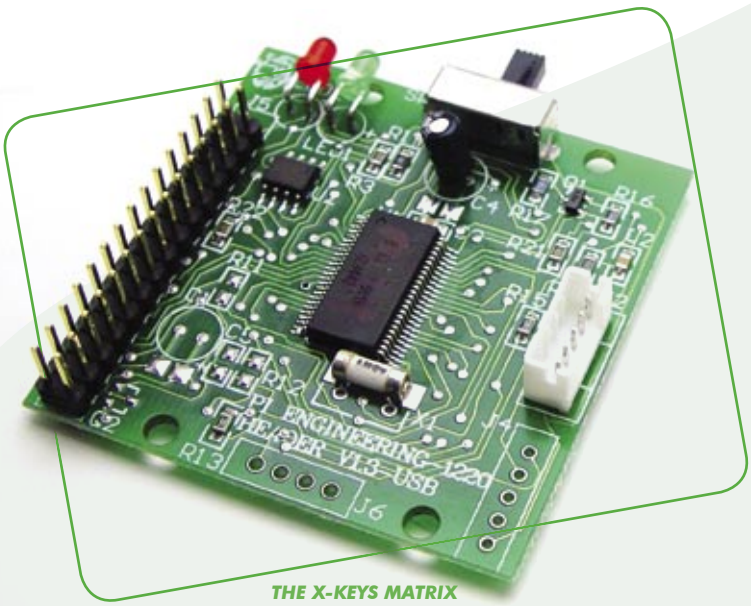
Cockpit Building Series

Adding Switches with the X-Keys Matrix

BY MATT EDWARDS

Many home cockpit builders build their cockpit not only to create a realistic place to slip into the simulation but also to simulate the functionality that a real flight deck offers. A real aircraft cockpit has switches that control a plethora of functions, and a home cockpit builder can take a big step forward by adding their own switches to the cockpit. There are several methods to add switches, and the X-Keys Matrix board by P.I. Engineering (www.xkeys.com) is one of the best. Let's explore how we can integrate switches into our flight deck using this hardware board.



THE X-KEYS MATRIX

P.I. Engineering is best known for their X-Keys programmable key pads. Their Matrix board is the project version of the control boards they put in their other products. The X-Keys Matrix project can be a large undertaking for the novice, but it is not that difficult after understanding the wiring concept and what kind of switches are needed. However, do expect to improve your experience with a soldering iron as up to 128 switch additions are possible.

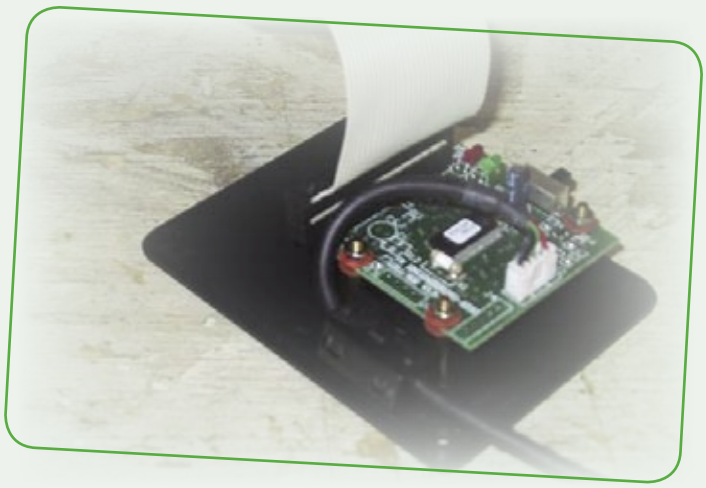
The Matrix Board

The Matrix is small, only 2"x 2", but it can do big things. Like most flight controllers it is possible to program the Matrix with simple mouse movements or complex keyboard macros. Also, on top of the 128 switch positions, you can also program one of these positions as a shift function and take your total number up to 254 functions. That should cover most home cockpit builders' needs for switches. However, if more switches are needed, another Matrix board can be used.

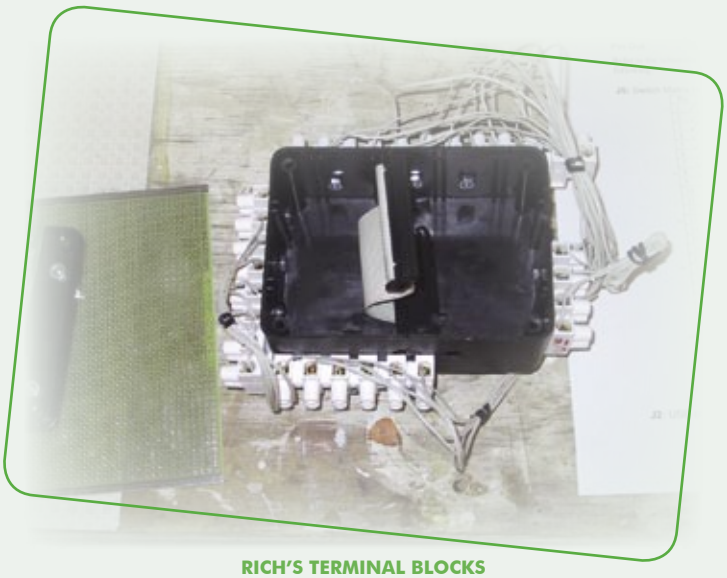
There is a PS/2 and a USB version of X-Keys Matrix. The PS/2 version can only have up to 96 switches while the USB can have up to 128 switches. There are also programming differences between the two. I would recommend the USB version due to the higher switch capability, easier programming, and more modern connection type. The PS/2 Matrix is available for simmers that specifically need a PS/2 connection. All Matrix units can be detected as a standard keyboard and mouse and be quickly interchanged between computers, even with differing operating systems.

Wiring the Matrix

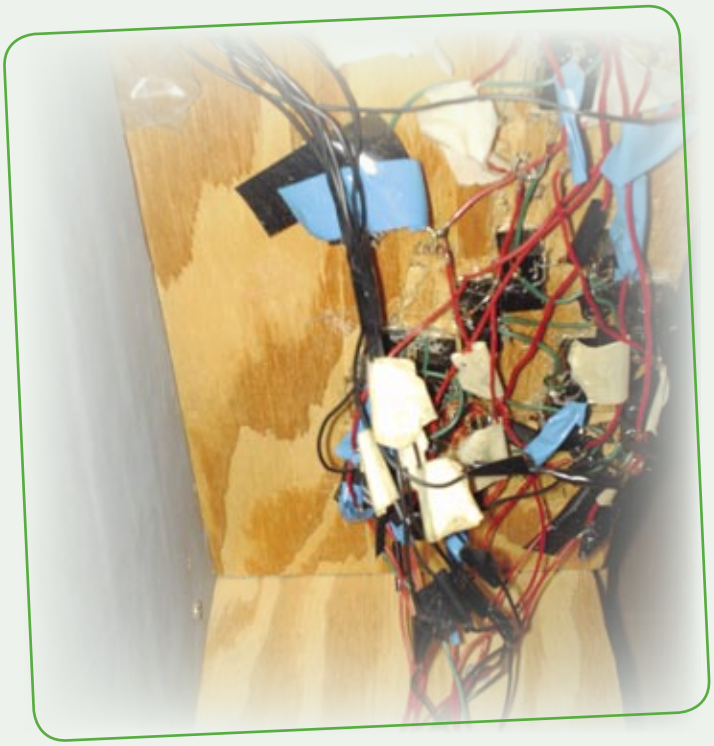
You can interface the switches with the Matrix via a 30.1" pin, double row male header located on the board. It looks similar to a standard IDE port, and while you can buy a special female header, many Matrix owners use an IDE ribbon cable. The special 30 pin female header is recommended by P.I. Engineering, but it can be hard to find. A higher pin count header can be used if you can find one. I used a 34 pin originally but found it hard to solder the wires to the pin header. Directly soldering wires to the Matrix board's pins is **not** recommended since you cannot easily remove them later and the heat could damage the board. The IDE cable is the best route for many users. I attached a spare cable and then inserted my wires into the other end and then hot glued them in place. This works well but there are countless possibilities out there as experience and knowledge levels provide. From the IDE cable you can use terminal blocks, breadboards, other electronic paraphernalia, or even directly wire to your switches as I did.



RICH "FLARELESS" SHERKIN'S MATRIX BOARD WITH RIBBON CABLE



RICH'S TERMINAL BLOCKS



MY MESSY, BUT EFFECTIVE WIRING

So Many Switches

There is myriad of switch types out there and it can be quite confusing to someone that has never dealt with them before. For starters, a new switch shopper will be presented with types like Single-Pole Single-Throw (SPST), Single-Pole Double-Throw (SPDT), and Double-Pole Double-Throw (DPDT). Add in that switch positions can be momentary, push button, toggle, rotary, center off, and you can have a momentary DPDT toggle with center off switch. Definitely confusing!

Here is how to decode some of the mystery. Poles refer to how many circuits the switch can support for each position. A single pole switch will have one circuit, while a double will have two, and a 3P will have three connections per position. For most situations, single pole switches are what is needed with the Matrix.

THE BACK OF SEVERAL SWITCHES INCLUDING A DPDT WITH ONLY ONE POLE WIRED, A FEW SMALLER SPSTS, AND TWO ROUND PUSHBUTTONS

Throws define how many closed circuit positions a switch has. A single throw has one position that the switch is on; a double has two positions. Switches that have more than two will usually be labeled by the number of positions, like 6 Position, 3 Pole. Center off is generally used in conjunction with double throws meaning that the switch has three physical positions but only the outside positions will complete the circuit.

Pushbutton, toggle, rocker, and rotary describe how switches move. Pushbuttons are just like they sound, there is a part that you push down on to close the circuit. Almost all pushbuttons are SPST. Many push buttons are momentary, meaning that they are spring loaded and only complete the circuit for as long as they are pushed down. However, you can also have push-on, push-off buttons that will stay on or off until you push them again. One other thing to check with pushbuttons is whether the circuit is normally closed or open. A normally closed momentary pushbutton will complete the circuit until you hold it down, which can cause problems unless programmed properly. Pushbuttons are usually used for radios, FMS, and MFD buttons.

Toggle switches are what most people picture when they think of switches. They are what you typically flip to turn on the lights in a room. Toggles can have different types of levers that make your project more realistic. Some even have safety covers or require you to pull out on them so you do not accidentally flip them. Rockers are very similar to toggles except that, instead of having an arm sticking up, you press down on a large rocker. Toggles and rockers are also quite common in airplanes with roles such as lights, electrical power, and anti-icing.

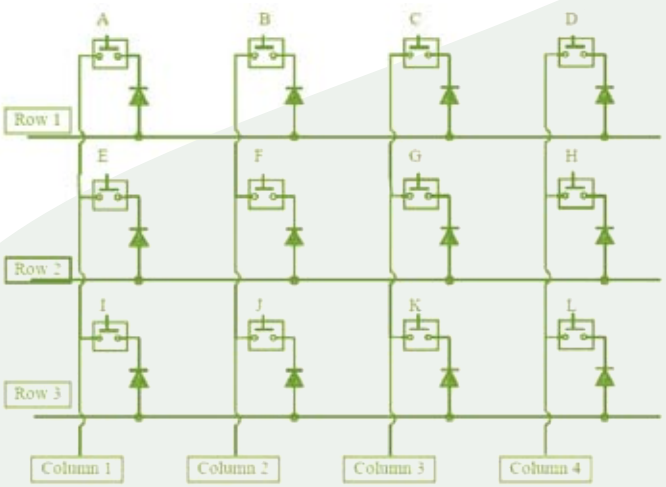
A ROW OF ROCKER SWITCHES IN A FRASCA 141 SIMULATOR

Rotary switches turn through their positions. They can have just one or multiple positions. Ignition, volume, and tuning knobs are some rotaries that are seen in aircraft.

Note that switches are also rated by how many volts and amps they can handle. Nearly all switches will work since the Matrix has a low voltage (5v) and low amps (15ma). Sources of switches can vary from cheaper local electronics stores, like Radio Shack, to expensive aviation switches from avionics suppliers and eBay.

Wiring the Switches

Wiring the Matrix to the switches requires following a "rows and columns" wiring scheme. There are 16 pins that are the columns and 8 pins that are the rows on the USB board. One column wire and one row wire provides one switch position. When the circuit is completed, it allows the Matrix to see that column x and row y are being connected and then send the keystroke programmed to that position. Since 16 columns can be attached to 8 rows, you then have 128 positions. An inexpensive 1N4148 diode is required on each position to prevent electricity from flowing down the column and sending errant keystrokes. Note that if you are using a double throw switch it will take 2 positions on your Matrix row/column layout if you want both positions to have unique commands. To get the maximum 128 switches, you must use only SPST switches or wire multiple positions with the same row/column slots.

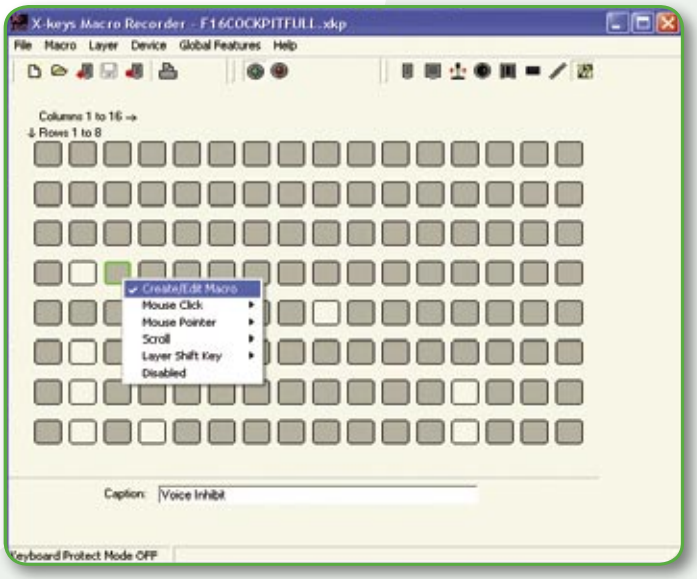


THE WIRING DIAGRAM FOR THE MATRIX

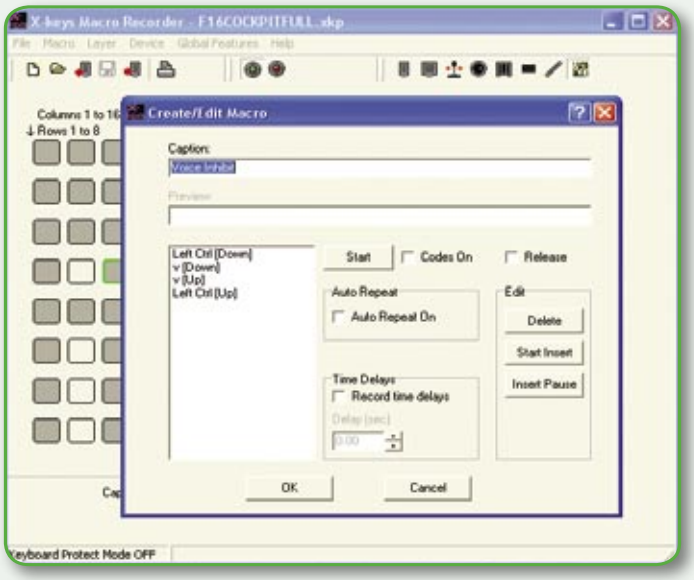
Programming the Matrix

Depending on the version of the Matrix, programming is similar to programming flight controllers. The PS/2 version has no programming software. To program it, the switch on the board is flipped to enter the programming mode. The switch that is being programmed is turned on and the assigned keystroke is pressed on the keyboard. This programming mode is slow and it's hard to know exactly what is programmed. This is the major reason why I do not recommend the PS/2 version.

The USB version can be programmed the same way as the PS/2 but the software is preferred. First, you need to determine how old your USB version is. If you buy a used USB Matrix and it was built before September of 2003 then you need a program called Macro Recorder. Matrix units built after that date are labeled as "X-Keys SE". These use the Macro Works software. The newer software does have more features that may make a buyer pay the extra price that new units normally demand. The two biggest features that Macro Works brings are quicker profile changes and the ability to assign joystick buttons to your switches.



MACRO RECORDER'S MAIN SCREEN



MACRO EDIT WINDOW

The Macro Recorder is fairly robust and very similar to the Works software. I still would recommend buying a used pre-SE unit if the price is right. Programming switches is easy with either utility. Just right-click the box that represents where the switch position is on the row and column. A pop up menu will allow you to record the macro, enter the mouse movement, and execute other options depending on your software.

Like other controllers that send chorded keystrokes (commands with Ctrl, Alt, and Shift), you want to keep the held commands to a minimum. Most switches should have a programmed keystroke and then an immediate release. For example, if an engine start toggle switch is programmed with a keystroke of "shift-e"; be sure to program a key up for both keys. Otherwise your shift and/or e keys will be held, causing problems for other commands. By selecting the release checkbox, the switch can also send keystroke when the switch is flipped back, like engine shut down. With commands like radio volume or ejection that need to be held or repeated for a few seconds, be sure to not use other switches until you are done using that switch.

Tips and Troubleshooting

My Matrix project was quite enjoyable. Here are my tips to make it even more enjoyable by preventing my common frustrations.

1. I found out the hard way that most mounting necks of switches are under a ½". The mounting material can't be much thicker than this and not impede the switch movement. Even less thickness is needed if you plan to secure the switches from the top. I had to replace my ½" thick cockpit side panels with ¼" plywood so I would still have extra depth to screw on the retaining nuts.

2. I suggest purchasing a plastic project enclosure box that will protect the Matrix board. Otherwise, anything and everything can fall on it.

3. Take your time when soldering switches. It will save time hunting down bad connections later. If switches are not working properly, be sure to continue down the row or column of that switch to see if the other switches are working or sending errant commands. This can help locate the bad connection or short. Also, check that your diode has the correct orientation since they only work one way.

4. When using multiple position switches, use the release programming to save you positions when possible. For example, a four position fuel selector knob can have only the middle two positions wired and rely on the release commands for the first and last position. However, do not skip in-between positions, the wrong release command may be sent when turning the knob both directions.

5. Ironically, sim toggle commands can actually be troublesome to program to toggle switches. For example, a single command like "g" is often used for raising and lowering the landing gear. If the physical switch is toggled up before entering the virtual cockpit for takeoff, the switch would have to be thrown down to send the keystroke to raise them in the sim after takeoff. There are two ways around this. One method is to pre-flight the switches so they are set properly before entering the sim. The other way is to utilize unique switch position commands, like "g" for gear down and "shift-g" for gear up, if the sim supports it.

The Matrix can be a daunting undertaking to an electronics beginner like I was. But it quickly turns into a fun adventure with big rewards at the end. It is great way to get a more useful and realistic cockpit. There is nothing like reaching for the switch instead of watching it being flipped on-screen. At only US$59.99, I highly recommend it to any cockpit builder – **www.x-keys.com** ✈