Transformer Data

A transformers VA rating is calculated by multiplying the secondary AC voltage and the secondary AC current. For example, a 24V, 2A transformer would have a rating of 48VA. Fig. 1 shows a full wave, centre tapped, rectifier circuit, allowing more current at a lower voltage (for the same VA) than the standard full wave bridge arrangement shown in fig. 2. Fig. 3 shows a half wave rectifier with a capacitor filter.

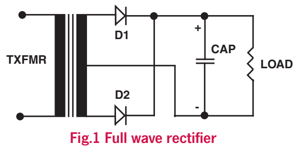


Fig.1 Full wave rectifier
Volts DC = 0.71 x Volts AC
Amps DC = Amps AC

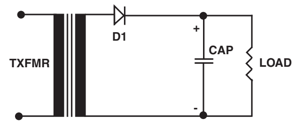


Fig.3 Half wave rectifier
Volts DC = 1.41 x Volts AC, Amps DC = 0.28 x Amps AC

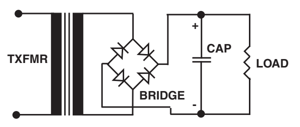
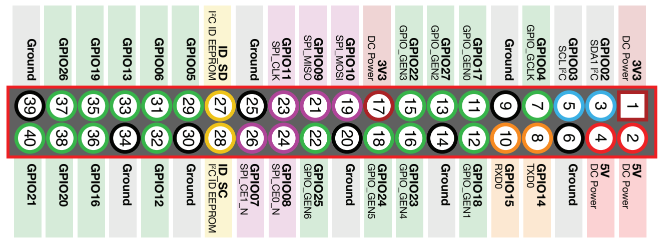


Fig.2 Bridge rectifier
Volts DC = 1.41 x Volts AC
Amps DC = 0.62 x Amps AC

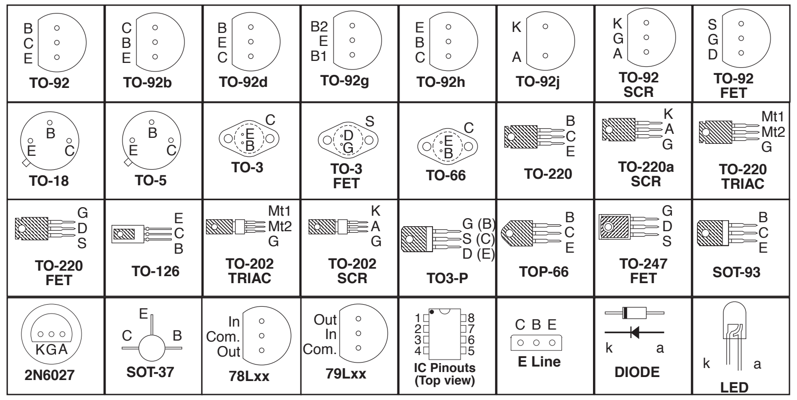
Volts AC = Secondary voltage, **Volts** DC = Supply output voltage, **Amps** AC = Max secondary current, **Amps** DC = Max supply output current

Raspberry Pi GPIO Header Pinout

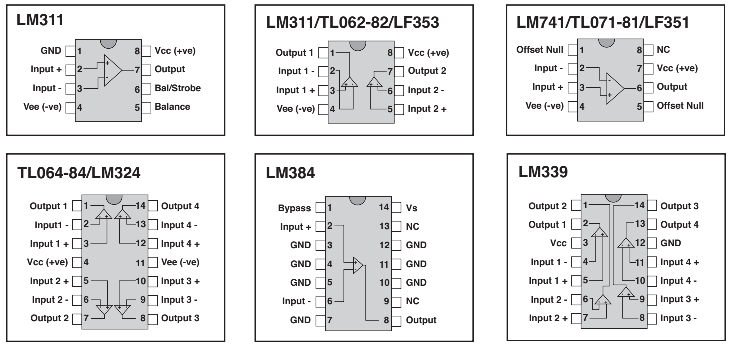


For more information, visit www.raspberrypi.org

Semiconductor Pinouts (Bottom View)

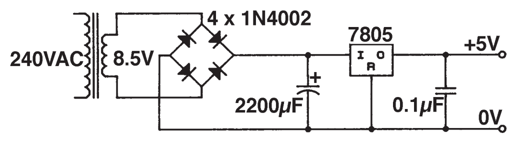


All viewed from below or the rear of the package, with the heatsinking surface upwards, unless otherwise noted.



Using Voltage Regulators

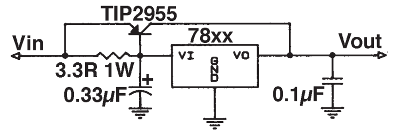
Regulators provide a power source which remains very close to a fixed value, independent of the load placed on it, provided that the current drawn doesn't exceed the rating of the device. Note: The minimum and maximum output voltage specs for fixed voltage regulators indicate the values which can be expected with variations in load on the device. The same specifications for adjustable regulators indicate the range of voltage output which can be achieved through external componentry.



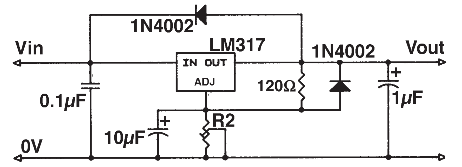
Suggested 5V Supply Schematic

Basic 1A regulated circuit with fixed regulator
The 78xx series of voltage regulators require the input pin to be at least 2.5 volts above the output voltage. When a bridge rectifier is used, the DC voltage before the regulator is going to be 1.414 x the AC secondary voltage of the transformer. For good regulation ensure that there is at least 3 volts on the input pin over and above the output voltage of the regulator. Note the maximum input voltage to the regulator should not exceed 35V.

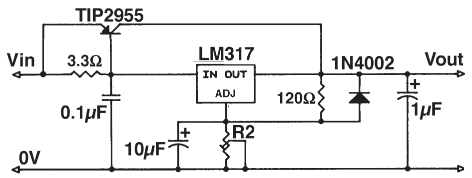
Boosting current output of voltage regulator
When more than one amp of current is required there are a number of options available. One way is to put in a more expensive higher current regulator and the other is to boost the one amp device with a bypass transistor. The following circuit shows the necessary configuration to boost the output to 4A.

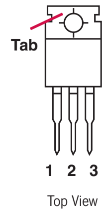


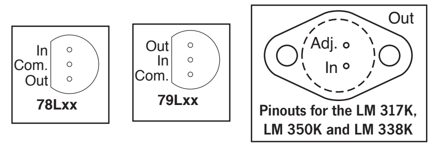
Basic voltage regulator using LM317T or LM350T
When a variable power supply is required, this circuit is an ideal solution. The diodes are not essential but are recommended to give short circuit protection. The maximum input voltage to the regulator should not exceed 40V.



Current boosted regulator using LM317T or LM350T
This circuit provides a high current capacity variable power supply, delivering 1.2 to 37V at up to 4A. Note the addition of the bypass transistor. Once again the maximum input voltage to the regulator should not exceed 40V.

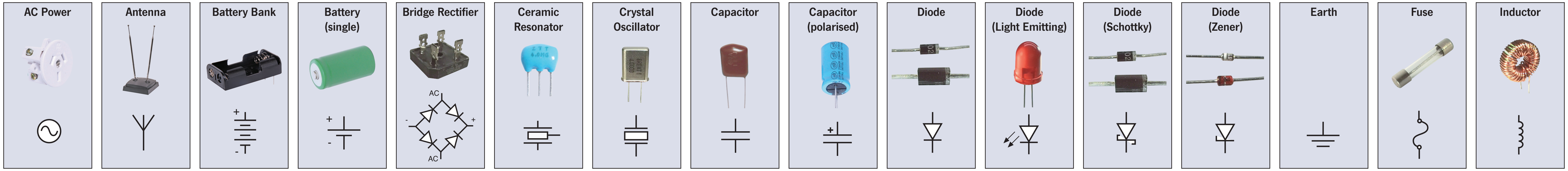


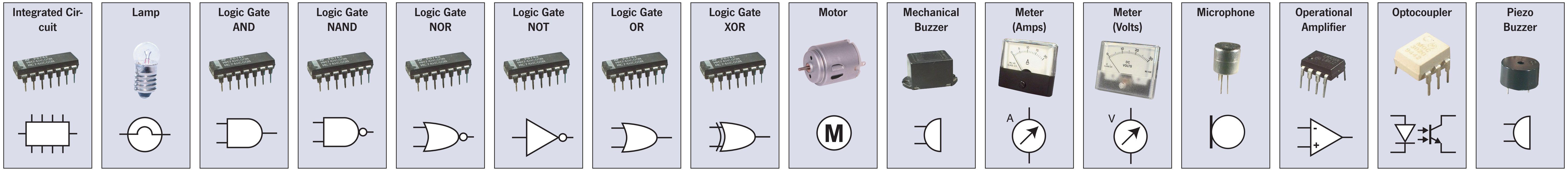


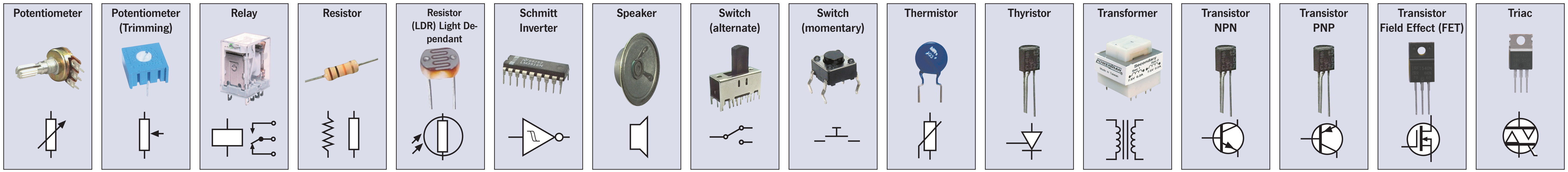


Bottom Views

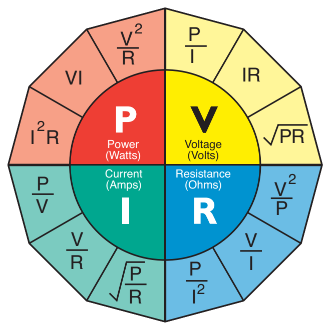
Package	Tab	Pin 1	Pin 2	Pin 3
78xx	Common	Input	Common	Output
79xx	Input	Common	Input	Output
LM317T	Output	Adjust	Output	Input
LM350T	Output	Adjust	Output	Input
LM337	Input	Adjust	Input	Output
LM2940CT	Common	Input	Common	Output







The Formula Wheel



Using this formula wheel it is possible to calculate power, volts, amps or resistance for a given problem. ie. if you have two of the variables, for example power and volts, it is possible to find the amps in a circuit. This wheel expresses volts as V, however, in old text books you may see volts shown as E.

POWER (Watts)

This formula is used in many situations, from calculating the wattage of a resistor, to working out if an appliance will overload a particular power source.

Power (Watts)	=	Current (Amps)	x	Voltage (Volts)
P	=	I	x	V

Where: V = Volts, I = Amps

A useful variation of this formula is :-

$P = I^2 \times R$

OHMS LAW

Ohms law is undoubtedly the most commonly used formula in electronics today. It defines the relationship between voltage, current and resistance. Its uses vary from calculating the value of a resistor to protect a LED (Light Emitting Diode) from destruction when run on a higher voltage supply than recommended, to calculating the current that a heater element will draw.

Voltage (Volts)	=	Current (Amps)	x	Resistance (Ohms)
V	=	I	x	R

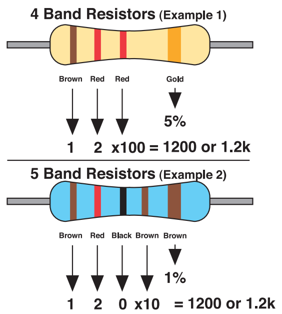
Where: V = Volts, I = Amps, R = Resistance

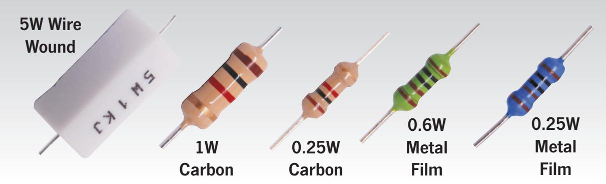
Resistors

Reading Resistor Colour Codes

Colour	1st digit	2nd digit	Multiplier
Black	0	0	1
Brown	1	1	10
Red	2	2	100
Orange	3	3	1,000
Yellow	4	4	10,000
Green	5	5	100,000
Blue	6	6	1,000,000
Violet	7	7	
Grey	8	8	
White	9	9	
Gold			0.1
Silver			0.01

	Tolerance
Brown	1%
Red	2%
Gold	5%
Silver	10%





A resistor will limit the current flow through itself to a calculable value based upon its resistance and the applied voltage (see Ohms Law). This means a resistor can be used to run a low voltage device from a higher voltage power supply by limiting the required power to a predetermined level. Resistors are not polarity sensitive.

Tolerance The tolerance of a resistor refers to how close its actual resistance has to be to the value marked on it. Common tolerances are 5% and 1%.

Wattage Depending on the power requirements of a circuit, resistor wattage needs to be calculated to ensure that they don't over heat. The more common ratings available for resistors are 1/4 Watt, 1/2 Watt, 1 Watt & 5 Watt. The wattage required for different circuits can be calculated by using the power formula described later.

Values Because it would be impractical to carry every possible value of resistor, they are available in pre-selected ranges. These ranges are known as preferred values. The E 12 series, which is the most common series, (12 Values per 100) is denoted as: 10Ω, 12Ω, 15Ω, 18Ω, 22Ω, 27Ω, 33Ω, 39Ω, 47Ω, 56Ω, 68Ω, 82Ω.
This does not limit the range of resistors to a total of twelve values, but each resistor value must begin with a number from the series and be a multiple of x0.1, x1, x10, x100, x1000, x10000 etc. i.e. 1.5Ω, 15Ω, 150Ω, 1500Ω, 15,000Ω.

The E 24 series has 24 values per 100 which includes the above sequence plus these extra values: 11Ω, 13Ω, 16Ω, 20Ω, 24Ω, 30Ω, 36Ω, 43Ω, 51Ω, 62Ω, 75Ω, 91Ω.

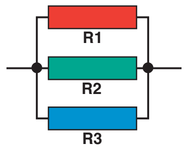
Resistors in Series

When two or more resistors are placed in series, (in line with each other), the overall resistance of the resistor network will change. The new value can be calculated from:-

$R_{Total} = R1 + R2 + R3 + etc...$

Resistors in Parallel

Calculating resistors in parallel is a little more complicated than resistors in series.



$$R_{Total} = \frac{1}{\left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + etc .....\right)}$$

Light Emitting Diode (LED) Data

LEDs are a type of diode which emits light when correctly powered. Typical voltage and current vary for each type and colour of LED. The LED's legs are called anode and cathode. Anode connects to positive power, cathode connects to the negative. Use the formulae & diagram below to determine which resistor to use with your LED for a given voltage.

Calculating Dropping Resistor Value

$$R = \frac{(VS - VLED)}{ILED}$$

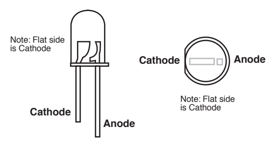
Where:

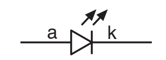
R = Value of required resistor
VS = Voltage source
VLED = Operating voltage of LED
ILED = Forward current of LED

If ILED= 20 mA @ 2.0V
If Vs = 3 Volts, R = 50Ω
If Vs = 6 Volts, R = 200Ω
If Vs = 9 Volts, R = 350Ω
If Vs = 12 Volts, R = 500Ω

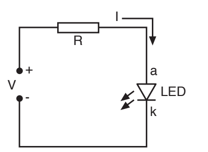
These values can be substituted for the closest 5% resistor values.

For 3 Volts	R	=	56 Ohms
6 Volts	R	=	220 Ohms
9 Volts	R	=	390 Ohms
12 Volts	R	=	560 Ohms



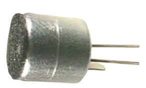


a = Anode, k = Cathode

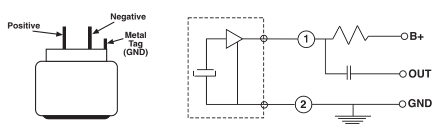


Connecting a dropping resistor

Electret Mic Inserts



Electret mics are designed to operate with a DC bias voltage across their terminals. The negative terminal is soldered to the tag on the case of the insert. The current through the microphone insert should be 0.5mA max. Hence, for a bias voltage (B+) value of 9V, the resistor would be 18kΩ minimum. The capacitor is normally a 1µF electrolytic type.



PCB Track Widths

When designing PCBs it is imperative that you design with current handling in mind. The table below allows you to design track widths to supply adequate current to components without significant temperature rise. For a 10° C temperature rise, minimum track widths are:

Current	Width (inches)	Width (mm)
0.5A	0.008"	0.20
0.75A	0.012"	0.30
1.25A	0.020"	0.50
2.5A	0.050"	1.27
4.0A	0.100"	2.54
7.0A	0.200"	5.08
10.0A	0.325"	8.25

RMS Voltage Equivalents

For a given AC voltage, the RMS equivalent will be the same as the DC voltage that gives the same heating effect as the AC voltage in question. Take note that the quantity Vp is the value from the zero crossing of the waveform to the peak, not from the neg. peak to the pos. peak.

$$V_{RMS}\ (Sine) = V_P / \sqrt{2} = V_P \times 0.707$$

$$V_{RMS}\ (Triangle) = V_P \times 0.577$$

The RMS value of a square waveform is equal to its peak value, as the magnitude of a square wave remains constant over the half-period. (Assuming a 50% duty cycle).

Capacitors

A capacitor works on the principal of having two conductive plates which are very close and are parallel to each other. When a charge is applied to one plate of the capacitor, the electrons will generate an approximately equal, but opposite charge on the other plate of the capacitor. Capacitors will pass AC current, but will block DC current. A capacitor can also be used to smooth out voltage ripple, as in DC power supplies. Capacitance is measured in Farads (F).

Capacitor Parameters

Capacitors have five parameters. Capacitance (Farads), Tolerance (%), Maximum Working Voltage (Volts), Surge Voltage (Volts) and leakage. Because a Farad is a very large unit, most capacitors are normally measured in the ranges of pico, nano and micro farads.

Working Voltage

This refers to the maximum voltage that should be placed across the capacitor under normal operating conditions.

Surge Voltages

The maximum **instantaneous** voltage a capacitor can withstand. If the surge voltage is exceeded over too long a period there is a very good chance that the capacitor will be destroyed by the voltage 'punching' through the insulating material inside the casing of the capacitor. If a circuit has a surging characteristic, choose a capacitor with a high rated surge voltage.

Leakage

Refers to the amount of charge that is lost when the capacitor has a voltage across its terminals. If a capacitor has a low leakage it means that very little power is lost.

Tolerance

As with resistors, tolerance indicates how close the capacitor is to its noted value. These are normally written on the larger capacitors and encoded on the small ones.

Code	Tolerance	Code	Tolerance
C	±0.25pF	D	±0.5pF
E	±1pF	G	±2%
J	± 5%	K	±10%
L	±15%	M	±20%
N	±30%	Z	+80-20%

Capacitor Markings

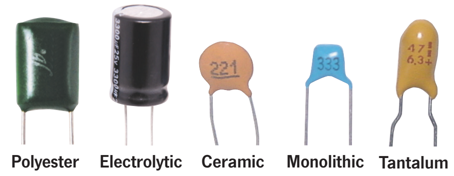
There are a two methods for marking capacitor values. One is to write the information numerically directly onto the capacitor itself. The second is to use the EIA coding system.

EIA Coding

The EIA code works on a very similar principle to the resistor colour code. The first two digits refer to the value with the third being the multiplier. The fourth character represents the tolerance.
When the EIA code is used, the value will always be in Pico-Farads (see Decimal Multipliers).

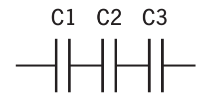
Example 1: 103K
This expands to:
1 = 1
0 = 0
3 = x 1,000
K = 10% (see Capacitor Tolerance for listings)
Then we combine these numbers together:
1 0 x1,000 = 10,000pF = 0.01µF,
at ±10% tolerance.

Example 2: 335K
This expands to:
3 = 3; 3 = 3; 5 = x 100,000; K = ±10%
Then we combine these numbers together:
3 3 x100,000 = 3,300,000pF = 3,300nF = 3.3µF, at 10% tolerance.



Capacitors in Series

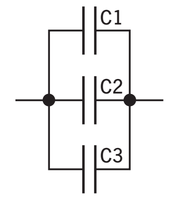
Capacitors in series can be calculated by:
Note:- The new value will always be lower.



$$C_{Total} = \frac{1}{\left(\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + etc .....\right)}$$

Capacitors in Parallel

When capacitors are placed in parallel they can be simply added together.



$C_{Total} = C1 + C2 + C3 + etc....$

Note :- The new capacitance value will be higher.

Using Diodes

Diodes can be likened to a one way street for electricity flowing in the direction of the arrow. (From anode to Cathode.) Diodes are polarised, with a Cathode at one end (K) and an anode end (A). The Cathode is marked with a stripe.

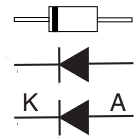
Different manufacturers may nominate the equivalent diode differently. E.g. 1N914 is equivalent to 1N4148.

Where equivalents are used these are normally specified. The markings on zeners vary, but are similar to capacitors, i.e. some are marked with manufacturers part number only, some with the voltage and some with both.

PL15Z	-	15V Zener
1N746	-	3.3V Zener
BZX85C4V3	-	4.3 Zener

0.4W Zener	
3V3	1N746
3V6	1N747
3V9	1N748
4V3	1N749
4V7	1N750
5V1	1N751
5V6	1N752
6V2	1N753
6V8	1N754
7V5	1N755
8V2	1N756
9V1	1N757
10V	1N758
11V	1N962
12V	1N963
13V	1N964
15V	1N965
18V	1N967
20V	1N968
22V	1N969
24V	1N970
27V	1N971
30V	1N972
33V	1N973
36V	1N974

1W Zener	
3V3	1N4728
3V6	1N4729
3V9	1N4730
4V3	1N4731
4V7	1N4732
5V1	1N4733
5V6	1N4734
6V2	1N4735
6V8	1N4736
7V5	1N4737
8V2	1N4738
9V1	1N4739
10V	1N4740
11V	1N4741
12V	1N4742
13V	1N4743
15V	1N4744
16V	1N4745
18V	1N4746
20V	1N4747
22V	1N4748
24V	1N4749
27V	1N4750
30V	1N4751
33V	1N4752
36V	1N4753
75V	1N4761



5W Zener	
3V3	1N4728
3V3	1N5333
5V1	1N5338
9V1	1N5346
12V	1N5349
13V	1N5350
15V	1N5352
18V	1N5355
22V	1N5358
24V	1N5359

Reactance

Capacitors and inductors have the property known as reactance which is the property that opposes any change in the current flow. It therefore most commonly applies to AC. Inductive reactance increases with frequency and capacitive reactance decreases with frequency. When reactance is combined with resistance a new property known as impedance is formed, which is similar to DC resistance, except it has an associate phase angle, due to its reactive component.

Inductive reactance is calculated as follows :-

$X_L = 2.\pi.f.L$

Capacitive reactance is calculated as follows:-

$$X_C = \frac{1}{2.\pi.f.C}$$

Where:

X_C = Capacitive impedance in ohms
X_L = Inductive impedance in ohms
C = Capacitance in farads
L = Inductance in henries
f = Frequency in hertz

The formula below will calculate the total impedance of a resistor in series with a reactive component. As follows:-

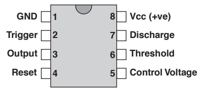
$Z = \sqrt{X^2 + R^2}$

Where:

Z = Complex impedance in ohms
X = Reactance
R = Resistance of the series resistor

555 Timer

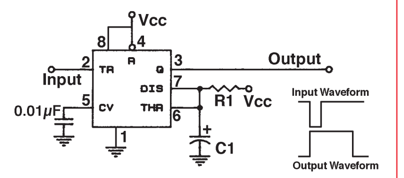
The 555 timer is one of the most versatile devices in electronics. There are many books devoted to it with thousands of application circuits published since its release. It can function in monostable (one shot) mode, or in astable mode, where it continues running at a user-set frequency. Power supply (Vcc) can be between 4.5V and 16V DC.



Mono Stable Multivibrator

This simple circuit has a main use as a 'wave generator'. When a pulse is applied to pin 2, a pulse of T seconds is produced at pin 3.

T = 1.1 x R1 x C1

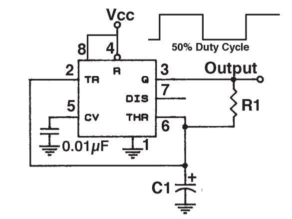


Astable Multivibrators

Fixed Duty Cycle

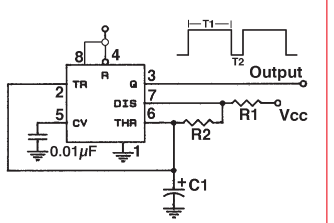
This is a great circuit for when a 50 / 50 oscillator is required. Once power is applied it is free running with a 50 % duty cycle. For more accurate timing use a CMOS type 7555 timer.

$$f = \frac{0.7}{R1 \times C1}$$



Adjustable Duty Cycle

This neat circuit will give output pulses of t1 seconds in length at an interval of t2. Shown are four formulas which will add the calculation of R1, R2 and C1 once the value of t1 and t2 have been chosen.



t1 = 0.693 x (R1+R2) x C1

$t2 = 0.693 \times R2 \times C1 = \frac{1}{T}$

$$f = \frac{1.44}{[(R1+(2 \times R2)] \times C1}$$

Period T = 0.693 x (R1 + (2 x R2)) x C1

ELECTRONICS DATA SHEET