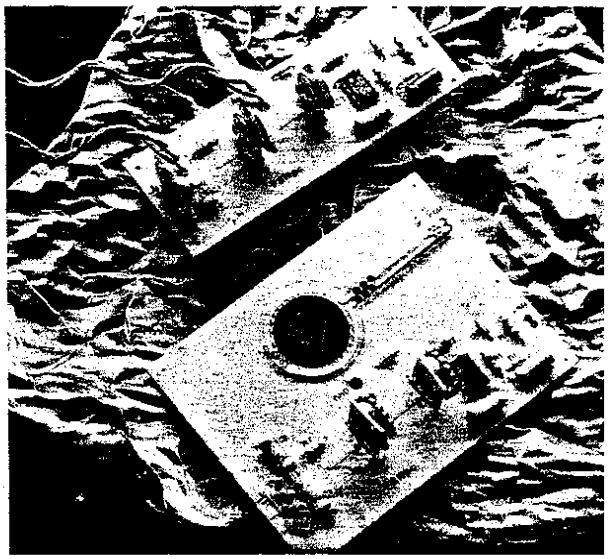
Fun Under Pressure

By Charles R. Fischer

The EM Presto puts expressive control at the tip of a finger.



MIDI and microprocessors have given musicians more than just sequencers and multitimbral modules. Velocity and pressure sensitivity are two of the great breakthroughs in electronic music. Before MIDI, these features were available only on a few high-end synths, but today it's just the opposite. All but the cheapest keyboards have velocity sensitivity, and most have at least channel aftertouch.

But there's plenty of room for improvement. For the last couple of years, I've been using devices that measure finger position and pressure to build more expressive MIDI controllers.

The *Force Sensitive Resistor* (FSR) is one of the more interesting items I've found. It's small, reasonably cheap, and can be interfaced with both analog and digital circuitry. Other devices can be used, but the FSR often performs as well, or better than, more expensive sensors. They have been used as drum sensors by manufacturers such as KAT, Akai, and Simmons.

ENTER THE FSR

Take a look at **Fig. 1**. It's from a business card from Interlink Electronics, and it includes an actual working example of a Force Sensing Resistor. The FSR consists of a grid of conductive ink and a "pad" of resistive ink printed on the card itself. When the resistive pad is placed over the conductive grid, the overall area of contact between the two elements changes with applied force.

The FSR behaves as a variable resistance in series with a momentary switch. With no pressure applied, it's virtually an open circuit; applying force to the sensor lowers the resistance radically. How much the resistance varies depends on the design of the individual FSR. A typical unit may vary over a range of 500 to 1, or even more.

Pairing the sensor with a fixed resistor forms a simple voltage divider, and this produces an output voltage proportional to force. A pair of op amps buffers and amplifies the raw output and provides calibrations for the voltage range and offset.

Most control-pedal inputs on today's instruments and accessories accept a DC control voltage in the range of 0 to 5 volts. This makes it easy to use the FSR with a variety of instruments. **Fig. 2** shows the complete circuit.

Zener diode D1, together with R1, provides a stable reference voltage for biasing the FSR. The FSR and R2 form a voltage divider; with no pressure applied to the FSR, the output of the divider is negligible. Once pressure is applied, the resistance of the FSR falls rapidly, causing the voltage across R2 to rise proportionally.

The reference voltage and the ratio of the FSR to R2 determine the maximum output voltage. Op amp IC1A buffers and amplifies the voltage divider output.

Trimpot R4 adjusts the sensitivity of the FSR by altering the gain of op amp IC1A. IC1B provides an adjustable bias voltage. Normally, R6 is set so that the output voltage is 0 volts when the FSR is untouched.

PUTTING IT TOGETHER

Since everything needs a cute name, I decided to call my circuit the Presto. The opening photo shows the completed project in two styles. The easiest way to build it is to purchase the PC board or parts kit from PAiA Electronics of Edmond, Oklahoma (see Parts List). If you prefer, you can etch your own board or wire the circuit with flea clips and perfboard.

The one hard-to-get part is the FSR itself. The manufacturer does not maintain retail distribution, and they have a $200 minimum order. PAiA has arranged to carry a stock of 7/8-inch, round FSRs. As it stands, they are the only source of these parts for hobbyists. (If you haven't gotten PAiA's catalog, you should. They have been around forever, and their list of accomplishments includes the first programmable drum machine and a user newsletter that later became a magazine known as *Electronic Musician*.)

The parts kit comes with single-turn trim pots for R4 and R6. If you prefer, you can use multiturn pots for extra precision and stability.

The Presto uses a regulated power supply of ±12 to ±15 volts. (Avoid batteries unless you're just breadboarding a temporary version.) If you don't have a bipolar power supply, you may find a suitable one at your local parts dealer. PAiA sells a bipolar power supply kit,

DAN ESCOBAR

FIG. 1: The Interlink FSR consists of two elements. The square pad on the left is a resistive ink, and the grid on the right is made up of conductive ink. When the pad is placed atop the grid, it forms an element whose resistance varies in proportion to pressure.

though it's rather large if the Presto is all you want to power. The November 1987 **EM** has an inexpensive power supply project. If you elect to build a supply, be sure that you observe suitable precautions with the AC from the wall.

SENSOR MOUNTING

The PC board offers several options for mounting the FSR. The board has a large ground-plane area with mounting holes for the sensor. You can mount the FSR over this area for a convenient, all-in-one assembly. If you mount the sensor on the etch side, you can mount the board upside-down so the sensor is accessible through an opening.

You can also bend the FSR out away from the board, or cut the board in half, and mount the sensor in the holes nearest the other components. Use caution when installing the FSR; excessive heat can burn or melt the plastic substrate, and this can damage or ruin the unit.

As the photo shows, you can also mount the FSR remotely. Use thin-diameter coaxial cable, such as RG-174/U, between the sensor and the circuit board. Attach the shield of the cable to the junction of R1, D1, and C3. The inner connector should connect to the end of R2 that also connects to pin 3 of IC1A.

The FSR is not polarized in any way, so the connection of shield and hot lead at that end doesn't matter. Be careful in attaching the cable to the FSR's leads, and use heat-shrink tubing—or something similar—to provide strain relief.

The FSR works best when mounted on a rigid surface. Warning: Never use *cyanoacrylate* adhesives (Krazy Glue) on the sensor; it will ruin the plastic substrate. Instead, use a silicone-based RTV for mounting.

It's a good idea to glue a thin piece of foam rubber or neoprene over the sensor. The rubber enhances the response of the FSR by spreading out the force applied. In addition, it helps protect the FSR against accidental damage.

TESTING AND CALIBRATION

Before you apply power, take time to inspect the finished board carefully. Is every part in the correct place? Are the ICs and capacitors oriented correctly? Are there any solder shorts? Take your time doing this; 90 percent of problems in home-built projects turn out to be simple construction errors. When you are satisfied that everything looks good, set both trimmers about midway and turn on the juice.

You will need a voltmeter or oscilloscope to test and calibrate the circuitry. First, verify that both supply voltages are reading correctly. If one or both are not where they should be, turn the supply off and initiate troubleshooting procedures.

If the supplies are OK, check the CV output. You should see a DC bias voltage of no more than ±4 volts. Now touch the sensor with your fingertip. If everything is working properly, the output voltage will rise and fall as you vary the pressure.

To calibrate the circuit, turn R4 (Span) up for full gain, then set R5 (Center) for zero volts at the output. Touch the FSR with your forefinger and set R4 for appropriate output at maximum force. Then take your finger off and readjust R4. There is a slight interaction between the two trims, so you may have to go back and forth a few times in order to get things close.

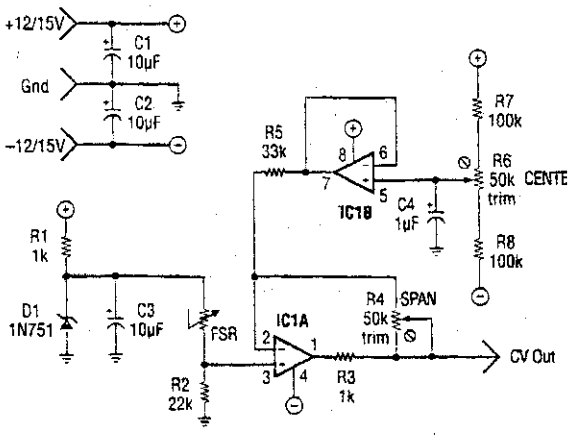


FIG. 2: The Presto interface circuit consists of a voltage divider and a variable-gain buffer with adjustable offset voltage.

If you want to increase the output level, replace R5 with a 22k or 20k resistor. You also can change the response of the FSR by substituting a smaller-value (not less than about 1k) resistor for R2.

APPLICATIONS

The Presto has a number of uses, including:

Momentary Footpedal. Many performers use footpedals for continuous control, but they have disadvantages in some situations. For vibrato control, you must bring the pedal all the way back when the modulation is unwanted (unless it's spring-loaded). Worse, some pedals have a tendency to slip

PARTS LIST

QUANTITY / DESIGNATION / VALUE

RESISTORS

2	R1, R3	1K	BRN-BLK-RED
1	R2	22K	RED-RED-ORG
1	R5	33K	ORG-ORG-ORG
2	R7, R8	100K	BRN-BLK-YEL

TRIM POTS

2	R4, R5	50K

CAPACITORS

3	C1, C2, C3	10uF/25V
1	C4	1uF/25V

DIODES

1	D1	5.6V ZENER
2	D2, D3	1N914 (OPTIONAL)

INTEGRATED CIRCUIT

1	IC1	5532 DUAL OP-AMP

MISC.

1	FSR	FORCE SENSING RESISTOR

POWER REQUIREMENT:

+/- 12 TO 15 VDC, 20MA REGULATED

toward the maximum position on their own. One alternative is to use the Presto as a momentary footpedal, producing a voltage only when the player places a foot on it.

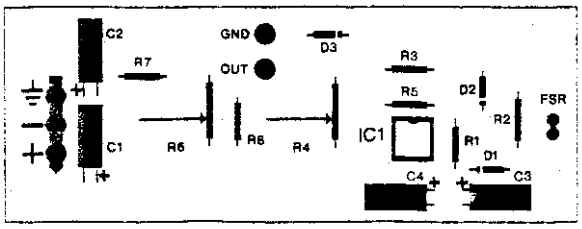


FIG. 4: Parts layout for the EM Presto.

Mount an FSR on a sturdy case of the proper size and shape. Cover the sensor with rubber to protect it and even out its response. You can put the entire circuit inside the case, or mount the FSR in one box, with the rest of the circuit elsewhere. Choose a box that provides a solid surface and feels comfortable after a long gig.

Pressure Pads. Old-time synthesists may remember the PPC pads found on late-model ARP Odysseys. This unusual device replaced the clumsy pitch bend knob on earlier units. The PPC consisted of three pressure-sensitive rubber pads, one for bending sharp, one for bending flat, and one to provide LFO modulation. The PPC was capable of very expressive results. Unfortunately for ARP, most synthesists preferred the Moog wheels.

You can mount one or more FSRs to provide a touch-sensitive pad anywhere you like. As with the pedal, be sure to cover the FSR with rubber or neoprene to enhance the feel. You can use a single pad for modulation or go crazy and stick any number of them on your axe to do whatever.

FSR-TO-MIDI

Many readers will want to use their FSRs with MIDI. The easiest way to convert the raw control voltage into a MIDI controller is to connect the Presto to an instrument's footpedal or CV input. The Anatek Pocket Pedal (reviewed in the May 1989 **EM**) is another possibility.

The best solution I've found is the "EM MIDI Volume Fader" (MVF) project from the February 1991 **EM**. By replacing the original slide pots with external control voltages, the unit becomes a powerful MIDI controller. For example, you could use one or two MVF inputs with the Presto(s) and still have six left over for use with faders, wheels, pedals, or joysticks. The MVF can generate Pitch Bend and Channel Aftertouch, as well as most Continuous Controller messages.

Fig. 5 shows the necessary modifications. First, decide which MVF input, or inputs, you want to use with the Presto. Disconnect both the pot's wiper and the appropriate bypass cap (C 14-21 on the MVF circuit board). Add diodes D2 and D3 to the the Presto circuit board and connect the CV out to the MVF's input. The diodes protect the MVF in case the Presto's output goes too high or low. Power up both boards and verify that everything is operating. You'll probably want to retweak the trimpots for the best feel.

CONCLUSION

It's hard for me to get excited about electronic gadgets, but the Presto is a definite exception. Maybe it's because it measures gestures associated with feel, making it a device for emotional, improvising musicians. You can squeeze it, press it, beat it, whatever. You'll find the **EM** Presto is just the thing for converting those gestures into something that your instruments can understand.

As a senior technician in the electronics industry, **Charles R. Fischer** *knows all about the fun of being "under pressure."*

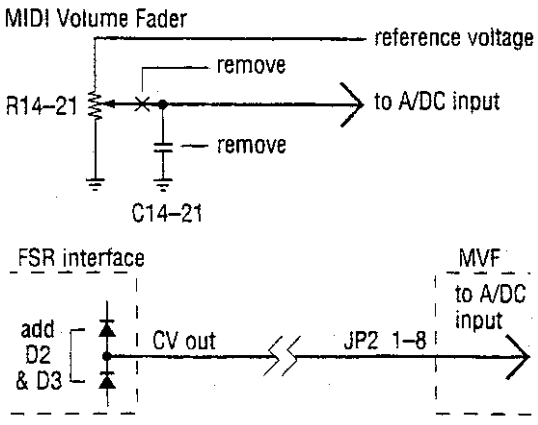


FIG. 5: To use the Presto with the MIDI Volume Fader (see February 1991 EM), install diodes D1 and D2 on the Presto and remove the bypass capacitor from the MVF input.