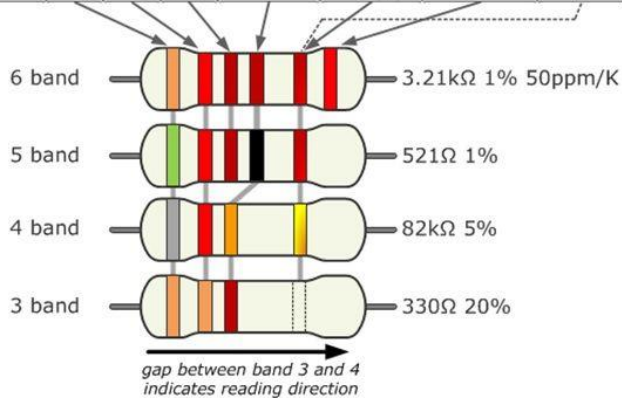
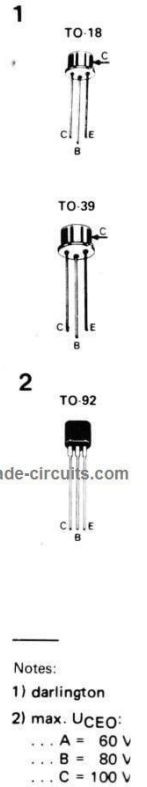


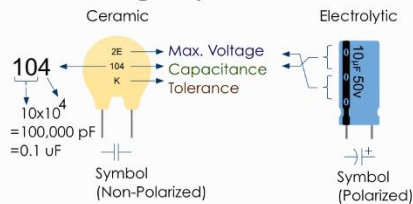
Color	Significant figures			Multiply	Tolerance (%)	Temp. Coeff. (ppm/K)	Fail Rate (%)
black	0	0	0	x 1		250 (U)	
brown	1	1	1	x 10	1 (F)	100 (S)	1
red	2	2	2	x 100	2 (G)	50 (R)	0.1
orange	3	3	3	x 1K		15 (P)	0.01
yellow	4	4	4	x 10K		25 (Q)	0.001
green	5	5	5	x 100K	0.5 (D)	20 (Z)	
blue	6	6	6	x 1M	0.25 (C)	10 (Z)	
violet	7	7	7	x 10M	0.1 (B)	5 (M)	
grey	8	8	8	x 100M	0.05 (A)	1(K)	
white	9	9	9	x 1G			
gold				x 0.1	5 (J)		
silver				x 0.01	10 (K)		
none					20 (M)		



Type	PNP	NPN	U <sub>CEO</sub> max (V)	I <sub>C</sub> max (mA)	P <sub>max</sub> (mW)	h <sub>FE</sub> I <sub>C</sub> (mA)	Complementary to:	fig.
BC 107	N	N	45	100	300	>110	BC 177	1
BC 108	N	N	20	100	300	>110	BC 178	1
BC 109	N	N	20	100	300	>110	BC 179	1
BC 140	N	N	40	1000	3700	>40	BC 160	1
BC 141	N	N	60	1000	3700	>40	BC 161	1
BC 160	P	P	40	1000	3700	>40	BC 140	1
BC 161	P	P	60	1000	3700	>40	BC 141	1
BC 177	P	P	45	100	300	>70	BC 107	1
BC 178	P	P	25	100	300	>70	BC 108	1
BC 179	P	P	20	100	300	>70	BC 109	1
BC 182	N	N	50	100	300	>110	BC 212	2
BC 183	N	N	30	100	300	>110	BC 213	2
BC 184	N	N	30	100	300	>110	BC 214	2
BC 212	P	P	50	100	300	>60	BC 182	2
BC 213	P	P	30	100	300	>60	BC 183	2
BC 214	P	P	30	100	300	>60	BC 184	2
BC 237	N	N	45	100	300	>110	BC 307	2
BC 238	N	N	20	100	300	>110	BC 308	2
BC 239	N	N	20	100	300	>110	BC 309	2
BC 307	P	P	45	100	300	>70	BC 237	2
BC 308	P	P	25	100	300	>70	BC 238	2
BC 309	P	P	20	100	300	>70	BC 239	2
BC 327	P	P	45	100	300	>70	BC 337	2
BC 328	P	P	25	100	300	>70	BC 338	2
BC 337	N	N	45	100	300	>70	BC 327	2
BC 338	N	N	25	100	300	>70	BC 328	2
BC 414	N	N	50	100	300	>100	BC 516	2
BC 416	P	P	50	100	300	>100	BC 517	2
BC 516	P	P	30	400	625	>30,000	BC 546	2
BC 517	N	N	30	400	625	>30,000	BC 547	2
BC 546	N	N	65	100	500	>110	BC 556	2
BC 547	N	N	45	100	500	>110	BC 557	2
BC 548	N	N	30	100	500	>110	BC 558	2
BC 549	N	N	45	100	500	>200	BC 559	2
BC 550	N	N	45	100	500	>200	BC 560	2
BC 556	P	P	65	100	500	>75	BC 546	2
BC 557	P	P	45	100	500	>75	BC 547	2
BC 558	P	P	30	100	500	>75	BC 548	2
BC 559	P	P	45	100	500	>125	BC 560	2
BC 639	N	N	80	1000	1000	>40	BC 640	3
BC 640	P	P	80	1000	1000	>40	BC 639	3



## Reading Capacitor Values



Capacitance Conversion Values		
Microfarads (μF)	Nanofarads (nF)	Picofarads (pF)
0.000001 μF	→ 0.001 nF	→ 1 pF
0.00001 μF	→ 0.01 nF	→ 10 pF
0.0001 μF	→ 0.1 nF	→ 100 pF
0.001 μF	→ 1 nF	→ 1,000 pF
0.01 μF	→ 10 nF	→ 10,000 pF
0.1 μF	→ 100 nF	→ 100,000 pF
1 μF	→ 1,000 nF	→ 1,000,000 pF
10 μF	→ 10,000 nF	→ 10,000,000 pF
100 μF	→ 100,000 nF	→ 100,000,000 pF

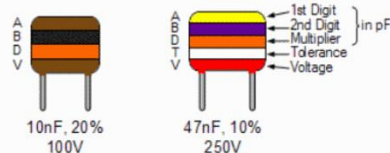
Max. Voltage	
Code	Max. Voltage
1H	50V
2A	100V
2T	150V
2D	200V
2E	250V
2G	400V
2J	630V

Tolerance	
Code	Percentage
B	± 0.1 pF
C	± 0.25 pF
D	± 0.5 pF
F	± 1%
G	± 2%
H	± 3%
J	± 5%
K	± 10%
M	± 20%
Z	+80%, -20%

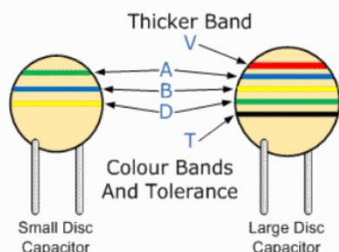
## Color Code Table

Band Colour	Digit A	Digit B	Multiplier D	Tolerance (T) > 10pf	Tolerance (T) < 10pf	Temperature Coefficient (TC)
Black	0	0	x1	± 20%	± 2.0pF	
Brown	1	1	x10	± 1%	± 0.1pF	-33×10 <sup>-6</sup>
Red	2	2	x100	± 2%	± 0.25pF	-75×10 <sup>-6</sup>
Orange	3	3	x1,000	± 3%		-150×10 <sup>-6</sup>
Yellow	4	4	x10,000	± 4%		-220×10 <sup>-6</sup>
Green	5	5	x100,000	± 5%	± 0.5pF	-330×10 <sup>-6</sup>
Blue	6	6	x1,000,000			-470×10 <sup>-6</sup>
Violet	7	7				-750×10 <sup>-6</sup>
Grey	8	8	x0.01	+80%,-20%		
White	9	9	x0.1	± 10%	± 1.0pF	
Gold			x0.1	± 5%		
Silver			x0.01	± 10%		

## Metalised Polyester Capacitor



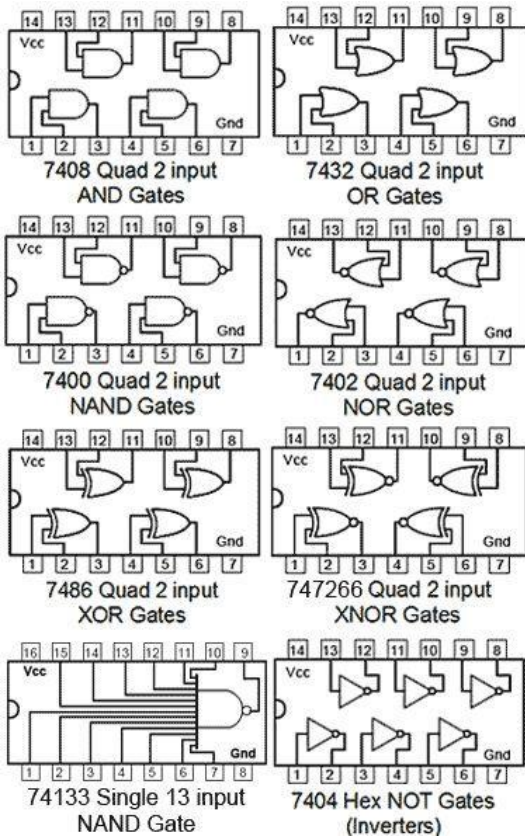
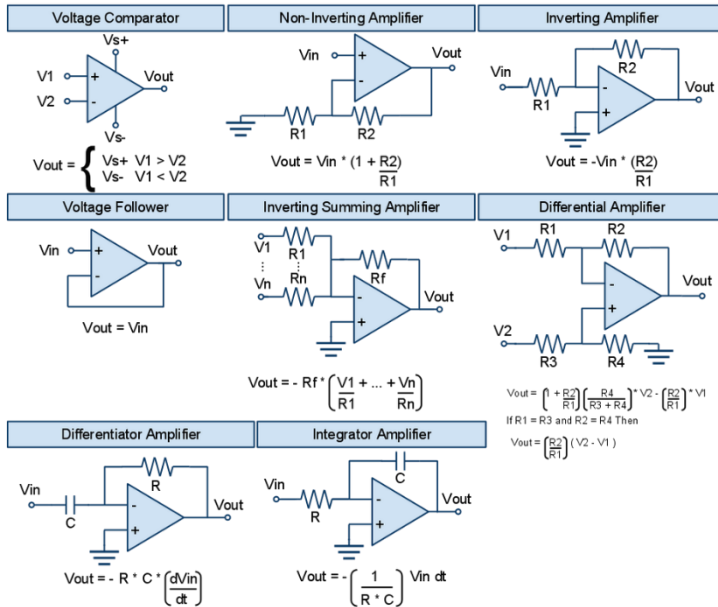
## Disc & Ceramic Capacitor



## Voltage Color Codes

Band Colour	Voltage Rating (V)				
	Type J	Type K	Type L	Type M	Type N
Black	4	100		10	10
Brown	6	200	100	1.6	
Red	10	300	250	4	35
Orange	15	400		40	
Yellow	20	500	400	6.3	6
Green	25	600		16	15
Blue	35	700	630		20
Violet	50	800			
Grey		900		25	25
White	3	1000		2.5	3
Gold		2000			
Silver					

## Basic Operational Amplifier Configurations



## RLC Circuits

the current at all points in a series AC circuit has the same amplitude and phase

$$\Delta v = \Delta V_{max} \sin \omega t$$

$$i = I_{max} \sin(\omega t - \phi)$$

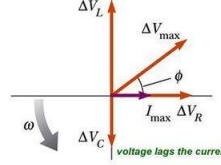
the current will be out of phase with the voltage

phase angle between the current and the voltage

Kirchoff's Voltage Sum Rule

$$\Delta v = \Delta v_R + \Delta v_L + \Delta v_C$$

voltage leads the current



$$\Delta V_{max} = V_{max} \sqrt{V_R^2 + (V_L - V_C)^2}$$

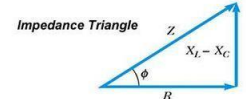
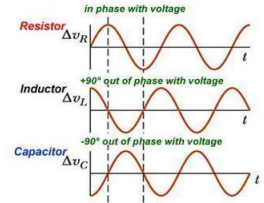
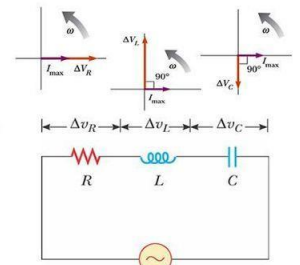
factoring out the Current I

$$\Delta V_{max} = I_{max} \sqrt{R^2 + (X_L - X_C)^2}$$

$$I_{max} = \frac{\Delta V_{max}}{\sqrt{R^2 + (X_L - X_C)^2}}$$

Impedance

$$\Delta V_{max} = I_{max} Z$$



phase angle

$$\phi = \tan^{-1} \left( \frac{X_L - X_C}{R} \right)$$

If  $X_L > X_C$  (which occurs at high frequencies)  $\phi$  is positive. Circuit is Inductive.

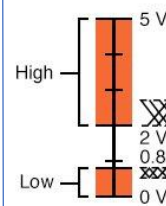
$$X_L = \omega L, X_C = 1/\omega C$$

If  $X_L < X_C$   $\phi$  is negative. Circuit is Capacitive.

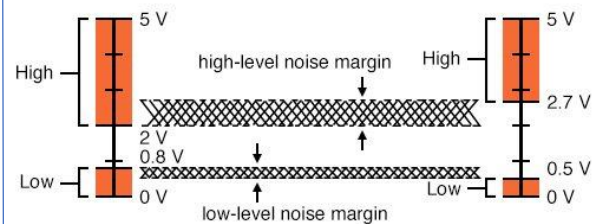
If  $(X_L - X_C) = 0$ , then  $Z = R$ . Circuit is Resistive

Circuit Element	Symbol	Current-Voltage Relationship in Time	Impedance
Resistor		$V = IR$	$R$
Capacitor		$I = C \frac{dV}{dt}$	$\frac{1}{j\omega C}$
Inductor		$V = L \frac{dI}{dt}$	$j\omega L$

Acceptable TTL Gate Input Signal Levels



Acceptable TTL Gate Output Signal Levels



PARAMETER	Bipolar op-amps		MOSFET op-amps		JFET op-amps			
	741	NE531	CA3130E	CA3140E	LF351	LF441	TL081	TL061
Supply voltage	±3V to ±18V	±5V to ±22V	±2V5 to ±18V (5 to 16V)	±2V to ±18V (4 to 36V)	±5V to ±18V	±5V to ±18V	±5V to ±15V	±2V to ±15V
Supply current	1.7mA	5.5mA	1.8mA	3.6mA	0.8mA	1.8mA	1.8mA	0.2mA
Input offset volts	1mV	2mV	8mV	5mV	5mV	0.8mV	5mV	3mV
Input bias current	200nA	400nA	5pA	10pA	50pA	50pA	50pA	5pA
Input resistance, Ω	1MΩ	20MΩ	1.5T	1.5T	1.0T	1.0T	1.0T	1.0T
Voltage gain, A <sub>o</sub>	106dB	96dB	110dB	100dB	88dB	106dB	106dB	76dB
CMMR	90dB	100dB	90dB	90dB	100dB	100dB	100dB	86dB
f <sub>T</sub>	1MHz	1MHz	15MHz	4.5MHz	4MHz	4MHz	3MHz	1MHz
Slew rate (V/μs)	0.5	35	10	9	13	15	13	3.5
IC outline	b	a	c	c	b	b	b	b

