Replacement of the potentiometer in a VPC1 sustain pedal with a non-contact sensor

Summary:

The potentiometer (pot) in the sustain pedal on my VPC1 has failed. It's not been practical to find a replacement pot that fits all the parameters (shaft diameter, shape and length, mounting diameter, shape and length, degrees of rotation, resistance and linearity), and if one could be found, unless it were a high-reliability type, it would fail again soon. Here is a way to repair the pedal permanently with a non-contact Hall effect pedal position sensor. It's not a plug-and-play solution, so it won't be for everyone.

Analysis: How the original VPC1 sustain pedal works.

The pedal contains a 20 Kohm linear pot. It is connected to the tip and sleeve of the pedal plug that has three contacts. When the pedal is plugged in, the pot, connected as a variable resistor using just two terminals, is fed current from a 3.25 V source through 4.44 Kohms on the circuit board, and the circuit board measures the voltage at the junction of the resistor and the pot to detect pedal position. The detected voltage is mapped to a midi output ranging from 0 to 127. The midi output is transmitted anew by the VPC1 on any change in the sensed voltage. Since Kawai recently included a pedal calibration facility in their software, the exact mapping of voltage to midi output is variable, to accommodate changes in the pedal assembly. The sense of the action is that there is no sustain when the voltage falls below the calibrated threshold (low resistance at the pot, when the pedal is fully up), and there is full sustain when there is high resistance. When the pedal is unplugged, a shorting contact in the jack closes to keep the sustain turned off.

Problem: Why the pedal fails.

The pot in the pedal is a carbon film type. It has a multi-filar wiper, which improves reliablity, but it's still not very high quality. Think how often a pedal can be operated. Suppose the piano is played for just one hour per day, 300 days per year, with music at an average tempo of 60 beats / minute, and one pedal operation per beat. That comes to 300 days/year * 60 min/day * 60 beats/min = ~1 million operations per year. Only very high reliability pots are rated for more than 1 million operations; good luck finding one that will fit.

Alternatives: To solve the problem.

1. Get the right replacement pot and install it, if you want to do that about once a year.
2. The VPC1 keyboard doesn't do anything with the pedal input except encode it and transmit it as midi levels, to be received and used by the virtual piano software in the computer. That means that one could get any suitable continuous pedal that would supply midi signals to the computer, with the VPC1 just providing note values. It could even be plugged in to the midi input of the VPC1, which will act as a midi combiner. But I don't know of a reliable pedal that would work.
3. Dump the pot, and use a non-contact position sensor. This has the advantage of reliability, since there's no wear and tear on the sensor. Also, the gears in the pedal that drive the pot can be removed, which will let it operate as smoothly and easily as the other two pedals.

Non-contact sensor:

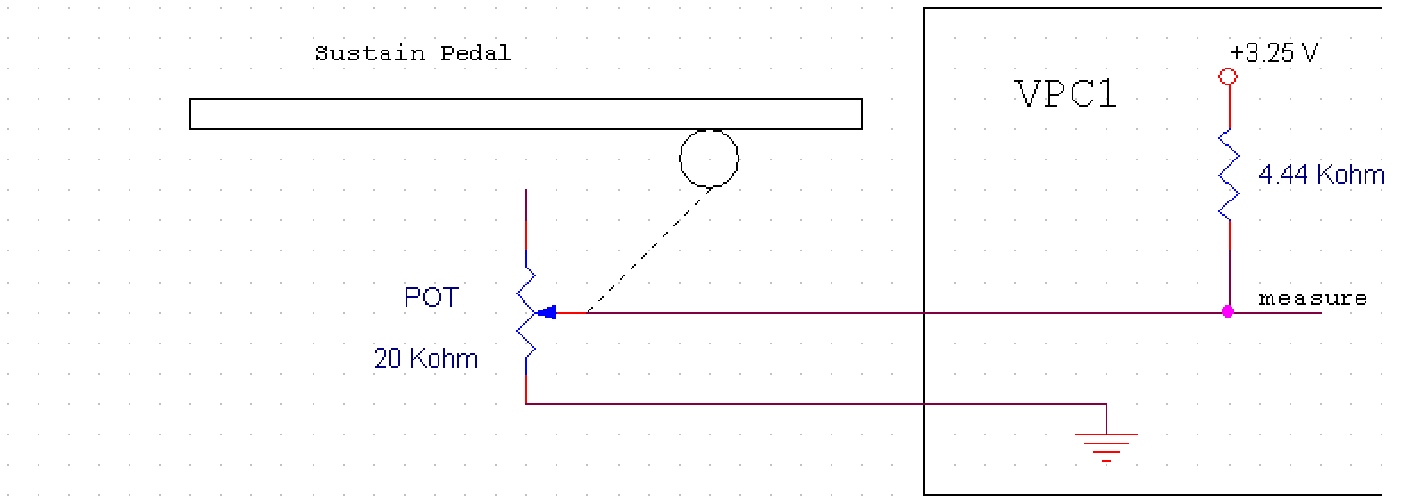
The sensor used is a Hall-effect sensor that is linear (i.e., not an on-off sensor). It's designed to work on about 5 V, and to provide an output from just above 0 V to almost 5 V for a change in magnetic field from -1 to +1 Gauss. The sensor chosen here is operated at 3.3 V, so that its output will be limited to the voltage expected by the VPC1. This is below the minimum voltage specified in the sensor data sheet, but it works. It was chosen because the available sensors made to work on 3.3 V are surface mount types, which are hard to work with. The sensor is designed to have a voltage output, not to look like a resistor, but the electrical effect is the same as long as it can sink the worst case current, which is about 0.7 mA (3.25 V / 4440 ohms) while maintaing a low output impedance, which it can.

The magnetic field source is a neodymium magnet glued to the pedal as shown in the picture. This magnet is 1/8" thick, magnetized through its thickness, with the north pole facing up. The thickness is chosen to give a strong change from south to north polarity for the amount of pedal movement at the magnet's mounting point on the pedal. It is glued with a strong epoxy. Don't use JB Weld or other steel-filled epoxy, because it will crawl up the surface of the magnet and make a big mess. Also, don't get epoxy between the magnet and the metal pedal, because if it's slippery, the magnet will snap to a different orientation, and everything will have to be cleaned up to start again. So, carefully apply the glue after the magnet is positioned on the pedal and let the glue harden before proceeding. It might be possible to superglue the magnet in position before applying the epoxy.

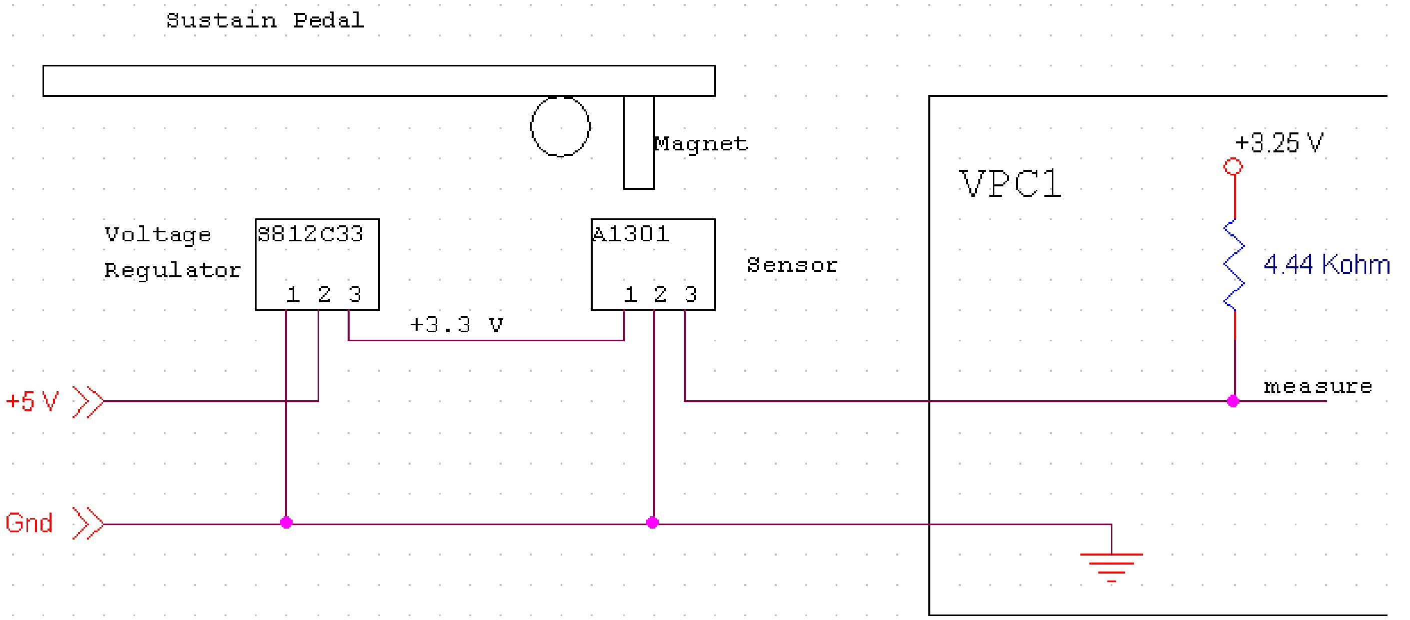
The sensor is soldered to three terminals on a small piece of punched circuit board, with about 3/4" of length left on the legs, so it can be bent closer to or further from the magnet. After the sensor is mounted, apply epoxy to the mounting terminals, to prevent small random movement. The circuit board is mounted on the pedal in the space where the pot was, by a pair of 2-56 machine screws tapped into the plastic pedal body. If the screw holes in the circuit board are elongated vertically, some adjustment will be possible. The top of the sensor should be slightly below the top of the magnet when the pedal is not pressed.

The 3.3 V is supplied by a small CMOS regulator from the 5 V that must be supplied to the pedal. A supply of 5 V was chosen because it's easier to find – it can come from any USB port, or any of the commonly available device rechargers that use a USB type connection.

Diagram:

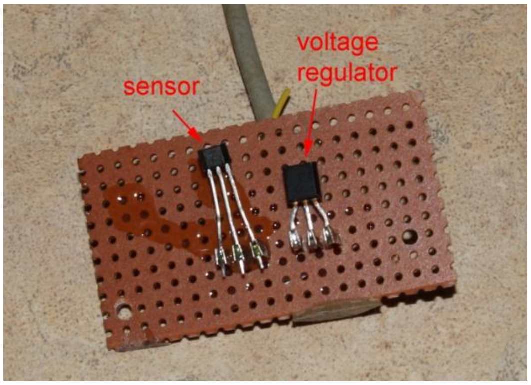


Original sustain pedal circuit

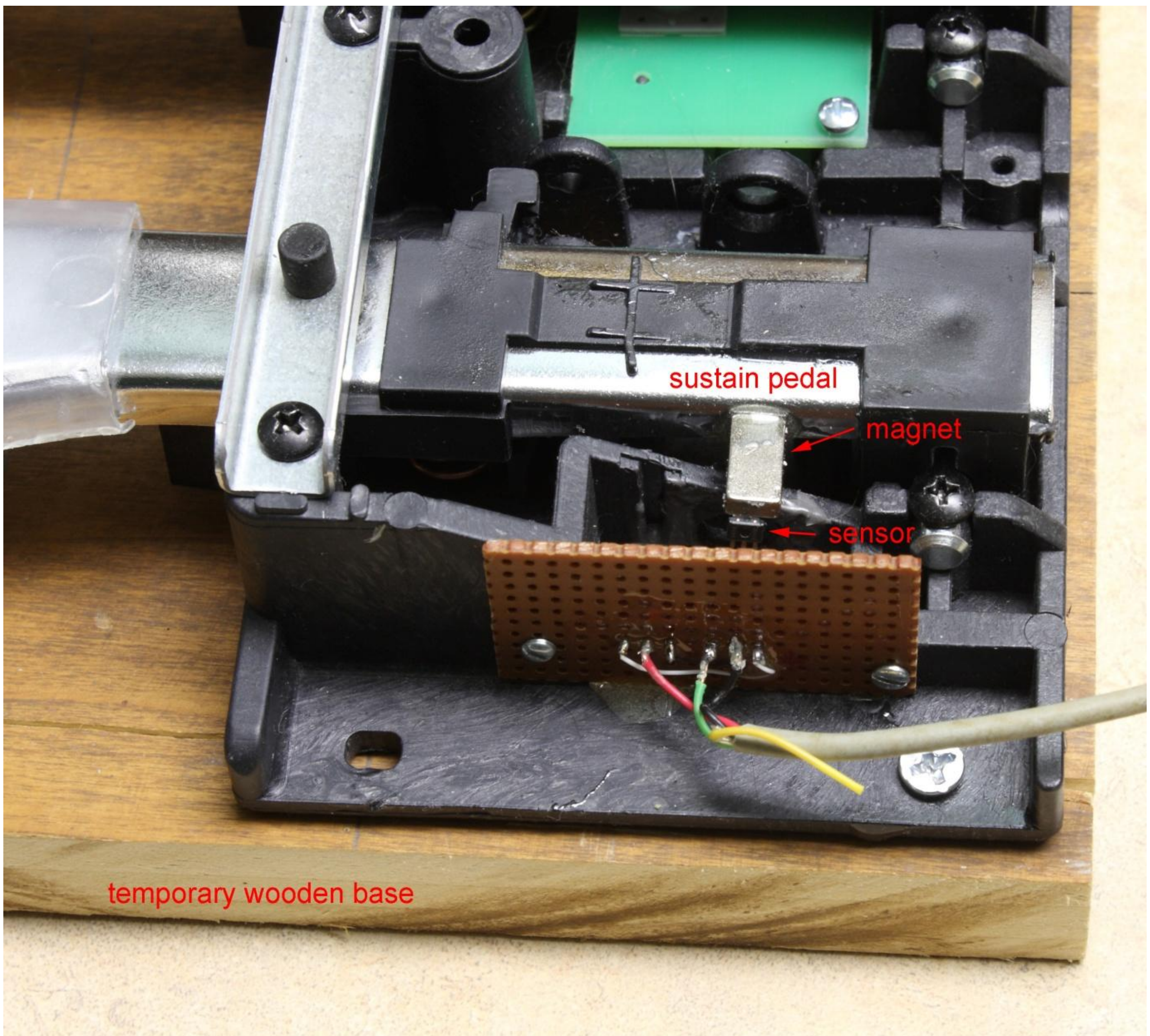


Non-contact sustain pedal circuit

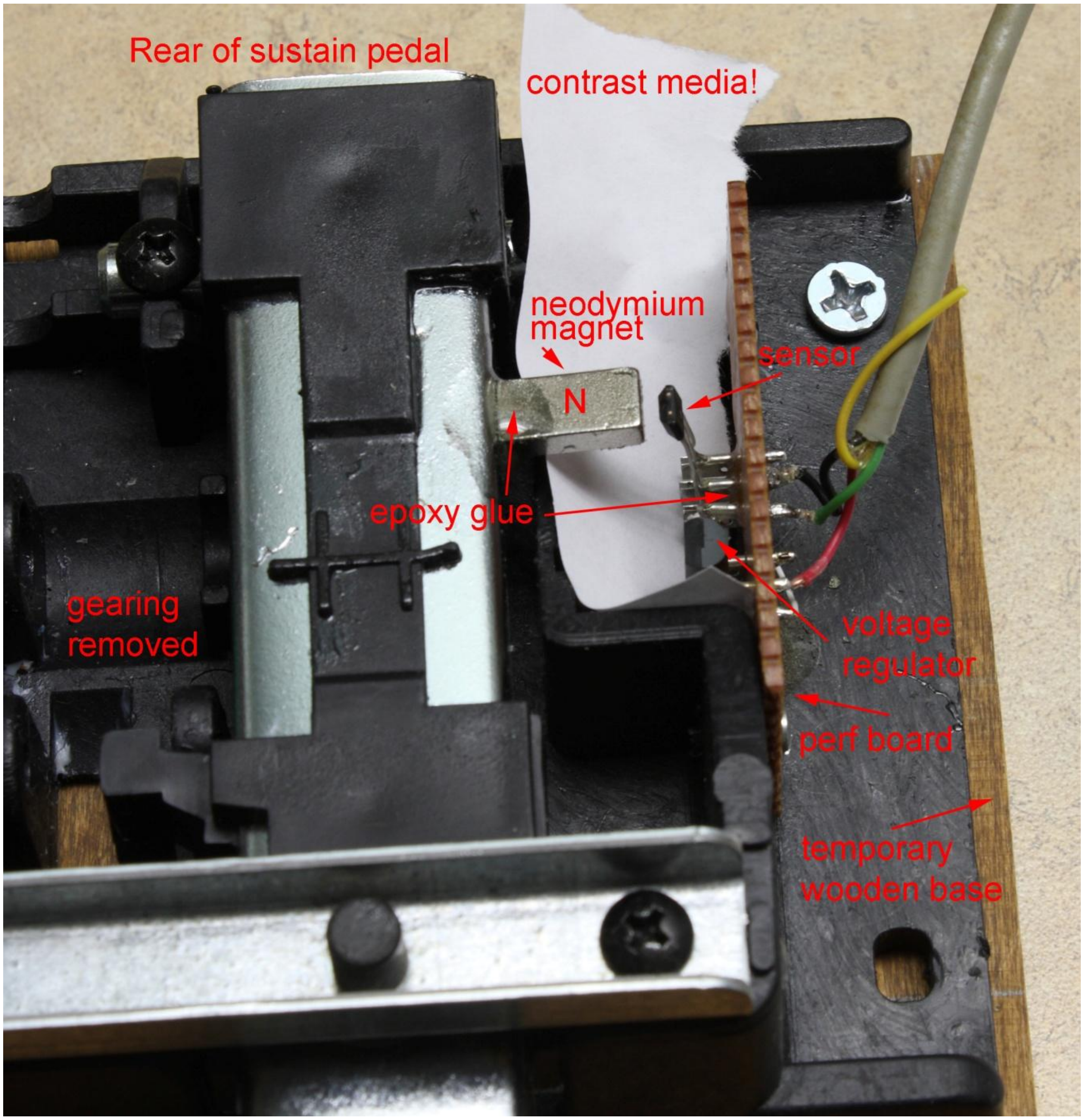
Pictures:



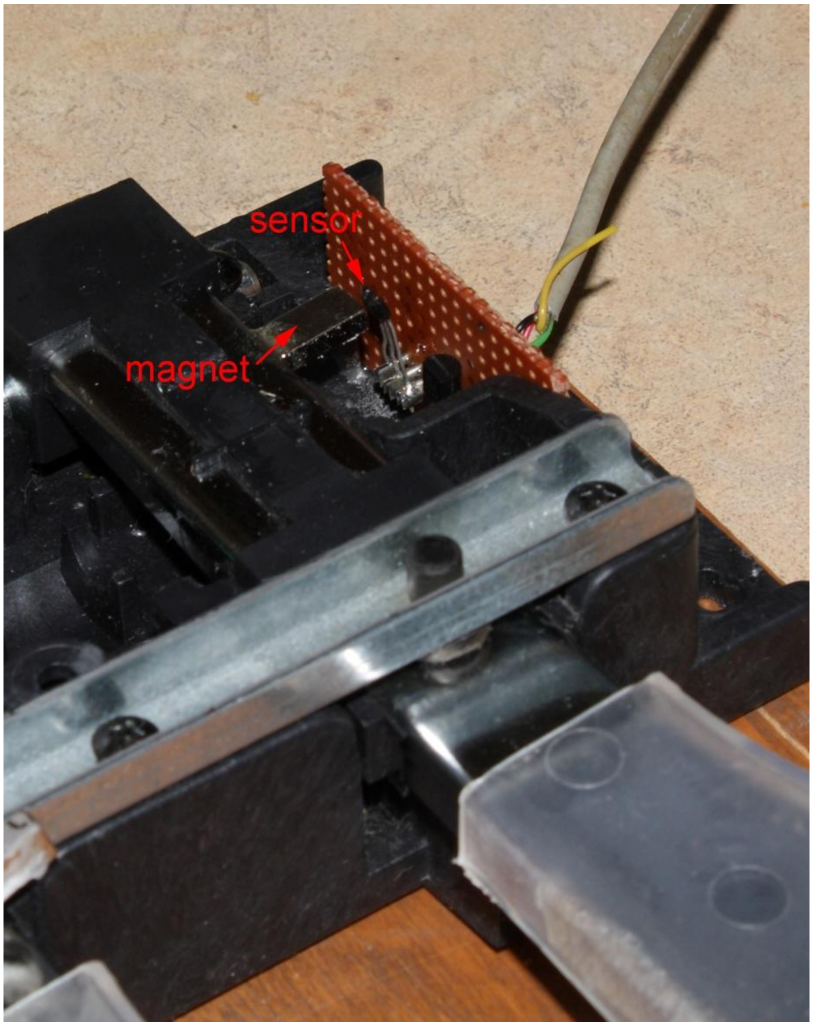
Perfboard with two ICs mounted and connected.



Perfboard in place on pedal, replacing pot.



Closeup, sensor next to magnet.



Another view.

Adjustment:

Experiments on the Kawai VPC1 sustain pedal calibration facility show its limits: the lowest voltage that will calibrate for midi output of zero is about 1.07 V. The highest voltage that will calibrate for midi 127 out is 2.67 V. The facility will accommodate a smaller range on both ends. So, the target range for output from the sensor will be a bit wider than those limits, at least to start with. This should be adjusted by vertical positioning (for offset) and horizontal positioning (for range) of the sensor.

Then, the pedal is calibrated using the program, and the pedal midi output should reach 127 when it is fully depressed, and zero when released. If it doesn't , check that the sensor voltage range mentioned is being reached.

Then, check how much additional movement is available after midi zero and midi 127 are reached at the pedal motion limits. There should be a little extra motion, to be sure that both limits can be reached, but not too much, so there will still be a wide range of motion for partial pedal. If there is too little range (the turn on of sustain is too sudden), the sensor should be pushed a tiny bit away from the magnet, and the pedal recalibrated. Repeat these steps until operation is satisfactory.

Because of how the pedal is built, the adjustments have to be made with the pedal out of its case and off its metal base. It will be useful to temporarily screw the pedal assembly to a piece of wood as shown in the picture, so it can be operated easily.

Parts list:	Descr/mfr part #	Source & part #	price
Sensor	Allegro A1301EUA-T	Digi-Key 620-1522-ND	$1.62
Regulator	Seiko S-812C33AY-B2-U	Mouser Electronics 628-812C33AY-G	$0.80
Magnet	K&J Magnetics B842 ½" x ¼" x 1/8"		$0.70
Terminals	Vector T42-1 (pkg 100)	Jameco Electronics 84147	$8.95
Board	Vector 64P44XXXP 4.5" x 6.5"	Jameco Electronics 43140	$8.95
Miscellany	wire, solder, epoxy glue, whatever.		

The suppliers above all sell online and are easily googled.

There may be better parts choices, and better arrangements of the parts can likely be found, but this at least shows the feasibility of a non-contact gradual sustain pedal using a simple circuit with inexpensive parts. It would have been harder to do without a strong neodymium magnet or without the Kawai pedal calibration program.

This PDF was prepared by John O'Flaherty about 3/6/2015.