RapidBrake

EMERGENCY STOP signalling for virtually any vehicle

Give the guy behind you more time to pull up!

PART 2 – by John Clarke

Last month we described how this project uses an accelerometer module to detect heavy braking and then flash the brake lights or hazard lights. This will give a dramatic warning to following drivers, so that they can avoid running into you. This month we give the assembly details for the PCB, show the various wiring permutations for brake and hazard lights in most vehicles and the set-up procedure to make sure that the signalling is triggered under heavy braking.

All the components for **RapidBrake** are assembled onto a single PCB, coded 05105171 and measuring 106 x 58.5mm.

This is housed in a plastic utility box measuring 129 x 68 x 43mm (Jaycar HB-6023 or Altronics H0153). The 3-axis accelerometer module (Jaycar XC-4478) is also mounted on the PCB.

Follow the diagram of Fig.4 when installing the parts. You can install the resistors first.

The colour codes for the resistors are shown in table on page 38 of last month's issue. A digital multimeter should also be used to check the values of each resistor since some of the codes can be hard to decipher.

Diodes D1, D2, D3 and ZD1 are the next to be installed and these need to be inserted with the correct polarity with the striped end (cathode, k) oriented as shown in the overlay diagram.

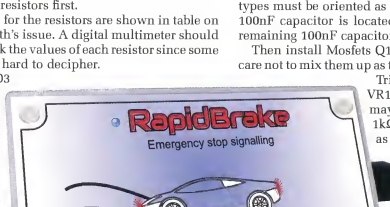
We recommend using an IC socket for the PIC micro, IC2. IC1 can be directly soldered to the PCB or you can also use an IC socket. Take care with orientation when installing the sockets and when inserting the ICs.

There are seven test points and you can install PC stakes for these if you prefer. These test points are located at TP1-TP5, GND & +5V. Install the two 3-way headers for JP1 and JP3 and the two 2-way headers for JP2 and the shunt keeper.

The capacitors can be installed next. The electrolytic types must be oriented as shown and note that a ceramic 100nF capacitor is located near the cathode of D2. The remaining 100nF capacitors are MKT polyester.

Then install Mosfets Q1 & Q2 and also REG1 and take care not to mix them up as they each use the same package.

Trimpots VR1 to VR4 are next. VR1, VR2 and VR4 are 10kΩ and may be marked as 103. VR3 is a 1kΩ trimpot that may be marked as 102. These are oriented with the adjusting screw as shown.



Install the XC-4478 accelerometer module by passing its five header pins through the allocated holes on the PCB. Then solder the header pins while ensuring the module is close to and parallel with the PCB.

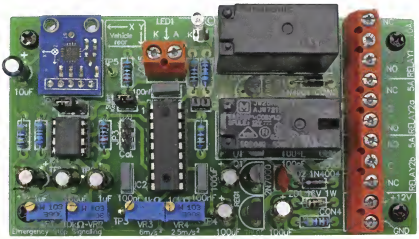
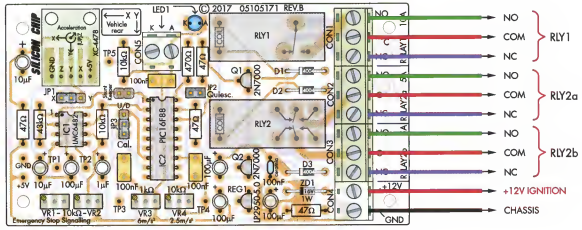


Fig.4 (below): the same-size component overlay for the RapidBrake with its connections shown – use these in conjunction with Figs.6-8 overleaf, depending on which wiring you choose. A same-size matching photo (at left) will also guide you with construction. We recommend the use of sockets to mount both ICs – just make sure the orientation is correct! Incidentally, there are some minor differences between the prototype photograph and the final version.



This step is most important because we rely on the fact that the horizontal axis of the accelerometer is parallel to the PCB – so don't mount it crookedly!

CON1 to CON5 can now be installed. CON1-CON3 are 3-way types and CON4 and CON5 are 2-way. CON1-CON4 are firstly connected together by using the dovetail mouldings on the side of each connector to slide the parts together. Install them with the wire entry closest to the edge of the PCB.

The optional CON5 (for an external LED, if required) is also installed with the wire entry to the outside edge of the PCB, as shown in the photos and Fig.4.

Finally, LED1, RLY1 & RLY2 can be installed. LED1 is placed with the top of its lens no higher than the top of the relays.

Carefully check that all components are correctly installed and soldered.

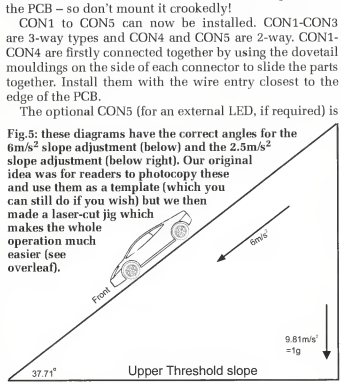


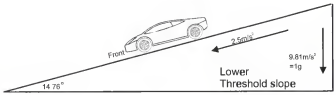
Fig.5: these diagrams have the correct angles for the 6m/s² slope adjustment (below) and the 2.5m/s² slope adjustment (below right). Our original idea was for readers to photocopy these and use them as a template (which you can still do if you wish) but we then made a laser-cut jig which makes the whole operation much easier (see overleaf).

Testing & setting up

Make sure IC2 is out of circuit and connect a 12V supply to the CON4 terminals. Check that there is close to 5V between the GND and +5V test points (left side of PCB). The voltage should be between +4.925V to +5.075V.

If all is correct, switch off power and install IC2. If the voltage is incorrect, check that the LP2950ACZ-5.0 regulator is placed in REG1's position and that the leads are soldered in correctly.

You need to install the PCB in the plastic box before you can set it up. Insert the PCB into the box and mark out the mounting hole positions on the base. Drill them to 3mm.



Fitting the completed PCB inside the case. It must be in the case before the compensation and calibration procedure can be commenced.

Attach the PCB to the box using four 6.3mm tapped spacers.

One or two holes are also required at one end of the box for the cable glands. If you are wiring to the brake switch, only one cable gland will be required. For wiring to the hazard lamps you will find it easier to use two cable glands to allow for the extra wiring.

Initially, you need only the wires for +12V and 0V (GND) connected to CON4.

The first step is to select the X or Y output of the accelerometer module to be monitored by the RapidBrake circuit. This gives you the option of having the long axis of the PCB (box) aligned with the long axis of the vehicle if you use the X output or having the long axis of the PCB aligned across the vehicle (ie, the short axis).

So you should place the shunt in the X or Y position of JP1 accordingly.

Power up the PCB and LED1 should light for about one second. Then wait several seconds (with the box sitting on a horizontal surface) and adjust VR1 so that voltage between GND and TP1 is around 4V. Similarly, adjust VR2 for about 2.5V at TP2.

These voltages are not critical but should be set to within about 200mV of the stated values.

Compensation/calibration jig

To do the adjustments for compensation and calibration, you will need two templates which match the angled slopes shown in Fig.5: one for the 6m/s^2 upper adjustment and the other for the 2.5m/s^2 adjustment.

These can be photocopied and glued or taped to cardboard and cut to shape to make the sloped templates.

However, as we went through the process for doing these adjustments, it became obvious that manipulating the plastic case and template and adjusting trimpots while monitoring voltages on the PCB with a multimeter was well-nigh impossible – you need four hands!

Since none of the SILICON CHIP staff actually have four hands, we decided to design and laser-cut a jig which would making holding the box at the required angles easy.

We have included pictures of the components of the jig, the jig in assembled form and how the jig is used for the various measurements.

To make our life a little easier, we designed this jig for adjustments on the X-axis, and laser-cut it from polycarbonate. The cut sections are shown at left with the assembled jig at right (see the photos which explain how we used it). We figured it would also make our readers' lives easier – so we've made it available from the SILICON CHIP online shop. (Cat SC4345).

The parts for the jig are available at low cost (just $5.00 plus p&p) from the Silicon Chip on-line shop and they just clip together.

Quiescent output adjustment

OK. So connect a 12V supply and monitor TP1 again with your DMM. We now need to find the angle of tilt for the Z-axis reading where the voltage is at its maximum.

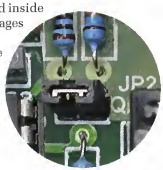
Ideally, this should be when the box is on a horizontal surface but it may be very slightly off from horizontal due to slight misalignment of the accelerometer PCB and/or the accelerometer IC.

Step 1: If the jumper at JP1 is set for the X-axis, go to step 2. If the jumper is set for the Y-axis, as before, slightly angle the box up a little at the CON1-CON4 end and then up a little at the IC1 end to find the angle where TP1 shows maximum voltage. You can use a piece of thin plastic to prop the PCB at this angle (we used the lid of the box as it was handy). Now go to Step 3.

Step 2: If the jumper at JP1 is set for the Y-axis, again using the box lid or something similar, tilt the PCB slightly at the trimpot **side** and then at the CON5 **side** to find the angle where the TP1 voltage is at maximum.

Step 3: Now, making sure the PCB is kept very still, insert a shorting jumper at JP2. You have one second before the voltages at TP2 and TP1 are stored inside IC2. These are the quiescent voltages for the accelerometer.

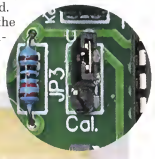
LED1 will light up once the values are stored and the jumper link can then be removed. If you need to measure and store the quiescent voltages again, reinstall the jumper.



Tilt compensation

Step 4: Compensation for tilt is done with a jumper shunt in the UP/DN position of JP3. This allows the gain of the compensation to be adjusted while angling the PCB to simulate a sloped road.

If JP1 is set for the X-axis, the case is angled up at the CON1-CON4 end and then up at the IC1 end by about 15° each way from horizontal.



If JP1 is set for the y-axis, angle the case up at the trimpot side and then up at the CON5 side by about 15° from horizontal in each direction.

The first photo shows the case sitting on the low level of the jig, corresponding to an angle of very close to 15° (14.76° to be precise).

Use your multimeter to check if the voltage at TP5 remains relatively constant for the ±15° range. Trimpot VR3 is adjusted to give the required compensation gain. Set VR3 so the variation in voltage over the ±15° range is less than 100mV in each direction.

There shouldn't be a variation of much more than

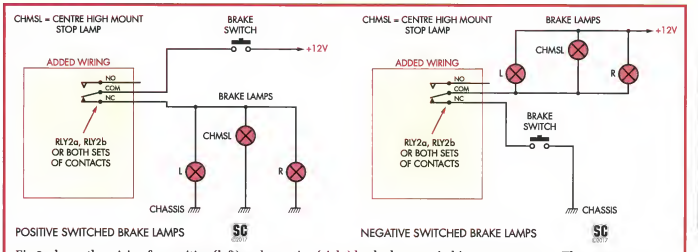


Fig.6: shows the wiring for positive (left) and negative (right) brake lamp switching arrangements. The common (COM) and normally closed (NC) contacts of RLY2 are connected in series with the brake switch in both cases.

100mV in each slope direction over the full 37.71° range (corresponding to the 6m/s^2 slope in the diagram of Fig.5).

Note however, that you will need to change the angle of the case very slowly, since the Z output reading is averaged out and so will not provide an immediate compensation of the X or Y output.

When the adjustment is satisfactory, remove the jumper from the UP/DN position. The compensation gain value will be stored in memory. Readjustment of VR3 in the next calibration step will not alter the compensation.

Deceleration calibration

Step 5: This step sets the 6m/s^2 and 2.5m/s^2 deceleration thresholds. Initially set TP3 to 3.3V, by adjusting VR3. Similarly, set TP4 to 2.8V, using VR4.

Place the shorting shunt for JP3 in the Calibrate position. In this position, the TP5 output shows the measured voltage of the X or Y signal and this is without any slope compensation.

This voltage is compared against the VR3 and VR4 trimpot settings that provide the upper and lower braking thresholds. When the TP5 voltage is above TP3, this will initiate the emergency brake signalling.

The emergency brake signalling will cease once the TP5 voltage drops below TP4.

In practice, RapidBrake is placed on the sloping planes of the test jig to set the upper and lower thresholds, as shown in our photos.

In each case, the little arrow for the X-axis (or Y-axis if that it what you have selected) needs to point up the slope. Hence, when you install the RapidBrake in the vehicle, that arrow should point to the back of the vehicle.

Step 6: VR3 is adjusted so the LED starts flashing when RapidBrake is raised just a little higher than the slope for 6m/s^2.

Step 7: adjust VR4 so the LEDs stop flashing just before RapidBrake is placed on the lower slope that is equivalent to 2.5m/s^2 deceleration.

That completes the calibration for RapidBrake. The jumper can be removed and placed in its keeper position located above JP3.

Installation & lamp wiring

Regardless of whether you have selected JP1 for monitoring the X or Y-axis of the accelerometer, the case must installed parallel to the floor of the vehicle.

You can install a red, orange or green LED for the emergency brake indication on your vehicle's dash, wired to CON5 so it that connects in parallel with LED1.

LED1 is a blue LED and has a nominal 3.3V drop across it when lit. A red, orange or green LED has a voltage drop of 1.8 to 2V drop and it will effectively disable the blue LED. Make sure the LED polarity is correct. The longer lead on the LED is the anode.

The +12V terminal should be connect to the switched side of the ignition so that power is only supplied when the ignition is switched on. The GND wire should be terminated to an eyelet for the screw connection to chassis.

As previously noted, you can connect either the brake lamps or hazard lamps for emergency brake indication.

The brake lamp option is the easiest to do but it does not have the same dramatic impact as having the hazard lamps flash repeatedly when the brake lamps light up.

Fig.6 shows the wiring for positive and negative brake lamp switching arrangements. The common (Com) and normally closed (NC) contacts of RLY2 are connected in series with the brake switch.

That way, the brake lamps will be switched on normally with the brake pedal switch, but will flash when RLY2 is switched on and off during emergency stop signalling.

Use 5A-rated automotive wire for the connections.

Fig.7(a) shows the wiring for the hazard lamps for negative side switching (ie, all lamps are connected to +12V). Fig.7(b) shows the detail for for positive switched lamps. In both cases, RLY1 isolates the connection to the indicator and hazard lamp flasher unit during emergency stop signalling.

For the negatively switched version RLY1 intercepts the connection from the + terminal of the flasher and the common of the indicator switch. For the positive switched lamps (Fig.7(b)) wiring diagram, RLY1 intercepts the C connection of the flasher to the Common of the indicator switch.

When RLY1 is switched on, the hazard lamps are temporarily prevented

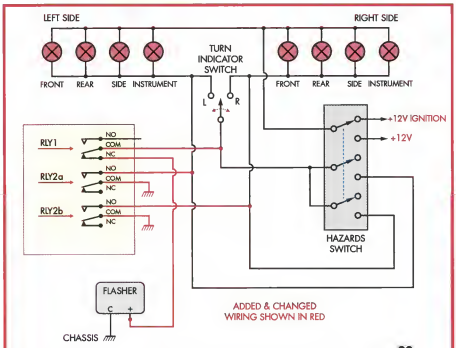


Fig.7(a): wiring for hazard lamps switched on the negative side

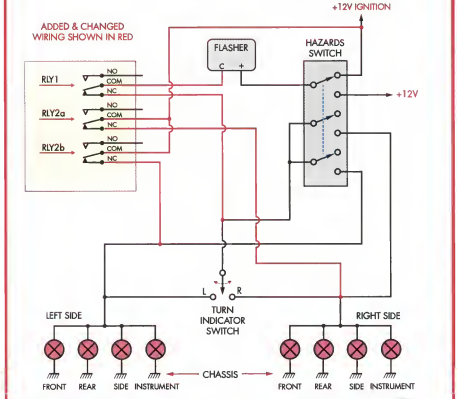


Fig.7(b): similarly, wiring for hazard lamps switched on the positive side

from operating and RLY2 then flashes them independently of traffic indicator operation. The double pole contacts for RLY2, switch the left and right side indicator lamps separately.

Note that some vehicles may drive their indicators in a different manner, eg, with individual lines from the body computer driving the lamps on each side or even controlling them via CANbus. So before you go to wire your vehicle up, check its service manual.

If the two sides are driven independently, you will need to drive a DPDT relay with the RLY1 outputs to disconnect both at the same time. SC