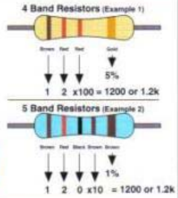
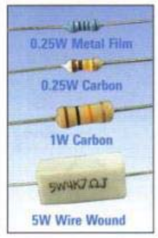
ELECTRONICS REFERENCE SHEET

Resistors

Reading Resistor Colour Codes

Colour	1st Band	2nd Band	Multiplier	Tolerance
Black	0	0	1	
Brown	1	1	10	1%
Red	2	2	100	2%
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	5%
Silver			0.01	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.

PCB Track Widths

When designing PCB's it is imperative that you design with current handling in mind. The following table allows you to design appropriate track widths to supply adequate current to components without significany 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

Static Precautions

Damage due to Electrostatic Discharge (ESD) is a very real problem in electronics. Even some of the most robust of components may not be completely destroyed but their reliability and life span may be questionable after electrostatic discharge.

Some tips to help prevent ESD damage:

- Don't remove any components from their antistatic material (bag or Velostat) until you are ready to install them on the circuit board.
- Try not to touch their leads where possible.
- We recommend you purchase an antistatic strap (Altronics Cat. No. T 4002) which can be earthed on any metal plumbing fixtures in your house or connected to the earth pin on a DC power supply.
- Use an earth-tipped soldering iron.

NOTE: Do not connect the strap directly to the mains socket earth pin!

Power (Watts)

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

Where: V = Volts, I = Amps

P = Power

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. 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

RMS Voltage Equivalents

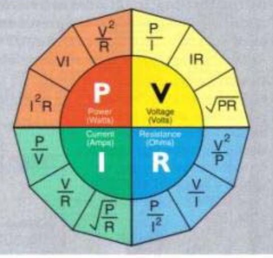
For a given AC voltage, the RMS equivalent will be the same as the DC voltage that gives the same heating effect as the AC voltage in question. Take note that the quantity Vp is the value from the zero crossing of the waveform to the peak, not from the negative peak to the positive peak.

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

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

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)

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.

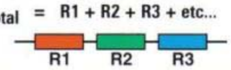
This wheel expresses volts as V, however, if you are studying old text books, you may see volts shown as E.

Resistors

Resistors in Series

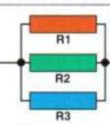
When two or more resistors are placed in series, (in line with each other), the overall resistance of the resistor network will change. The new value can be calculated from:-

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



Resistors in Parallel

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

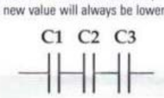


$$R_{Total} = \frac{1}{\left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \text{etc .....}\right)}$$

Capacitors

Capacitors in Series

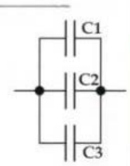
Capacitors in series can be calculated by:
Note:- The new value will always be lower.



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

Capacitors in Parallel

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



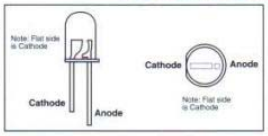
$$C_{Total} = C1 + C2 + C3 + \text{etc....}$$

Note :- The new capacitance value will be higher.

Light Emitting Diode Data

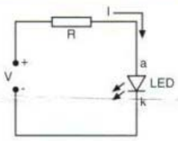
Light Emitting Diodes, or LEDs as they are known are a special type of diode which emits light when correctly powered. Typical voltage and current for every LED in the Altronics range can be found in the components section.

The LED's legs are called anode and cathode. The anode is the leg that needs to be connected to the positive of the power source. Normally a LED has different lead lengths to identify which is the positive lead. However if the leads have been trimmed, the cathode is denoted by a flat face on round LEDs or the larger internal part of the LED.



Ohms Law dictates the following:

$$R = \frac{(V_S - V_{LED})}{I_{LED}}$$



Where: V_S = Voltage source
V_{LED} = Volt drop of LED
I_{LED} = Current draw of LED

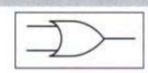
If I_{LED}= 20 mA @2.0V
If V_S = 3 Volts, R_1 = 50Ω
If V_S = 6 Volts, R_1 = 200Ω
If V_S = 9 Volts, R_1 = 350Ω
If V_S = 12 Volts, R_1 = 500Ω

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

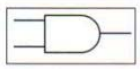
For 3 Volts	R	=	56 Ohms
6 Volts	R	=	220 Ohms
9 Volts	R	=	390 Ohms
12 Volts	R	=	560 Ohms

Logic Gates

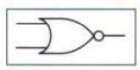
OR Gate: Output is a logic "0" only if both inputs are "0". A logic "1" at either or both inputs produces a logic "1" output.



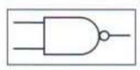
AND Gate: Output is a logic "1" only if both inputs are "1". A logic "0" at either or both inputs produces a logic "0" output.



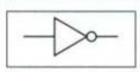
NOR Gate: Output is a logic "1" only if both inputs are "0". A logic "1" at either or both inputs produces a logic "0" output.



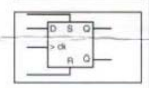
NAND Gate: Output is a logic "0" only if both inputs are "1". A logic "0" at either or both inputs produces a logic "1" output.



Inverter or NOT gate: Output is a logic "1" when input is "0". Output is a logic "0" when input is "1". ie Inverts the input state.



D Flip-Flop: Transfers the input at D to the output at Q (and it's inverse to Q-bar), on the rising edge of the clock signal at C. No change in any outputs on the falling edge of the clock pulse.

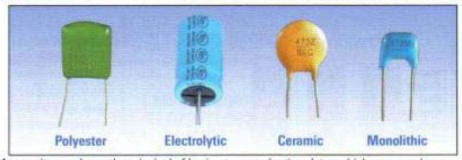


Trimpots

"Trimpots", or trimmer potentiometers are marked using the EIA standard, and are read in the same fashion as a capacitor. i.e. **104** marking is **1 0** plus multiplier of **4** (i.e. 0000). so **104 = 100,000 ohm = 100k ohm**

An Easy Way to Determine a Value is as Follows:
Write down the first two digits, one and then zero so you end up with the number 10. Next to this number write the same number of zeros as the last digit on the trimpot, in this example four zeros. You end up with the digits one, zero, zero, zero and zero. Put together you get the number 100000. This is the value of the trimpot in ohms (Ω). To convert this number into kilo ohms (kΩ) place a decimal point three digits in from the right. You then get 100.000 (or 100). So the value is 100kΩ. To get the value in meg ohm (MΩ) move the decimal place a further three digits to the left. You then get .100000 (or 0.1). So the value is 0.1MΩ.

Capacitor Data



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. Generally leakage is very small and is not normally a consideration for general purpose circuits.

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.

Potentiometers

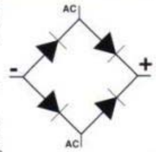
Potentiometers (usually called pots) are essentially a variable resistor. There are two common types of potentiometers. These are linear and logarithmic types. These relate to the change in resistance with respect to rotation of the potentiometer shaft. Logarithmic pots are commonly used in volume control applications.

Linear pots are commonly marked with a "B" prefix, and log pots with an "A" prefix.

For example
B100K = 100 k ohms - linear
A20K = 20 k ohms - logarithmic

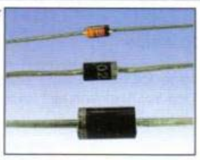
ELECTRONICS REFERENCE SHEET

Diode Bridges



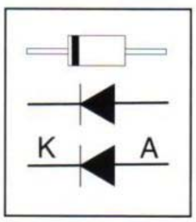
Diode bridges are a package of four diodes connected in a full wave bridge rectifier configuration. They can be encapsulated in plastic or steel/epoxy cases, and even DIL and surface mount packages for the smaller units. The square metal packages usually have one AC terminal marked, with the other terminal diagonally opposite it. The DC terminal is marked, with the negative terminal diagonally opposite it. Plastic square packages often have all terminal markings embossed in the package. Inline plastic packages take up less PCB real estate while still maintaining a reasonable current capacity, and usually have their terminals marked, with the AC connections being the inside two leads.

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 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 in the kits.
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 (400mA) Zener Diode Table

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

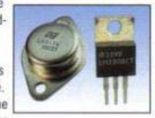
1W Zener Diode Table

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

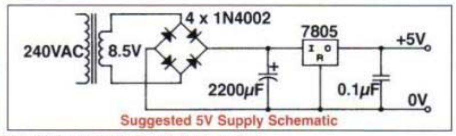
5W Zener Diode Table

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

Voltage Regulator Data



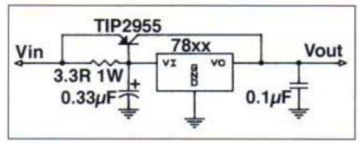
Regulators provide a power source which remains very close to a fixed value, independent of the load placed on it, provided that the current drawn doesn't exceed the rating of the device. Note: The minimum and maximum output voltage specifications for fixed voltage regulators indicate the values which 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

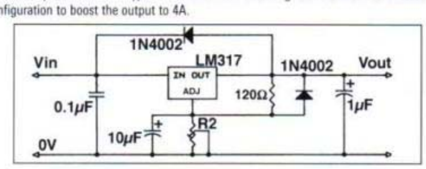
Basic 1A regulated circuit with fixed regulator

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.



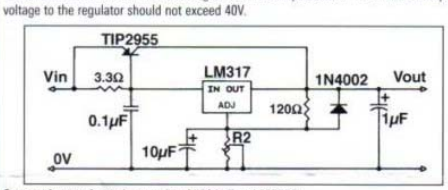
Boosting current output of voltage regulator

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.



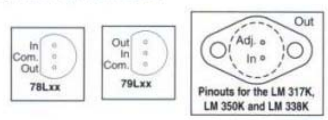
Basic voltage regulator using LM317T or LM350T

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.

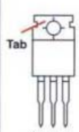


Current boosted regulator using LM317T or LM350T

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.



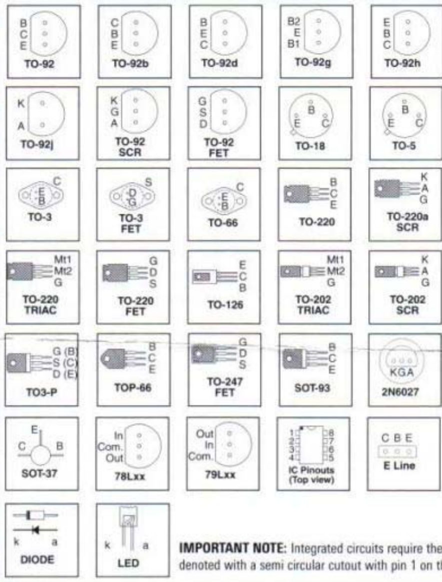
Pinouts for the LM 317K, LM 350K and LM 338K



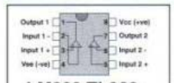
Package	Tab	Pin 1	Pin 2	Pin 3
78xx	Common	Input	Common	Output
79xx	Input	Output	Input	Common
LM317T	Output	Input	Output	Adjust
LM350T	Output	Input	Output	Adjust
LM337	Input	Output	Input	Adjust

More handy data available from the Altronics website at: www.altronics.com.au

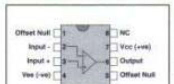
Semiconductor Package Pinouts (Bottom View)



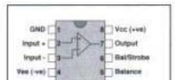
All packages are viewed from below or the rear of the package, with the heatsinking surface upwards, unless otherwise noted. When handling IC's and semiconductors always follow anti-static handling procedures.



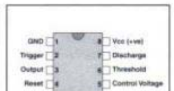
LM833, TL062, TL072, TL082 LF353 Dual Op Amps



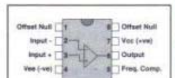
LM741, TL071, TL081, LF351 Op Amps



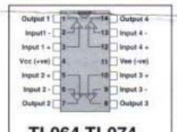
LM311 Comparator



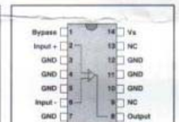
NE555 Timer



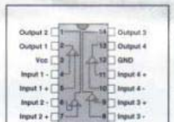
NE5534N Low Noise Op Amp



TL064, TL074, TL084, LM324 Quad Op Amps



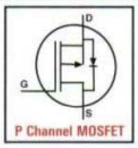
LM384 5 Watt Audio Amp

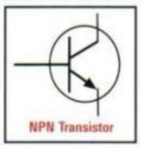


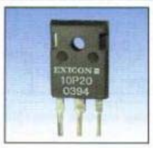
LM339 Quad Comparator

IMPORTANT NOTE: Integrated circuits require the correct orientation in the PCB. Pin 1 is marked in differently by various manufacturers. It is typically denoted with a semi circular cutout with pin 1 on the left side (viewed from top). Alternatively pin 1 can be marked with a dot on the surface of the IC.

Transistors & FET's





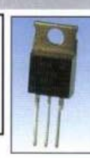


Transistors can be labelled slightly differently by different manufacturers. Transistors and FET's are basically electronically controllable switches and amplifiers. Some examples of notation by manufacturers are as follows:

BC547	C547.B, BC547A, BC547B, BC547C
ECFIOP20	Exicon 10P20 0394
BC639	C639PH179

Note the above devices must be inserted in circuit with the correct orientation. Some transistors, and most FET's and Mosfets are **static sensitive**. See "static precautions" on how to handle these devices.

Diacs & Triacs



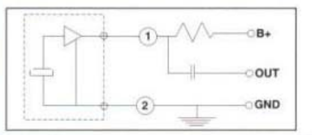
Diacs are very similar in appearance to diodes, they are glass encapsulated and usually marked with a stripe around their middle rather than at one end like a diode. Triacs have three terminals, and are similar in appearance to a transistor or an SCR. They operate like a controllable AC switch. Some examples of notations which appear on triacs are: BT137600, BT137F, MAC320, MAC320D.

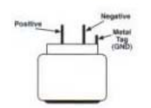
Rotary Switches

Enclosed rotary switches have a toothed washer with a series of numbered mating sockets in the top of the switch. The position of the tooth determines how many positions the switch will have. For example, if a four position switch is required, remove the nut and toothed washer then place the tooth in numbered socket "4", now replace the nut. The switch is now a 4 position type. Make sure the washer is not dislodged during further handling or installation.

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.





Guide To Soldering

The single most common cause of circuit failure is bad solder joints. A solder joint can at first glance look to be okay, but under close examination it could turn out to be a 'dry joint'. A dry joint is when either the circuit board or the leg of the component has not been properly heated to allow the solder to flow between the surfaces freely. This creates an intermittent or no electrical connection. This can also be caused by a lack of flux, which is impregnated in the solder, or if you reuse old solder. Quite often, reheating a bad join will cure the problem but in a lot of cases, the old solder will need to be removed and some new solder applied.

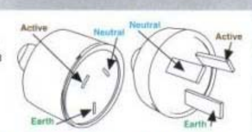
Bad Solder Join The solder has not taken to the PCB and the leg has formed a ball of solder on it. Cause:- Not enough heat to PCB track.

Bad Solder Join Solder has flowed over PCB but the leg of the component remains un-soldered. Cause:- Not enough heat to the components leg.

Good Solder Join The solder has flowed over PCB and Component leg.

240V Mains Wiring

If you are about to undertake a project that requires the use of 240 volts, use extreme caution. All mains wiring should be performed by a licensed electrician. Earth leakage breakers help prevent electrocution due to a faulty or incorrectly wired appliance.



WARNING 240 Volts Can Kill!