SECTION 1: INTRODUCTION

1.1: WHAT IS 'MAGIC WIRE'

Magic Wire is additional hardware and software that works with the Lesvedome system from Pierre de Ponthiere. The Lesvedome system is a system for controlling an astronomical observatory dome and shutter, full details are available at http://www.dppobservatory.net/DomeAutomation/DomeDriver.php. Briefly, the Lesvedome system comprises an ASCOM software driver that controls a hardware interface board made by Velleman nv in Belgium, either a self-assembly K8055 board or the ready built VM110. They are identical in use. The hardware board provides a number of signal outputs and inputs under the control of the Lesvedome ASCOM software. It is these signals that, after further conditioning, actually control the motors that causes the dome to rotate and the shutter to open or close.

The Lesvedome website has schematic design examples for various types of relay circuits to suit different types of dome and shutter. All the designs use electrical relays to switch the current to the motors on and off in response to the signals from the ASCOM driver via the Velleman board. The Velleman board incorporates driver chips (ULN2803a) that are sufficiently powerful to drive the relays that in turn switch the motors on and off and set the direction of rotation for the motors. These relay circuits are built by you - the user of the Lesvedome system.

This arrangement of the Lesvedome ASCOM driver software driving an interface board that then drives relays which finally drive the motors that do the work provides a relatively simple system that is suitable for building at home and has been used by many amateur astronomers to allow their observatories to automatically rotate in synchrony with their telescopes. However, for control of the observatory shutter there is one problem that the Lesvedome system does not solve. For most dome type amateur observatories, the shutter is in the rotating part of the observatory - the dome itself. This means that it is very difficult to make any permanent wired connections between the static part of the observatory and the rotating part without the risk of the connecting wires becoming tangled, snapping, etc.

This in turn means that it is normal to use a battery, mounted in the rotating dome, to power the motor that drive the shutter. Leaving aside the need to recharge the battery after use, if full automation is desired there is still the problem of how to send the output signals from the Velleman board - mounted somewhere in the static part of the observatory - to the relays and motor in the moving dome.

This is what the Magic Wire system does. It is a solution to that problem that uses of a pair of inexpensive radio transmitter/receivers that, when installed with suitable control circuits, provide the required signals as if the Velleman hardware board outputs were connected to the shutter relays using a length of 'magic' wire. There is of course, no wire but the Magic Wire output driver chip is identical to the one provided on the Velleman board and so the Magic Wire will solution will work with any of the published relay circuit designs without needing any other changes.

1.2: HOW HARD IS IT TO MAKE 'MAGIC WIRE'?

These are the words that come from the LesveDomeNet Help files - with some additions. Please be aware of them before deciding to attempt this project!

LesveDomeNet system is not a "Plug and Play" solution - And neither is the 'Magic Wire' Radio Link.

The Magic Wire system requires soldering, wiring and assembly.

If you can understand basic circuit diagrams and use a voltmeter then you will do fine. You also need the ability to solder using a fine-tip soldering iron. This job does not require you to be an expert in electronic and electrical engineering, nevertheless some minimum of knowledge is required. If you don't feel comfortable, try to find a friend to help you.

To make things as simple and reliable as possible, the two Magic Wire modules that you will need to make both use ready-made printed circuit boards and all the components in the Parts List in Section 2 are designed to fit these boards. You don't need to design anything or make any calculations. All you need to do is identify what component goes where on each circuit board and solder it in place.

All the connections that are made to the completed circuit boards are made using screw connectors so the final hook-up is kept simple.

I have included some hints and tips in Appendix 1 to help you with learning how to add components to ready-made printed circuit boards like the ones that magic Wire uses.

You will need a basic set of tools as described in Section 2: Construction. If you don't already own these then you should budget about €50 - €100 to buy all the tools needed. Of course, when you have bought them they will go on being useful for many years.

You will need to download the free Arduino software onto your computer and then use it to upload the Magic Wire programs to the modules once you have made them. I have tried to give full instructions on how to do this so you don't need any previous experience. You will also use the Arduino software to configure the operation of Magic Wire in a way that you want.

Don't forget that Magic Wire is only one part of the Lesvedome system. You will still need to decide on which type of relay controller you are going to use then select suitable components and finally build it.

Finally, unless you are very fortunate, you are also going to have to design, fabricate and install the actual hardware to rotate the dome and open and close the shutter. This requires a considerable investment in time and energy as well as having a practical nature and being comfortable using construction tools.

1.3: HARDWARE OVERVIEW

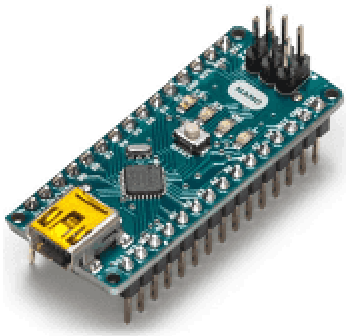
The Magic Wire system comprises two hardware modules, each built on its own purpose designed printed circuit board. One module, called the STATIC module, is located near to the Velleman hardware board (K8055 or VM110). This will normally be in the static, non-rotating part of the observatory. The second module is the MOVING module and this is mounted near to the relay board (or box) that actually controls the shutter drive motor. In use, the two modules communicate via radio signals. The STATIC module is connected to the two Digital Outputs on the Velleman board that are used to control the shutter motor (DO5 - motor on/off and DO6 - motor direction). The Lesvedome software sets these outputs so that the shutter can be opened or closed as required and the STATIC module sends this information to the MOVING module which then exactly reproduces the states of the Velleman Digital Outputs using a relay driver chip that is identical to the one on the Velleman board. So, the relay circuit in the dome sees the Lesvedome commands (open shutter / close shutter) as if they came directly from the Velleman board in the non-rotating part of the observatory.

Each module uses a low cost, pre-built radio transmitter/receiver and an Arduino Nano microcontroller to supervise the transmission and receiving of the information. Because we are using microcomputers to control the radio chips we can also add some additional functions to the design. These are described in more detail in the next section. The hardware for the STATIC and MOVING modules already includes all the components needed to allow these extra functions. It is up to you, the user, to decide which of the options you want to include and you can then activate your choice by making some simple changes to the software.

1.3.1: Radio Modules.

The radio transmitter / receiver modules are based on the Nordic Semiconductor nRF24L01+ radio ICs. To keep things simple, ready built radio modules are used in this design. The modules incorporate the nRF24L01+ chip with together with all the components needed to make a functioning radio transceiver. These modules are readily available at a low cost, for example in the UK from https://hobbycomponents.com/wired-wireless/156-nrf24l01-24ghz-wireless-radio-transceiver-module at a cost of £1.99 each.

1.3.2: Arduino Nano V3 Clone

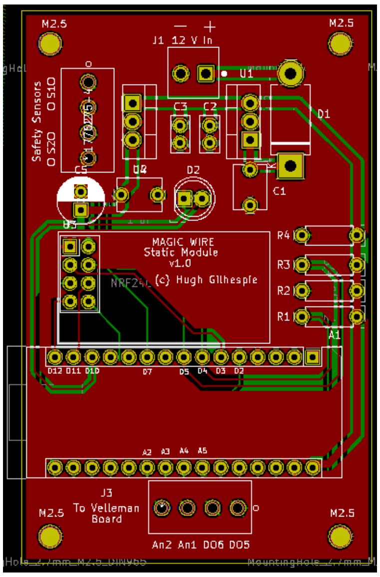


1.3.2: Arduino Nano V3 Clone - Continued

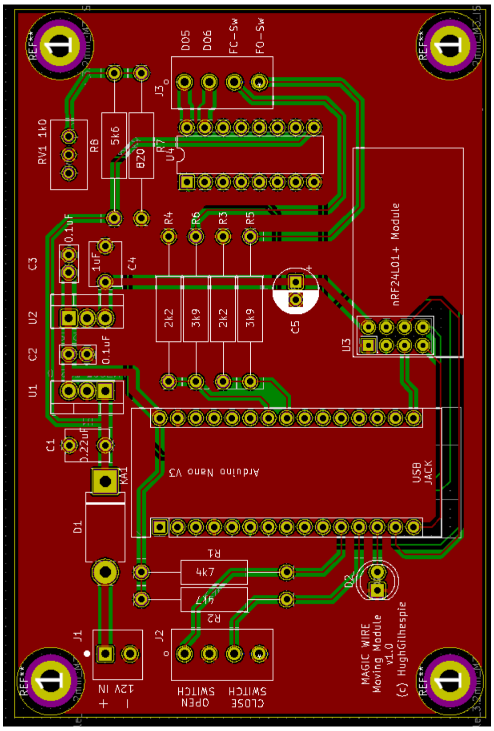
To use the radio module it needs to be connected to a microprocessor. This design uses the Arduino Nano board (or suitable clone) to supply the microprocessor part of the design. Nano V3 clones are also readily available for around £3.50 from UK based suppliers on EBay or, in the UK, at a cost of £3.89 from https://hobbycomponents.com/development-boards/638-arduino-compatible-nano-with-ch340-usb-ic.

1.3.3: Static and Moving Module Printed Circuit Boards

Static Module PCB



Moving Module PCB



The Magic Wire system consists of two separate units. The Magic Wire Static module that is mounted in the non-moving part of the observatory, near to the Velleman board and the Magic Wire Moving module that is mounted in the rotating observatory dome. Each module has a purpose designed printed circuit board (PCB) that the Arduino Nano and the nRF24L01 plug into. Each PCB also has the components needed to supply power to the Arduino (5 volts) and the nRF24L01+ (3.3 volts) and some extra components that are needed for operation of each unit.

The connections to the boards are made using screw connectors for ease of use. The PCBs are available from various suppliers both in the UK and internationally. See Section 1.4 for details. Please note that the boards are supplied as bare boards and you will need to purchase separately all the components needed and then solder these onto the boards. All components are 'through-hole' type to make the soldering as easy as possible. The components in the Parts List in Section 2 are all designed to fit theses boards.

1.3.4: Additional Circuitry

Radio Module Power Supplies

Most if not all hardware designed to work with the Lesvedome will use a 12 volt or sometimes even 24 volt supply to run the relays and motors. This design is based on using 12 volts as the supply voltage but it could be adapted to use a 24 volt supply if needed. Each of the two radio modules, the static module and the moving module need a way of obtaining a 5 volt supply for the Arduino Nano and a 3.3 volt supply for the nRF24L01 radio from the 12 volt already available. This is done using simple 3-terminal linear voltage regulator chips with decoupling capacitors.

Radio Module External Connections

To make life as easy as possible, screw terminals are used to connect the modules to the external world. Both static and moving modules have screw terminals to connect to the 12 volt power. The static module has screw terminals to connect to the Velleman board outputs and inputs as required and the moving module uses screw terminals to connect to the motor relays and limit switches. There are also additional screw connectors on the static module that allow two safety sensors to be connected if desired. If sensors are used, when they activate they cause the shutter to close automatically. The moving module has connections for a manual switch that will allow the shutter to be opened and closed at any time.

Moving Module Relay Driver

The moving module has to operate the relays that control the shutter motor and the outputs available from an Arduino Nano are not powerful enough to do this on their own. The moving module uses a separate driver IC connected to the Arduino output signals to provide enough power to drive the relays. The driver IC used is a ULN2003a, which has the same internal circuits as the ones used by the Velleman board. Thus, if the relay circuit works when directly connected to the Velleman board, it will also work using the radio module.

SECTION 2: CONSTRUCTION

2.1: CAUTIONS

These are the words that come from the LesveDomeNet Help files - with some additions. Please be aware of them before deciding to attempt this project!

LesveDomeNet system is not a "Plug and Play" solution - And neither is the 'Magic Wire' Radio Link.

The system requires soldering, wiring and assembly.

If you can understand basic circuit diagrams and can use a voltmeter then you should do fine. You also need the ability to solder using a fine-tip soldering iron. This job does not require you to be an expert in electronic and electrical engineering, nevertheless some minimum knowledge is required. If you don't feel comfortable, try to find a friend to help you.

Finally, although it is not directly related to the Magic Wire system, my personal view is that you should not try to build an automated observatory using mains powered electric motors. Low voltage DC motors are MUCH SAFER!

2.2: LESVEDOME AND LIMIT SWITCHES

The Lesvedome ASCOM driver needs to make sure that when the shutter moves, it has reached the fully opened or fully closed position. To achieve this, the Lesvedome software operates the shutter in one of two ways. The simplest way is that the shutter motor is turned on for a pre-set time period. The motor is held on for long enough to make sure the shutter has fully transitioned from either fully open or fully closed to the opposite state. The second way of operating is to monitor limit switches that are activated by the movement of the shutter when it reaches either fully open or fully closed. These limit switches perform two functions. The main function is to cut off the power to the shutter motor when the shutter has reached either fully closed or fully open. The secondary function occurs when these limit switches are also connected to two Analog inputs on the Velleman board and inform the Lesvedome software when an open or close operation has been completed. The advantage from this is that instead of having to wait a pre-determined time, the Lesvedome system is ready again as soon as the fully open or fully closed shutter state is detected.

This is what the Lesvedome help file says about using limit switches:

> **CAUTION:** The limit switches have to switch off the shutter motor, when the shutter move is completed.
>
> **Don't rely on software to switch off the shutter motor**

So, whichever way you decide to operate the shutter, either just using the timer in the Lesvedome User Interface setup form or connecting the outputs from the limit switches directly to the Velleman board - YOU SHOULD BE USING LIMIT SWITCHES TO TURN OFF THE MOTOR POWER WHEN A SHUTTER MOVE IS COMPLETE.

2.2.1 The Magic Wire Relay Schematic

Firstly, please be aware that the Magic Wire system is just the two boards for transferring the relay control signals by radio. It DOES NOT INCLUDE the relays and other components that are needed to make a functioning shutter control system. These notes are designed to help if you choose to use the Shutter Relay schematic included in Appendix 5.

There are a number of schematic files on the Lesvedome web site that show how to wire up the relays for shutter operations. Some of these use limit switches and some do not. If you haven't yet built your Lesvedome shutter controller **I STRONGLY RECOMMEND** that you use the Shutter Relay schematic included in Appendix 5. If you have an existing shutter relay controller, **I STRONGLY RECOMMEND** that you retro-fit limit switches to your installation.

The Magic Wire Shutter Relay schematic has been thoroughly tested with the Magic Wire system. This section gives some notes on the specifications for the parts you will need if you want to build the Magic Wire Shutter Relay from the schematic in Appendix 5.

If you are not using the Magic Wire Relay Schematic, you will still need to fit suitably rated limit switches that have SPDT (Single Pole Double Throw) changeover contacts. These will have THREE connections. One connection will be marked C (Common), one is N/C (Normally Closed) and the third is N/O (Normally Open). You will also need to wire your shutter control relays using the Relay Schematic given in the CONSTRUCTION section of this document.

The contact marked C for Common, is connected to the 12 volt power to the motor, the N/C (Normally Closed) contact is connected to the motor. This contact is connected to the Common contact all the time the switch is NOT activated, so the motor receives power until the switch activates at the end of the shutter travel. This cuts off the power to the motor. At the same time, when the switch activates in connects the C contact, at 12 volts, to the N/O (Normally Open) contact. This contact is connected to the Magic Wire MOVING board and the board detects the voltage and sends a signal, via the radio link, to the Static Module that connects to the Velleman board.

<u>Magic Wire Relay Schematic Limit Switch Specifications</u>

If you use the Magic Wire Relay Schematic you will need two limit switches, one for fully open and one for fully closed. The limit switches needed for the Magic Wire Relay Schematic are 'changeover' type switches with 3 contacts. They are usually described a SPDT (Single Pole Double Throw) types. The switch contacts must be rated for the motor current. A switch with a contact rating of 10 amps DC will normally be suitable.

The best type of switches in my experience are Snap-Action Roller Arm types. A suitable part from DigiKey is

DigiKey part No. SW705_ND. This is an Omron switch, rated for 10 amps DC at up to 30 volts and the January 2020 price from DigiKey is £2.72 each.

<u>Magic Wire Relay Schematic Diode Specifications</u>

The operation of the relays relies on 4 diodes to control the direction of the flow of current through the relays. Another 2 diodes are used to suppress high-voltage transients across the relay coils. All diodes are the same type and most rectifier diodes would be OK. I suggest using 1N4007 diodes. A suitable part from DigiKey is 1N4007-TPMSCT-ND. These are £0.08 each.

2.2.1 The Magic Wire Relay Schematic - Continued

Magic Wire Relay Schematic Relay Specifications

The relays will need to be chosen to suit the current rating of the shutter drive motor. The Magic Wire system is designed for 12 volt operation and the relays should be 12 volt types. They need to have DPDT type contacts. I would recommend relays with contacts rated for a minimum of 10 amps DC operation.

The relays need to have coil operation currents of below about 250 mA. The maximum current from the ULN2003A is 500 mA any one channel, so for operating two relays simultaneously a maximum coil operating current of 250 mA per relay is safe.

The Lesvedome web site recommends relays meeting the following specifications:

> Lesvedome Website Relay specifications
>
> A lot of relays can be used, e.g. Velleman item VR10HD122C
> http://www.velleman.be/es/en/product/view/?id=317946
>
> These relays are plugged on Velleman SO8P sockets
> Coil voltage 12VDC
> Coil resistance 160 Ohm [Coil current about 75 mA]
> Contacts: 2 x inverter (DPDT: Double Pole Double Throw)
> Contact rating 10A/24VDC or 220 VAC

If you prefer a DigiKey part, I suggest DigiKey 1864-2789-ND. This is a 12 volt operated relay with 10 amp DPDT contacts. The relays are designed to fit a DIN rail mounted socket, DigiKey part 1864-2883-ND. The total cost for two relays and two sockets in January 2020 is about £18.00 excluding shipping and VAT.

Boxes for Lesvedome with Magic Wire

If you intend to make a nice, neat job of your Lesvedome system it is almost certain that you will want to mount the components in some sort of enclosure. And so you should! But DO NOT PUT THE MAGIC WIRE BOARDS IN METAL ENCLOSURES! Plastic enclosures are fine but the radios won't work if enclosed in metal boxes.

2.3: TOOLS REQUIRED

This section discusses the tools you will need to make, test and calibrate the Magic Wire system. It is specific to the Magic Wire part of the overall Lesvedome system although of course the tools you use for Magic Wire will almost certainly be used throughout the overall project.

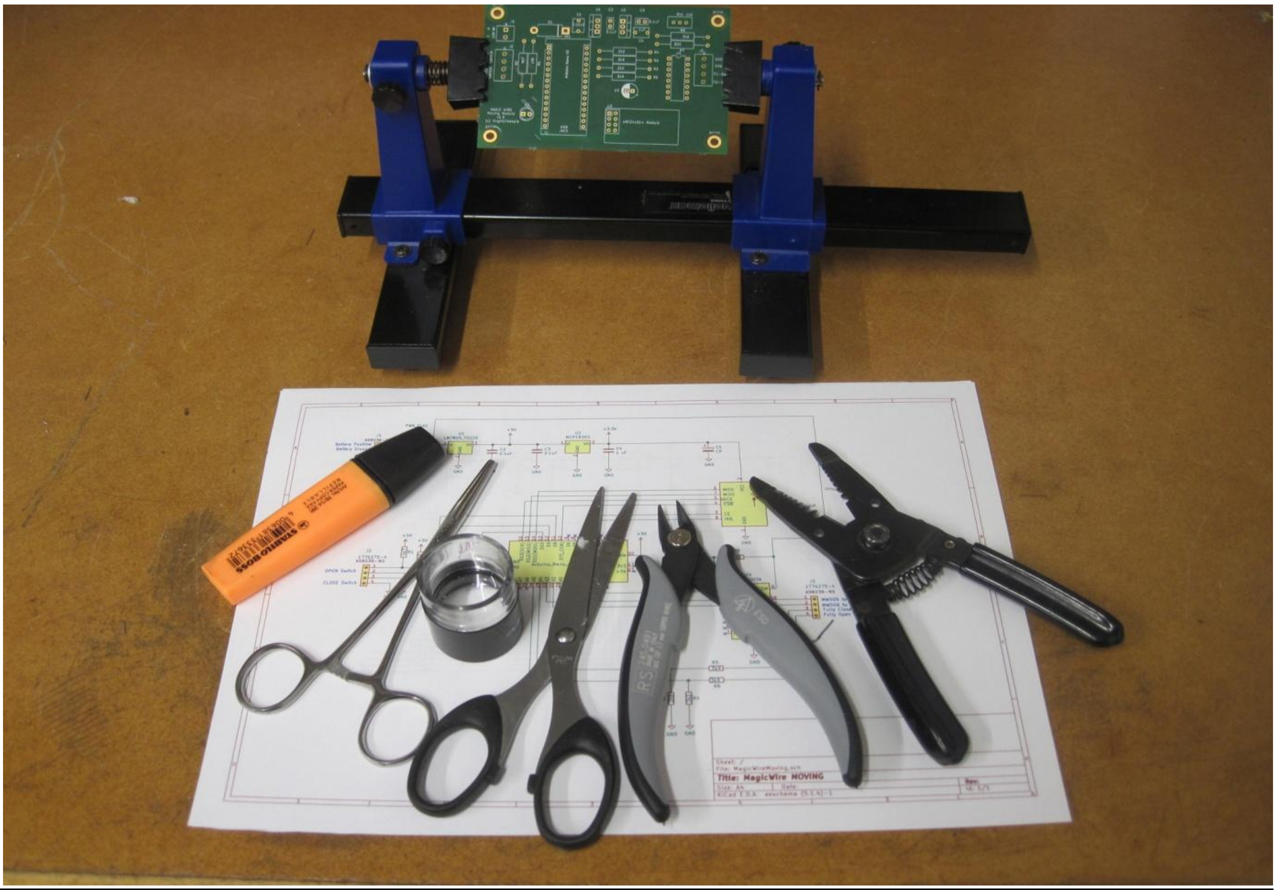
2.3.1 Soldering Tools

Although not strictly necessary, I recommend using a temperature controlled soldering station. These make soldering so much easier that they are worth the extra cost. The one illustrated below is from Circuit Specialists Europe and including VAT, costs about £36.00. See https://www.circuitspecialists.eu/soldering/soldering-stations/csi-deluxe-60w-digital-soldering-iron-station-csi-station3dlf-792/ for more details. The important thing is to get an iron with a fine chisel tip, about 1 to 2 mm wide is good.

If you don't want to to spend that much, Amazon has temperature adjustable soldering irons with fine tips for under £10.00.

You will also need to buy a coil of fluxed solder wire. My personal preference is to use leaded solder and a 0.5 kg coil of 0.7 mm cored wire has lasted me for over 10 years so I don't feel too guilty about polluting the environment.

2.3.2 Other Construction Tools



Your mileage may vary but the tools in the picture are the ones I think are 'must haves'. They are:

- Printed circuit board holder. Very useful but not absolutely essential. Cost from Amazon £10.00 ish.
- Wire strippers. Make sure that they can strip fine (24 awg) wire, some cheap ones won't work on fine wires.
- A good quality magnifying glass (jeweler's loupe) for inspecting EVERY soldered joint.
- Artery Forceps - very useful for bending wires and for heat sinking during soldering.
- Side cutter. If you don't have one, buy the best quality you can.
- Sharp scissors. Always useful.
- HighLight pen.
- Not actually shown - but you should have a spare copy of the schematic drawing for the circuit you are building.

2.3.3 Multimeter for Testing and Calibrating

You will definitely need a decent digital multimeter. I have had mine for probably 15 years and it is still going strong. However, it was an expensive model and nowadays there is no need to pay a fortune for a decent digital multimeter.

Almost all models have dozens of different functions. Most of those you will never use so don't be too impressed with marketing hype. The functions that you will use over and over again are continuity checking and it is helpful to have a buzzer so you don't have to look at the display while you are checking. DC voltage is the next most useful function. Ideally autoranging and also showing the correct polarity. Finally resistance measuring is also useful for checking resistors if you don't want to bother decoding the colour codes.

Once again, Amazon is probably the easiest place to buy from. They are currently selling a Neoteck Multimeter which has a built in stand - a very useful feature - for £12.99. I don't own one so I can't say how good or bad it is but it does have a sizeable number of 5 star ratings. Worth a try!

The link is https://www.amazon.co.uk/Neoteck-Multimeter-Resistance-Transistor-Continuity-Multimeters/dp/B01N35ZVKY/ref=pd_rhf_cr_s_pd_crcbs_0_2/260-8633381-9135726?_encoding=UTF8&pd_rd_i=B01N35ZVKY&pd_rd_r=4e5be403-127a-442d-8a6d-1b8f61ffef70&pd_rd_w=5zUHy&pd_rd_wg=l1xyS&pf_rd_p=e288c7fa-be1e-4d8d-af73-2fafa294c07b&pf_rd_r=51CZ9WSBM22PJA8ZVP8R&psc=1&refRID=51CZ9WSBM22PJA8ZVP8R

2.4: ORDERING THE PARTS

This section gives some information about how to order the various components that need to be assembled to make the two Magic Wire circuit boards. I have tried to make it as widely applicable as possible so you will be able to source the parts in most countries, certainly in Europe and the USA.

It is obviously advantageous to keep the number of suppliers to a minimum. To keep things as simple as possible, I recommend buying as many components as possible from a single supplier. To this end I have selected DigiKey. The advantages of using DigiKey are that they are truly international and can supply almost everywhere. For Europe, they offer free shipping for orders in excess of £33 (Euro 35) and their prices are competitive. They are also able to supply in small quantities. Of course you are free to use any component supplier you wish but bear in mind that the printed circuit boards were designed around the footprints of the components supplied by DigiKey. If you use different suppliers please make sure that the components will fit the holes on the PCBs.

2.4.1: The DigiKey Parts List

Component	Digikey Part #	Total Quant.	Unit Cost £	Total Cost £	
ScrewTerminal 01x02	A98036-ND	2	0.56	£1.12	
ScrewTerminal 01x04	A98038-ND	4	1.13	£4.52	
Protection Diode	1N4004RLGOSCT-ND	2	0.16	£0.32	
LED, 5V working	516-1339-ND	2	0.55	£1.10	
Linear Regulator, LM7805, 5.0 V	296-47192-ND	2	1.25	£2.50	
Linear Regulator, MCP1826S, 3.3 V	MCP1826S-3302E/AB	2	0.82	£1.64	
Capacitor, ceramic, 0.22 uF	399-14070-1-ND	2	0.35	£0.70	
Capacitor, ceramic, 0.1 uF	399-9870-1-ND	4	0.2	£0.80	
Capacitor, ceramic, 1.0 uF	399-13923-1-ND	2	0.45	£0.90	
Capacitor, electrolytic, 22 uF, 25 V	493-14236-ND	2	0.42	£0.84	
Socket Header 02x04	S7107-ND	2	0.56	£1.12	
Socket Header 01x40	HDR100IMP40F-G-V-TH-ND	2	0.88	£1.76	
Resistor, metal film, 0.5 W, 4k7	BC4329CT-ND	8	0.11	£0.88	
Resistor, metal film, 0.5 W, 2k2	BC4312CT-ND	2	0.11	£0.22	
Resistor, metal film, 0.5 W, 3k9	BC4325CT-ND	2	0.11	£0.22	
Resistor, metal film, 0.5 W, 820	BC4339CT-ND	1	0.11	£0.11	
Resistor, metal film, 0.5 W, 5k6	BC4335CT-ND	1	0.11	£0.11	
Trimmer Pot, 25 turn, 0.5 W, 1k0	490-2874-ND	1	1.21	£1.21	
Relay Driver IC, ULN2003a	497-2344-5-ND	1	0.41	£0.41	
IC Socket, 16 pin DIL	ED3016-ND	1	0.61	£0.61	
Open/Close switch, momentary action	EG2389-ND	1	2.77	£2.77	
Optional Items					
Case Moving Module	HM110-ND	1	5.44	£5.44	
Case Static Module	HM110-ND	1	5.44	£5.44	
LED Indicators, 5 V working, panel mount	350-2125-ND	2	1.95	£3.90	
				£38.64	Nett
				£7.73	VAT
				£46.37	Gross

NOTES:

1: DigiKey orders over £33.00 net are shipped free.
2: The blue highlighted area can be copied/pasted directly into the DigiKey order page
3: The two equipment cases are optional
4: The panel mount LED indicators replace the board mounted LEDs if the optional cases are used.

2.4.2: Ordering the nRF24L01+ Radio Transceivers

These are widely available from many different suppliers. They come in different shapes and sizes and you need to be sure that the ones you order are compatible with the Magic Wire printed circuit boards. The ones we want are the LOW power type (nRFL01+) with a built-in printed circuit aerial and an 8 pin (2 x 4) male connector with the pins protruding from the bottom of the board.

This is a picture taken from ebay.co.uk and shows the sort we want. A Google search should find plenty like this and you should expect to pay about £2 to £4 pounds for each transceiver. Try and buy from a UK (or local to you) supplier otherwise you will wait a long time for a delivery from China. One suggestion for the UK is https://hobbycomponents.com/wired-wireless/156-nrf24l01-24ghz-wireless-radio-transceiver-module. You need 2 of these for the Magic Wire project.

2.4.3: Arduino Nano v3 Clone

These are more standard. Again there are many suppliers. It is important that you buy the Version 3 type with the CH340 chip. Try and find a UK supplier and find ones with the header pins already soldered. The guide price, including p&p is around £4.00.

These are also available from the same UK supplier as the nRF24L01+ modules https://hobbycomponents.com/development-boards/638-arduino-compatible-nano-with-ch340-usb-ic. Again, two of these are needed.

This is a typical ebay listing of the type you want.

y listing

2.4.4: Ordering the Printed Circuit Boards

There are several suppliers who will supply PCBs in small quantities for relatively little money. The cheapest are based in China but there are some European ones as well. To order the PCBs for the Magic Wire project you need to send the design files, known as Gerber files to the PCB manufacturer. I don't have much experience of this as the Magic Wire PCBs are the first ones I have ever designed and had made. There are a couple of points to be aware of. Firstly, you will probably have to order a minimum of at least 3 and maybe 5 identical copies of each board. Secondly, if you chooses to use Chinese suppliers and choose a low-cost shipping method, you might wait quite a long time for the boards to arrive.

My recommendation would be to use one of the following suppliers:

- Aisler.net (Based in Germany)
- Pcbway.com (Based in China)

I designed the PCBs using KiCad, an excellent free software package. The PCBs I used for the prototype development and testing were made by Aisler.net, who are based in Germany.

Note that all the files referred to in this document, including the pcb design files, are listed in Appendix 5.3. The files themselves are posted on the Lesvedome group website, lesvedome@groups.io, and can be downloaded from there.

Ordering PCBs from Aisler.net

Aisler offer native support for KiCad files so the files you need to send with your order are the KiCad board files. For the Static and Moving modules, the files you send are respectively:

- MagicWireStatic.kicad_pcb
- MagicWireMoving.kicad_pcb

Note that you will need two separate orders, one for the Static module and one for the Moving module. However, Aisler will send both sets of boards with a single delivery charge. For each order, Aisler have a viewer that shows you what the finished board will look like.

I found the process reasonably easy despite never having done it before. The boards took about 2 weeks from placing the order.

Ordering PCBs from Pcbway.com

The procedure for ordering from Pcbway is slightly different. You need to send a set of Gerber files for each board. The Gerber files for each board are then compressed into a single .zip file for each board and it is these .zip files that you need to send to Pcbway.com.

- MagicWireStatic.zip
- MagicWireMoving.zip

Once again, you will make two separate orders, one for each board type, but Pcbway will only charge for the shipping once. I haven't used Pcbway yet but they have a good reputation.

2.5: STARTING CONSTRUCTION

2.5.1 Prerequisites

It is recommended that all the required components are available before you start construction. That will enable you to check that everything will fit as it is meant to before soldering components in place. If you are unfamiliar with or out of practice making circuits on printed circuit boards, please read Appendix 5.1 Notes on Soldering Printed Circuit Boards before starting.

The construction of the two boards is straightforward. It is recommended that the construction is done in the following order: First the STATIC board and then the MOVING board. That way each board can be tested as soon as it is finished. If you have made a mistake on the STATICboard, it may prevent you making the same mistake on the MOVING board.

2.5.2 Component Soldering Sequence

I strongly recommend that you solder in the components in order of the height they protrude above the board. This will let you put the components in place then hold them in place before soldering by turning the board upside down and pressing down on a flat surface. Don't try to put more than one or maybe two components in place before soldering. If you do, some will fall out and you may miss some solder joints.

Several of the components MUST be put in the right way round. These components are identified in the next section and details are given to make sure you put them in the board with the correct orientation.

So, for these boards the recommended soldering order is:

1. Resistors
2. Protection Diode
3. IC Socket (Moving board only)
4. Ceramic capacitors
5. Terminal strips
6. Electrolytic capacitor
7. 2 x 4 Header for nRF24L01+
8. 2 x 15 way Socket Pin headers for the Arduino Nano
9. Trimmer Pot (Moving board only)
10. Voltage Regulator ICs
11. LED Fault Indicator (Choose board or panel mount type)

2.5.3 Soldering Checks

When you have soldered in a component you should immediately check the solder joint by examining it using a jeweller's loupe. If the joint looks anything but perfect, re-melt the solder and add a little fresh solder to the joint. It is surprising how many dodgy joints you will find even when taking a lot of care. The solder / examine / rectify procedure should eliminate problems with poor solder joints.

I also recommend that you print out a copy of the schematic diagram for the PCB board you are working on and using a highlight pen, mark off each component when it has been soldered onto the board. It is surprisingly easy to find you have left out one or two components.

2.5.4: Component Orientation

This is **VERY IMPORTANT**. Many of the components for both boards MUST be inserted in one way only. If you get it wrong the board won't work! Here is a list of component types showing which are sensitive to orientation and on the next pages are photos of the boards that show components fitted with the correct orientation.

All Resistors

These can be put in either way round although if your OCD is well developed, it is nice to keep the same orientation so that the colour codes can all be read the same way.

All Ceramic capacitors

Can be put in either way round.

Protection Diode D1.

CHECK ORIENTATION. The silver band on the diode should match the silk screen printing on the board. The silver band end is soldered to the SQUARE pad.

IC Socket U4. (Moving board only).

CHECK ORIENTATION. The semi-circular notch in the socket should match the silk screen printing. Then when you insert the actual IC, the notch on the IC must be in line with the

Electrolytic capacitor C5.

CHECK ORIENTATION. If you bought the DigiKey part, it comes with a red stripe on the top of the can. The red stripe indicates the NEGATIVE wire. (Very unhelpful!) On both boards, the red stripe should be in line with the white stripe on the silk screen print. On the STATIC board the red stripe is closest to the Safety Sensor input terminal block. On the MOVING board the red stripe is closest to the Arduino Nano socket.

Screw Terminal Blocks.

CHECK ORIENTATION. Just make sure that the holes that you put the connecting wires into are facing OUTWARDS.

2 x 4 Socket Header for nRF24L01 module.

This can be soldered in any orientation. However, when you plug in the nRF24L01+ module make sure that you put it in the correct way round. For the STATIC board, the printed aerial on the module points to the four resistors. On the MOVING board, the module points away from the Arduino.

Two off 1 x 15 Socket Pin Header strips for mounting the Nano .

NOTE: The Socket Pin header from the DigiKey order is a 1 x 40 length of strip. This needs to be cut to give 2 off 1 x 15 strips. The strip is easily cut using a side cutter. Don't try and cut between sockets. Counting in from one end, cut by placing the blades of your side cutter over the centre of the 16th socket position. This will give you one length with 15 sockets. Now cut again, on the 16th socket counting from the other end.

The Socket Pin header strips do not have a particular orientation. However, the Arduino Nano must be plugged in the correct way round. The position for the Arduino USB socket is marked on the silk screen printing. On the STATIC board, the Arduino USB socket is on the same side of the board as the Safety Sensor terminal block. On the MOVING board, the USB socket is on the same side as the 2x4 header for the nRF24L01 module.

2.5.4: Component Orientation - Continued

Trim Pot RV1. (Moving board only).

CHECK ORIENTATION. The silk screen printing indicates the position of the adjustment screw with a letter s in a small box. Insert so that the screw is closest to the fixing hole in the corner of the board.

Voltage Regulator ICs.

The silk screen printing attempts to show where the metal backs of the chips should go. For the STATIC board the 5 volt regulator U1 (LM7805) goes next to the protection diode, D1. The metal back is FURTHEST from the diode. The 3.3 volt regulator U2 (MCP1826S) goes in next to the Safety Sensor terminal block. the metal back is furthest from the terminal block.

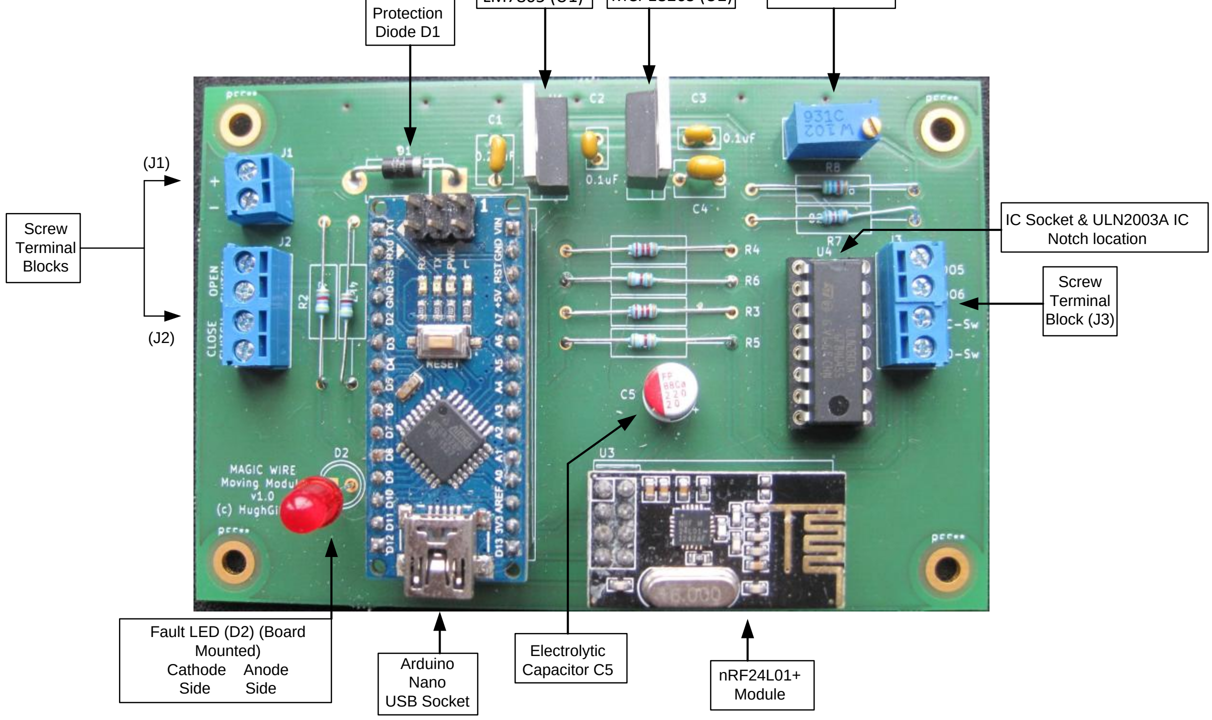
On the MOVING board, the 5 volt regulator U1 (LM7805) goes closest to the protection diode, D1. The metal back is CLOSEST to the diode. The 3.3 volt regulator U2 (MCP1826S) goes in nearer to the trimmer pot. The metal back is CLOSEST to C3, C4 and the trimmer pot.

LED Fault Indicator D2

If you choose to use the board mounted LED, DigiKey part 1516-1339-ND, the LED anode lead is the longer lead. The cathode lead is shorter and the plastic base of the LED is flat next to the cathode lead. The silk screen printing indicates the flat part and the flat on the LED should line up with this. It also shows + and - signs. The anode lead goes to the round pad, marked with a + sign. The cathode lead goes to the SQUARE solder pad with a - sign.

If you are intending to use the plastic case and will use the panel mounted LED this comes with flying leads that are coloured red and black. The red lead goes to the round pad, marked + and the black lead to the square pad marked -.

2.5.5: MOVING BOARD COMPONENT ORIENTATIONS



2.5.6: STATIC BOARD COMPONENT ORIENTATIONS