MJoy16-C1

Multifunction Home Simulator Cockpit Controller

User's Manual

version 1.1

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Contents

Disclaimer

This documentation is provided for the purpose to be useful aid for implementing MJoy16-C1 for your own application. It is meant to be used while complying with all safety and sensitive electronics handling measures. We CAN NOT BE HELD RESPONSIBLE for any damage or injury of any kind which may occur or could occur either during building, testing, use or storage. Use this material AT YOUR OWN RISK AND JUDGEMENT.
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Introduction

At first what the name MJoy16-C1 means. The name MJoy16-C1 consists of two parts. MJoy16 is a new USB controller design which has evolved from the original MJoy. "16" means that it uses a more powerful chip which is, of course, better than 8.
As MJoy16 is capable of performing a lot of different tasks "C1" has been added to indicate that this MJoy16 is a multifunction home sim-cockpit controller.
MJoy16-C1 is a cost-effective hardware solution for those who want to build aircraft or other cockpit simulator. Under Windows it will be conveniently recognized as a Plug-and-Play joystick. But it is much more! It has significant enhancements which make it much better suited for cockpit applications than an ordinary joystick.
It has 8 high resolution analogue axes inputs. These inputs may be connected to various analogue input controls like joystick or yoke axes, rudder pedals, throttle(s), flaps, trimmers etc.
In addition to precision axes MJoy16-C1 supports many buttons and switches. It supports as much as 64 simple pushbuttons, 16 toggle switches, 4 rotary switches and 1 hat switch.
If you choose a simple cockpit solution you might just need to prepare a front panel with holes and artwork, place buttons, pots and switches and connect them to controller. This connection is done by simply soldering wires of MJoy16-C1's flat ribbon cables straight to the controls. Connecting joystick, pedals, throttle and other axes might involve more work. You may as well choose to use this MJoy16-C1 controller in tandem with your favourite joystick. In this way you'll have even less work on analogue axes as you may put MJoy16-C1's analogue controls as potentiometers on the panel which may be used for trimmers, mixture, flaps etc.
Of course, as always, more reality in your cockpit means more work for yourself.
USB interfacing makes this controller a true Plug-and-Play device. You just need to plug it into your PC's USB port and let Windows discover it. It's just that simple!
As a next step you will have to map your new joystick controls to your favourite flight simulator.

Below is the features and characteristics list of MJoy16-C1:

Interface to host computer	**USB 1.1**
USB interface speed	**Low**
Analogue axes and rotary switches update period	**30ms**
Buttons and toggle switches update period	**60ms**
Number of analogue inputs	**8**
Analogue inputs resolution	**10 bits**
Number of pushbuttons	**64**
Number of toggle switches	**16**
Toggle switch action	**Double**
Number of rotary switches	**4**
Rotary switch action	**Double-speed**
Number of 8-way hat switches	**1**
Automatic calibration feature	**Included**
Centring feature with disabling possibility	**Included**
Controls mapping mode selection feature	**Included**

Controls

This chapter describes the types of controls supported by MJoy16-C1. It will also explain how they operate and how to use them.

Analogue axes inputs

The controller’s analogue axes appear in Windows game control panel as X, Y, Z, Rx, Ry, Rz, Dial and Slider. They all have 10 bits resolution.
Input signal is simply a voltage between roughly 0 and 5 Volts. It is usually taken from potentiometers that are connected to various rotating and sliding controls.
Details how to connect them are given in the wiring section.
MJoy16-C1 has an auto calibration feature so you don’t have to worry about calibration in Windows. To calibrate all controls simply move the control back and forth to its travel edges.
If you need to recalibrate controls press and hold the “Init” button while plugging the controller into USB. In this case all axes controls will loose their calibration and will need to be recalibrated.
Axes X, Y and Rx have a centring feature. These axes are usually used for joystick / yoke and rudder controls which are usually spring-loaded and return to centre position when released. This centre position is read during controller start-up and used during operation. Therefore it is important to leave these axes (joystick/yoke and pedals) in centre position when powering on your PC or plugging in MJoy16 to USB. This centring feature may be disabled by “Centre” switch.

Button Controls

The controls described in following sections are common as they all are digital controls and use joystick button states to transfer their data to PC. Please note that here by joystick button we mean not buttons wired on the panel but rather joystick button states which are transmitted to PC via the USB cable. We will call the physical buttons “pushbuttons” to indicate a clear difference. How controls are connected and what button presses are generated during their operation is described in the Controls Mapping section.

Pushbuttons

These are most basic controls found on every joystick. Their operation is exactly the same as on any ordinary joystick. The only difference is that there are lots of them. Ordinary joysticks usually have from 4 to 12 pushbuttons. This controller has support for 64 pushbuttons giving much more possibilities.
Pushbutton contacts are of the “normal open” type. When engaged their contacts are “closed”.

Toggle switches

Toggle switch support is an enhanced MJoy16-C1 feature. It translates changes of toggle switch position into momentary joystick button presses. There might be two ways of performing this translation. One way is generating the same button press when toggle switch is switched "ON" or "OFF". The other way is generating different button presses when switch is toggled "ON" and "OFF". And guess what - this way is used in MJoy16-C1 controller. That's why their type is called "double-action".
Toggle switches are arranged in rows by 8. As each toggle switch generates different button presses for "ON" and "OFF" flip. 8 toggle switch rows generate up to 16 different button presses. These button positions are arranged in such a way that lower 8-position row buttons are momentary activated when toggles switches are flipped to "ON" position. Whereas the upper row is activated when they are flipped "OFF".
To illustrate: Suppose we flip toggle switch 1 to "ON" position. It generates a brief Button 17 press. Then we flip it back to "OFF". It generates Button 25 press. It's like Gear Up / Down.
MJoy16-C1 has support for up to 16 toggle switches. Exact mapping which toggle switches generate which button presses is described in Controls Mapping chapter.
Please read about "Init" button to learn more about toggle switches.

Rotary switches

Support for rotary switches is implemented in flight simulators to facilitate control of radios, autopilot settings etc. All these controls are operated by rotary knobs. One example of such simulator is Microsoft Flight Simulator tm.
MJoy16-C1 supports "phase-shifted" rotary switches. They have three leads and look very similar to ordinary pots. How to connect these switches is described in wiring installation chapter.
In similar fashion as with toggle switches, the controller translates raw signals from these rotary switches to corresponding momentary button presses. One brief button press is generated when this rotary switch is rotated in clockwise (CW) direction and other when in counter-clockwise (CCW). Depending on the exact type of rotary switch full rotation of it might generate from around 10 to 20 pulses.
For example: If we map CW and CCW button presses Button1 and Button2 to increase or decrease Com1 radio frequency fractional part then we'll be able to exactly adjust frequency setting fractional part by rotating rotary switch knob in one or the other direction.
This would be very nice but inconvenient if you need to change from one frequency to another which is far apart. To solve this real radios have two co-axial knobs one inside another, which change either whole or part of the frequency.
In MJoy16-C1 this is solved in a different way. In this controller rotaries' processing is made dependent on how fast you rotate the rotary switch. It sends one button press if you rotate knob slowly and other if you twist it fast. So in this case fast knob rotation would generate button presses Button9 and Button10. As you can see one rotary switch utilizes 4 buttons. If you map Fractional_Increment to Button1, Whole_Increment to Button9 and decrements to buttons 2 and 10 respectively you will get fully functional rotary switch operation to control Com radio frequencies etc.

In this way it provides natural and comfortable use and it does not require any time to get used to. You instinctively rotate the knob faster when you want to change the number by larger amount.

“Init” button

MJoy16-C1 has another convenient feature which is related to toggle switches and axis calibration. If the “Init” button is pressed during the powering of MJoy16 the calibration data is reset to defaults and all axes will be recalibrated as from a fresh start. By powering on we mean powering on the PC while having the MJoy16 connected or re-plugging the MJoy16 into USB port of your computer
During normal operation this “Init” button may be used to transmit all double-action toggle switches states by generating short key presses of according switches that are transmitted to computer. It might be useful when you start a new game or flight and want your simulator to be in sync with toggle switches states of your panel.
If you use this button it is recommended to place it at a convenient place on the panel where it would not interfere with main simulator controls but would be easily accessible for start-up initialization of the flight.

Controls Mapping “Mode” switch

This mapping mode switch allows you to choose between two layouts of buttons. It initializes the mode when MJoy16 is powered on. The “Off” position means Mapping Mode 1 and “On” – Mapping Mode 2. About the exact mapping of controls please read the Controls Mapping chapter.
Please note that if you change Mode switch selection you will need to restart the MJoy16 controller. For this you should disconnect the MJoy16 and reconnect it back to the host USB port.

“Centre” switch for auto centring feature disabling

This switch controls whether to use auto centring feature or not. If this switch is left open or in the “Off” position then auto centring is enabled and axes X, Y and Rx register their centre position when MJoy16 is powered up. This is useful when MJoy16-C1 is used as main controller in the sim cockpit which has connected joystick, rudder pedals, throttle etc.
When this switch is “On” and contacts are closed auto centring feature is disabled. In this case centre is not being read from axes X, Y and Rx during start-up. This mode might be useful if MJoy16-C1 is used for other controls like throttle quadrant, flaps, trimmers etc.
The same as “Mode” this switch takes effect only during start-up of the controller. If you change its selection you will have to restart the controller.

Controls naming convention

By convention we will reference all wires of matrix which are outputs of microcontroller as columns and inputs as rows. Matrix is of 12 rows x 8 columns format.
By convention buttons are named by a Latin letter identifying a row and a digit which identifies a column. So rows are named A, B, C, D, E, F, G, H, I, J, K, L. Columns are numbered from 1 to 8. Examples of names are A2, C3, and F5 etc.
This is simple with pushbuttons which use one contacts pair. But more complex controls like rotary switches would require more pairs. In this way phase shifted rotary switch will use two buttons. For example one rotary will utilize buttons contact pairs D1 and D2. It will be named as D1-2 or D12.
This naming convention will be used to refer to specific controls in text, diagrams and tables throughout this document.

Controls matrix layout

Controls are laid out in a matrix fashion in MJoy16-C1 controller. Names for controls are used as described in naming convention above. Below is the table which shows what controls use what positions in the matrix:

		Column							
		1	2	3	4	5	6	7	8
Row	A	Button	Button	Button	Button	Button	Button	Button	Button
	B	Button	Button	Button	Button	Button	Button	Button	Button
	C	Button	Button	Button	Button	Button	Button	Button	Button
	D	Button	Button	Button	Button	Button	Button	Button	Button
	E	Button	Button	Button	Button	Button	Button	Button	Button
	F	Button	Button	Button	Button	Button	Button	Button	Button
	G	Button	Button	Button	Button	Button	Button	Button	Button
	H	Button	Button	Button	Button	Button	Button	Button	Button
	I	Toggle	Toggle	Toggle	Toggle	Toggle	Toggle	Toggle	Toggle
	J	Toggle	Toggle	Toggle	Toggle	Toggle	Toggle	Toggle	Toggle
	K	Rotary		Rotary		Rotary		Rotary	
	L	Init	Mode	Centre		Hat switch			

As we see from the table above we have 64 pushbuttons named from A1 to H8, 16 toggle switches named from I1 to J8, 4 rotary switches named from K12 to K78, “Init” button L1, “Mode” switch L2, “Centre” switch L3 and hat switch L5678.

Boards description

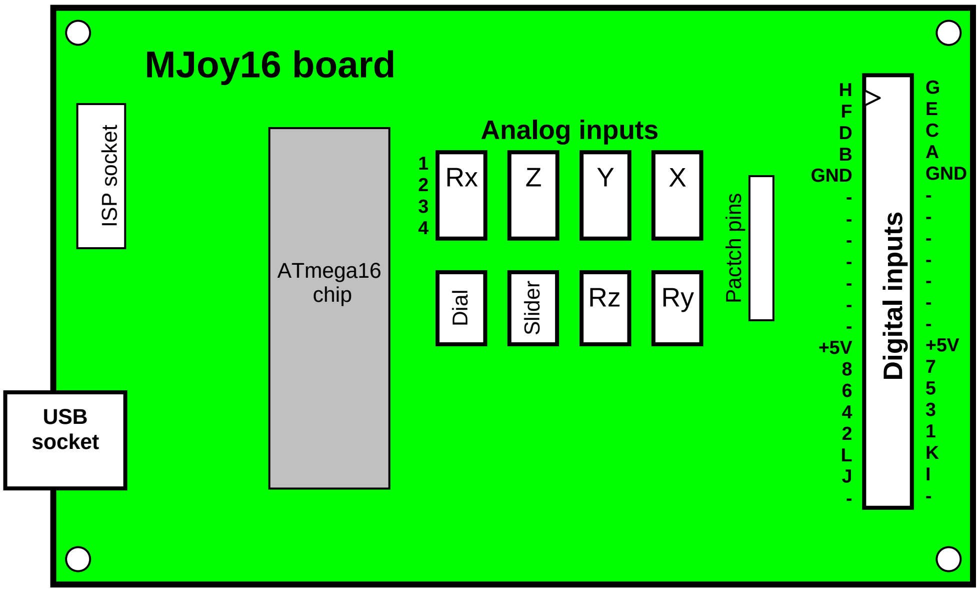
MJoy16-C1 consists of two boards:

- MJoy16
- Key Matrix board.

Key Matrix board is not necessary but helps to reduce the wiring complexity.

MJoy16 board description

MJoy16 board layout is illustrated below:



The main connectors on MJoy16 board are USB socket, Analogue Inputs and Digital inputs. The board USB socket takes a B type USB cable which connects it to host computer.

Analogue inputs are eight 4-pin sockets for connecting potentiometers or other analogue sensors for axis inputs. Corresponding axis of each socket is marked on the MJoy16 board diagram. Pin names and functions are shown in the table below:

Pins	Signal Name
1	Input Signal
2	GND
3	-
4	+5V

Analogue sensor wiring is explained in detail in wiring chapter.

Digital input is done via one 40-pin socket which is used to connect all digital controls such as pushbuttons, toggle switches, hat switches etc. This socket may be used to connect the controls directly or via Key Matrix board. Direct wiring would require complex wiring including diodes to be connected directly to the switches on the backside of the panel. Using Key Matrix board does simplify wiring a great deal.
Names of each pin of the Digital Inputs connector of MJoy16 are shown on the board layout diagram above and in the corresponding table below:

MJoy16 Digital Inputs connector pin-out

Signal Name	Pins	Pins	Signal Name
Row H	1	2	**Row G**
Row F	3	4	**Row E**
Row D	5	6	**Row C**
Row B	7	8	**Row A**
GND	9	10	**GND**
-	11	12	**-**
-	13	14	**-**
-	15	16	**-**
-	17	18	**-**
-	19	20	**-**
-	21	22	**-**
-	23	24	**-**
+5V	25	26	**+5V**
Column 8	27	28	**Column 7**
Column 6	29	30	**Column 5**
Column 4	31	32	**Column 3**
Column 2	33	34	**Column 1**
Row L	35	36	**Row K**
Row J	37	38	**Row I**
-	39	40	**-**

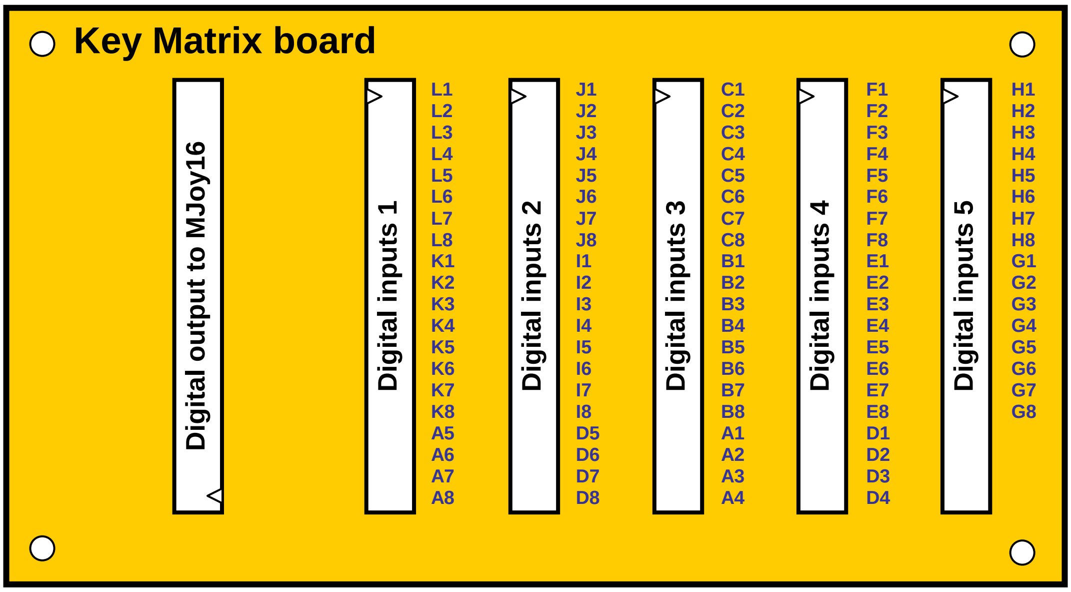
For example if you would connect Row A pin to Column 3 pin you will get button A3 press.
Detailed wiring of different digital controls is described in the wiring chapter.

Patch pins are reserved for possible future use. They can be connected to Analogue inputs by jumper wires to provide additional digital connections on the Digital Inputs interface. Of course for this application a different code will be needed in the ATmega16 chip which would use these pins not as ADCs but as general purpose digital pins.

The ISP connector is for connecting the MJoy16 to a computer for writing software to the ATmega16 chip.

Key Matrix board description

Key Matrix is an optional board which significantly reduces digital controls wiring complexity. Below is the picture of Key Matrix board layout:



Key Matrix board consists of digital inputs and outputs.
The Output socket is meant to be connected to MJoy16 via 40 wire flat ribbon cable. It could be the type of cable that is used for IDE hard disk drives in PCs. But you can also make this cable easily yourself. For this you'll have to buy from local electronics shop required length of plain 40-pin flat ribbon cable and 40-pin snap-on connectors. These connectors are exactly the same as on IDE cables but are in non-assembled condition yet. Two connector parts are simply pressed against each other onto the cable till they clamp on and make a good contact with wires. It is recommended to use some kind of table press device as it won't be enough force to do it by hands. Doing this with pliers could result in uneven pressure or even break of connector. Making this cable yourself would allow you to choose the length which best suits your installation layout.
General recommendation is to keep this cable as short as possible.
Digital inputs sockets accept 40-pin connectors with flat ribbon cables going directly to controls. This cable is similar to one described above but with 40-pin connector only on one end. Each two adjacent pins form a contact pair for one button control in matrix. Pair names are shown on the above layout diagram according to the naming convention next to input connector's positions. For example if you want to connect button C3 you will use wires 5 and 6 of flat ribbon cable connected to "Inputs 3" socket.

Below is the table which shows Key Matrix board input connectors' layout structure in detail:

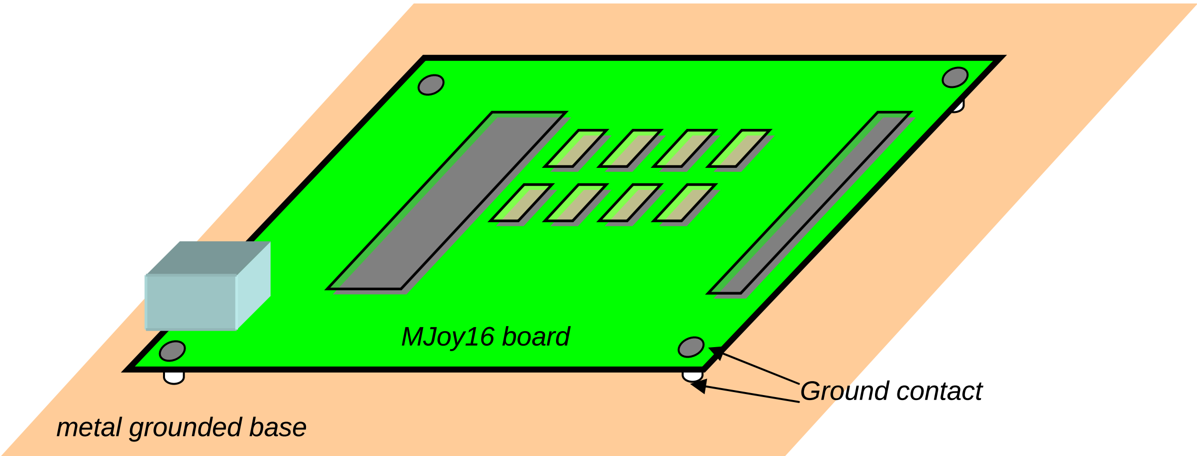
Position	Pins	Pins	Inputs 1	Inputs 2	Inputs 3	Inputs 4	Inputs 5
1	1	2	**L1**	**J1**	**C1**	**F1**	**H1**
2	3	4	**L2**	**J2**	**C2**	**F2**	**H2**
3	5	6	**L3**	**J3**	**C3**	**F3**	**H3**
4	7	8	**L4**	**J4**	**C4**	**F4**	**H4**
5	9	10	**L5**	**J5**	**C5**	**F5**	**H5**
6	11	12	**L6**	**J6**	**C6**	**F6**	**H6**
7	13	14	**L7**	**J7**	**C7**	**F7**	**H7**
8	15	16	**L8**	**J8**	**C8**	**F8**	**H8**
9	17	18	**K1**	**I1**	**B1**	**E1**	**G1**
10	19	20	**K2**	**I2**	**B2**	**E2**	**G2**
11	21	22	**K3**	**I3**	**B3**	**E3**	**G3**
12	23	24	**K4**	**I4**	**B4**	**E4**	**G4**
13	25	26	**K5**	**I5**	**B5**	**E5**	**G5**
14	27	28	**K6**	**I6**	**B6**	**E6**	**G6**
15	29	30	**K7**	**I7**	**B7**	**E7**	**G7**
16	31	32	**K8**	**I8**	**B8**	**E8**	**G8**
17	33	34	**A5**	**D5**	**A1**	**D1**	
18	35	36	**A6**	**D6**	**A2**	**D2**	
19	37	38	**A7**	**D7**	**A3**	**D3**	
20	39	40	**A8**	**D8**	**A4**	**D4**	

For simple pushbuttons there are 2 wires running directly to each button straight from the connector. For more complex controls like rotary switches and hat switch there are more wires running to each control. Exact wiring of each type of the controls is described in the wiring chapter.

Installation

Installing MJoy16 and Key Matrix boards

ESD Hazard Note: MJoy16 and Key Matrix board contain sensitive semiconductor devices and are subject to Electrostatic Discharge (ESD) hazard. So care should be taken when handling them. It is strongly advised to wear an electrostatic wrist wrap connected to ground or chassis of the installation site.
MJoy16 has some sensitive analogue circuits for reading analogue controls therefore it is advised to install MJoy16 board to a grounded site. Four mounting screws may provide a ground connection of the MJoy16 board to the panel. It is also advised to have the back of the board supported by ground-shielded plate. Possible good installation places may be grounded metal or metal-covered cockpit panel backplane. This could also be an unetched PCB board etc. All of this is advisory. You will have good quality operation even without these special shielding measures and you might not experience any problem. Nevertheless good shielding will contribute to good jitter-free analogue axis operation.
Below is an example of MJoy16 installation on grounded base:



Generally your cockpit frame should be grounded to minimize possible interference. But some cockpit designs might have some power actuators installed. In these cases such power devices ground should be separated from signal ground and filtering measures installed if needed. MJoy16 board should be connected to signal ground plane.
The Key Matrix board does not carry analogue signals so it does not require explicit shielding measures. General advice is to install Key Matrix at a location where it will have the shortest lengths of cables.
Key Matrix is connected to sim cockpit panel controls using 40-wire flat ribbon cables. These cables have 40-pin connector clamped on one end which connects to the 40 pin sockets. Other end wires will be split and run directly to the controls of the panel. It is recommended to keep these wires laid out in bundles along panel sides provide a convenient and nice layout.

Power supply

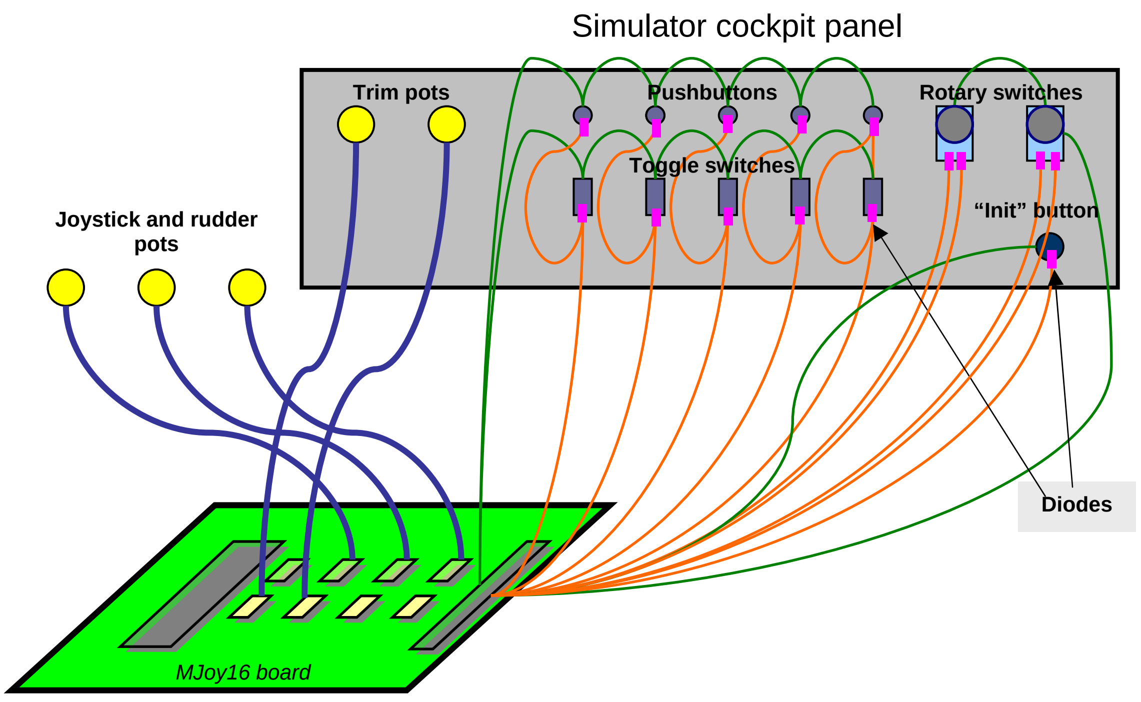
MJoy16-C1 is powered from USB bus and no external power supply is needed.
Current consumption of MJoy16-C1 may reach up to 50mA. It is not much but PC USB host controller power supply also has its limits. Current from all connected USB devices adds up and puts stress on that power supply. If you have already connected several USB-powered devices such as scanners, webcams and similar then it is better to place a USB hub with its own power supply adapter. You can safely connect MJoy16-C1 to it without any fear to overstress your PC USB ports.
In case you plan to use more than one MJoy16-C1 or another USB device in your cockpit it is recommended to place a self-powered USB hub inside of cockpit enclosure. Then you would run USB cable to computer and hub's power supply adapter to mains socket. This would save you from many USB cables running to the cockpit.

Wiring MJoy16-C1

MJoy16-C1 wiring is simply connecting it to USB and connecting all the controls. USB is a simple connection of MJoy16 to host computer USB ports via a USB cable. This is standard type B USB cable which is sold in computer shops.
Control wiring consists of wiring analogue controls and digital controls. Please refer to the appendixes for complete MJoy16-C1 wiring schematic diagrams.
Next sections will explain wiring of different types of controls in detail.

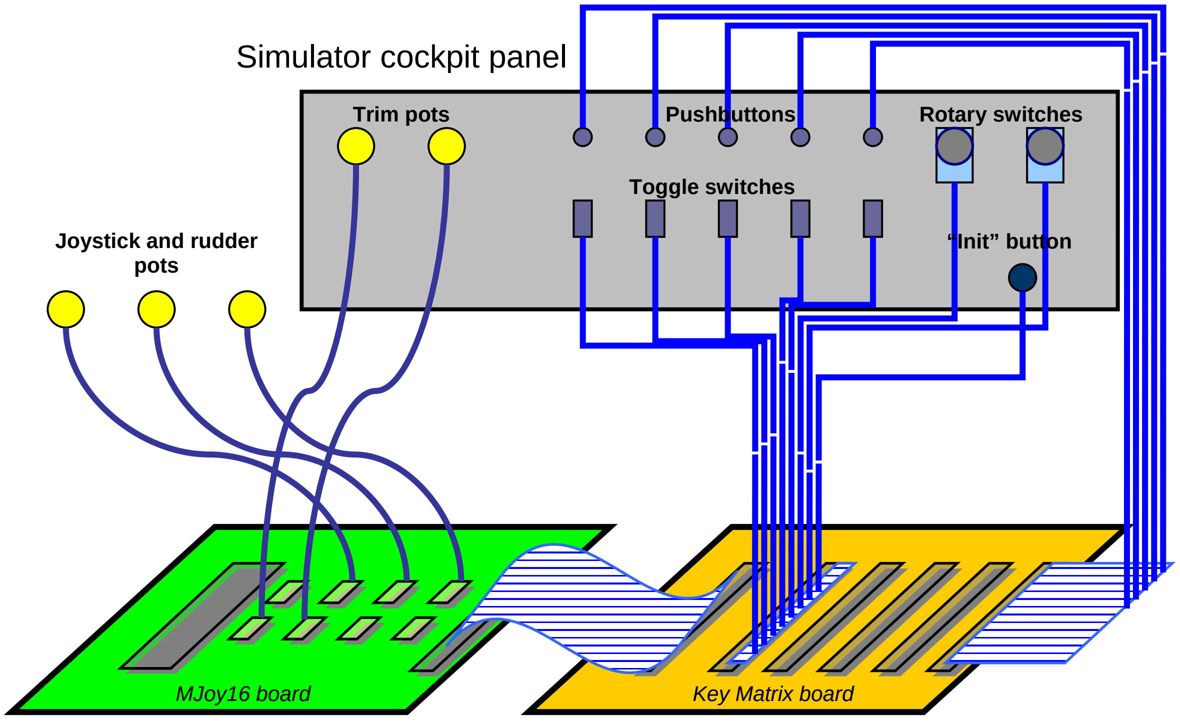
Overall wiring layout

If you are using Key Matrix board, the wiring job is significantly simplified. But you can also do it with just a MJoy16 board alone.
Below is simplified wiring layout diagram should a Key Matrix board not be used and all controls are directly connected to the MJoy16 board:



As you see in the diagram above you must form a wiring matrix of all buttons and switches directly on the panel plus soldering the diodes to each digital control.

Below is a simplified example of cockpit panel wiring when using Key Matrix board:

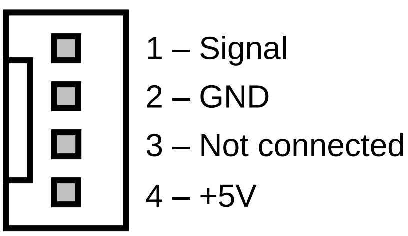


In this layout all wires can be laid out as a bundle along the edges of the panel. This provides easy maintenance access to all buttons and switches.

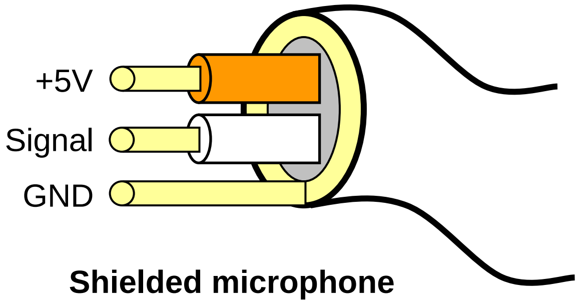
Wiring potentiometers and other analogue sensors

Analogue controls are usually standard linear potentiometers. The value of potentiometers may be different but not less than 10 kOhm. Choosing a potentiometer value is a matter of compromise. Smaller values will give better noise characteristics but will draw more current from USB power supply. Greater values will put fewer loads on USB power supply but will be more subject to noise and inter-axis interference.
For example 10k pot will have very good noise characteristics but will draw a 0.5 miliAmperes current per each axis. A 100k pot will draw only 0.05 miliAmperes but will be a bit more sensitive to external noise and interference.
As a general rule any linear pot in the range between 10k and 100k should do well with barely noticeable differences.
Analogue sensors can be any sensors providing an output voltage between 0 and +5V. In most cases it is required to have a linear sensor output to get linear response over the full movement range.
Sensors should be connected using shielded cable. Suggested type of cable for this is microphone cable. They have two wires surrounded by a shield. Inside wires are usually coloured white and red. Shield is connected to the ground (GND), red wire to +5V and white to the signal terminal.
In case of rotary potentiometers the middle pin is always the slider, the signal output. If you are using a sliding potentiometer, the slider pin position depends on type of the potentiometer used.
If you are using other type of sensors, please consult the sensor documentation about pin-out and operation of the specific sensor. Many sensors have GND and +5V for power supply and one pin as a signal output. Connect them accordingly.

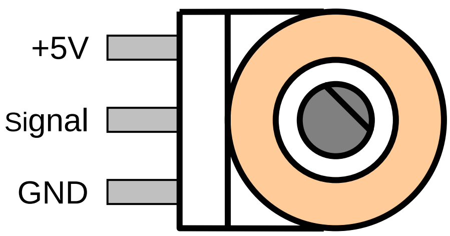
Below are the pictures of the connector of analogue input, shielded cable and potentiometer:



Analog connector on MJoy16



Shielded microphone cable



Potentiometer

It is recommended to connect potentiometer using shielded cable as short as possible.

If you are not using some of the axes then connect their signal terminal to the ground. Otherwise unconnected inputs may generate random inputs that might be induced from other inputs, external signals etc.

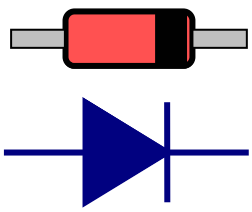
Wiring digital controls

Digital controls are connected using unshielded wires. General recommendation to use wires as short as possible still applies. Depending on whether you use Key Matrix board or not wiring will be different.

About use of diodes and their polarity

All diodes shown in below sections are required to eliminate so-called "Phantom-Buttons" effect which occurs in matrix key layouts when three or more buttons are pressed simultaneously. They are already included on the Key Matrix board. If you are using the Key Matrix board then don't bother reading this section.
The diodes shown are widely popular 1N4148 but may be any other type of low power fast switching diodes.
Since diodes are asymmetric devices it does matter which way you connect them. The black band shown on the diode in below illustration corresponds to polarity marking of 1N4148:

Diode 1N4148

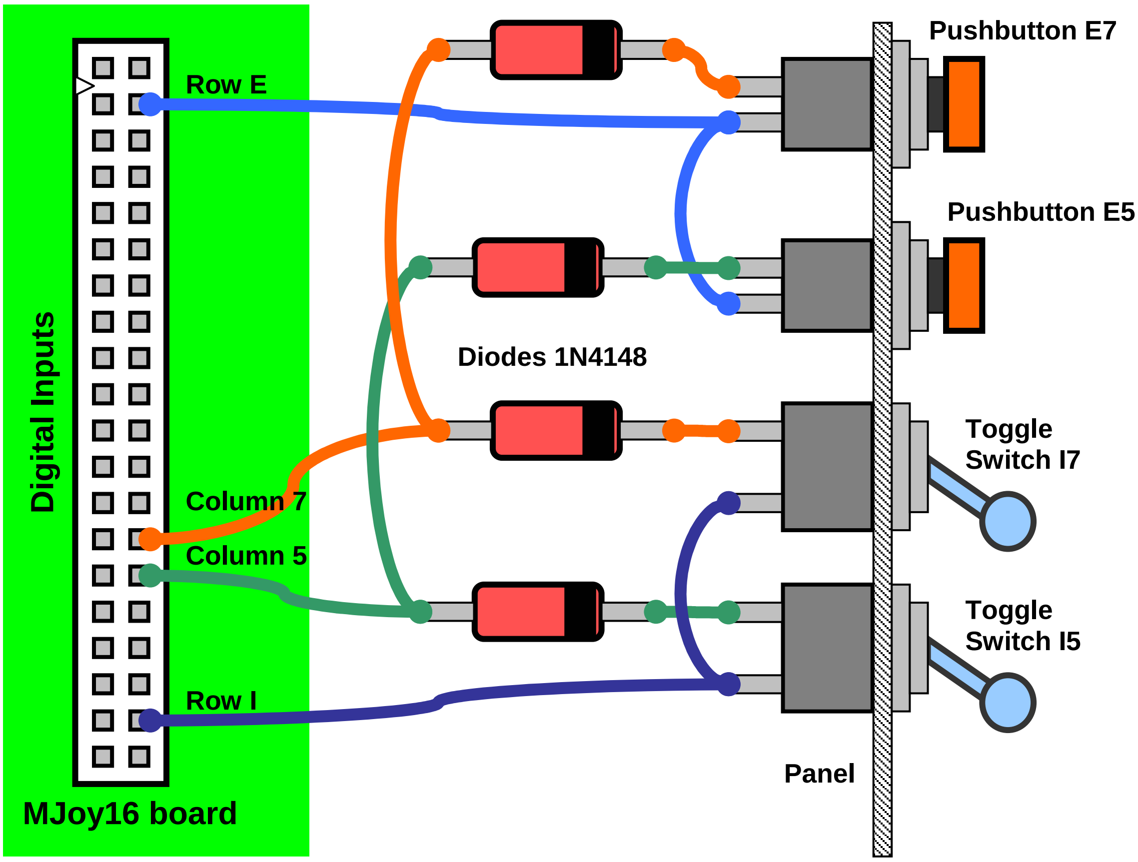


This band colour may be other colour depending on typical body colour of the diode. Other types may have different marking convention.
If you are not sure about the polarity of diodes you have you can easily test find this out by simple test described below:

1. Connect MJoy16 to PC via USB cable. Don't connect any digital controls yet. Make sure that Windows has installed the MJoy16 and open Game Controllers panel for "MJ16". This is done via Control Panel in Windows.
2. Take two wires Row A and Column 1 from MJoy16 digital inputs connector. When you connect these two wires together you should see Button 1 lighting up on "MJ16" panel.
3. Place the diode you have between these two wires in one or other way. When Button 1 lights up again make a note of the diode marking and remember this position as a reference.
4. When wiring all other controls use this reference to place all other diodes the same way.

Wiring digital controls without Key Matrix board

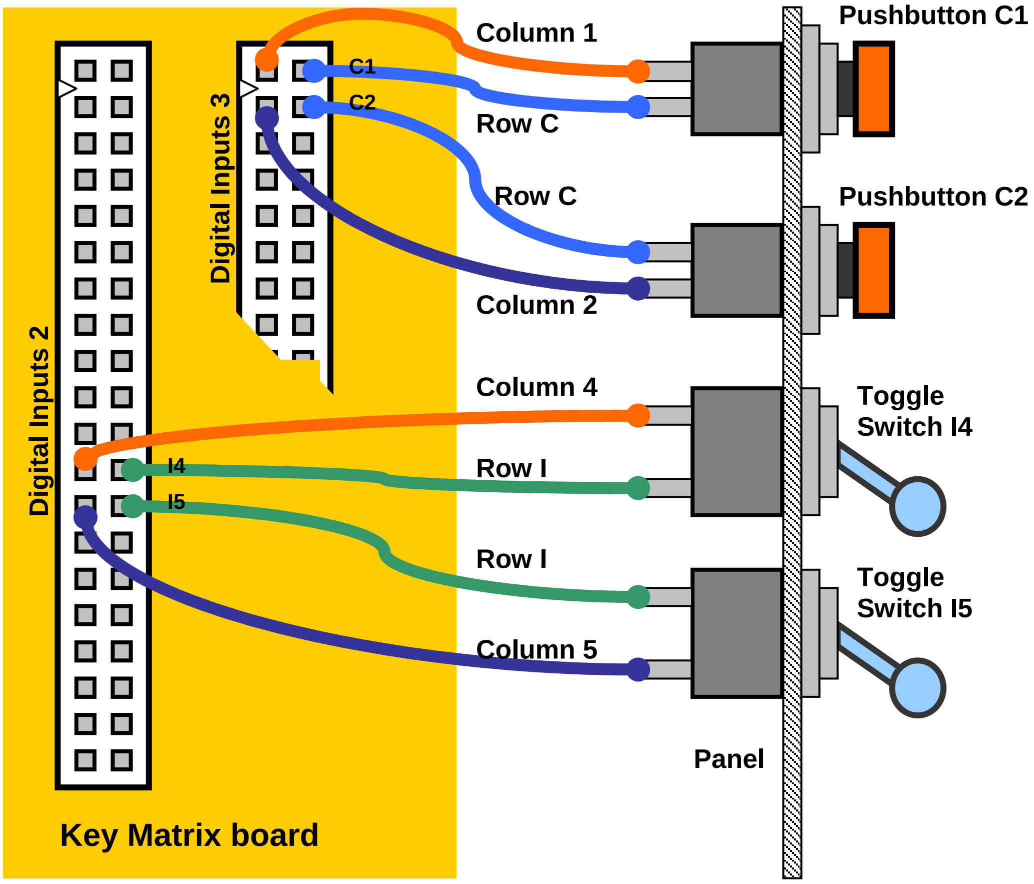
If you don't use Key Matrix board you will have to solder diodes directly to pushbuttons and switches. These diodes are necessary to avoid so-called "Phantom Buttons" presses. They should be soldered directly next to each button control. Below are some examples how pushbuttons and toggle switches are wired directly to MJoy16 board:



It can be seen that a lot of soldering is made directly to the panel and there are wires that are going from one control or diode to another. With more controls this complexity increases even more. Different types of digital controls are wired in slightly different ways. Exact wiring of them will be described further in this chapter. Key Matrix greatly simplifies wiring and possible rewiring of the panel.

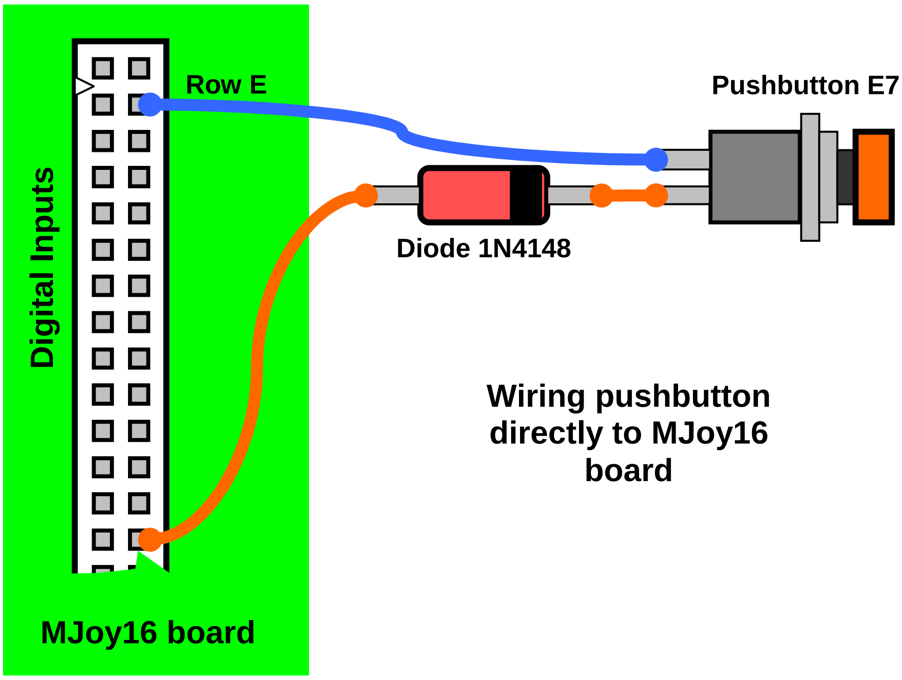
Wiring digital controls with Key Matrix board

When wiring with Key Matrix board wires from buttons and switches go directly to digital input connectors on Key Matrix board. An example of wiring pushbuttons and toggle switches is shown below:

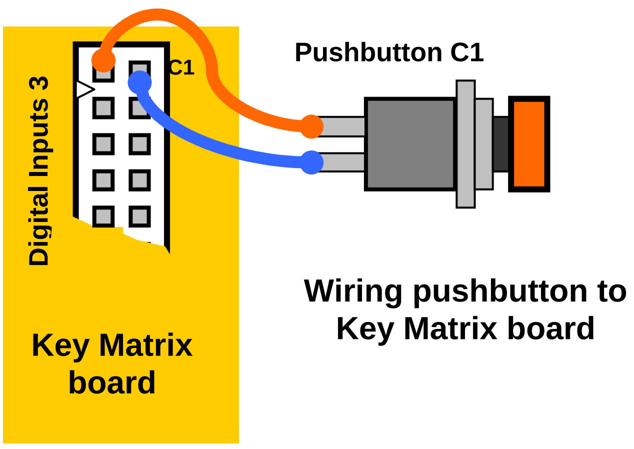


Wiring pushbuttons

If you don't use Key Matrix board you will need to solder a diode in series to one of the pushbutton pins. A wiring example is shown below:



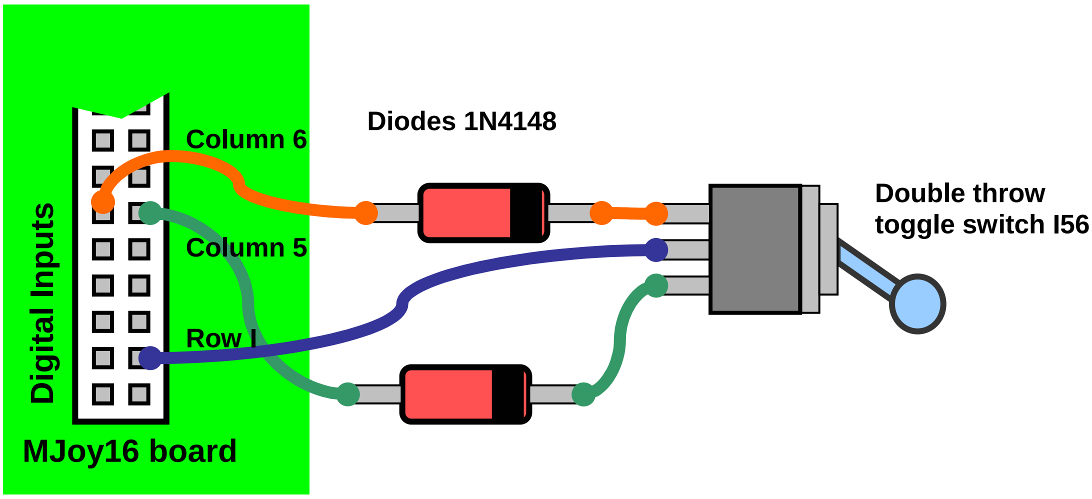
Pushbutton wiring example with Key Matrix board is shown below:



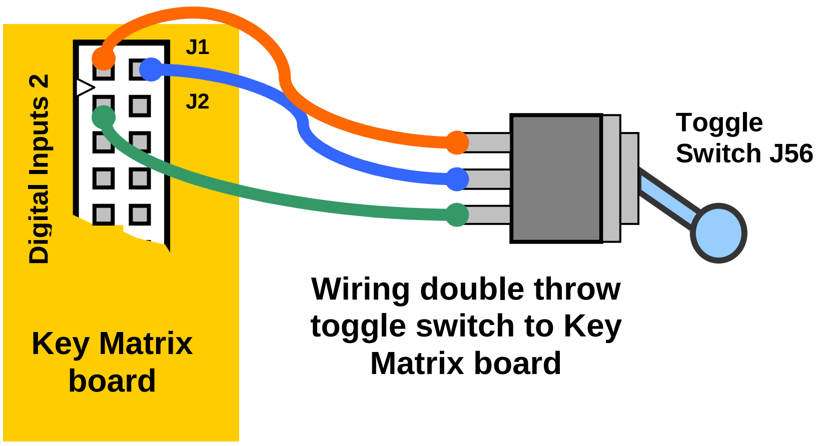
Note that no diode is needed as it is already included in Key Matrix board.

Wiring toggle switches

Toggle switches can be single throw or double throw. MJoy16-C1 is mainly designed for single throw toggle switches but double throw toggles may also be used if required by your cockpit application.
Single throw toggle switches have two positions: "On" and "Off". Single throw toggle switches are wired exactly as pushbuttons so please refer to pushbutton wiring description for wiring the single throw toggle switch.
Double throw toggle switches have three positions: "On1", "Off" and "On2". "Off" is the middle position. These toggle switches use 2 pairs of contacts on keys matrix. The principle of connecting them is that common pin is connected to Column signal wire and the other two pins are connected to different Row signal wires. Below is example of wiring double throw toggle switch without Key Matrix board:



Below is an example of a double throw toggle switch wiring to the Key Matrix board

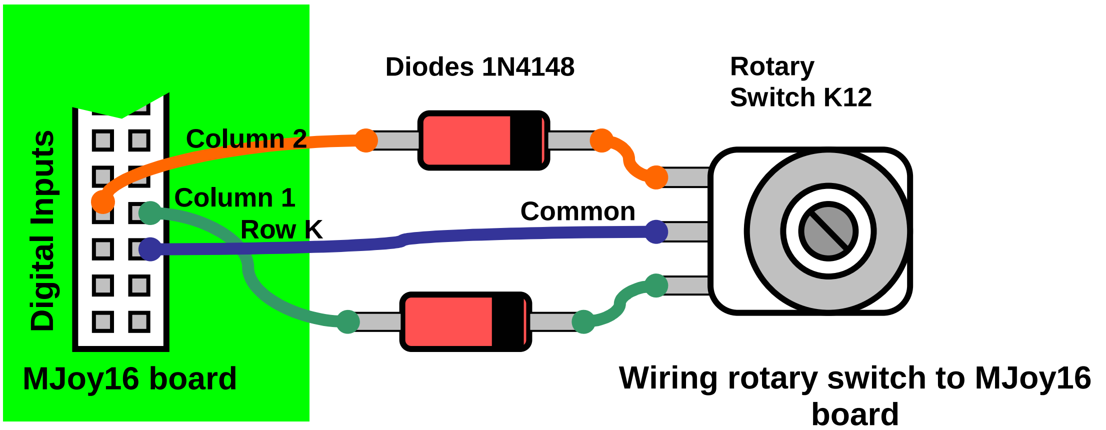


Wiring double throw toggle switch to Key Matrix board

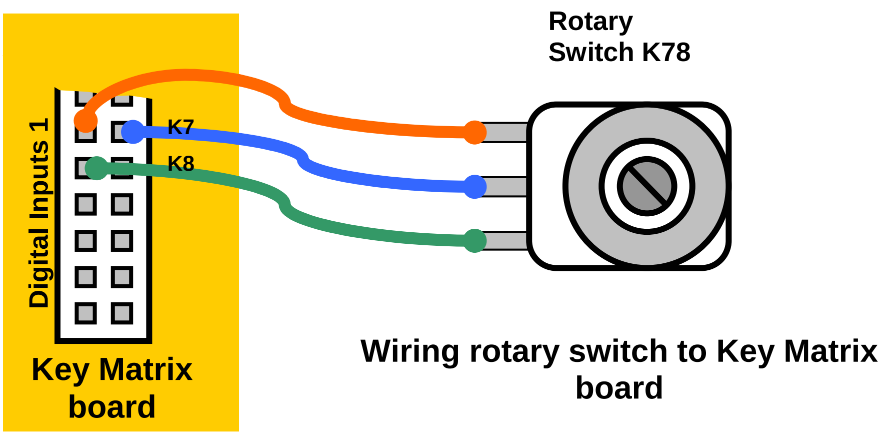
Please note that in above diagram wire from pin 4 (next to green wire) of digital inputs was not used. This is because pins 2 and 4 are already interconnected on the connector so extra 4^{th} wire is not needed.

Wiring rotary switches

Wiring of phase shifted rotary switches is similar to wiring of double throw toggle switches. The first thing is to find out which pin on the rotary switch is common. Its position depends on the type of rotary. On some rotary switches it may be in the middle but some may have it on one side.
Below is an example how to directly wire a rotary switch to the MJoy16 board:

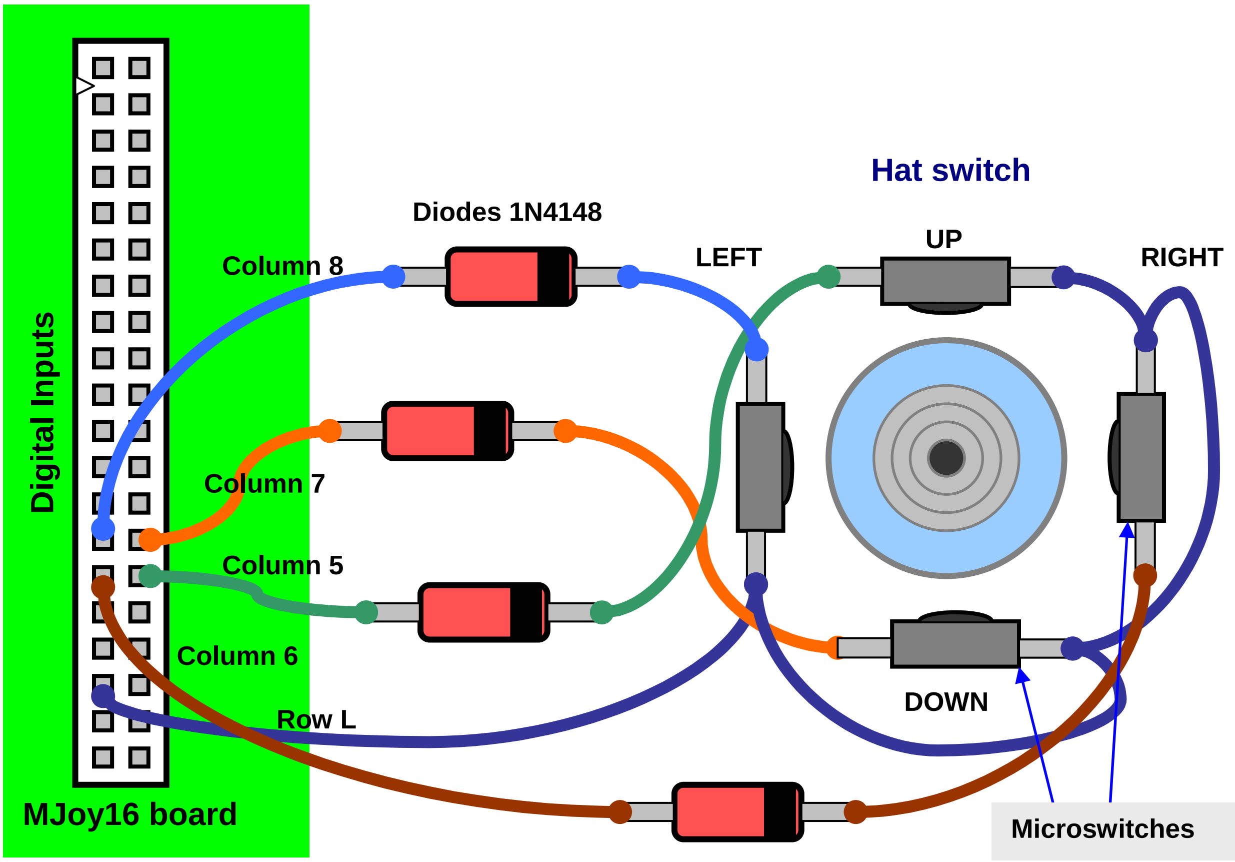


If you wire rotary switch through Key Matrix board you should follow the example below:

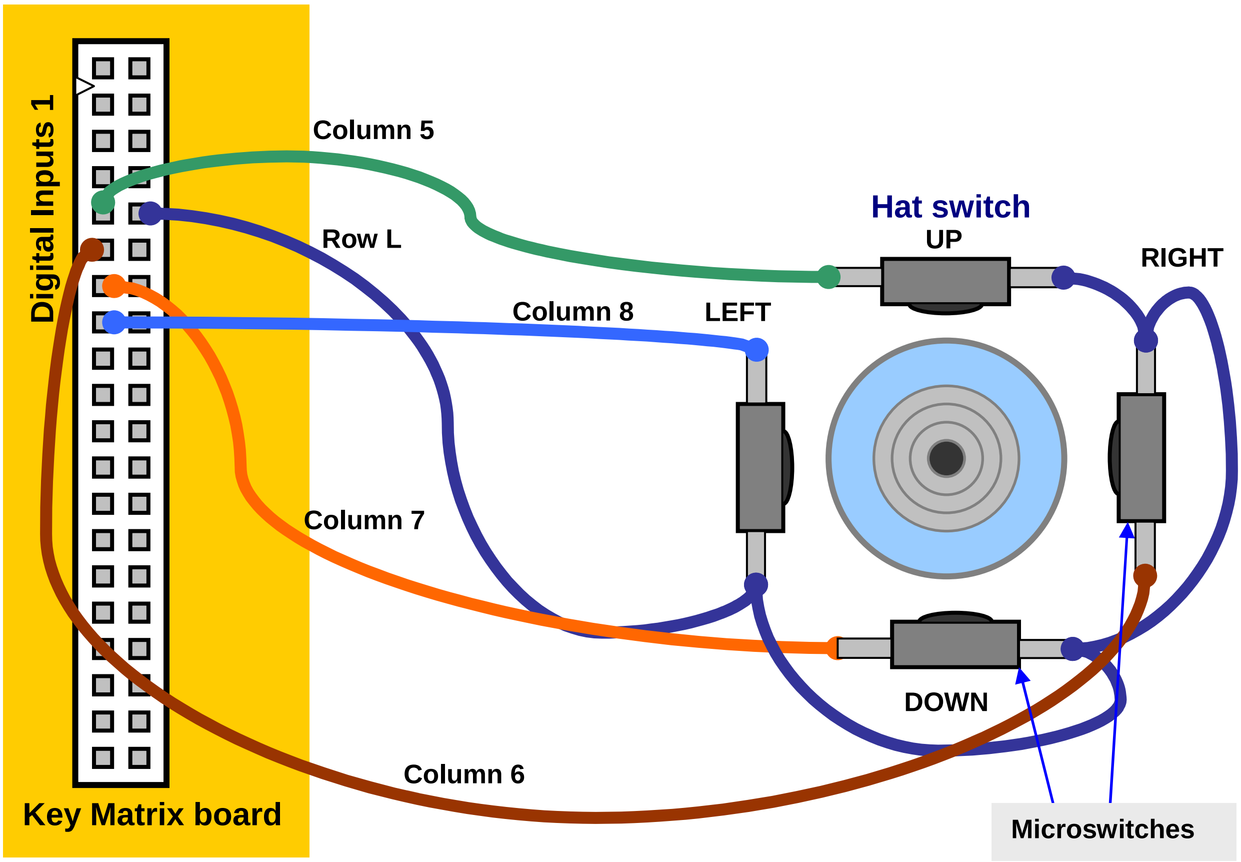


Wiring Hat switch

Hat switch is 8-way hat switch and it is made of 4 microswitches arranged on 4 sides of hat switch enclosure. A small joystick handle presses one or two switches at a time depending on angle of deflection. When only one switch is pressed it gives four main directions at 90 degrees angles: "UP", "RIGHT", "DOWN" and "LEFT". When two switches are pressed it gives intermediate directions: "UP-RIGHT", "UP-LEFT", "DOWN-RIGHT" and "DOWN-LEFT".
Below is a diagram showing how to wire the hat switch directly to the MJoy16 board:



Below is a diagram showing how to wire hat switch to the Key Matrix board:



Wiring "Init" button

The Init button is wired the same way as any other pushbutton. Refer to the wiring in the pushbutton section for information how to wire the "Init" button.

Wiring "Mode" and "Centre" switches

These switches set the mode of operation of MJoy16-C1. This mode is usually set during the installation phase and never needs to be changed unless some cockpit rework is to be done. So they may be placed somewhere inside of the panel as user do not need to change them at any time during operation. These switches may also be substituted by simple shorted or open pair of wires which resembles to "On" or "Off" state of the switches. They might also be jumpers. On the Key Matrix board you may short contact pairs L2 and/or L3 or leave them open. If you don't use the Key Matrix board you must connect the contacts via diode as if using a simple pushbutton.

Controls Mapping

MJoy16-C1 has two modes of mapping controls. They differ from each other by the numbering of buttons assigned to pushbuttons, toggle switches and rotary switches. Mapping Mode 1 puts pushbuttons first, toggle switches next and rotary switches last.
Mapping Mode 2 is basically bottom-up version of this layout. It puts rotary switches first, toggle switches next and pushbuttons last.

Below is the table of mapping of controls in Mode 1:

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Btn A1	Btn A2	Btn A3	Btn A4	Btn A5	Btn A6	Btn A7	Btn A8
9	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Btn B1	Btn B2	Btn B3	Btn B4	Btn B5	Btn B6	Btn B7	Btn B8
17	**18**	**19**	**20**	**21**	**22**	**23**	**24**
Btn C1	Btn C2	Btn C3	Btn C4	Btn C5	Btn C6	Btn C7	Btn C8
25	**26**	**27**	**28**	**29**	**30**	**31**	**32**
Btn D1	Btn D2	Btn D3	Btn D4	Btn D5	Btn D6	Btn D7	Btn D8
33	**34**	**35**	**36**	**37**	**38**	**39**	**40**
Btn E1	Btn E2	Btn E3	Btn E4	Btn E5	Btn E6	Btn E7	Btn E8
41	**42**	**43**	**44**	**45**	**46**	**47**	**48**
Btn F1	Btn F2	Btn F3	Btn F4	Btn F5	Btn F6	Btn F7	Btn F8
49	**50**	**51**	**52**	**53**	**54**	**55**	**56**
Btn G1	Btn G2	Btn G3	Btn G4	Btn G5	Btn G6	Btn G7	Btn G8
57	**58**	**59**	**60**	**61**	**62**	**63**	**64**
Btn H1	Btn H2	Btn H3	Btn H4	Btn H5	Btn H6	Btn H7	Btn H8
65	**66**	**67**	**68**	**69**	**70**	**71**	**72**
Tgl I1 On	Tgl I2 On	Tgl I3 On	Tgl I4 On	Tgl I5 On	Tgl I6 On	Tgl I7 On	Tgl I8 On
73	**74**	**75**	**76**	**77**	**78**	**79**	**80**
Tgl I1 Off	Tgl I2 Off	Tgl I3 Off	Tgl I4 Off	Tgl I5 Off	Tgl I6 Off	Tgl I7 Off	Tgl I8 Off
81	**82**	**83**	**84**	**85**	**86**	**87**	**88**
Tgl J1 On	Tgl J2 On	Tgl J3 On	Tgl J4 On	Tgl J5 On	Tgl J6 On	Tgl J7 On	Tgl J8 On
89	**90**	**91**	**92**	**93**	**94**	**95**	**96**
Tgl J1 Off	Tgl J2 Off	Tgl J3 Off	Tgl J4 Off	Tgl J5 Off	Tgl J6 Off	Tgl J7 Off	Tgl J8 Off
97	**98**	**99**	**100**	**101**	**102**	**103**	**104**
Rot K12 CW	Rot K12 CCW	Rot K34 CW	Rot K34 CCW	Rot K56 CW	Rot K56 CCW	Rot K78 CW	Rot K78 CCW
105	**106**	**107**	**108**	**109**	**110**	**111**	**112**
Rot K12 FCW	Rot K12 FCCW	Rot K34 FCW	Rot K34 FCCW	Rot K56 FCW	Rot K56 FCCW	Rot K78 FCW	Rot K78 FCCW

Bold numbers in above table show button number as it is seen by Windows. These are the same numbers which are seen in joystick control panel from game controllers menu. Mnemonics in the table mean following: Btn – pushbutton, Tgl – toggle switch, Rot – rotary switch, CW – clockwise, CCW – counter-clockwise, FCW – fast clockwise, FCCW – fast counter-clockwise.
For example Pushbutton A3 acts like a joystick Button 3 in Windows. When you switch toggle switch J6 to "On" position it generates joystick Button 86 brief press. When you

slowly rotate rotary switch K12 clockwise it generates joystick Button 97 press pulses in Windows. If you quickly rotate the same K12 rotary switch in counter-clockwise direction it will generate joystick Button 106 presses.

If you select Mode2 you will have controls mapping as shown in table below:

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Rot K12 CW	Rot K12 CCW	Rot K34 CW	Rot K34 CCW	Rot K56 CW	Rot K56 CCW	Rot K78 CW	Rot K78 CCW
9	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Rot K12 CW	Rot K12 CCW	Rot K34 CW	Rot K34 CCW	Rot K56 CW	Rot K56 CCW	Rot K78 CW	Rot K78 CCW
17	**18**	**19**	**20**	**21**	**22**	**23**	**24**
Tgl I1 On	Tgl I2 On	Tgl I3 On	Tgl I4 On	Tgl I5 On	Tgl I6 On	Tgl I7 On	Tgl I8 On
25	**26**	**27**	**28**	**29**	**30**	**31**	**32**
Tgl I1 Off	Tgl I2 Off	Tgl I3 Off	Tgl I4 Off	Tgl I5 Off	Tgl I6 Off	Tgl I7 Off	Tgl I8 Off
33	**34**	**35**	**36**	**37**	**38**	**39**	**40**
Tgl J1 On	Tgl J2 On	Tgl J3 On	Tgl J4 On	Tgl J5 On	Tgl J6 On	Tgl J7 On	Tgl J8 On
41	**42**	**43**	**44**	**45**	**46**	**47**	**48**
Tgl J1 Off	Tgl J2 Off	Tgl J3 Off	Tgl J4 Off	Tgl J5 Off	Tgl J6 Off	Tgl J7 Off	Tgl J8 Off
49	**50**	**51**	**52**	**53**	**54**	**55**	**56**
Btn A1	Btn A2	Btn A3	Btn A4	Btn A5	Btn A6	Btn A7	Btn A8
57	**58**	**59**	**60**	**61**	**62**	**63**	**64**
Btn B1	Btn B2	Btn B3	Btn B4	Btn B5	Btn B6	Btn B7	Btn B8
65	**66**	**67**	**68**	**69**	**70**	**71**	**72**
Btn C1	Btn C2	Btn C3	Btn C4	Btn C5	Btn C6	Btn C7	Btn C8
73	**74**	**75**	**76**	**77**	**78**	**79**	**80**
Btn D1	Btn D2	Btn D3	Btn D4	Btn D5	Btn D6	Btn D7	Btn D8
81	**82**	**83**	**84**	**85**	**86**	**87**	**88**
Btn E1	Btn E2	Btn E3	Btn E4	Btn E5	Btn E6	Btn E7	Btn E8
89	**90**	**91**	**92**	**93**	**94**	**95**	**96**
Btn F1	Btn F2	Btn F3	Btn F4	Btn F5	Btn F6	Btn F7	Btn F8
97	**98**	**99**	**100**	**101**	**102**	**103**	**104**
Btn G1	Btn G2	Btn G3	Btn G4	Btn G5	Btn G6	Btn G7	Btn G8
105	**106**	**107**	**108**	**109**	**110**	**111**	**112**
Btn H1	Btn H2	Btn H3	Btn H4	Btn H5	Btn H6	Btn H7	Btn H8

In this mode advanced controls are arranged at the beginning of buttons range. This provides some advantage when setting up this joystick in Windows because some Windows games have limitations. Possible ways of overcoming these limitations is described in next chapter about setting up MJoy16-C1 in Windows environment.

Setting up MJoy16-C1 in Windows

About limitation of 32 buttons per joystick

This joystick controller has 112 buttons. This number of buttons is supported by recent Windows and DirectX versions. Older versions of Windows supported only up to 32 buttons per joystick device. This limitation was removed by introducing alternative DirectX version 5 and newer interface to joysticks. This enables all contemporary programs to process more than 32 buttons from single joystick.
Yet still some games use old interface to joystick and thus have limitation of 32 buttons per joystick device. One example of such games is Microsoft Flight Simulator 2004 (MSFS) which – unfortunately - still has this limitation.
This was the reason of introducing two controls mapping modes. If your priority is to use rotary and toggle switches of MJoy16-C1 then you should use mapping mode 2. In this mode you will be able to use rotary switches and first 8 toggle switches directly from simulator software. Otherwise you may use mode 1 which places 32 pushbuttons in the first rows.
Mapping modes concept will work even better if you will use several MJoy16-C1 controllers. Then some controllers may be set to mode 1 and some to mode 2.
For example if you have two MJoy16-C1 sets, you can use the first set in mode 1 and the second set in mode 2. This will allow you to use 32 pushbuttons, 4 rotary switches and 8 toggle switches directly from Microsoft Flight Simulator.
There is another possibility to use all buttons from on MJoy16-C1. To be able to use all 112 buttons in MSFS you should use some software which translates joystick button presses to keyboard key presses. One example is described in next section.

Translating joystick buttons to keyboard keys

There are programs which can translate joystick buttons to keyboard key presses. As these programs and their availability is rapidly changing please see MJoy16-C1 product page on http://www.mindaugas.com website. Known available options will be listed there.

Multiple joysticks in Windows

First of all it is perfectly possible to have several joysticks or other game controller devices connected to the same computer. USB HID drivers allow up to 16 simultaneously operating gaming devices. You can still use your favourite joystick and have multiple MJoy16-C1 boards connected together.
All connected gaming input devices appear in Windows “Game Controllers” panel list in some order. Newly discovered devices are placed in certain list position automatically. The order of devices in this list is important when you setup joystick controls in your favourite simulator game. Normally you would prefer to have your main joystick first on the list, secondary – second and so on.
Unfortunately current Windows versions including Windows XP SP2 and older don’t allow you to change this list order. There is a chance that Microsoft might implement this capability in their later Windows versions but for now we must live with that.
This order depends on internal identifier numbers of gaming devices. These identifiers are Vendor ID and Product ID. These two IDs identify different Plug-and-Play devices from various manufacturers. Certain Vendor IDs are assigned to each vendor. All different products from one vendor will have the same Vendor ID but they will have different Product IDs.
The order of gaming devices in “Game Controllers” panel list is arranged in ascending Vendor ID and then Product ID order. That’s why Thrustmaster Afterburner joystick will always be above Logitech Wingman series joysticks and Thrustmaster Top Gun (R) Afterburner will be above Thrustmaster Top Gun (R) Fox2 Pro joystick.
Fortunately for us we can choose Vendor ID and Product ID whichever we like. MJoy16-C1 just as later MJoy versions by default uses Vendor ID = 0 which puts these MJoys on top of the list.
MJoy16-C1 controllers are available in several modifications which differ by Vendor ID, Product ID and the Product Name which appears in “Game Controllers” list. First modification name is “MJ16”. This is the default modification which should be installed if you use only one MJoy16-C1 in your cockpit. Other modifications are named “MJ62”, “MJ63” and so on. They will appear in Windows in corresponding order:

MJ16
MJ62
MJ63
....

If you already have “MJ16” (this is default) modification in your cockpit and you want to expand it with another MJoy16-C1 controller you should order “MJ62” modification. If you are expanding even further you should go for “MJ63” and so on.
It is possible to program MJoy16 to have your custom IDs and name. The procedure how to change Vendor ID, Product ID and Product Name of MJoy16-C1 is included in “Programming MJoy16-C1” manual which is located on http://www.mindaugas.com website in MJoy16-C1 product section. Programming is more advanced and complex procedure and it was left out of scope of this manual.

Credits

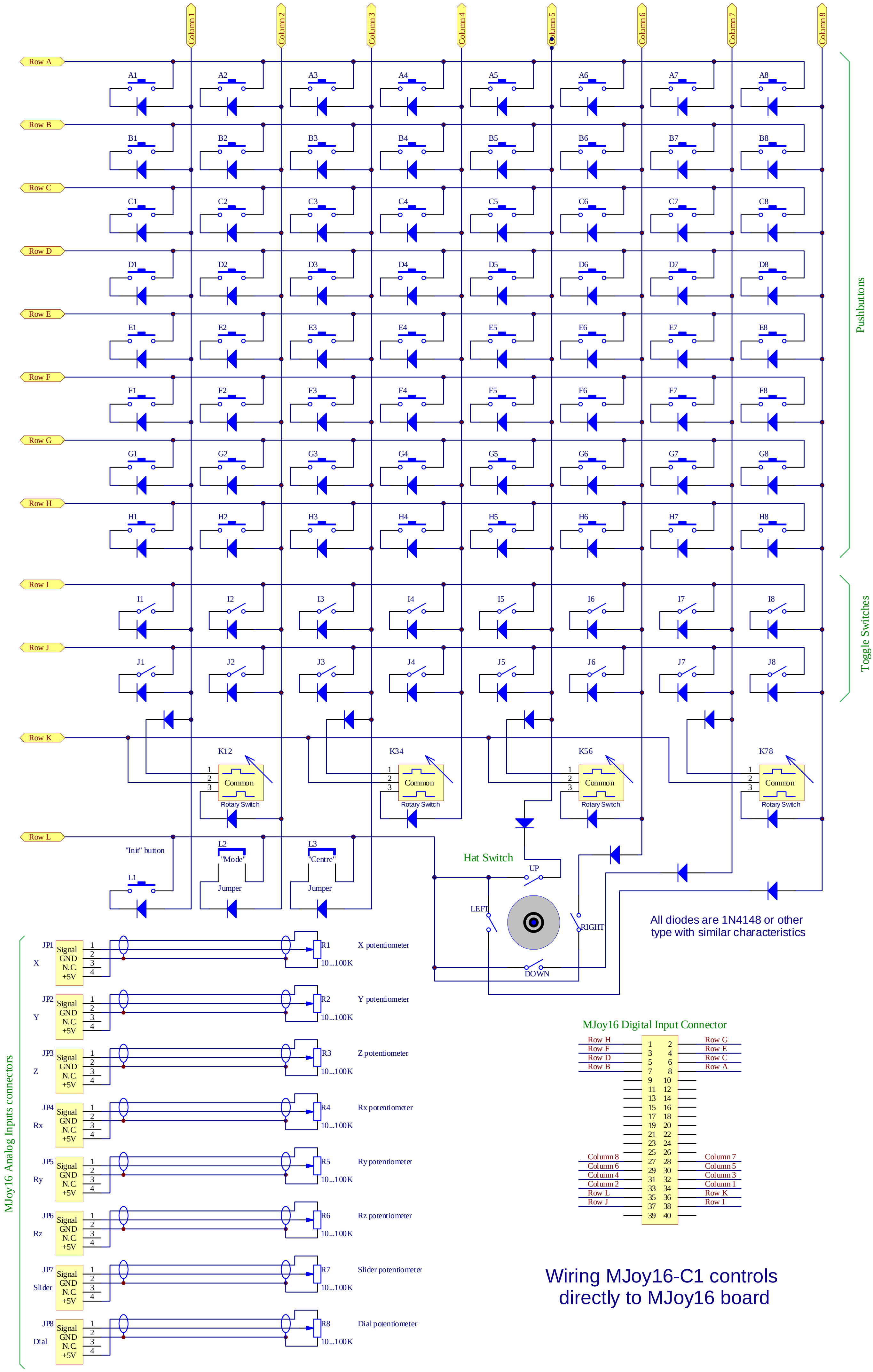
*Very big **Thank You** to **Jan L. F. Bos** for his great help on this project!*

Legal

Appendixes

A1. MJoy16-C1 wiring schematic diagram without Key Matrix board

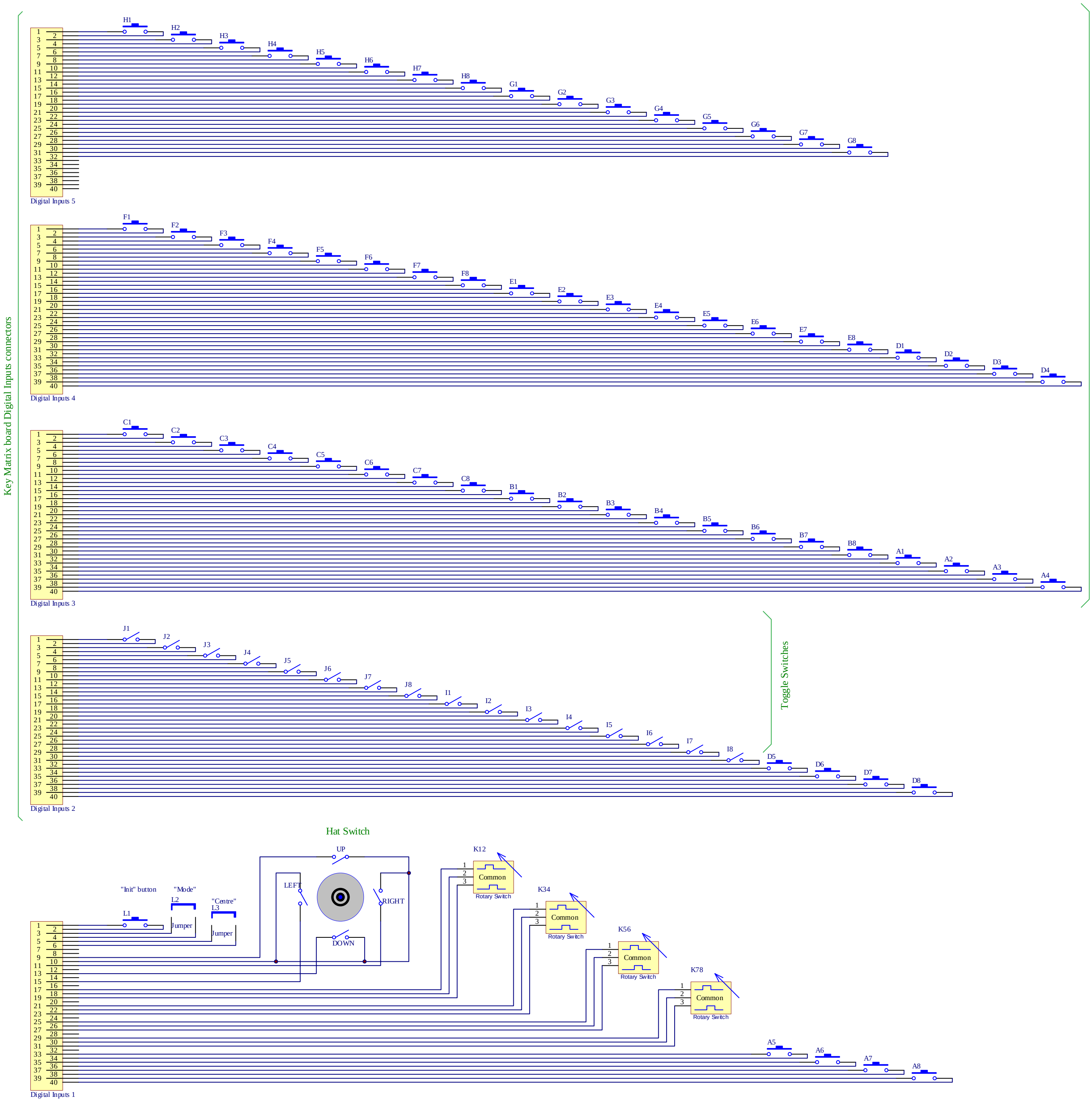
Schematic diagram of wiring MJoy16-C1 controls directly to the MJoy16 board is displayed on the next page.

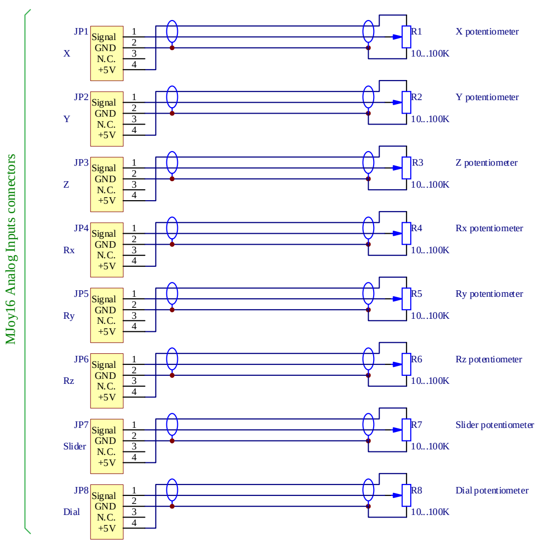


Wiring MJoy16-C1 controls directly to MJoy16 board

A2. MJoy16-C1 wiring diagram with Key Matrix board

Schematic diagram of wiring MJoy16-C1 controls to the Key Matrix board is displayed on the next page.





Wiring MJoy16-C1 controls to Key Matrix board