# *Bauer* "REMI 2" – EWI MIDI Controller

## Design and Construction Notes

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## References

General introduction to MIDI wind controllers and the REMI concept:
www.mjbauer.biz/REMI_Intro.htm

Main project web-page with overview and download links:
www.mjbauer.biz/Build_the_REMI_mk2.htm

Latest firmware release with source code and MCU programming instructions:
github.com/M-J-Bauer/REMI-2-EWI-MIDI-Controller

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## Touch-pad Layout and Fingering Schemes

There are two touch-pad layout options to choose from. The firmware has a configuration parameter allowing selection of either option. The physical layout of touch pads for each of the two options is shown below.



Above: Touch-pad layout for the "standard" (recorder-like) fingering schemes

Below: Touch-pad layout for the "alternate" (generic EWI) fingering scheme



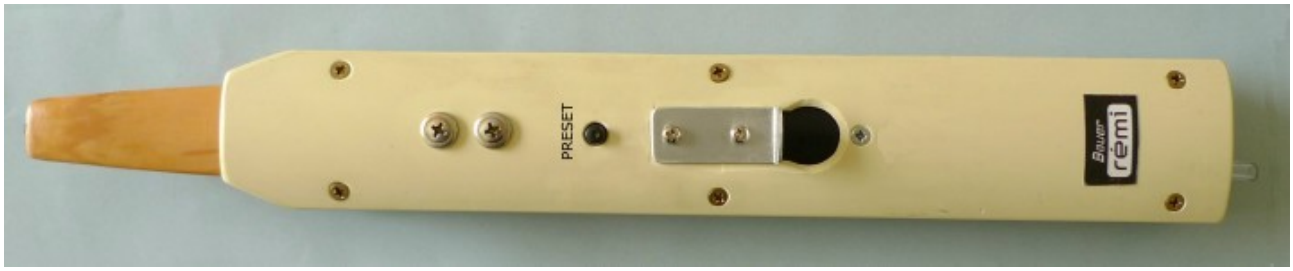
The first option (top picture) is more reminiscent of a recorder and should appeal to regular recorder players. Use this layout if you choose a fingering scheme which emulates an acoustic recorder. The second option is a little abstracted from the recorder. An extra pad (LH4) operated by the left-hand little finger is added, but the 5$^{th}$ right-hand pad (RH5) is omitted. This is a simpler scheme which is compatible with some of the commercial EWIs out there.

## Construction

This section describes the physical construction of the author's prototype instrument. There are many different construction methods possible, of course, and I encourage makers to improvise with alternative designs and materials. Perhaps the simplest construction method is to use two pieces of 3mm acrylic plastic (Perspex, Plexiglas) cut to size 300 x 40 mm, separated by 25mm spacers. The mouthpiece can be made from stiff plastic tubing, e.g. 12mm garden irrigation tube, moulded into the desired shape using a hot-air gun. If you have access to a 3D printer, this could be used to fabricate a mouthpiece and/or enclosure.

My prototype enclosure was made from two pieces of PVC plastic cut from a scrap of drain pipe, 110mm outside diameter, 3mm wall thickness. A suitable scrap of pipe may be found perhaps on a building site. The curved surface makes the plastic covers very rigid and strong. The upper piece has 3 wooden "ribs" (8~12mm thick) glued to it, allowing the bottom cover to be attached with self-tapping screws. Side strips of thin timber are glued to the ribs. The plastic surfaces are not painted, but rubbed with fine abrasive cloth (P400) to give a smooth matte finish. The result is a very "retro" (1950's) look and feel.

The bottom cover has 2 octave pads, a 'PRESET' button and Modulation Pad.
The metal bracket near the "Mod Pad" is a thumb rest which is wired to GND.

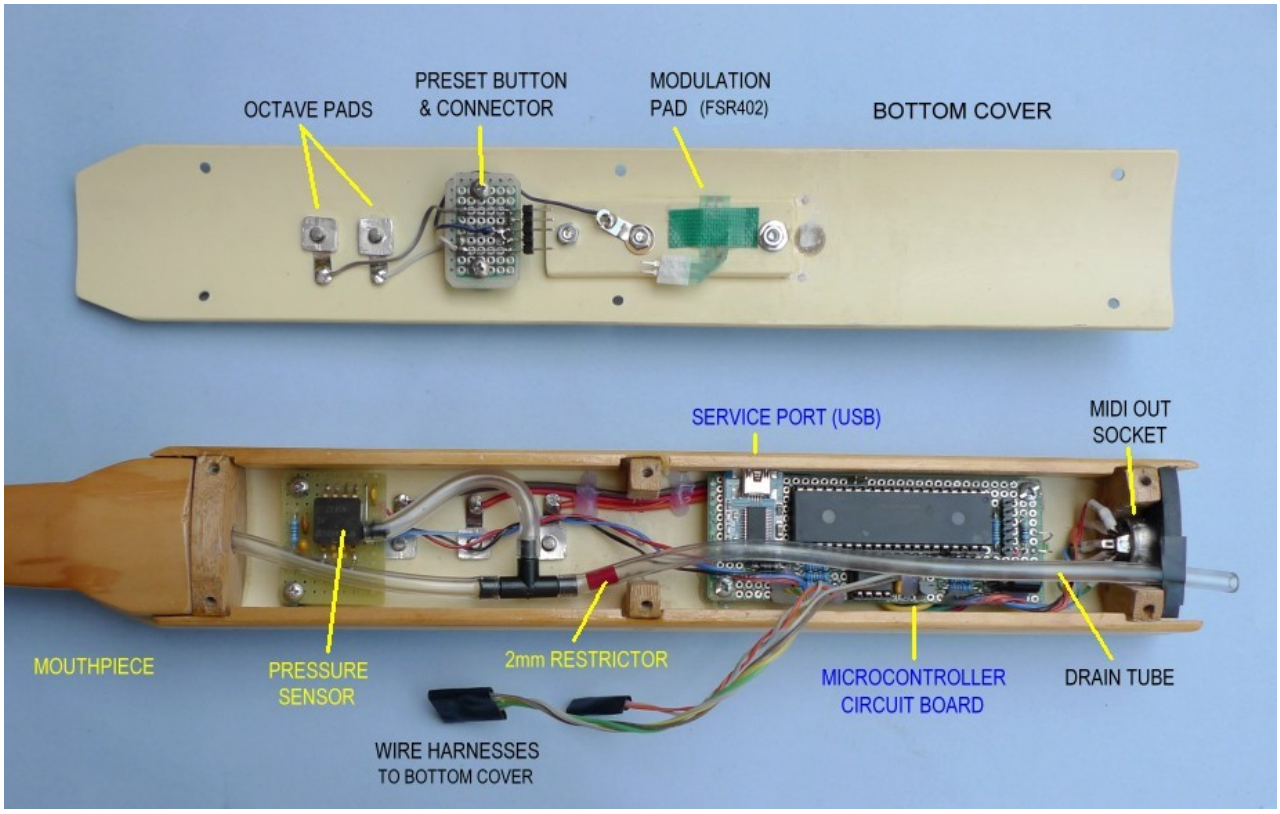



The touch-pads in the prototype are self-tapping screws with a broad flat head. These are inserted through holes in the upper surface, fastened on the inside with DIY aluminium retainers (approx. 9mm square). But there are better options...

Chicago screws, used for leather-work, book-binding, etc, make excellent touch-pads. These are available in a variety of metal finishes, e.g. brass, nickel, gun-metal, stainless-steel, etc.

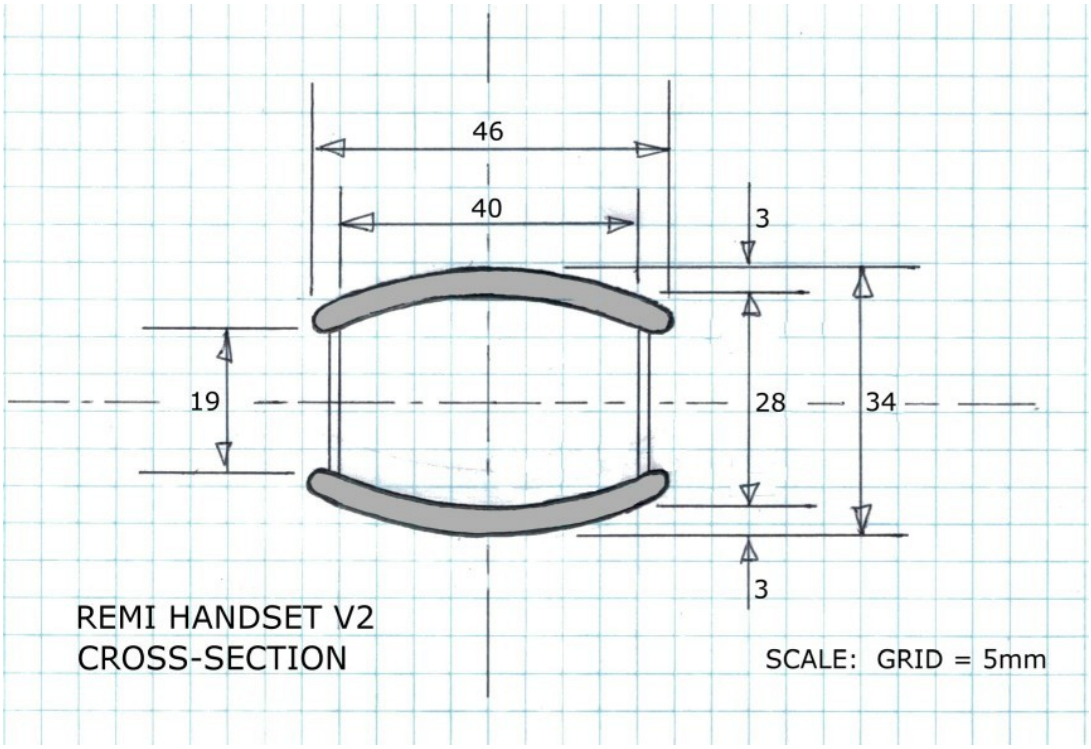
The size required is 4mm (shank length to suit panel thickness) x 10mm diameter head. Available at low cost from suppliers on AliExpress!






Internal parts layout

A drill template for the upper and lower surfaces is available for download from the project web-page. A cross-section drawing of the body is shown below:



The mouth-piece on the prototype REMI 2 was carved out of wood with a 6mm hole drilled through the middle. It is coated with a water-based sealer to prevent moisture absorption in the wood. The 5.5mm OD nylon tubing is inserted into the 6mm hole, all the way through to the tip, held in place with a water-based sealer (e.g. PVA glue). The mouth-piece is attached to the upper plastic cover with 4 self-tappers, so that it is easily removable.

Warning: Do not use a paint or lacquer with oil-based solvent on the mouthpiece, for 3 reasons... (1) it tastes terrible, (2) it could be a health hazard to the player, and (3) the vapours given off by the solvent could damage the Fluoro-silicone membrane in the pressure sensor device. Recommended coating for the mouthpiece is water-based polyurethane or some other safe product used to varnish wooden toys.

## Pressure sensor "plumbing"

Tubing and other bits and pieces needed to make the airways inside the instrument may be sourced from the garden irrigation section of your local hardware store. The prototype used clear nylon tubing (3mm ID, approx 5.5mm OD) for the internal airways linking the mouth-piece, pressure sensor IC and the drain tube. The T-joiner needed the barbs to be cut off to fit the 3mm tubing.

The sensor air inlet barb is slightly less than 3mm in diameter, which is a fraction too small to make a good seal with the 3mm ID nylon tube. An easy solution is to fit a short bit of 2.5mm diameter heat-shrink tubing over the barb, shrink it with a hot air blower or whatever (taking care not to melt the sensor!), then fit the 3mm nylon tube over it.

A drain tube is recommended because moisture condensation occurs inside the airways and it is probably sensible to provide an exit for the moisture. Also, the drain tube allows air-flow, which is preferable to a sealed system for playability. However, the exit air flow needs to be restricted somewhat to produce a sufficient range of pressure inside the sensor. This can be achieved by fitting into the drain-tube a small plug with a 2mm hole through it, perhaps cut from a bit of plastic insulation sleeve if you can find some of suitable size (3mm OD, 2mm ID). The best place to fit the restrictor is close to the T-joiner, to minimise moisture condensation.

It is also recommended to mount the pressure sensor above the T-joiner, close to the mouth-piece, to prevent moisture from getting into the sensor.

## Modulation Pad

Provision of a modulation control (pad, lever, knob, or whatever) is optional, but highly recommended to enhance musical expressiveness.

The simplest option is to use a force-sensitive resistor (FSR-402). This is quite satisfactory as an "effect controller", e.g. for vibrato depth, timbre modulation, etc. The FSR is mounted behind a round hole (16mm diam.) in the bottom cover. A plastic "backing support", made from the same material as the covers, is fixed to the inside of the bottom cover with machine screws. A piece of PVC insulation tape is stuck over the top of the FSR402 to prevent damage. In operation, the right-hand thumb presses the FSR against the backing support.

Note: The FSR402 is fragile. Take care not to damage the flex strip. Don't bend it too tightly. Insert thin washers (0.5 ~ 0.8 mm) between the REMI body (bottom cover) and the FSR support piece to prevent the FSR edges from being compressed.

The sensitivity of the “Mod Pad” can be adjusted by a configuration setting in the firmware. It can also be adjusted by the value of the resistor in series with the FSR-402. Recommended minimum value is 1k ohm. Higher resistance values increase the sensitivity.



Mod Pad (FSR402) mounted on plastic support piece

Another idea to make a modulation control, assuming your workshop skills are adequate, is to construct a spring-loaded lever mechanism forming part of the right-hand thumb-rest. The lever position can be transformed into a control voltage (fed directly into an ADC input pin) using an optical proximity sensor device, e.g. CNY70 or similar.

## Electronics

The REMI 2 electronic circuit design is based on a popular low-cost 8-bit PIC micro-controller (PIC18F**45**K22 or PIC18F**25**K22) with capacitive touch-sense inputs for the touch-pads.

The REMI has a classic MIDI OUT connector (5-pin DIN) with "Power-over-MIDI", compatible with the MIDI IN socket on the **ItsyBitsy M0 Synth** module. The MIDI IN connector on the IstyBitsy M0 synth supplies 5V DC power to the instrument. The REMI can connect to other MIDI sound modules, or to a computer, via a simple DIY **MIDI-USB adapter module**.

The micro-controller circuit board has a **USB-serial bridge** (FTDI FT232RL breakout board) allowing the instrument to be connected to a PC running a terminal emulator app ("**PuTTY**"). The USB/serial "service port" provides a command-line user interface (CLI) to facilitate setting up and testing REMI operation. The CLI serves no purpose in normal operation.

Note: Provision of a permanent USB-serial bridge on the REMI circuit board is optional. Instead, a 4-way SIL pin header may be fitted to access the MCU UART (TX and RX pins) externally. A USB-serial bridge adapter/cable can be made to connect to the UART header whenever it is required to run the “Service Port” CLI.

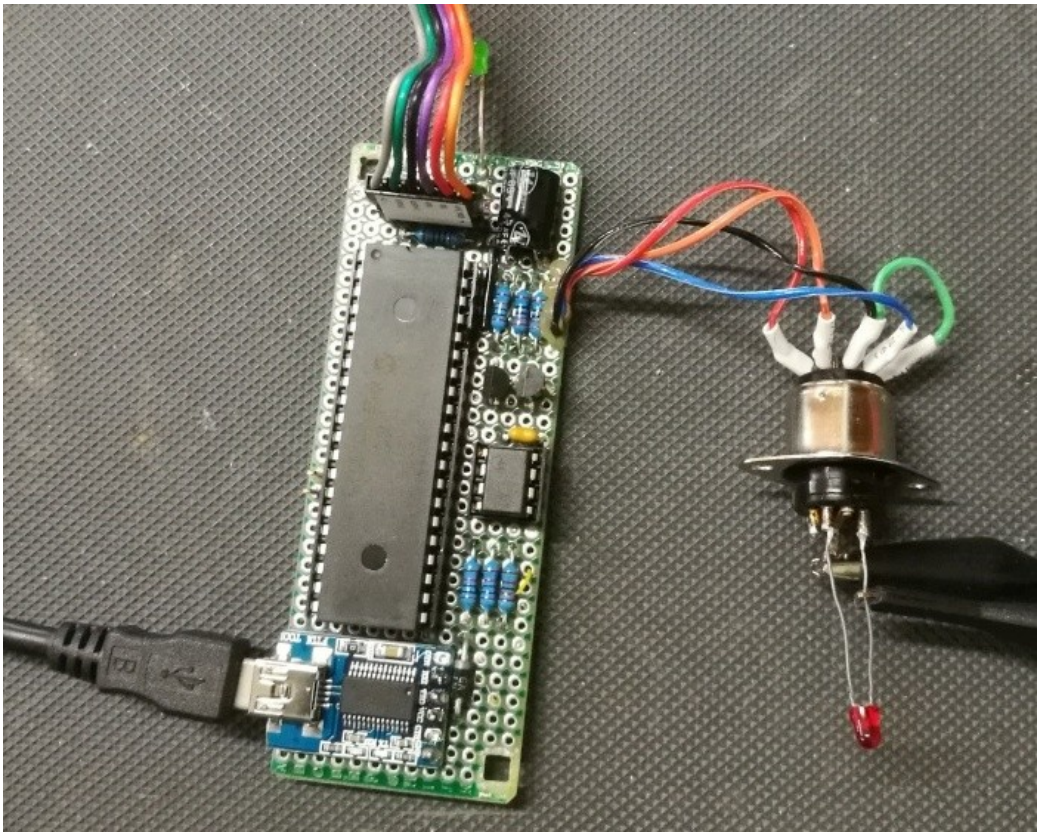
The REMI micro-controller circuit board is constructed on a piece of prototyping board. A 40-pin DIL socket for the PIC18F45K22 MCU chip takes up most of the board area.

A 6-pin SIL header for connection of the MCU programming tool (PICkit 3) is located at the "bell" end of the board (near the MIDI OUT socket).

The USB-Serial bridge is best located such that the USB receptacle is accessible through the **left side** panel. The prototype (pictured) has the USB socket on the right side panel, which was a mistake because the USB cable gets in the way of the player's right hand.

Hookup wires to the touch-pads, MIDI socket, sensors and other off-board parts may be soldered directly onto the main circuit board.

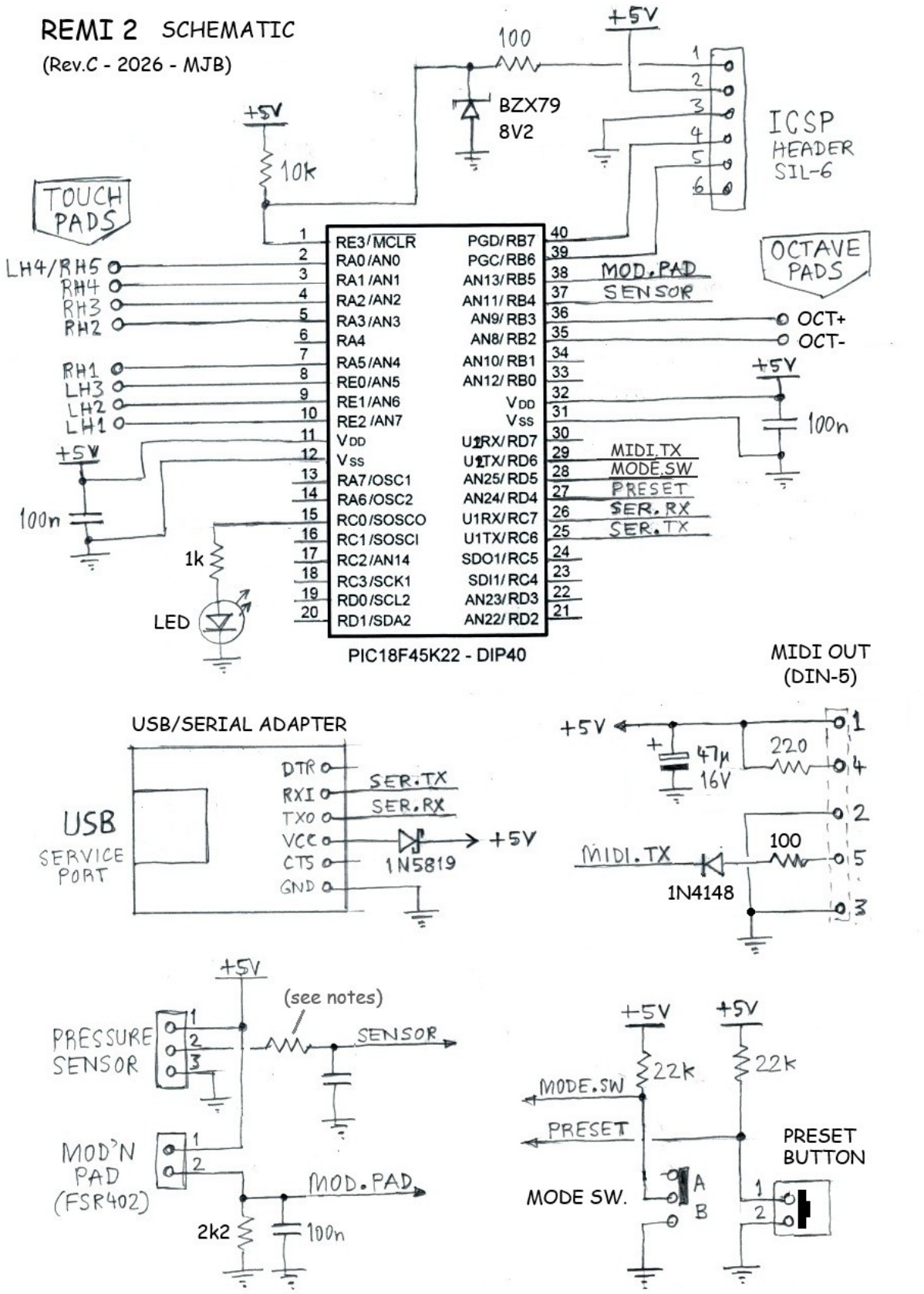
The photo below shows the MIDI OUT socket wired to the MCU board. The socket has a plug inserted with a LED wired between the OUT+ and OUT− pins for testing. An oscilloscope was used to test the performance of the MIDI OUT driver circuit, in particular for compliant rise and fall times in the output signal. (You don't need to do this – the circuit passed the test!)



The USB/Serial bridge supplies 5V power to the REMI MCU when using the Service Port CLI, so there is no need to plug in a MIDI cable at the same time. There are many different types of USB/Serial modules available. Be sure to buy one that outputs 5V on the Vcc pin and has 5V logic levels on the TX and RX signal lines. Some types are settable for either 3.3V or 5V.

Note: The REMI 2 can be built using a 28-pin variant of the MCU (PIC18F**25**K22) which saves space and has enough I/O pins for the application. The 28-pin MCU type will need a different firmware build. (More about that later… watch for notifications on the REMI 2 web-page.)

The 40-pin part (PIC18F**45**K22) was chosen initially because I had planned to incorporate a **wireless MIDI transmitter** device into the REMI as an optional extra, allowing cordless operation (battery powered). An RF module was interfaced to the MCU via an SPI port and a few GPIO pins, but I dropped the wireless MIDI idea because it was problematic.




Note: The schematic has been revised (simplified) since the prototype board was made.

## Breath Pressure Sensor

The pressure sensor device is mounted on a separate little board located very close to the mouthpiece. The air inlet port should face away from the mouthpiece, i.e. downward, to prevent moisture from entering the sensor.

The sensor type fitted in the REMI prototype is a MPXV5010-GP, but this part is now expensive (~US$30) and may also be hard to obtain. There are other options for the pressure sensor, easier to find and at lower cost.

For example, a low-cost pressure sensor with integrated electronics - XGZP6857A - is now available from online suppliers (try AliExpress). The device comes in a range of maximum pressure values; 5 kPa is ideal for an EWI breath sensor (part number: XGZP6857A-005). The 10 kPa type (XGZP6857A-010) is also quite suitable.

The sensor output voltage is suitable for direct feed to an ADC input. No external signal conditioning is required. Be sure to order the part type with 5V supply voltage (Vcc = 5V).

If you want to try something more radical, it is possible to make a breath (air-flow) sensor using a movable membrane, or flexible vane, and an optical proximity sensor, e.g. CNY70.

The idea is to deflect the membrane by blowing air through a hole in the mouthpiece. The opto sensor detects a small movement in the membrane, up to about 6mm. There is a YouTube video showing a ridiculously simple EWI with a mouthpiece made from the neck of a plastic bottle, a membrane made from a piece of a party balloon, and a CNY70. Search for "**KLIKsophone**". (No doubt, a more elegant sensor could be devised!)

Whatever your choice of breath sensor, the essential requirement is to produce an output signal of sufficient magnitude to feed directly into an ADC input on the micro-controller. The ADC input voltage span, i.e. difference between minimum and maximum pressure, should be about 3V or more ideally, but must be at least 1 volt. The voltage at minimum pressure (no air-flow) should be near zero, but in any case it should be well below 1V.

Instructions for hardware testing and sensor calibration are given in the REMI 2 User Manual.

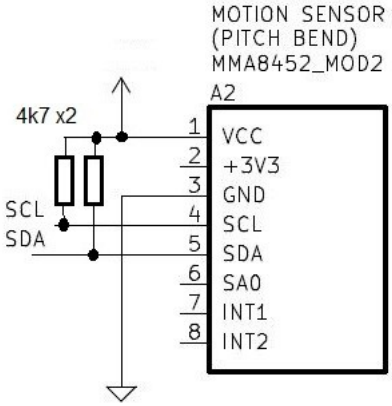
## Pitch Bend Sensor

The REMI 2 firmware supports optional Pitch Bend capability using a motion sensor, 3-axis accelerometer IC, type MMA8451 or MMA8542. Suitable MMA8451/52 breakout modules are available on AliExpress for about $1.50 (under 1 euro!). The firmware adapts itself automatically to support either the MMA8451 or MMA8452, or none if omitted.

The motion sensor measures the tilt, i.e. angle of the instrument, while a note is playing. Any change in tilt position from the start of a note will cause a change in pitch, up or down, assuming of course that the connected synthesizer responds to MIDI Pitch Bend messages. Pitch bend range and sensitivity are determined by the synthesizer... not by the REMI itself. Pitch Bend MIDI messages may be enabled or disabled by setting a configuration parameter in the firmware (using the CLI).

Hardware additions for pitch bend are very easy... only 4 wires are needed to connect the MMA8451 module to the PIC18 MCU, as shown in the diagram below. The 4.7k pull-up resistors on SCL and SDA pins are not necessary... the breakout module will have pull-ups already fitted. Vcc pin is connected to +5V. Caution: Some modules may have different pin ordering, but the signals are the same.




The sensor module should be mounted "upside-down", i.e. with the MMA8451 chip facing the bottom cover of the REMI. If the sensor is mounted so that it faces the top cover, the pitch bend direction will be reversed, i.e. upward tilt will result in lower pitch.

## MIDI-USB Adapter box

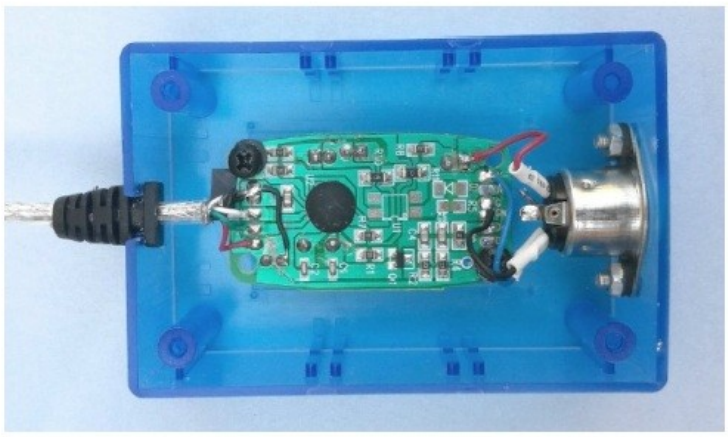
The MIDI-USB adapter is simply a commercial device re-fitted and re-wired into a new housing. The adapter/cable pictured below is readily available at very low cost (under A$10) from online suppliers.




The original adapter casing can be easily broken apart by cutting around the join with a hacksaw or utility knife, taking care not to damage the circuit board inside. The two MIDI cables with DIN-5 plugs on the end are removed from the circuit board and discarded. The USB cable and connections are kept intact.

The circuit board is removed from its casing and mounted in a small plastic box together with a 5-pin panel-mount DIN socket for MIDI input (from REMI 2 or other MIDI controller). Plastic standoffs are glued into the box to hold the circuit board in place. A translucent box was chosen to allow the LED indicators to be visible through the top of the box.

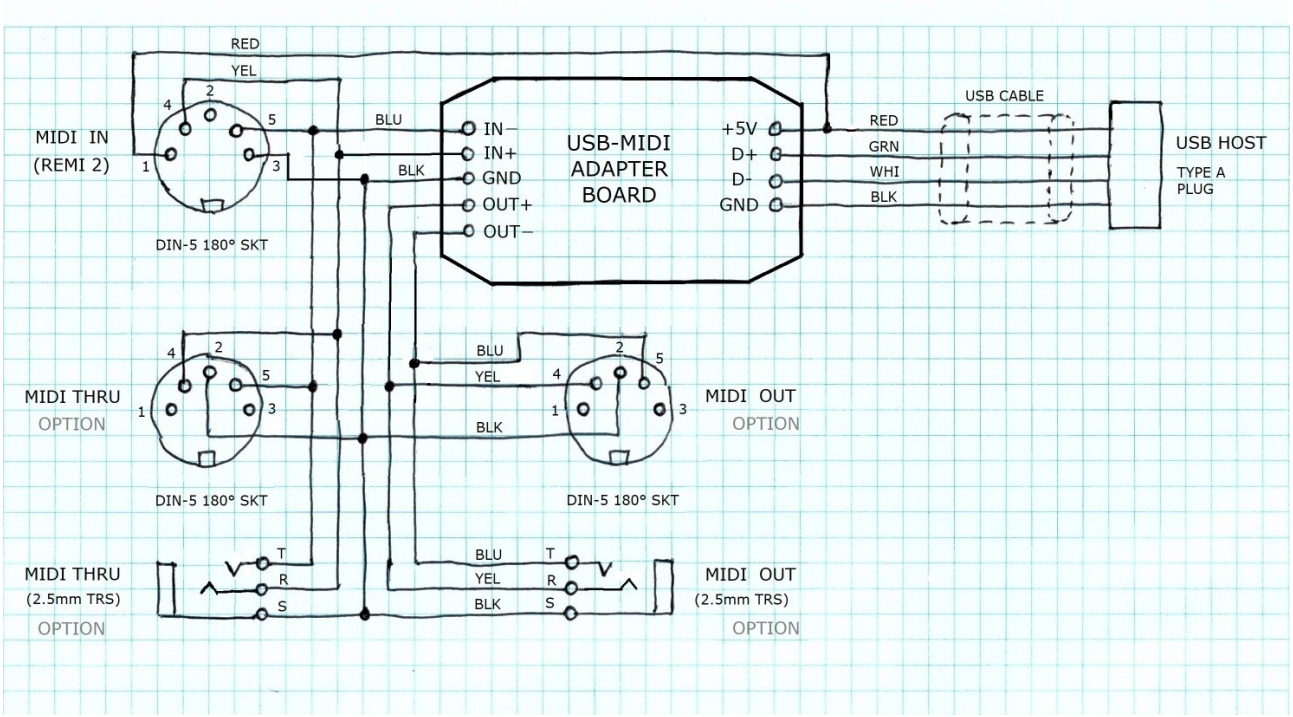




The MIDI-USB adapter uses 2 spare pins on the MIDI IN connector to supply 5V DC power to the REMI. Similar "Power over MIDI" schemes are used by various commercial manufacturers, including Arduino for their MIDI “shields" to supply 5V to MIDI devices. The MIDI-USB adapter uses the same pin allocations as Arduino, i.e. pin1 = +5V, pin3 = 0V (GND).

The USB cable on the MIDI adapter supplies power to the REMI from any regular 5V USB power pack (phone charger) or from a host computer.

The circuit diagram below gives wiring details for the adapter. The diagram also shows connections for optional 'MIDI THRU' and 'MIDI OUT' sockets. These may be DIN-5 types or 2.5mm "micro" TRS types, as fitted on some low-end mini synthesizers. Provision of a MIDI THRU socket allows the REMI to operate with any synth having a MIDI IN connector.



Provision of a MIDI OUT socket allows the adapter to connect a computer to an external synth with a classic MIDI input.

If you just want MIDI IN (for your REMI) and USB for the host computer, you don't need to house the parts in a new box. You could use the original adapter casing. All that needs to be done is to remove the two MIDI cables and add a new MIDI IN cable with an inline 5-pin DIN plug for the REMI. The adapter casing can be joined back together with PVC tape.

Note: A standard MIDI connection requires only pins 4 and 5 to be wired. Some ready-made MIDI cables have only 2 cores inside (plus screen = pin 2). Be sure to buy (or make) a MIDI cable with all 4 cores (plus screen) to connect your REMI 2 EWI to the MIDI-USB adapter or a Bauer “ItsyBitsy Sigma-6” synthesizer.