP2955	PNP	TO-218	-60	-100	-15A	20 min -4A	2.5 min -500mA	90W	1.39	PNP Power amp & switch	 TO-3
2N2222A	NPN	TO-92 (17)	40	75	600mA	100 min 150mA	300 min 20mA	625mW	83.3	NPN amplifier & switch	
2N3053	NPN	TO-5	40	60	700mA	50 min 150mA	100 min 150mA	1.0W	35	NPN amplifier & switch	
2N3055	NPN	TO-3	60	100	15A	20 min 4A	0.8 min 1A	115W	1.5	NPN Power amp & switch	
2N3638	PNP	TO-92 (17)	-25	-25	-500mA	25 min -10mA	100 min -10mA	300mW	83.3	PNP amplifier & switch	
PN100	NPN	TO-92 (72)	45	60	500mA	60 min 150mA	350 min 50mA	600mW	83.3	GP NPN amplifier & switch	 TO-92 (72)
PN200	PNP	TO-92 (72)	-45	-60	-500mA	50 min -150mA	250 min -50mA	600mW	83.3	GP PNP amplifier & switch	

2. Voltage Regulators

TYPE	POL.	V _{OUT}	I _{OUT} max	V _{IN} min	V _{IN} max	CASE
7805/LM340T5	POS	+5V fixed	1A	+7.5	+35	TO-220
7806/LM340T6	POS	+6V fixed	1A	+8.6	+35	TO-220
7808/LM340T8	POS	+8V fixed	1A	+10.6	+35	TO-220
7809/LM340T9	POS	+9V fixed	1A	+11.7	+35	TO-220
7812/LM340T12	POS	+12V fixed	1A	+14.8	+35	TO-220
7815/LM340T15	POS	+15V fixed	1A	+17.9	+35	TO-220
7824/LM340T24	POS	+24V fixed	1A	+27.5	+40	TO-220
78L05	POS	+5V fixed	100mA	+7.3	+30	TO-92
78L12	POS	+12V fixed	100mA	+14.5	+35	TO-92
LM317K	POS	+1.2 — 37V	1.5A	V _{OUT} + 3.0	V _{OUT} + 40	TO-3 ²
LM317T	POS	+1.2 — 37V	1.5A	V _{OUT} + 3.0	V _{OUT} + 40	TO-220 ³
LM338K	POS	+3.0 — 35V	3A	V _{OUT} + 3.0	V _{OUT} + 35	TO-3 ²
LM350K	POS	+1.2 — 32V	5A	V _{OUT} + 3.0	V _{OUT} + 35	TO-3 ²
7905/LM320T5	NEG	-5V fixed	1A	-7.5	-25	TO-220
7909/LM320T9	NEG	-9V fixed	1A	-11.8	-30	TO-220
7912/LM320T12	NEG	-12V fixed	1A	-14.8	-30	TO-220
7915/LM320T15	NEG	-15V fixed	1A	-17.9	-30	TO-220
LM337T	NEG	-1.2 — 37V	1.5A	V _{OUT} - 3.0	V _{OUT} - 40	TO-220 ³

POSITIVE REGS



3. SCRs and Triacs

TYPE	V _{FX} max	I _F max (RMS)	I _{GATE} max	dV/dt (V/μs)	CASE	Connections
C103B	200	800mA	+200μA	20	TO-92	 TO-92 TO-220 TO-220A
C10601	400	4A	+200μA	8	TO-220 ¹	
C122E	500	8A	+25mA	50	TO-220	
SC141D	400	6A	±50mA	100	TO-220 ²	
SC151D	400	15A	±50mA	250	TO-220 ²	 TO-220 TO-220A TO-220B
TAG225	400	5A	±25mA	250	TO-220 ²	
BT137F	600	8A	±35mA	100	TO-220 ²	

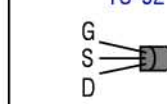
Note 1: C10601 may alternatively be in TO-126/TO-202 package, with virtually same connections

*Except BT137F

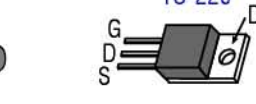
4. MOSFETs and JFETs

TYPE	Polarity, Description	BV _{DSS}	IDSS max	P _{tot}	R _{DS(on)} max	CASE
BUK456-60	N-channel power MOSFET	60V	52A	150W	28mΩ	TO-220
BUZ71	N-channel power MOSFET	50V	14A	40W	100mΩ	TO-220
NTP3055E	N-channel power MOSFET	60V	12A	40W	150mΩ	TO-220
2SJ162	P-channel power MOSFET	-160V	-7A	100W	1.0Ω	TO-3P
2SK1058	N-channel power MOSFET	160V	7A	100W	1.0Ω	TO-3P
MPF105/2N5459	N-channel gen. purp. JFET	-25V (g-s)	16mA	310mW	—	TO-92
2N5484	N-channel VHF JFET	-25V (g-s)	5mA	310mW	—	TO-92

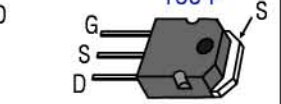
TO-92

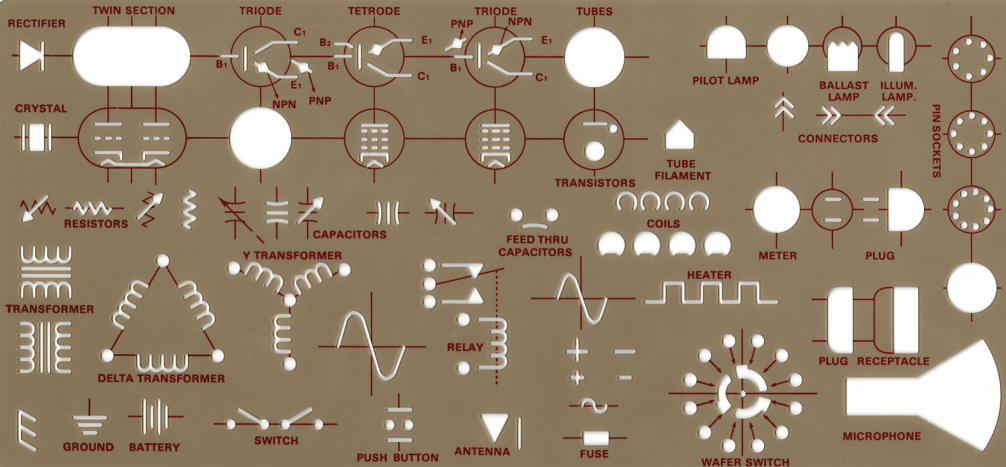


TO-220

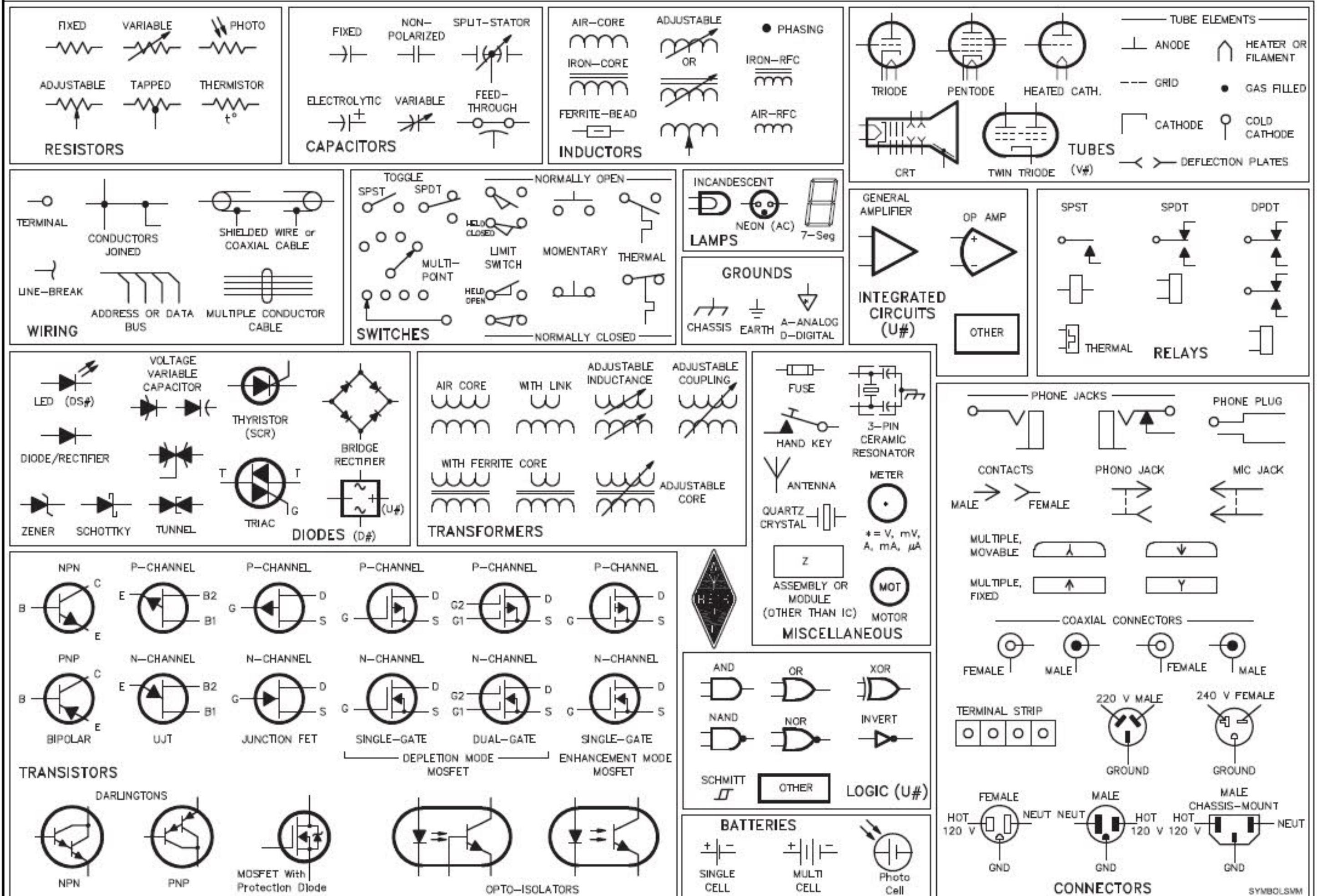


TO3-P

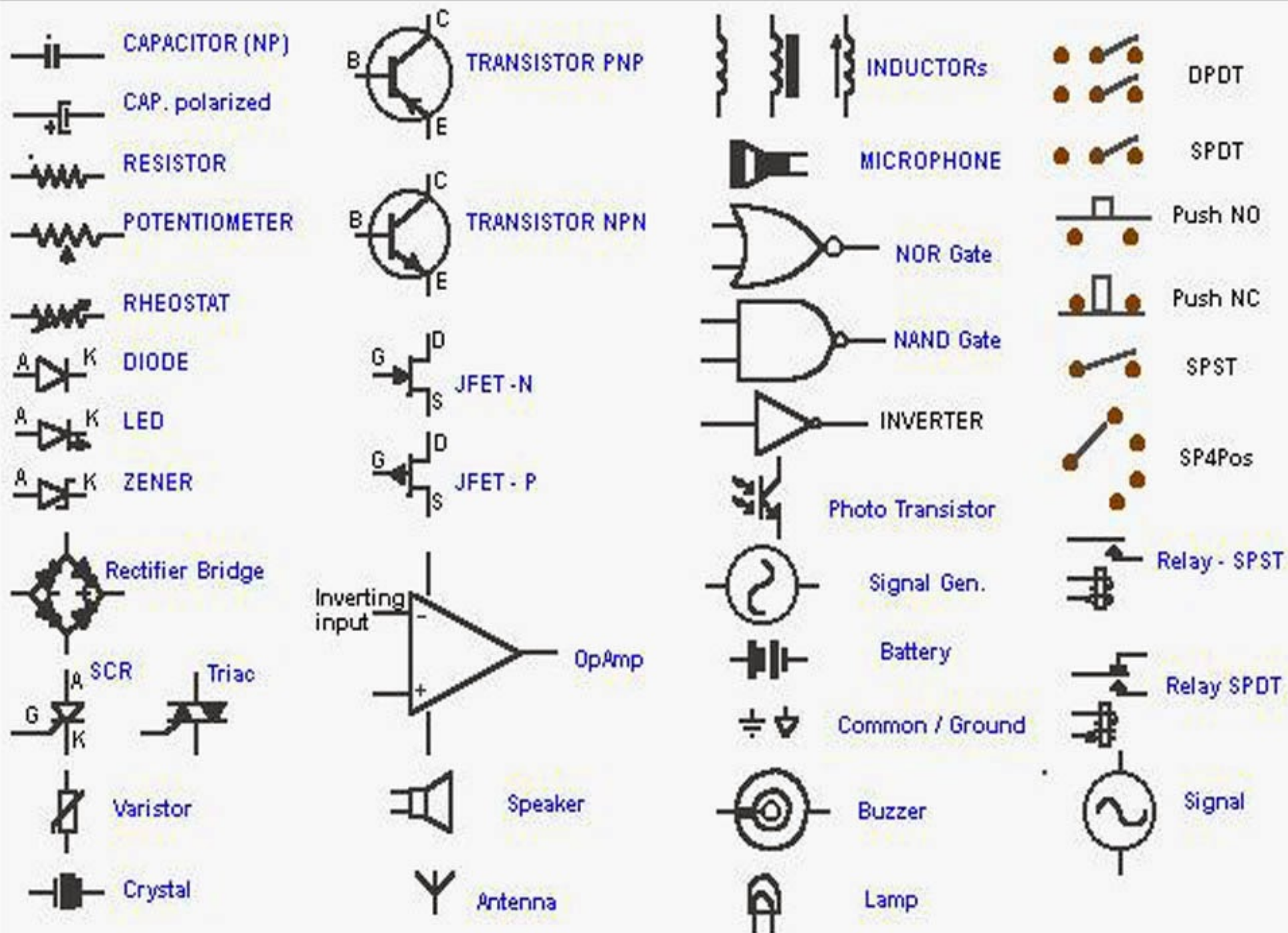




Common Schematic Symbols Used in Circuit Diagrams



Some Basic electronic symbols



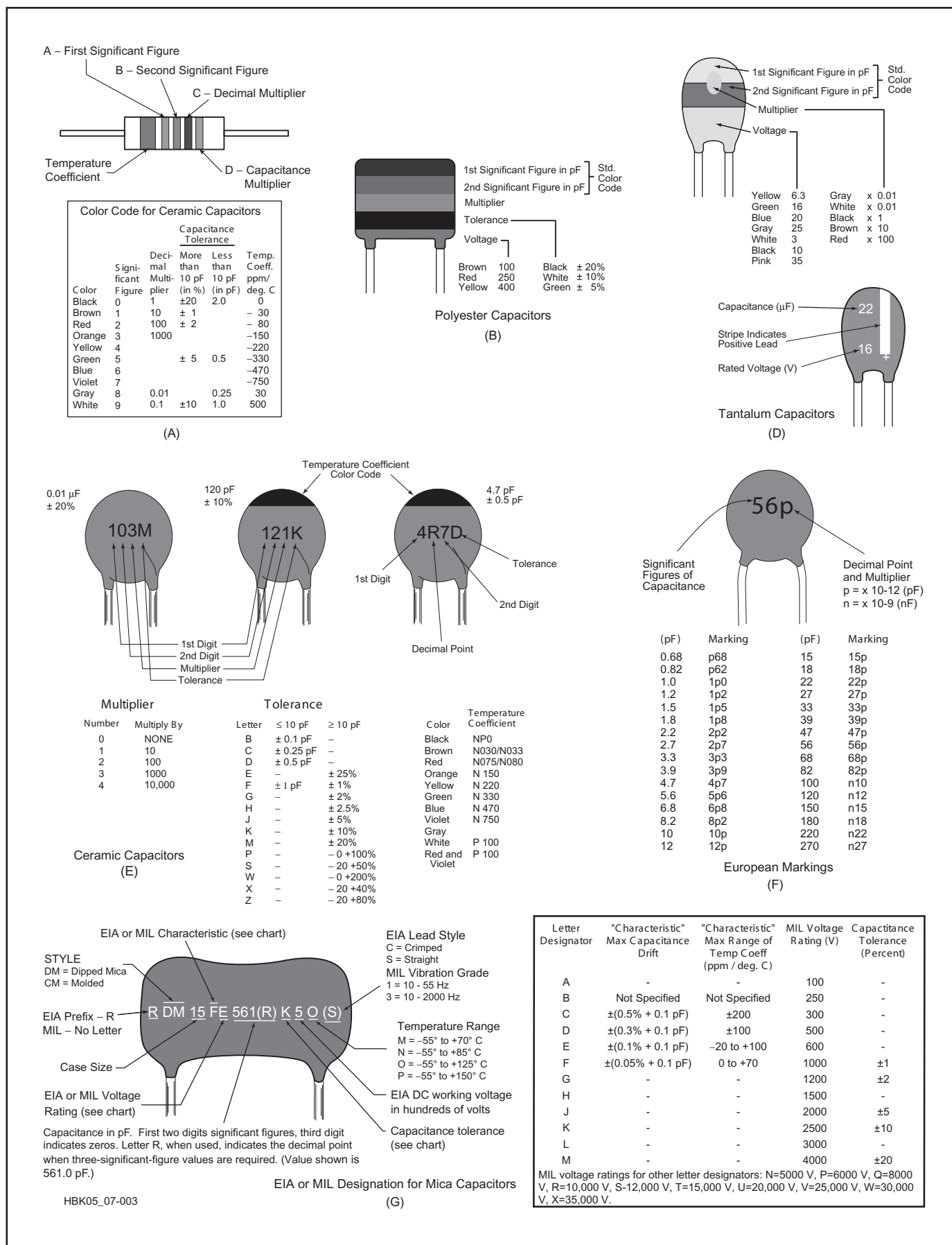
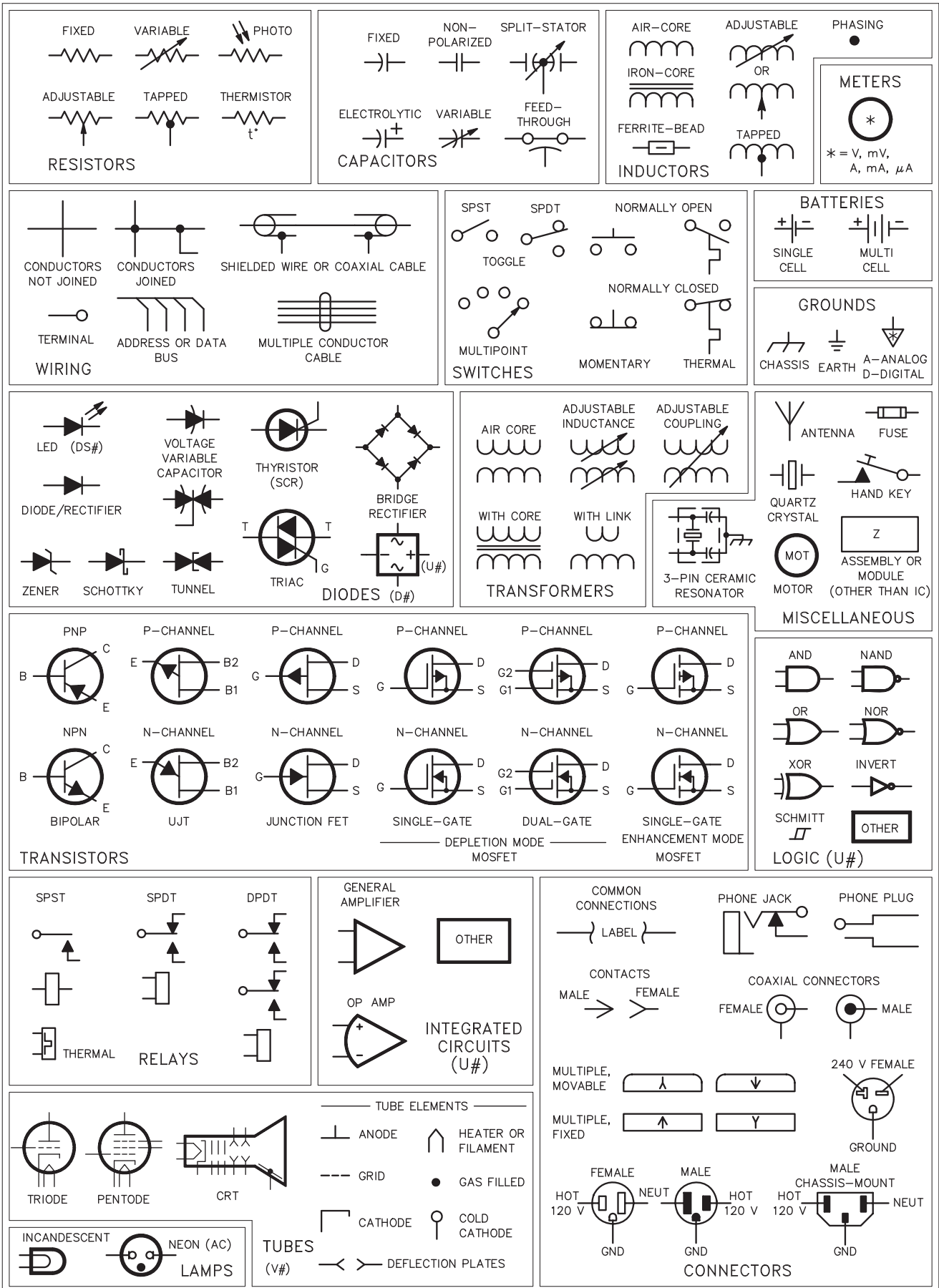


Fig 7.3—Capacitors can be identified by color codes and markings. Shown here are identifying markings found on many common capacitor types.



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It is only for the education of the new amateur
radio

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