Technical Guide

locktronics

Simplifying Electricity

- Electrical specifications
- Carrier layouts
- Application ideas
- Safety information

MATRIX

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With the warning triangle shown here, we have hghlighted any products which we consider to require special care and attention when in use. However, you should always use these products with appropriate attention to the health and safety of yourself and those to whom you owe a duty of care. The lack of a specific warning does not imply that Matrix Multimedia Ltd. takes any responsibility for harm caused by inappropriate use of these products.

The electrical specifications contained in this document are intended purely to assist in the design of correctly functioning experiments and demonstrations - they do not imply the limits of safe usage. Should the customer wish to use these products beyond any safety margins that are explicitly recommended in this document, then responsibility for any harm or loss caused is the sole responsibility of the customer.

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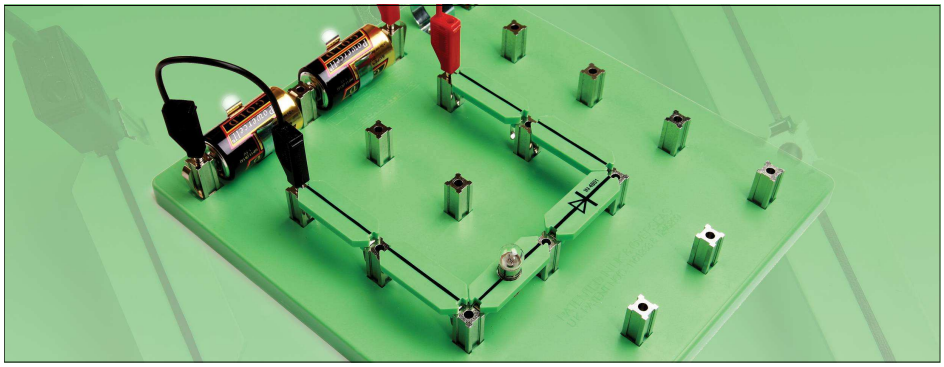
Locktronics principles

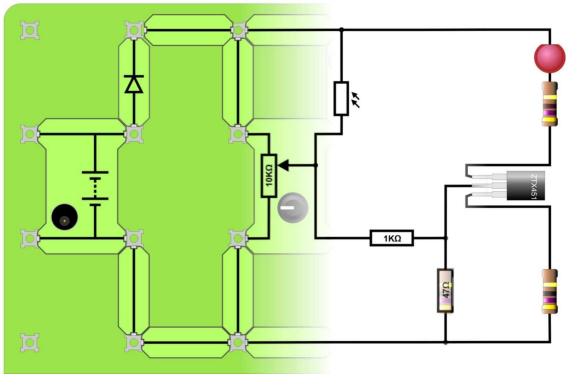
Carriers and baseboards



The locktronics range of components is designed to make the construction of electronic circuits as simple as copying a circuit diagram into an exercise book. No soldering or tools are necessary.

The plastic component carriers each support either a discrete electronic component, or a functionally distinct circuit building block. Connections between components are then made by simply slotting the carriers between the pillars of a baseboard. As there are only two sizes of component carrier, it is very easy to exchange one carrier for another in order to demonstrate the the effect on the circuit.

The electronic components are usually visible on the underside of the carrier (unless this would compromise safety or circuit behaviour) , so students also learn the appearance of many common electronic components. Where it is necessary to interact with a circuit element (for example, light sensors), the component will be mounted above the carrier - but there will still be a circuit symbol printed alongside it.



Locktronics makes clear the equivalence of carriers, symbols and electronic components.

Symbols and schematics

The top of every carrier is printed with the standard circuit symbol for the part (s) that it carries, so constructing a circuit simultaneously constructs that circuit's schematic, and vice versa. The standard carriers follow the DIN (European) standard for schematic symbols, but carriers with ANSI (USA) symbols are also available should they be required. Component values are clearly marked using the relevant SI units.

Some complex modules may require more connections than are available on a large carrier. In this case additional connections are made using 2mm sockets. With a few exceptions, it will be connections to the power source that will be made this way, in order to retain the clarity of the circuit schematic.

Typical small locktronics carrier

Typical large locktronics carrier

Safety first

As the electrical connections and components of the locktronics system are always exposed, it is important to remember that they are only to be used for low voltage, low current applications - we recommend 14Volts at 1Amp as a safe maximum.

If in any doubt whatsoever, please ask for our advice - we are able to supply power sources that we have tested and know to be safe to use with these products.

Where it is possible that components could still cause harm due to high temperatures or the discharge of high currents, we have made every effort to incorporate safety features into the carrier designs. As far as possible, we have done this in a way that will not affect the behaviour of the circuits in which the carriers are likely to be used.

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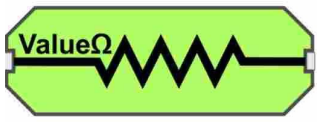
Resistors

Fixed resistors

All fixed resistors are mounted on small (two legs) locktronics carriers. Resistor carriers are available printed with either DIN symbols or ANSI symbols - ANSI carriers have the suffix 'A' appended to their part numbers. The illustrations to the right show the general form of resistor carriers.

DIN resistor carrier



ANSI resistor carrier

The following table indicates the electrical ratings of our fixed resistor carriers.

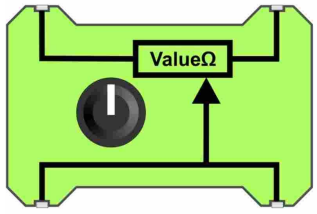
Resistance value	Power rating	Tolerance
3.9Ω	3W	±5%
10Ω to 12Ω	1W	±5%
47Ω to 500Ω	0.5W	±5%
560Ω upwards	0.25W	±5%
Rx (120Ω)	0.5W	±5%

Resistor Rx (LK5252, LK5252A) carries a 120Ω resistor, but with the value printed as 'Rx'. This is intended for use where students are required to determine the resistance value by experimentation or the use of instruments.
Blank resistor carriers are also available as products LK7215 and LK7215A. These are complete with riveted legs and generic circuit symbol, but have no resistor component and have no resistance value indicated. These can be used to construct resistor carriers with custom values.

Please see our catalogue or visit our website for a complete list of available resistance values.

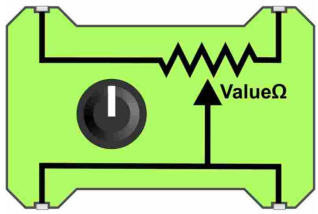
Potentiometers

All potentiometers are mounted on large (four legs) locktronics carriers. Potentiometer carriers are available printed with either DIN symbols or ANSI symbols - ANSI carriers have the suffix 'A' appended to their part numbers. The illustrations to the right show the general form of potentiometer carriers.



DIN potentiometer carrier

All potentiometer carriers above 25Ω in value also include a fixed resistor connected to the wiper terminal (see schematic, right). This is to limit the current flow when the wiper is set to either extreme. This will prevent damage to components or user injury due to overheating.

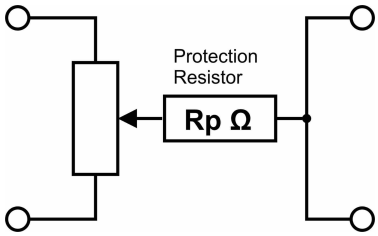


ANSI potentiometer carrier

The following table indicates the electrical ratings of our potentiometer carriers. 'Rp value' is the value of the protection resistor shown in the schematic.

Resistance value	Power rating	Tolerance	Rp value
25Ω	5W	±20%	Not Fitted
250Ω	5W	±20%	10Ω
1KΩ to 1MΩ	0.5W	±20%	27Ω

Please see our catalogue or visit our website for a complete list of available resistance values.



Circuit schematic

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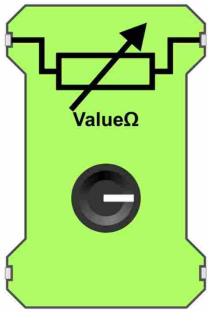
Locktronics technical guide - resistors

Variable resistors

Variable resistors consist of a potentiometer mounted on a large carrier (four legs), with only two terminals connected - as shown to the right. They can be used to simplify the circuit schematic in situations where the additional connections of a potentiometer carrier might cause confusion, or to free up an extra pair of baseboard pillars for the use of other carriers.
Resistance rises from zero to maximum with clockwise rotation of the control.
The following table indicates the electrical ratings of our variable resistor

Part No.	Resistance	Power rating	Tolerance
LK3893	250Ω	5W	±20%
LK6630	10KΩ	0.5W	±20%



Variable resistor carrier

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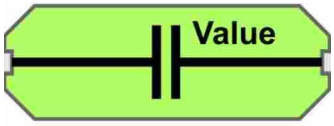
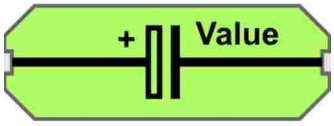
Locktronics technical guide - capacitors

Capacitors

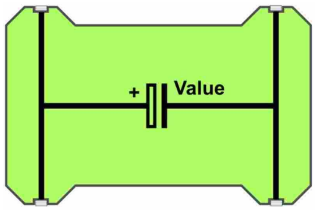
Small value capacitors are mounted beneath a small (two leg) carrier.
Larger values are mounted beneath a large (four leg) carrier with pairs of shared legs. The general form of these is shown to the right.
See below for the 22000µF capacitor, this is a special case due to its unusually high capacitance.
Polarity is clearly indicated on the carrier for electrolytic capacitors.



Polyester capacitor carrier



Small electrolytic capacitor carrier



Large electrolytic capacitor carrier

The following table indicates the electrical ratings of our capacitor carriers.

Capacitance	Type	Max. volts	Tolerance
0.1µF to 2.2µF	Polyester	100V	±10%
4.7µF to 150µF	Electrolytic (small)	25V	±20%
1000µF to 4700µF	Electrolytic (large)	16V	±20%

Please see our catalogue or visit our website for a full list of available capacitor values.

22000µF Capacitor

The 22000µF capacitor design is shown to the right. Because of its extremely high capacitance, the design is unlike our other capacitor carriers. The especially high value is ideal for demonstrating the principles of storing electrical energy for later use.
As well as the obvious differences in physical design, there are extra circuit elements included. A resettable fuse ensures that the capacitor cannot deliver dangerous currents if discharged too quickly. Should the fuse be tripped, it is easily reset by simply removing the carrier from the baseboard for a few minutes.
There is also a schottky diode for protection against reverse biasing. Neither of these features affects the capacitor's behaviour when used correctly.

22,000µF capacitor carrier

Part No.	Capacitance	Type	Max. volts	Tolerance
LK3662	22000µF	Electrolytic	16V	±20%

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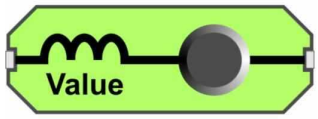
Inductors

Chokes

Chokes are mounted onto a small (two leg) carrier. The general form of these is shown to the right.



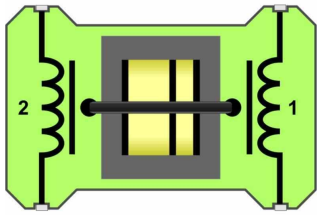
Choke carrier

The following table indicates the electrical specifications of our choke components.

Part No.	Inductance	Tolerance	DC resistance	Max.DC current	Self-resonant frequency
LK6214R3	4.7mH	±10%	32Ω	40mA	800kHz
LK6214R1	10mH	±5%	40Ω	40mA	400kHz
LK6214R2	47mH	±5%	52Ω	13mA	120kHz
LK6215	68mH	±10%	67Ω	11mA	90kHz
LK9877	200mH	±5%	424Ω	39mA	70kHz

Transformer - 2:1 turns ratio

This carrier uses a high efficiency audio transformer with a simple two to one ratio between the windings.
The windings are clearly identified on the carrier.



2:1 ratio transformer carrier

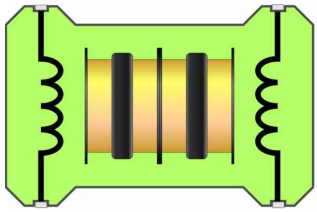
Specifications taken at 1kHz into a 600Ω output load.

Part number LK4123
Turns Ratio 2:1
Bandwidth 16Hz to 20kHz (-3dB)

	Impedance	DC Resistance	Inductance
Winding 1	1kΩ	7Ω	125mH
Winding 2	4kΩ	20Ω	500mH

2:1 Transformer with retractable ferrite core

Two 400 turn coils are mounted on top of this carrier with their axes aligned. A seperate ferrite rod is provided which can be inserted along the the shared axis of the coils.
It is thus possible to demonstrate the effect that different materials have on the efficiency of transformers. The relatively low efficiency also makes it simple to investigate the effects of poor coupling in transformer circuits.



2:1 transformer carrier with retractable core

Part No. LK7483
Each coil has identical specifications as follows...

	Impedance	DC Resistance	Inductance
No ferrite	<10Ω (1kHz)	9Ω	1.6mH
With ferrite	40Ω (1kHz)	9Ω	13mH

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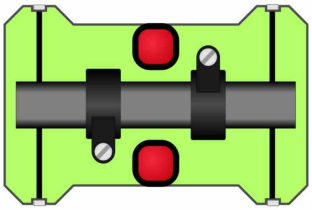
Ferrite rod carrier

The ferrite rod carrier is intended to act as core for winding custom coils. Two press terminals provide an easy way to connect the tail ends of the coil winding to the carrier legs.

Part number LK4021



Ferrite rod carrier

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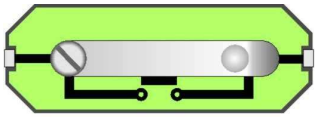
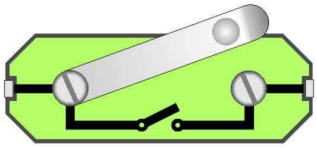
Switches

Metal strip switches

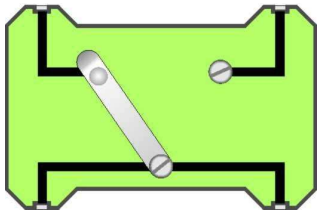
This is our budget range of switches, supplied as standard with most of our kits and solutions. A sprung steel metal strip is used to make the circuit connection by linking together metal studs on the carrier top.
As the metal strip functions as a circuit conductor, this range of switches may be unsuitable for circuits which are sensitive to picking up electrical noise (for example, contact 'bounce') or electromagnetic radiation (for example, mains 'hum'). For such circuits, see our range of toggle switches below.
There are three types of metal strip switch, illustrated to the right...



Press switch carrier



On/off switch carrier



Changeover switch carrier

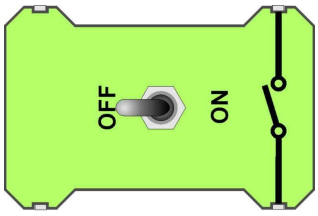
LK6207 Momentary press switch
Press the metal strip to make connection, and release it to break the connection - just like a vintage morse code key.

LK6209 On/off switch
On this version, the metal strip swivels sideways to make and break the connection, and remains in either position when released.

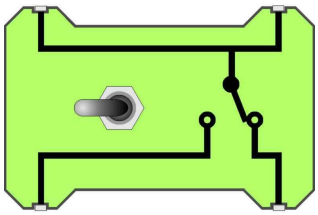
LK6208 Changeover switch
The metal strip swivels sideways to make or break either of two connections. The strip remains in position when released.

Toggle switches

These switches use a sturdy spring loaded toggle, which is fully isolated from the electrical signals connected to the carrier terminals.
There are three switch functions available, illustrated to the right...



On/off switch carrier

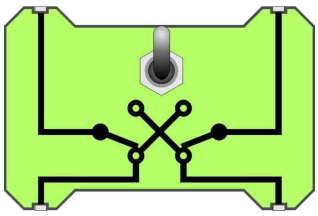


Changeover switch carrier

LK6633 On/off toggle switch
A simple single pole latching on/off switch. On and off positions are clearly marked on the carrier top.

LK6224 Changeover toggle switch
A double throw version of the toggle switch. The position of the toggle matches the orientation of the circuit diagram printed on the carrier top.

LK6632 Reversing switch
A double pole, double throw toggle switch pre-wired to allow the two input terminals to be connected to the two output terminals either directly or crossed over. Primarily used for switching the polarity of motors (and hence their direction of rotation.)



Reversing switch carrier

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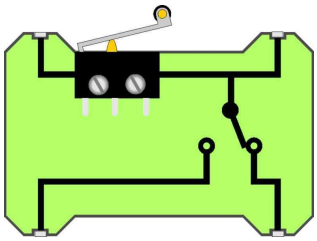
Locktronics technical guide - switches

Microswitch

A single pole, changeover contact microswitch, as commonly used in industrial machinery for sensing the position of moving parts.
The microswitch toggle has a small roller at its tip, and projects from the side of the carrier, from where it can be easily actuated by the moving parts of solenoids, motors etc.

Part number	LK6634
Switchover force max.	0.5 N
Activation travel	1 mm
Over travel	1 mm

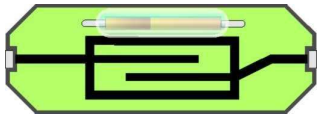


Microswitch carrier

Reed switch

The reed switch will change from open circuit to closed circuit in the presence of a magnetic field of either polarity.
Our small bar magnet (LK0123) will activate the reed switch at a range of approximately 5mm.

Part number	LK5404
Current max.	0.5 A
On threshold	> 15 AT
Off threshold	< 5 AT



Reed switch carrier

Note that care should be taken when using this carrier. In order not to reduce its sensitivity, the reed switch is mounted on the carrier top, exposing the fragile glass envelope. Should the glass be damaged, the carrier will no longer function.

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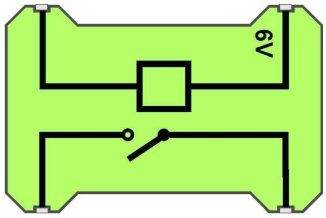
Relays

Standard relays

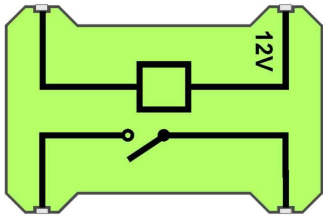
Relay carriers are available with a choice of either 6V or 12V coils, and with a choice of a single normally-open contact or double-throw change-over contacts.
Changeover relays have a 2mm socket on the carrier top for the common contact. The appropriate lead is provided, and is available with either a 4mm plug (add 'L' suffix to part no.) or 2mm plug ('LE' suffix) at the far end.

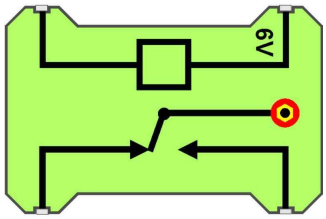
	6 V Coil	12 V Coil
Part number (normally open)	LK5403	LK5280
Part number (changeover)	LK7889	LK7049
Coil activate voltage max.	3.0 V	5.5 V
Coil release voltage min.	0.5 V	1.2 V
Coil voltage absolute max.	12.0 V	24 V
Coil resistance	110 Ω	55 Ω
Contact rating	5.0 A	5.0 A

Note that, in order to allow flexibility in baseboard placement, these carriers include no shunting of the back e.m.f. generated by de-energising the coil. You may wish to include a diode carrier in parallel with the coil in order to protect other components in your circuit from these potentially damaging currents.

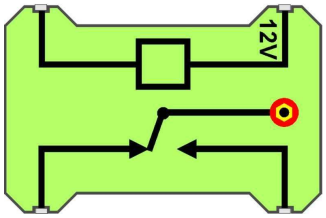


Normally-open relay carriers





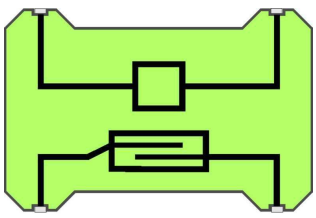
Changeover relay carriers



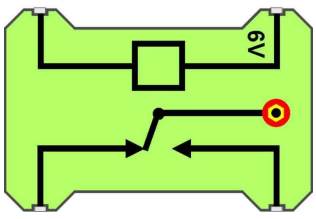
Reed relays

Reed relays have the advantage over the standard relays of being much more sensitive. The coils have a much higher resistance, thus requiring a far smaller current to switch the contacts.
However, note that the current carrying capacity of the contacts is much reduced compared to the conventional relays.
There is a choice of either a single normally-open contact or double-throw (changeover) contacts.
The changeover reed relay has a 2mm socket on the carrier top for the common contact. The appropriate lead is provided, and is available with either a 4mm plug (add 'L' suffix to part no.) or 2mm plug ('LE' suffix) at the far end.

Part number (normally open)	LK5405
Part number (changeover)	LK4103
Coil activate voltage max.	3.0 V
Coil release voltage min.	1.5 V
Coil resistance	750 Ω
Contact rating	0.5 A



Reed relay carriers



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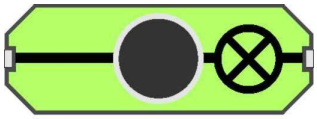
Optoelectronics

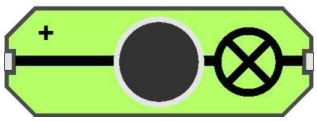
Lampholders

The lampholder carriers will accept any standard MES screw fitting bulb. They are available in two forms; with or without polarity markings. The polarised lampholder carrier is intended for use with LED bulbs, as are becoming increasingly common as panel indicators and in automotive applications.
For our range of MES filament bulbs and LEDs, see page 32 in the 'Non-carrier products' section of this document.

Part number - standard lamp holder LK5291
Part number - polarised lamp holder LK5287



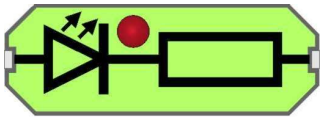
Standard lamp holder carrier



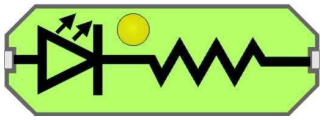
Polarised lamp holder carrier

LEDs

LED carriers are available in three colours. Each carrier also includes a current limiting resistor which is shown on the carrier schematic. There is a choice of two resistor values suitable for powering the LEDs from either 5V or 12V supplies.
You can also choose between having the resistor shown with the DIN circuit symbol or the ANSI symbol - add the suffix 'A' to the part number for the ANSI option.



LED carrier - DIN version

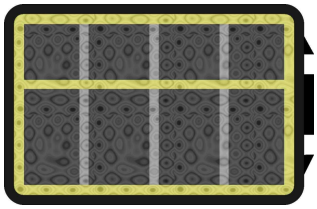


LED carrier - ANSI version

	5V LED	12V LED
Part number - Red	LK6635	LK6430
Part number - Green	LK6636	LK6432
Part number - Yellow	LK6637	LK6431
Limiting resistor value	120 Ω	470 Ω
Forward current	20 mA at nominal voltage	
Peak light wavelength - Red	660 nm	
Peak light wavelength - Green	590 nm	
Peak light wavelength - Yellow	560 nm	
Viewing angle	30°	

Solar cell

A panel of photovoltaic cells attached to the top of a large locktronics carrier.
The panel includes diode protection to prevent reverse voltages from flowing back into the cell, making it suitable for demonstrating the trickle charging of rechargeable devices.
Note that the panel overhangs the edges of the carrier, so some allowance for this may need to be made when laying out circuits on the baseboard.



Solar cell

Part number LK7746
Output voltage 3 V
Output current max. 100mA
Panel dimensions 95 mm × 65 mm

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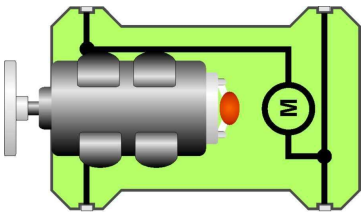
Motors and generators

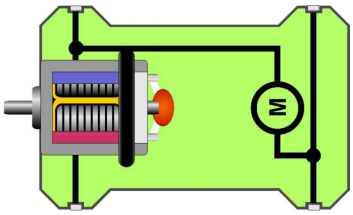
DC motors

There is a choice of three DC motors available to suit different circuit parameters and applications.
LK6706 is a large cylindrical motor mounted high on a carrier and fitted with a small gear so that it is able to interface with the LK6707 optical sensor for constructing tachometer circuits etc. It is also able to work with the widest voltage range of the three DC motor carriers.
LK4102 is an open-frame motor, ideal when teaching the theory of motors as the rotor, magnets and commutator can all be seen through a small perpex window.
Both LK6706 and LK4102 are protected by current limiting resistors, and include shunt capacitors to suppress electrical interference.
LK4663 is a very low inertia motor ('Solar motor') designed to be driven from a very small current such as that supplied by a solar cell or storage capacitor.
Technical specifications are as follows...

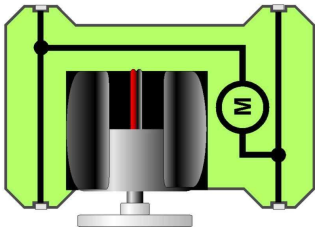
	LK6706	LK4102	LK4663
Nominal operating voltage	6.0 V	6.0 V	2.0 V
Voltage min/max	3.0 - 12 V	3.0 - 9.0 V	0.75 - 3.0 V
Load at max. efficiency	10 g.cm	4.5 g.cm	5.5 g.cm
No load current	230 mA	85 mA	25 mA
Optimal load current	650 mA	220 mA	60 mA
No load speed	9000 rpm	11700 rpm	2200 rpm
Optimal load speed	8000 rpm	8500 rpm	1500 rpm



3 V to 12 V motor carrier



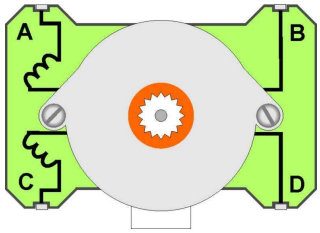
Open frame motor carrier



Solar motor carrier

Stepper motor

This is a two phase bipolar stepper motor mounted onto a large carrier. It can be moved in precise discrete steps by applying voltages of the correct polarities to the four carrier legs labelled A, B, C, and D. The voltage sequences are shown in the table to the right, simply repeat the sequence to keep the motor turning.
Our LK4690 programmable PIC microcontroller or a Matrix MIAC unit are ideal for generating these sequences with suitable speed and precision.



Stepper motor carrier

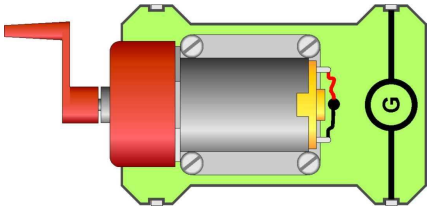
Step	A	B	C	D
1	-ve	+ve	+ve	-ve
2	-ve	+ve	-ve	+ve
3	+ve	-ve	-ve	+ve
4	+ve	-ve	+ve	-ve

Clockwise ↓ ↑ Anti-clockwise

Part number LK4322
Step Angle 7.5°
Nominal voltage 12V
Current 0.5 A per phase
Phase windings 25 Ω, 40 mH
Maximum speed 300 steps per second

Hand cranked generator

This carrier is used to demonstrate how mechanical energy can be turned into electricity. A gearbox on the front of the generator ensures a healthy output voltage at a relatively low turning speed.
It also demonstrates very well the opposing back e.m.f. when the generator is connected to a load - the handle is much harder to turn when loaded.



Hand cranked generator carrier

Part number LK4893
Gearbox ratio 30:1
Output (120 rpm into 100Ω load) 12 V, 100mA

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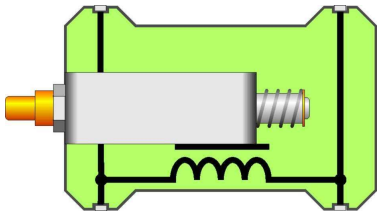
Electromechanical

Solenoid

A solenoid attached to a large carrier with a plunger that will push out from the carrier body when energised by a DC voltage of either polarity.



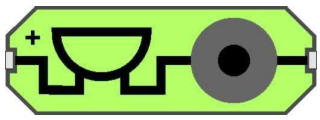
Solenoid carrier

Part number	LK6838
Plunger stroke length	9 mm
Plunger force at 5 mm extension	0.04 N
Plunger holding force at full extension	0.3 N
Coil voltage	6.0 V
Coil current	0.5 A
Coil DC resistance	12 Ω

Note that, in order to allow flexibility in baseboard placement, this carrier includes no shunting of the back e.m.f. generated by de-energising the coil. You may wish to include a diode carrier in parallel with the coil in order to protect other components in your circuit from these potentially damaging currents.

Buzzers

The buzzer carriers have a low current piezo-electric sounder attached to the top surface. The sounder includes a built in oscillator circuit, so a simple DC voltage across the terminals is all that is required to generate a sound.
Buzzers are available with a choice of two voltage ratings.

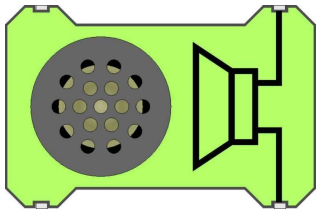


Buzzer carrier

	6 V buzzer	**12 V buzzer**
Part number	LK6423	LK3246
Operating voltage range	4 to 8 V DC	8 to 15 V DC
Operating current	30 mA	
Sound pressure level	85 dB @ 10 cm	
Frequency	2300 Hz ± 300 Hz	

Speaker

A small moving coil loudspeaker attached to a large carrier. The speaker diaphragm is protected from damage by a plastic grille. A high impedance voice coil has been chosen to eliminate the need for a high power audio amplifier.



Speaker carrier

Part number	LK8932
Impedance	100 Ω
Power max.	0.3 W rms
Sound pressure level max.	80dB @ 10 cm
Frequency response	1.2 kHz to 10 kHz
Resonant frequency	1.2 kHz

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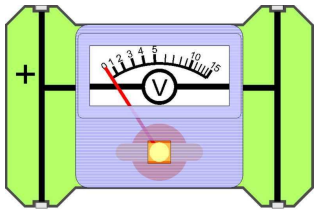
Moving coil meters

A range of four traditional moving coil meters are available, all mounted onto large carriers with the correct connection polarity clearly indicated.

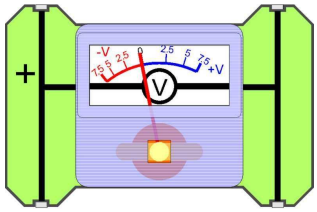
This saves the added complexity of using multimeters and test leads to measure the characteristics of a circuit layout, and makes it simple to incorporate multiple measurement ponts into a single circuit.

The use of a moving coil mechanism is also far more intuitive for students when studying values which are changing - there's no need to account for the the placing of decimal points, or differing measurement ranges that can so easily lead to errors when reading a digital multimeter.

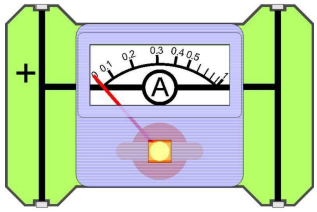
Part Number	Type	Range	Resistance
LK3982	Voltmeter	0 V to 15 V	15 kΩ
LK9438	Voltmeter	-7.5 V to +7.5 V	15 kΩ
LK9381	Ammeter	0 mA to 100 mA	1.5 Ω
LK8397	Ammeter	0 A to 1 A	< 0.1 Ω



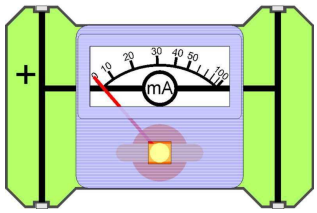
Voltmeter carrier, 0 to 15 V



Voltmeter carrier, ±7.5 V



Ammeter carrier, 0 to 1 A



Ammeter carrier, 0 to 100 mA

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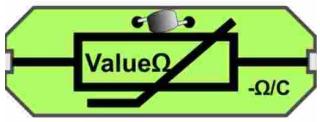
Sensors

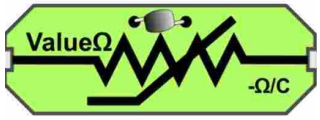
Temperature sensors

Thermistors

Thermistors are mounted on a small (two legs) carrier with the thermistor component protruding from the top of the carrier.
These carriers are available with either DIN or ANSI (products with an 'A' suffix) circuit symbols printed on them.
Both thermistor carriers have a negative temperature coefficient - the resistance will decrease as temperature rises. The nominal resistance printed on the carrier is the value at 25°C.



DIN thermistor carrier



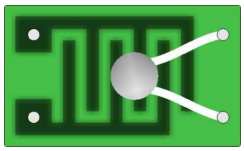
ANSI thermistor carrier

The following table indicates the electrical ratings of the thermistors.

Part No.	Resistance	Power rating	Tolerance	Coefficient
LK5401	470Ω	450mW	±3%	-3.8%/°C
LK5402	4.7KΩ	450mW	±3%	-4.5%/°C

Thermistor and moisture sensor PCB

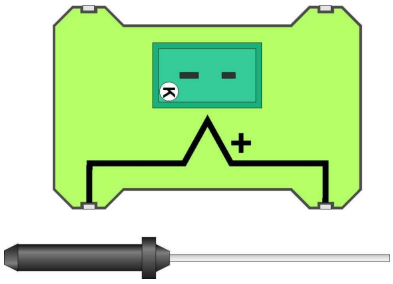
This a small circuit board with a thermistor on one side, and a moisture sensor on the reverse. Four terminal pins allow the board to be connected to a locktronics circuit using crocodile clip leads (LK5570).
The board can then be attached, for example, to the inside of a tank to sense the water level.
The thermistor characteristics are identical to LK5402 (see above)


Thermistor and moisture sensor PCB

Part number LK6850

Thermocouple

This consists of a large carrier fitted with an industry standard thermocouple socket, and a seperate type-K thermocouple probe attached to the appropriate plug via a one metre lead.
The probe is a metal rod 80 mm long attached to an insulated handle, and is fully sealed so that it can be safely immersed in liquids

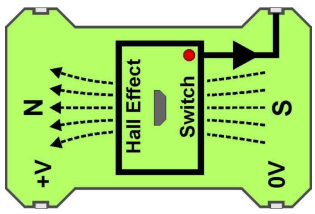


Thermocouple carrier and probe

Part number LK8988
Thermocouple Type K (chromel-alumel)
Sensitivity 40 µV / °C

Hall effect switch

The hall effect sensor is used to detect magnetic fields. Typically it is used to sense the passing of a magnet attached to the moving parts of machinery for positional sensing or counting the revolutions of a drive shaft.
The device used incorporates circuitry to provide a simple on/off output suitable for interfacing to digital circuits. The output is normally on, and turns off in the presence of a magnetic field; there is also an on-board LED to show the ouput status.



Hall effect switch carrier

Part number LK6734
Device used A1102EUA
Supply voltage (V+) 3.8 V to 14 V
Supply current 7.5 mA
Output on voltage V+ × 0.6
Output current 25mA
Magnetic flux for turn on 175 G
Magnetic flux for turn off 10 G

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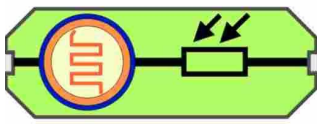
Locktronics technical guide - sensors

Light sensors

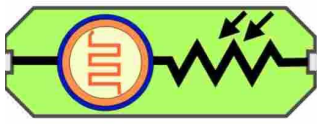
Light dependent resistor

The light dependent resistor (LDR) is mounted on the top of a small carrier (two legs). It is available with either a DIN or ANSI (add an 'A' suffix) circuit symbol.

Part number	LK5144
Light resistance (at 10 lux)	5 kΩ to 12 kΩ
Dark resistance	2.5 MΩ
Peak light wavelength	550 nm
Power rating	250 mW



DIN LDR carrier

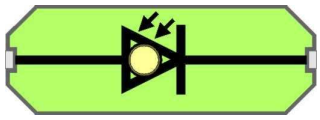


ANSI LDR carrier

Photodiode

This small carrier has a photodiode attached to the carrier such that its light collecting lens shows through the carrier top. The device used has been chosen becuase it is sensitive to approximately the same light spectrum as the human eye.

Part number	LK7361
Device used	TEPT5700
Light spectrum	440 nm to 800 nm
Angle of incidence	±50°
Peak light wavelength	470 nm
Maximum voltage	6 V
Dark current max.	50 nA
Light current at 100 lux	75 µA

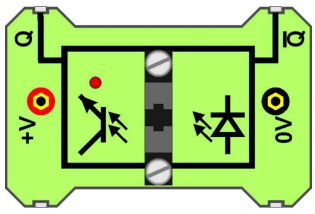


Photodiode carrier

Slotted opto switch

This carrier has an infra-red LED and phototransistor mounted either side of a slot in a plastic mounting. The photodiode senses when the slot is obstructed, its output is then passed to the output via a CMOS buffer circuit for easy interfacing.
An LED on the carrier top also indicates the ouput status.
The slotted mounting is positioned so that it can accomodate the gear-wheel on the LK6706 DC motor, such that the revolutions of the motor can be counted.
Power for the carrier is supplied via two 2mm sockets, the leads for which are supplied as standard.

Part number	LK6707
Supply voltage	4.5 V to 16 V
Supply current max.	50 mA
Output high min.	V+ × 0.95
Output low max.	V+ × 0.05
Output current max.	20 mA
Slot width	3mm



Slotted opto switch carrier

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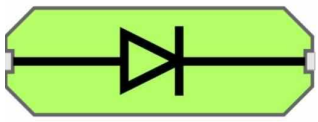
Semiconductors

Diodes

There is a wide selection of diode carriers available, all mounted beneath small (two legs) carriers. The illustration to the right shows their general appearance



Diode carrier

Diode, germanium

This is a type OA91 device. It is especially suitable for low level signals due to its low forward voltage drop.

Part Number	LK5242
Max. forward current (average)	50mA
Max. forward current (peak for <1s)	500mA
Max. reverse voltage	90V

Forward current	**Forward voltage (typical)**
0.1mA	0.18V
10mA	1.2V
30mA	2.1V
Reverse voltage	**Reverse current (typical)**
1.5V	1.5mA
10V	4mA

Diode, silicon

This is a type 1N4148 device, designed for applications where fast switching is required.

Part Number	LK5249
Max. forward current (average)	450mA
Max. forward current (peak for <1µs)	2A
Max. reverse voltage	75V
Reverse Current (Vr < 20V)	<0.1mA

Forward current	**Forward voltage (typical)**
0.1mA	0.5V
10mA	0.7V
30mA	0.8V

Diode, power, 1A, 50V

This is a high current diode suitable for rectification and protection against reverse power polarity. The device used is a 1N4001.

Part Number	LK5248
Max. forward current (average)	1A
Max. forward current (peak for <10µs)	30A
Max. reverse voltage	50V
Reverse Current (Vr < 20V)	<0.1mA

Forward current	**Forward voltage (typical)**
0.1A	0.75V
1.0A	0.9V
10A	1.3V

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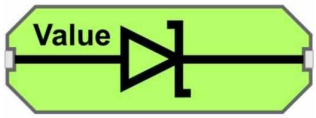
Locktronics technical guide - semiconductors

Zener diodes

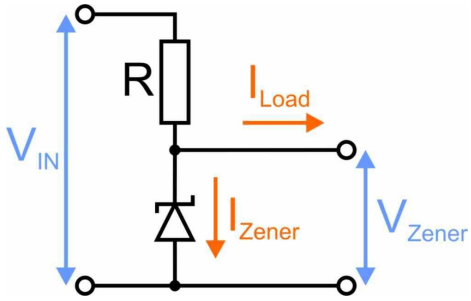


Zener diode carrier

These are designed to provide a simple form of voltage regulation. When reverse biased, the voltage across the diode is clamped to the breakdown (zener) voltage of the semiconductor junction.
For breakdown to occur there must be sufficient reverse current passing through the zener diode.
The diagram to the right shows a zener diode in a typical circuit configuration - in series with a resistor to set up a voltage divider. The maximum value of the resistor can be found by the following equation...

$$R_{Max} = \frac{V_{In} - V_{Zener}}{I_{Zener} + I_{Load}}$$

A range of zener diodes are available with different breakdown voltages, the other specifications are the same for the entire range, and are shown below.

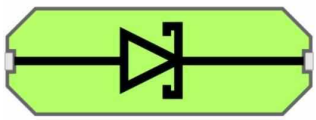


Typical zener diode Circuit

Zener current 5mA
Max. power dissipation 500mW
Zener voltage tolerance ±5%

Part Number	Zener Voltage
LK5247	4.7 V
LK5253	6.8V
LK5254	8.2 V
LK5258	12V

Schottky diode



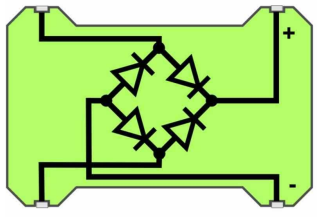
Schottky diode carrier

The schottky diode has a very small forward voltage drop, a very fast switching time and good power handling.
This makes it ideal for very high frequency circuits, and for making extremely efficient rectifiers and power circuits.
The locktronics schottky diode carrier has the following characteristics.

Part number LK8000
Max. forward current (average) 1A
Max. forward current (peak for <10ms) 25A
Max. reverse voltage 30V
Max. reverse current 1mA

Forward current	Forward voltage (typical)
100mA	0.35V
1A	0.5V
10A	1.3V

Bridge rectifier



Bridge rectifier carrier

This incorporates four 1N4001 diodes wired to the four legs of a large carrier to provide a ready made bridge rectifier (full wave rectifier)
See the previous page for the 1N4001 (Diode, power) electrical specifications.

Part Number LK5286

This carrier is NOT intended for the rectification of the mains electricity supply. It is only to be used for demostrating the principle of rectification using an appropriate low voltage AC source (14 Vrms at 1 A is recommended as a safe maximum)..

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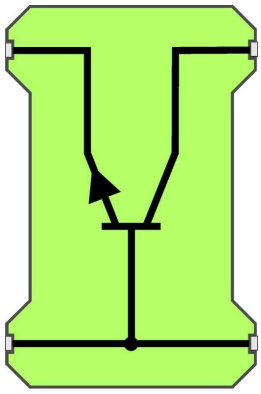
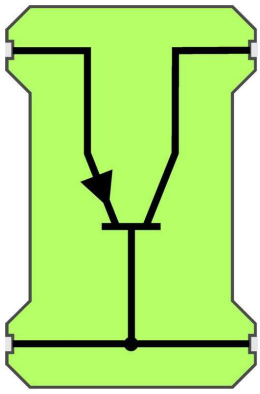
Bipolar transistors

General purpose bipolar transistors

There are both NPN and PNP general purpose transistor carriers, each of which is available with two different connection layouts (see pictures, right). The different layouts make it simpler to choose a carrier that makes best use of the space on a baseboard.
To tell them apart, hold the carrier with the base terminals at the bottom - the emitter terminal will then be either be facing left (LHF carrier) or to the right (RHF carrier). The electrical characteristics are not affected by the different layouts.
The two NPN carriers use ZTX451 devices and the PNP carriers use ZTX551. The electrical specifications of these two devices are identical, apart from the change in junction polarity.



Transistor carrier, LHF, NPN



Transistor carrier, LHF, PNP

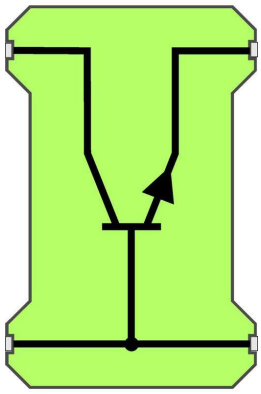
Base-collector voltage	max. 80 V
Collector-emitter voltage	max. 60 V
Emitter-base voltage	max. 5V
Collector current	max. 1 A
Power dissipation	max. 1W
DC current gain (h_{FE})	min.50, max.150
Base-emitter saturation voltage	max. 1.1 V

Part Number	Description
LK5240	NPN, RHF (ZTX451)
LK5241	NPN, LHF (ZTX451)
LK5255	PNP, RHF (ZTX551)
LK5256	PNP, LHF (ZTX551)

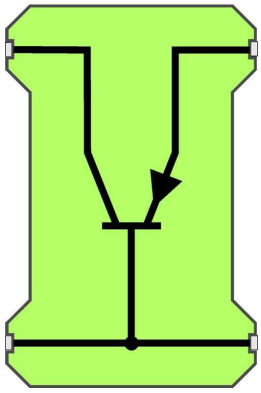
High power bipolar transistors

Where greater power or currrent handling are required, there is a choice of two power transistor carriers. They are both NPN devices, using the right-facing carrier layout (RHF, NPN - shown right).

Part Number	**LK6705**	**LK7203**
Transistor device	BD135	2N3055
Collector-base voltage max.	45 V	60 V
Collector-emitter voltage max.	45 V	70 V
Emitter-base voltage max.	5.0 V	7.0 V
Collector current max.	1.5 A	15 A
Power dissipation max.	8 W	115 W
DC current gain (h_{FE})	25 - 40	20 - 70



Transistor carrier, RHF, NPN



Transistor carrier, RHF, PNP

Although these carriers are <u>capable</u> of driving extremely high power loads, please remember that the locktronics system exposes many live conductors. For your safety, we advise you to use this product below a safe limit of 14 V at 1 A.

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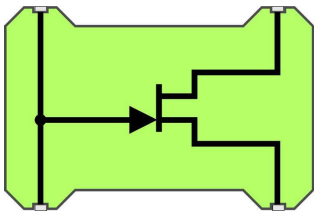
Locktronics technical guide - semiconductors

Field effect transistors

N-channel FET

There is a choice of two field effect transistor carriers, both of which are n-channel devices suitable for switching digital or analogue signals. The carrier layout is shown to the right.
Both carriers work in depletion mode - that is, they are normally conducting, and require a negative voltage at the gate in order to turn off the drain-to-source signal.
The main differences is that LK5146 is a JFET device with greater power handling.

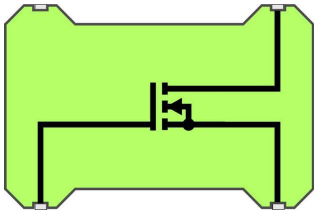


N channel field effect transistor carrier

Part Number	LK5146	LK7219
Device Type	2N5457	2N3819
Drain-source voltage max.	25V	25V
Drain-gate voltage max.	-25V	-25V
Cutoff voltage (gate-source)	-0.5 to -6 V	-0.5 to -7.5 V
Power max.	625 mW	350 mW
Forward transconductance	5.0 mS	5.5 mS

High power MOSFET

This is a high power n-channel device which works in enhancement mode - that is, the drain to source channel is normally non-conducting, and requires a positive voltage at the gate terminal to turn the channel on.



N channel MOSFET carrier

Part number	LK8011
Device type	RFP30N06LE
Drain-source voltage max.	60 V
Drain-gate voltage max.	60 V
Drain current max.	30 A
Gate on threshold	min. 1V, max. 2 V
Drain-source on resistance max.	0.05 Ω
Power max.	96 W

Although this carrier is capable of driving extremely high power loads, please remember that the locktronics system exposes many live conductors. For your safety, we advise you to use this product below a safe limit of 14 V at 1 A.

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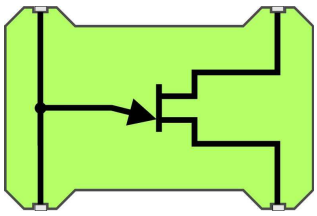
Locktronics technical guide - semiconductors

Unijunction transistor

The unijunction transistor is used in pulse generation and oscillator circuits. There is normally a high resistance between the two base terminals. As the emitter voltage is raised, it reaches a trigger point, where the current between the two base terminals rapidly rises - negative resistance in the transfer curve - after which point the conductivity drops again.

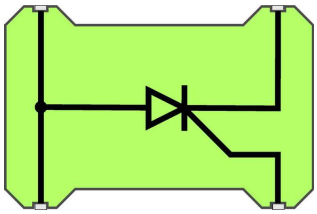


Unijunction transistor carrier

Part number	LK5246
Device type	2N2646
Base current max.	2.0 A
Interbase voltage max.	30 V
Power max.	300 mW
Interbase resistance (no bias)	min. 4.7 kΩ, max 9,.1 kΩ
Emitter trigger threshold	min. 0.56 V, max. 0.75 V

Thyristor

The thyristor is also sometimes known as a silicon controlled rectifier (SCR), and as that name suggests is mainly used for the control of AC voltages.
If the anode-cathode junction is forward biased, a signal at the gate terminal will make the device conduct. The gate signal need only be a short pulse, as the device will then continue to conduct for as long as the junction is forward biased.
Once there is a reverse bias across the anode-cathode junction, the device will cease to conduct.



Thyristor carrier

Part Number	LK5248
Device type	C106D1G
Cathode-anode voltage max.	400 V
Cathode-anode current max.	2.5 A
Trigger voltage max.	0.8 V
Trigger current max.	0.2 mA
Cathode-anode hold current max.	3 mA
Gate reverse voltage max.	-6 V

This carrier is NOT intended for the rectification of the mains electricity supply. It is only to be used for demostrating the principle of rectification using an appropriate low voltage AC source (14 Vrms at 1 A is recommended as a safe maximum)..

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Logic gates

All six basic combinational logic functions are available in the Locktronics range, all based around standard 4000 series CMOS quad gate ICs.

Each carrier has two inputs (marked A and B) and a single output, apart from the NOT gates which require only one input. The output status is also indicated by an on-board LED.

Each input includes a resistor to protect it against excessive input voltages and to limit current draw. There is also a pull-down resistor on each input to ensure that unconnected inputs represent a logic low state.

The current rating of the outputs has been maximised by connecting all four gates of each quad IC in parallel, enabling the carriers to easily drive LEDs or piezo-electric buzzers without the need for a buffer circuit.

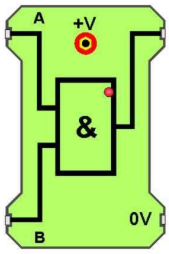
Power is taken from a red 2mm socket on the top of the carrier, the lead for which is provided. There is a choice of either 4mm (L suffux) or 2mm (LE suffix) connectors for the PSU end of the leads.

The carriers are available with either SB (Systems block) or ANSI (US standards) symbols printed on the top. The illustration below shows the complete range, including their part numbers ('LK' codes), and truth tables for each gate's function.

Specifications:

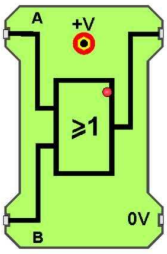
Supply voltage (V_{DD})	3 V to 15 V
Logic input high min.	V_{DD} × 0.75
Logic input low max.	V_{DD} × 0.25
Logic output high min.	V_{DD} × 0.99
Logic output low max.	V_{DD} × 0.01
Input current max.	2 mA
Output current max.	40mA

AND gate IC	MC14081BC
OR gate IC	MC14071BC
NOT gate IC	MC14001BC
NAND gate IC	MC14011BC
NOR gate IC	MC14001BC
XOR gate IC	MC14070BC



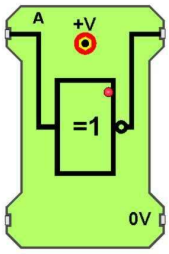
LK6860
AND Gate
LK6870

A	B	Out
0	0	0
1	0	0
0	1	0
1	1	1



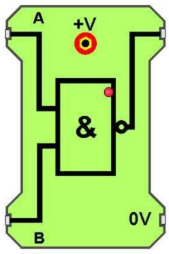
LK6861
OR Gate
LK6871

A	B	Out
0	0	0
1	0	1
0	1	1
1	1	1



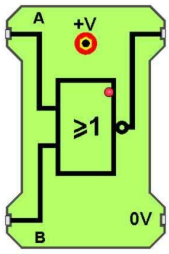
LK6862
NOT Gate
LK6872

A	Out
0	1
1	0



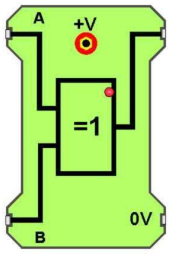
LK6863
NAND Gate
LK6873

A	B	Out
0	0	1
1	0	1
0	1	1
1	1	0



LK6864
NOR Gate
LK6874

A	B	Out
0	0	1
1	0	0
0	1	0
1	1	0



LK6865
XOR Gate
LK6875

A	B	Out
0	0	0
1	0	1
0	1	1
1	1	0

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Systems blocks and ICs

Systems blocks

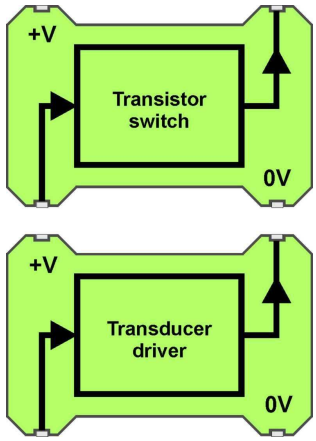
System block carriers feature a variety of small ready-made circuits rather than the usual single components. They provide small building blocks intended to show how an electronic control system can be defined as a series of generic functions, without the need to understand their behaviour at the level of individual components.

Driver blocks

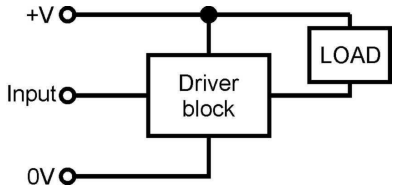
There is a choice of two driver blocks, each of which takes a low-current on/off input and has an output for driving a more powerful load.
The **transistor switch** carrier is suitable for resistive loads requiring up to 200 mA.
The **transducer driver** carrier can drive loads up to 6 A and has built in protection against back EMFs, making it suitable for inductive and capacitive loads such as motors and relays.
The carriers and a typical application circuit are shown to the right.

	Transistor switch	Transducer driver
Part number	LK6831	LK6832
Load current max.	200 mA	6 A
Load voltage max.	25 V	200 V
Power max.	600 mW	70 W
Input saturation point	0.65 V	3 V
Input impedance	39 kΩ	100 kΩ

Although the transducer driver carrier is capable of driving extremely high power loads, for your safety, we advise you to use this product with no more than 14 V at 1 A.



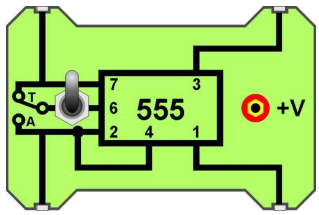
Driver block carriers



Typical driver block connection

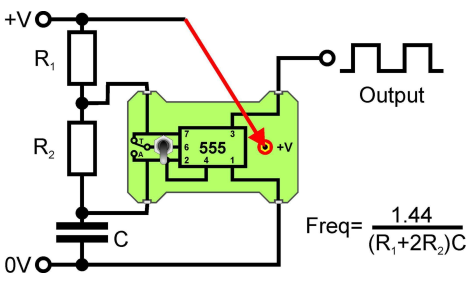
555 Timer

This carrier uses the ubiquitous NE555 IC to make a carrier that can be used for creating monostable and astable timer circuits using the bare minimum of external components.
A toggle switch on the carrier top is used to select the mode used; 'A' for astable mode - a square waveform oscillator; or 'T' (timer mode) - a monostable circuit for generating individual pulses and time delays.
The carrier receives power from a 2mm socket, for which the lead is supplied as standard. Power supply decoupling is also included.
Typical application circuits are shown below.

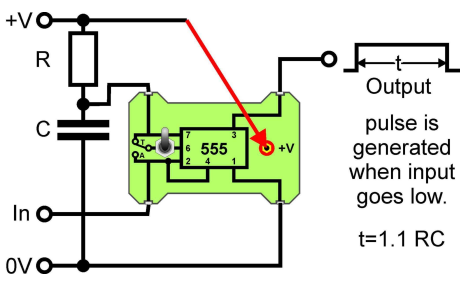


555 Timer carrier

Part number	LK6300
Power supply (V_{cc})	4.5 V to 18 V
Supply current	15 mA
Output current max.	200 mA
Input trigger threshold	V_{cc} × 0.33
Input current	2 µA



555 Timer astable circuit



555 Timer monostable circuit

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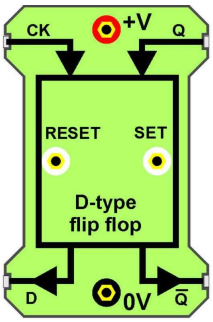
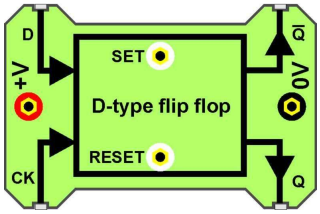
Locktronics technical guide - systems blocks and ICs

D-type flip-flop carriers

These carriers feature a D-type flip flop circuit with access to every possible input and output line.
In order to make best use of the space on a baseboard, it is available with two different arrangements of the carrier connections; referred to as vertical and horizontal - the illustrations opposite will help you to decide which is most appropriate.
Whenever there is a transition from false to true at the clock (CK) input, the value on the data (D) input is passed to the Q output. The data at the output is then locked in place until the next false to true clock transistion.
An inverted output ($\overline{Q}$) always outputs the opposite logic state to the Q output.
Set and reset inputs are also provided, which force the Q output to a logic true or false value respectively when triggered by a false to true transition.
Power, set and reset inputs are all on 2mm connectors; a pack of four leads is provided with the carrier.



D-type flip-flop carrier - vertical

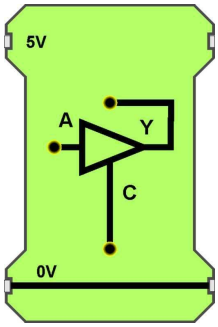


D-type flip-flop carrier - horizontal

Part number - horizontal	LK6500
Part number - vertical	LK6501
Power supply (V_{cc})	3 V to 15 V
Input logic low max.	V_{cc} × 0.3
Input logic high min.	V_{cc} × 0.6
Input current max.	1 µA
Output logic low max.	V_{cc} × 0.05
Output logic high min.	V_{cc} × 0.95
Output current max.	8 mA (V_{cc} = 15 V)

Tri-state buffer

This carrier acts as a buffer between two digital devices.
When the clock (C) input is high, the input logic state is passed directly from the input (A) to the output (Y).
When the clock input is low, the output enters a high impedance state, effectively dicsonnecting the device from the output circuit.
This is especially useful for switching and multiplexing circuits, where signals need to be selectively connected to a device without the possiblilty of unselected signals interfering with each other.
2mm sockets are used for several of the connections - the appropriate leads are provided with the carrier.



Tri-state buffer carrier

Part number	LK6708
Power supply	4.5 V to 5.5 V
Input logic low max.	0.7 V
Input logic high min.	2 V
Input current max.	20 µA
Output logic low max.	0.5 V
Output logic high min.	2.5 V
Output current max.	20 mA

Note that this carrier uses a 74 series TTL device and will require particular care to ensure the the power supply and logic level voltages are within its acceptable range.

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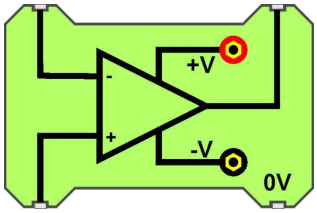
Op-amp module

This is a large carrier fitted with a TL081 operational amplifier IC. Diodes are also included to protect the IC from incorrectly connected power supply voltages. Inputs and outputs are also protected against shorting to 0V or either power rail.
Two 2mm sockets provide the inputs for positive and negative power rails, for use in typical dual-rail amplifier circuits. The appropriate leads are provided with the carrier.

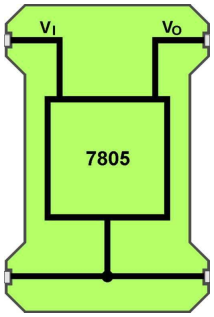


Op-Amp module carrier

Part number	LK7234
Supply voltage rails	±3.5 V to ±18 V
Open loop gain min.	90 dB
Gain•bandwidth	3 MHz
Common mode rejection min.	70dB
Input impedence	$10^{12}\,\Omega$
Power max.	650 mW

Voltage Regulator (7805)

The 7805 regulator takes a high DC input voltage (> 7 V), and outputs a steady 5 V at up to 1 A. The output voltage is regulated to keep the output steady regardless of fluctuations in the power source.
The device is fully protected against short-circuits, overheating and excessive output loads.



Voltage regulator carrier

Part number	LK7208
Output voltage	4.8 V to 5.2 V
Input voltage	7 V to 35 V
Line regulation	4 mV
Load regulation	9 mV
Output current max.	1 A
Short circuit current	230 mA
Output resistance	15 mΩ

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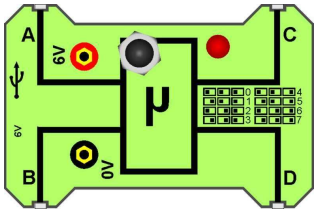
PICmicro microcontroller

The PICmicro microcontroller carrier is essentially an entire small computer system mounted to a locktronics carrier, which can be programmed via its USB connection to perform an endless variety of tasks.
A quick summary of its features is outlined below - a more detailed data sheet can be found on our website (www.matrixmultimedia.com), where you can also find downloads of example programs, and software enabling the device to be programmed from your PC.



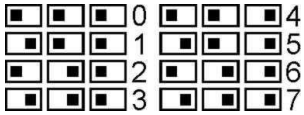
PICmicro microcontroller carrier

Inputs and outputs

The device has four input/output connections labelled A, B, C and D.
You can choose whether these should be inputs or outputs with suitable programming. All four connections have the ability to be digital inputs or outputs in any combination.
In addition, connectors A and B can be used for sampling analogue voltages; and connectors C and D can output PWM signals for driving servos, or to use as analogue outputs (with the addition of a simple low-pass RC filter)

Multiple programs

The PICmicro's internal memory can hold up to 12000 instructions.
These can be divided into eight separate programs. You can then decide which program to run using three small slide switches on the carrier side - the chart to the right (also printed on the carrier) shows the binary switch combinations for each program.
Programs can be reset and started again using the push button on the carrier top.



PIC micro program selection

Dual power sources

The carrier can be powered from either a 6 V power supply via 2mm sockets (leads provided), or from a USB connection to your PC.

USB Reprogrammable

The carrier can be reprogrammed at any time by connecting it to a PC using a USB A to mini-B cable. You can download ready-made programs from our website that tie in with Matrix curriculum worksheets, or use our Flowcode software to write your own.
Programs are retained in the carrier's memory when the power is removed. The device then functions as a stand-alone microcontroller; the USB connection is not needed in order for programs to run.
An LED on the carrier top is used to show when the device is running, and also uses a system of flashes to indicate the flow of data on the USB connection.
We can also supply spare microcontroller ICs (LK8372); useful if you wish to build up a library of programs without the need to keep reprogramming the carrier or have limited access to a PC.

Part number	LK4690
Microcontroller device	PICmicro* PIC18F2455
Power supply	USB, or 6 V PSU
Inputs and output current max.	25 mA
Program memory	12000 instructions
Random access memory	2 k bytes
Non-volatile (EEPROM) memory	256 bytes
Clock speed	4 MHz
Analogue to digital convertor	10 bit resolution

** PICmicro is a registered trademark of Microchip Technology Inc.*

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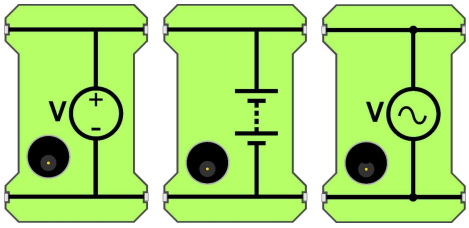
Power/battery carriers

Power source carriers

These are large carriers fitted with a 2.1 mm coaxial power socket. suitable for our plug top power supplies. They are available with a choice of three circuit symbols; a generic DC voltage source symbol, a battery symbol or a generic AC source symbol.
The DC and battery symbol carriers are wired with the centre pin of the socket to the positive terminal and outer conductor to the negative terminal.

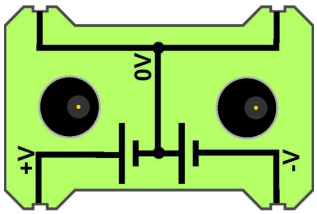


Power source carriers

DC voltage source symbol	LK7461
Battery symbol	LK8275
AC voltage source symbol	LK2340

Dual voltage rail carrier

This has two 2.1 mm coaxial power sockets connected so that two power supplies can be used to provide dual power rails - positive and negative, with a shared 0V line.
The two power sockets are wired with the centre pin as positive, outer conductor as negative.

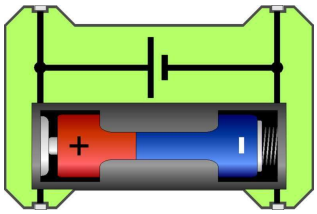


Dual voltage rail power carrier

Part number	LK8492

AA battery holder carrier

This large carrier has a moulded compartment for an AA-size battery - the battery terminals are then available on the carrier legs



AA battery holder carrier

Part number	LK7409

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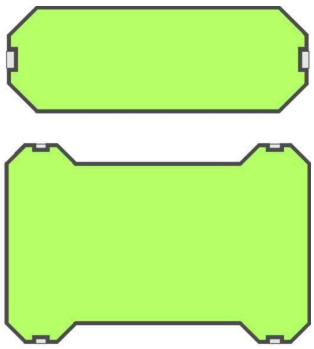
Blank carriers

Blank carrier packs

If the precise component you require is not available in the Locktronics range, we can supply packs of unprinted carriers to which you can solder your own components.
These carriers have the sprung metal legs already attached, and circuit symbols are easily drawn on the carrier top with a solvent based permanent marker.

Carrier size	Part number	Carriers per pack
Small	LK5800	20
Large	LK5900	10

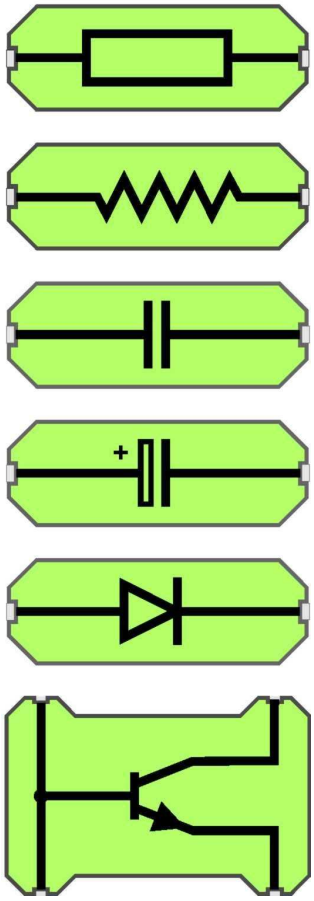


Blank carriers

Print-only carriers

We can also supply individual carriers already printed with generic circuit symbols for the most common component types.
With these, you can construct your own carriers to meet your specific requirements, but still have a smartly printed and wear-resistant circuit symbol.

Carrier symbol	Carrier Size	Part number
Resistor (DIN symbol)	Small	LK7215
Resistor (ANSI symbol)	Small	LK7215A
Capacitor - unpolarised	Small	LK7216
Capacitor - electrolytic	Small	LK7217
Diode	Small	LK8013
Transistor	Large	LK7218



Print-only carriers

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Miscellaneous carriers

Connecting link

A small carrier with a direct link between the two legs. Used as 'wires' to connect other components together.

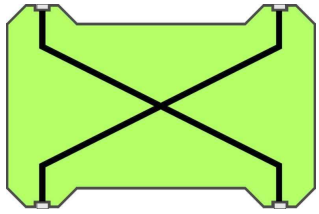
Part number LK5250

Connecting Link

Crossover link

A large carrier with diagonal pairs of contacts connected together. Allows links between circuit elements to cross without shorting together.

Part number LK5251

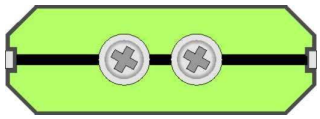


Crossover Link

Fuse/universal component carrier

A small carrier with the two contacts connected to metal pillars with screw terminals. A simple fuse can be constructed by attaching a short length of fuse wire between the terminals. Alternatively any two leaded electronic component can be attached.

Part number LK7936

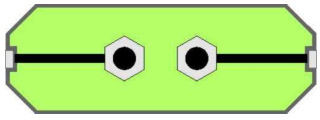


Fuse/universal component carrier

Sampler carrier

A small carrier with large metal pillars connected to the two contacts. Offers a fast way of substituting components by simply touching them to the two contacts - for demonstrating the difference between conductors and insulators, for example.

Part number LK5290

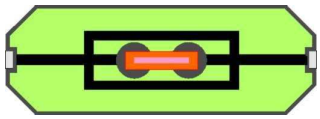


Sampler carrier

Automotive fuse carrier

A small carrier fitted with a fuse holder for standard mini blade fuses, as commonly used in vehicle fuse boxes. Supplied as standard with a five amp quick blow fuse fitted.

Part number LK4786



Automotive fuse carrier

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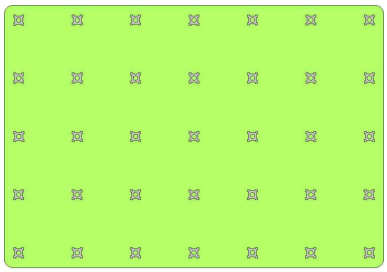
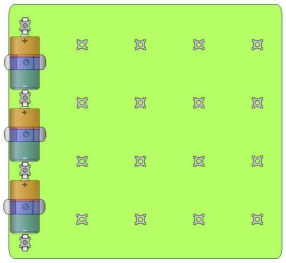
Baseboards

Baseboards are an essential component of the Locktronics system, into which carriers are slotted in order to construct circuits.
Each has a regular grid of plated brass pillars, which are slotted to accept the sprung terminal 'legs' of the carriers. Each pillar also has a socket at its tip to accept the plugs on our range of leads.
The most commonly used baseboard has a seven by five grid of pillars - large enough for arranging the vast majority of the circuits included in our curriculum packs. If a smaller, more portable system is needed, we also have a four by four baseboard - this also includes battery clips to hold up to three C size cells connected in series, enabling you to continue using Locktronics when mains power is not available. (batteries not included)
There is also a choice of two baseboard pillars - with 4mm sockets for standard 'banana' connectors, or with 2mm sockets for labs where 4mm connectors are reserved for high voltage work.
It is also possible to purchase spare pillars and battery contacts to enable baseboards to be repaired in the field.



7 × 5 baseboard



4 × 4 baseboard with battery holders

	4mm sockets	2mm sockets
7 × 5 baseboard	LK8900	LK7302
4 × 4 baseboard	LK3000	LK5940
Spare pillar and bolt	LK3293	LK5939
Battery contact	LK3288	
Battery clip	LK8615	

Power supplies

Adjustable DC supply

This is a plug top power supply ideal for powering the vast majority of Locktronics projects.
The output voltage can be set using a small recessed switch to any of the following voltages:

3 V, 4.5 V, 6 V, 7.5 V, 9 V, 13.5 V

Maximum current output is 1.5 A - enough for any of our curriculum projects, but low enough to be safe in the classroom. It is fully protected against short circuits and overloading.
DC output is on a 1 metre lead, supplied with a range of interchangeable plugs - including the 2.1mm coaxial power plug used by our power source Locktronics carriers.
The versatile switched mode design, and interchangeable mains connectors mean that it is truly international - suitable for use at any mains voltage from 100 V to 240 V, and from 50 Hz to 60 Hz.

Adjustable DC supply

AC power supply

Where an AC source is needed, for example, when teaching rectification, this plug top 12 V, 1 A supply is ideal. All of the principles of AC electricity can be taught without any chance of coming into contact with the mains supply. Available to suit three different mains standards.

Triple rail ±12V power supply

This is a more specialised supply, used for our Engineering Panels, Electronic Workstation and Protostation. There are three voltage outputs:

+12 V at 2 A, +5 V at5 A, -12 V at 800 mA

The input will accept any mains voltage from 90 V to 250 V at between 50 Hz and 60 Hz. We can supply IEC mains cables suitable for using this supply in a range of territories.

	Part No.
Adjustable DC supply	HP5328
AC power supply, UK	HP3728
AC power supply, Euro	HP4429
AC power supply, USA	HP4688
Triple rail ±12V supply	HP8405
IEC main lead, UK	HP3701
IEC mains lead, Europe	HP3702
IEC mains lead, USA	HP3703

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Non-carrier components

MES bulbs

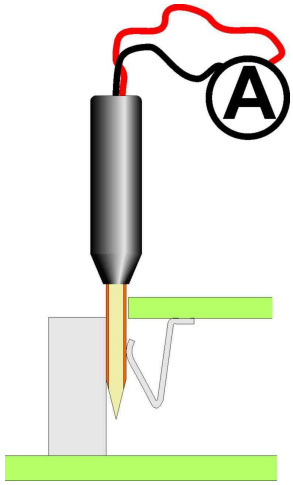
We stock a wide variety of both traditional incandescent bulbs, and LED bulbs, to fit the MES sockets on our lampholder carriers.
LED bulbs are becoming increasingly common, especially in automotive applications, due to their long life, low running temperature and high efficiency. Like all LEDs, they must be connected with the correct polarity - so we have designed a carrier specifically for this purpose with the polarity clearly marked. Series resistors are not needed with these LEDs as they are incorporated into the body of the bulb.
The table to the right shows data for the complete range of MES bulbs.
See page 12 for suitable lampholder carriers.

Part no.	Type	Voltage	Current
LK2341	Incandescent	2.5 V	200 mA
LK2347	Incandescent	6.0 V	40 mA
LK2350	Incandescent	6.5 V	300 mA
LK2363	Incandescent	14 V	60 mA
LK6749	LED, Red	12 V	20 mA
LK6822	LED, Yellow	12 V	20 mA
LK6841	LED, White	12 V	20 mA

Current probe

Taking current measurements using a multimeter can sometimes be rather awkward - the ammeter needs connecting in series, requiring a break to be made in the circuit.
The Locktronics current probe makes this much more easy: a thin blade coated each side in copper simply slips between any carrier contact and baseboard pillar, through the small notch at the root of each carrier 'leg'.
A pair of leads teminated in 4mm plugs then allow a multimeter (or one of our moving coil meters) to be connected across the gap created in the circuit.
An insulated handle ensures that there is no need to touch the live contacts on the baseboard or carrier.

Part number LK5100

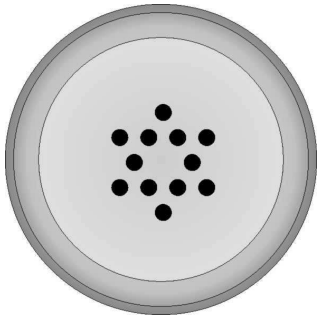


The locktronics current probe inserted between pillar and carrier

Earphone/microphone

A telephone style moving armature transducer that will function equally well as either a microphone or an earpiece.
Complete with 40cm flying leads terminated with 4mm 'banana' plugs.

Part number	LK5270
Impedance	2400 Ω (1 kHz)
DC resistance	280 Ω
Frequency response	200 Hz to 1000 Hz (-3 dB)
Power max. (earphone)	200 mW
Sensitivity (earphone)	120 dB SPL / mW
Typical output (microphone)	0.5 mV (speech at 2.5 cm)



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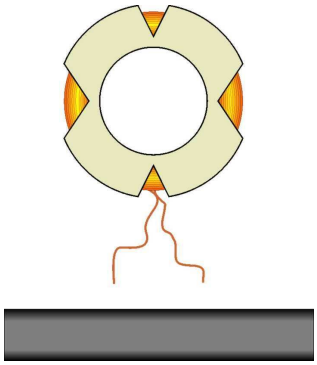
Magnetism and inductors

Induction coil and ferrite

The induction coil is a 400 turn coil of enamelled copper wire wound onto a small toroidial plastic former, with the free ends stripped of insulation ready for attaching to crocodile clips or terminal pins.
A ferrite rod is available seperately that can be inserted through the coil to show the increase in inductance, or to couple two coils together to demonstrate mutual inductance.



Inductance coil and ferrite

Inductance coil

Part number	LK5299
Outer diameter	21 mm
Hole diameter	11 mm
Inductance without core	2.4 mH
Inductance with ferrite core	12 mH

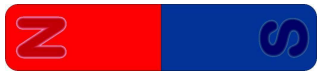
Ferrite rod

Part number	LK3290
Length	50 mm
Diameter	9 mm

See our Ferrite rod carrier on pg.8 if you need a more permanent mounting for the coil and ferrite.

Bar magnet

A small ferrite block magnet suitable for use with our reed switches (see pg.10) and Hall effect sensor (pg. 16).
North and south poles are clearly marked.



Bar magnet

Part number	LK0123
Dimensions	40 mm × 8 mm × 8 mm

Small compass

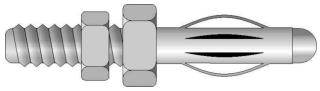
A small plotting compass that can be used to show the orientation of the magnetic field when demonstrating magnets and electromagnetism.

Small compass

Part number	LK0124
Dimensions	Ø15 mm × 5 mm

Terminal post

This provides a convenient way to attach loose components or bare lead-out wires to your locktronics system. At one end is a threaded screw terminal, and at the other, a 4mm 'banana' connector.



Terminal post

Part number	LK5295

Leads

We offer a complete range of leads, in a variety of colours, lengths and connector types. All are rated to at least 3 A at 50 V.
Please see our website or catalogue for a complete listing.

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Laws of electromagnetism apparatus

Lenz's Law

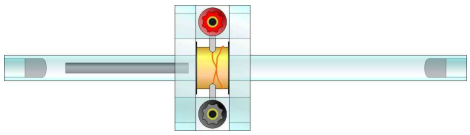
Used to demonstrate the rule that a moving magnet induces a current in a conductor that always opposes its motion.
This consists of a copper tube and two metal cylinders. When you drop the cylinders through the tube, one moves much more slowly than the other - because, although it looks identical, it is actually a powerful neodymium magnet.
A perpex window in the copper tube means that the motion of the cylinders can always be seen clearly.
Removable plastic end caps ensure that you won't lose the cylinders when the apparatus is not in use.

Lenz's law apparatus

Part number LK7487
Dimensions Ø18 mm × 330 mm

Faraday's Law

An apparatus for demonstrating the current induced in a conductor by a moving magnetic field.
Consists of a clear perspex tube containing a powerful neodymium rod magnet. Wound around the centre of the tube is a 400 turn coil terminated with 4mm binding posts.
When the tube is turned over, the magnet drops through the coil, and a current can be measured on an oscilloscope or ammeter as it passes through the coil.
The magnet is sealed inside the apparatus, and the coil is bonded to the surface of the tube - so the parts cannot become seperated and lost.

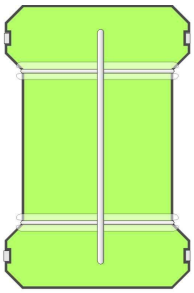


Faraday's law apparatus

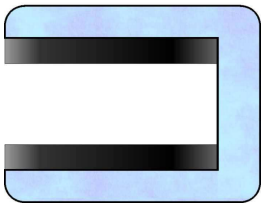
Part number LK7489
Dimensions 400 mm × 60 mm × 40 mm

Fleming's left hand motor rule

This is used to demonstrate that a conductor carrying a current has a force exerted upon it when placed in a magnetic field; and that the direction of that force can be predicted from the direction of the current and magnetic field.
It consists of two metal 'bus bars' stretched across a large locktronics carrier. A plastic yoke holds two magnets above and below the carrier to provide the magnetic field. A small length of metal rod placed on the bus bars will jump off the carrier as soon as a current is applied to it via the bus bars.



Fleming's left hand rule apparatus



Part number LK6482

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Instruments

Multimeter

This is a 3½ digit digital multimeter, complete with test probes, PP3 battery and holster.
As well as 32 different measurement ranges, there is a continuity buzzer and a semiconductor testing socket.
The holster enables the meter to be wall mounted or placed at a convernient angle on a desktop.

Part number	LK1110
DC voltage ranges	200mV, 2V, 20V, 200V, 1000V
AC voltage ranges	200mV, 2V, 20V, 200V, 700V
DC current ranges	20µA, 200µA, 2mA, 20mA, 200mA, 2A, 10A
AC current ranges	20µA, 200µA, 2mA, 20mA, 200mA, 2A, 10A
Resistance	200Ω, 2kΩ, 20kΩ, 200kΩ, 2MΩ, 20MΩ, 200MΩ
Semiconductors	Diode, transistor NPN, transistor PNP
Continuity	Buzzes at < 50Ω

3MHz signal generator

A desktop function generator with 4 digit LCD frequency display and outputs on standard BNC connectors.

Part number	LK8990
Waveforms	Sine, triangle, square (variable PW, symmetry)
Frequency range	0.03 Hz to 3 MHz
Output	2 mV to 20 V peak to peak
Impedance	50 Ω or 600 Ω

PC based oscilloscopes

We have a choice of two USB oscilloscopes. Signals are connected via standard BNC sockets, and passed to your PC via the USB connection. Signals are then displayed on your PC monitor using the included PicoScope* software.
This has many advantages over a traditional CRT oscilloscope, including the ability to store multiple readings to your hard drive, spectrum analyser display, frequency and timing analysis, and a far smaller footprint on your lab bench.

	Pico 2203	**Pico 4000**
Part number	LK4679	LK6730
Bandwidth	DC to 5 MHz	DC to 20 MHz
Sampling rate max.	40 MS/s	80 MS/s
Buffer memory	8 kS	32 MS
Resolution (standard)	8 bit	12 bit
Resolution (enhanced)	12 bit	16 bit
Channels	2	2
Input impedance	1 MΩ	1 MΩ
Signal generator	Custom waves	n/a
Input range	20 V pk-pk	100 V pk-pk

PicoScope is a registered trademark of Pico Technology Ltd.

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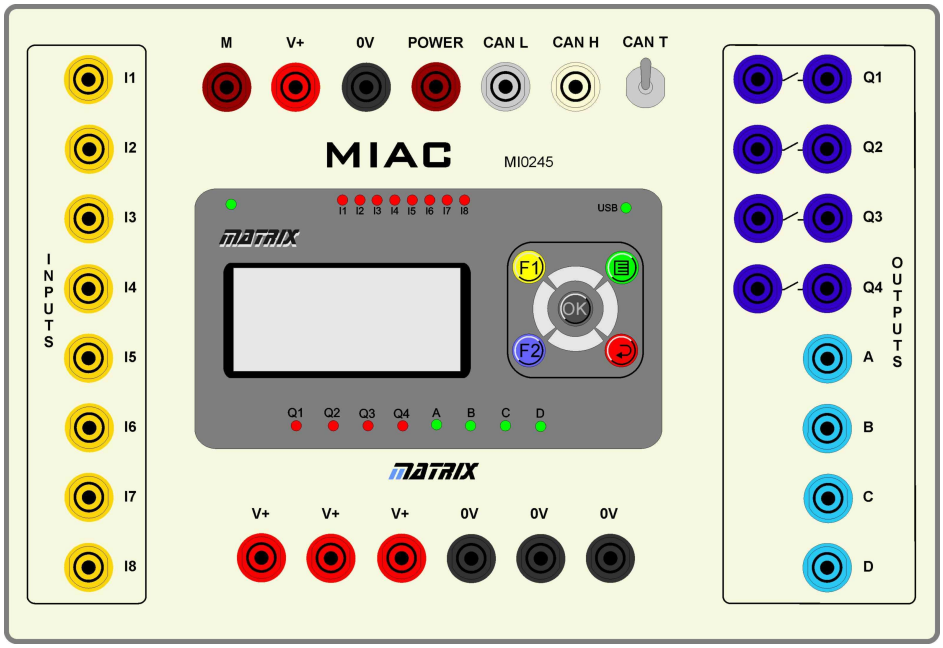
MIAC



This is one of our MIAC programmable industrial controllers adapted to make it easier to use with the Locktronics range.

The controller 'brain' is based around a PICmicro microcontroller which can be connected to a PC via USB and programmed to perform a limitless variety of functions. We also have available software for programming the MIAC, and a suite of ready-made programs suitable for use with our curriculum worksheets

There are inputs and outputs for sensing and controlling both digital and anaogue signals, including high current transistor outputs and relays for directly connecting motors and actuators.

An LCD screen and a set of rubberised control buttons allow the user to interact with the programs as they run.

CAN bus connections allow the simulation of the interfacing between modern automotive and industrial control and sensing modules.

The whole unit is fitted into into a sturdy ABS plastic case, and all of the inputs and outputs are brought out to the top panel on shrouded 4mm 'banana sockets'.

A more detailed description of the MIAC, alonng with programming software and demonstration programs, can be found on our website at www.matrixmultimedia.com.

Part number MI0245

Main features

- 8 inputs suitable for analogue or digital signals
- Four relays
- Four high current motor outputs, 2 with with programmable PWM.
- CAN bus with switchable termination.
- Multiple power outputs
- LCD screen
- Keypad with cursor keys and function buttons.
- LED indicators for all inputs and outputs
- Protected from shorts circuits, overloading, reverse polarities
- Program memory: 12000 instructions
- RAM: 2k bytes
- USB programmable using Flowcode, C++ or assembly
- LabView and Visual Basic compatability
- Sturdy ABS casing with shrouded 4mm sockets

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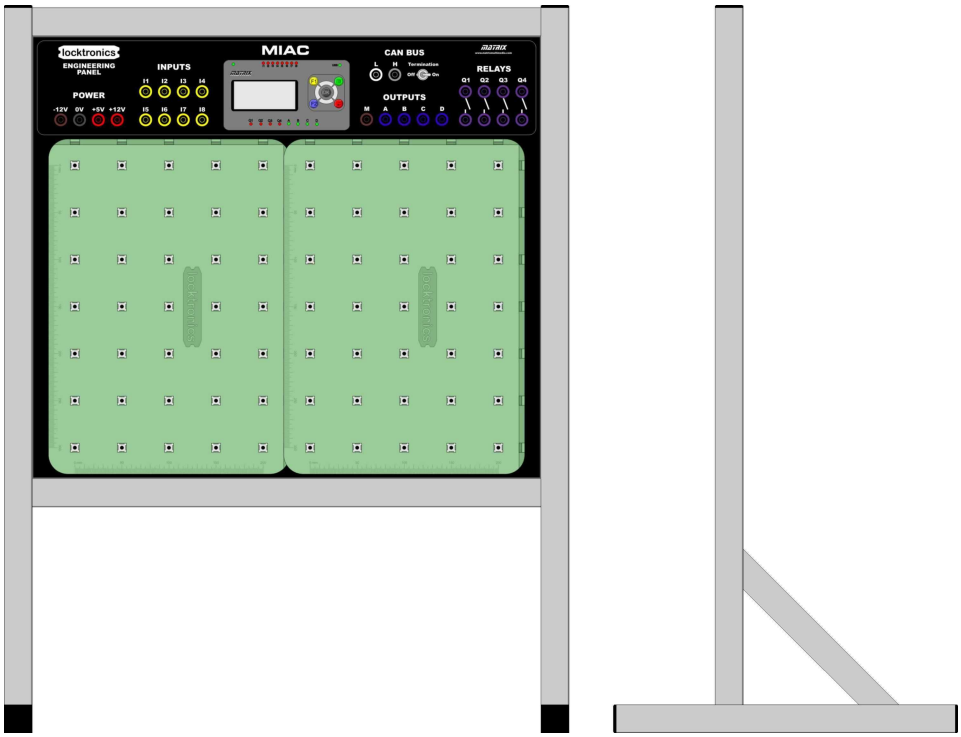
Engineering panel



Like the MIAC unit described on the previous page, this unit integrates a programmable inductrial controller with the locktronics system.

In this case, the unit is designed around a strong aluminium frame, supporting the MIAC 'brain'; 4mm connectors for inputs, outputs and power; and two interlocking locktronics baseboards for a total grid of ten by seven pillars. A triple rail power supply provides -12V, +5V and +12V sources as up to 5A (+5V).

This product will be appreciated by organisations teaching electronics for automotive and industrial applications, where complex circuit configurations may be required. The MIAC unit, with its CAN bus connection, is able to simulate the complex interaction of components used in modern vehicle systems and process automation.

For a full specification we have a .pdf data sheet, and application examples, available from our website at www.matrixmultimedia.com

Part number HP2673

Main features

- 8 inputs suitable for analogue or digital signals
- Four relays
- Four high current motor outputs, 2 with with programmable PWM.
- CAN bus with switchable termination.
- Multiple power outputs
- LCD screen
- Keypad with cursor keys and function buttons.
- LED indicators for all inputs and outputs.
- Protected from shorts circuits, overloading, reverse polarities.
- Program memory: 12000 instructions
- RAM: 2k bytes
- USB programmable using Flowcode, C++ or assembly
- LabView and Visual Basic compatability.

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Further information

More detailed descriptions of many of these products can be found on our website - along with details of our other product lines, software downloads, access to technical support, and our range of freely downloadable teaching resources. Alternatively you can contact us at the address below with your enquiries Our sales staff will be happy to provde a free, no obligation quotation should you be considering ordering from us.

Contact details

Matrix Multimedia Ltd.
The Factory
Emscote Street South
Halifax
West Yorkshire
HX1 3AN
UK

Telephone: 01422 252380
Fax: 01422 252381

Web: www.matrixmultimedia.co.uk
Email: sales@matrixmultimedia.co.uk

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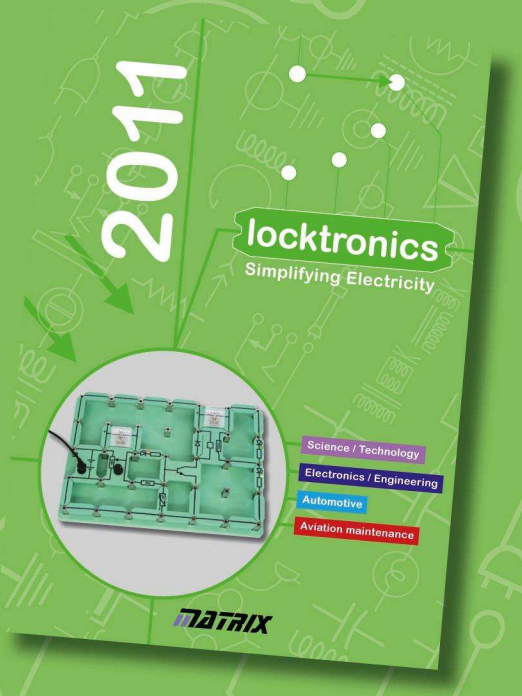

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Matrix Multimedia Limited
The Factory, Emscote Street South,
Halifax, West Yorkshire, HX1 3AN, UK.

Tel: 01422 252 380
Fax: 01422 252 381

Email: sales@matrixmultimedia.com