Listen to the Earth with this Seismic Detector

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Want to find out what's happening underfoot? You can do just that with this inexpensive unit.

If you live in a seismically active area, you are no doubt aware of the "non-permanence" of the ground that you are standing on Did you ever wonder if you have just felt a small earthquake, or was it only a passing truck? Perhaps you would like to explore the concept of volcanic eruption predictions

The human body can detect a seismic event of about 2 5 or above on the Richter scale A seismograph would be nice, but who can afford to have reams and reams of paper spewing out on the floor day after day? Besides, commercial seismographs are very expensive instruments and most are not portable

To the rescue comes the Seismic Detector presented here, a portable and paperless device that is inexpensive and versatile In addition to seismometers, the basic circuit can be used with other transducers such as LVDTs, differential pressure sensors, and accelerometers to name a few Even with the use of expensive low-power components, the cost for parts is currently about $40; lower-cost standard components can be used if battery life is not a concern

Design Features. Several features of the Seismic Detector contribute not only to its low cost but its usefulness as a geologist's instrument Sensitivity is less than 2 on the Richter scale At that level, it will be able to detect and record seismic events that we wouldn't notice Up to eight separate one-minute events can be recorded and stored by the unit Once an event has been detected and recorded, a light-emitting diode indicates that a seismic event has taken place and is stored in the system's memory.

The Seismic Detector can be connected to a PC for real-time monitoring of seismic events That does not mean, however, that the Seismic Detector is restricted to any area that has a convenient wall outlet Designed for portability and use in the field, it can run for about one year on a fresh set of batteries. Since it can collect data that might occur months apart, the date and time of each event is also stored by the unit

Naturally the computer interface can also be used for downloading any stored information for plotting and analysis.

Circuit Description. The schematic diagram of the Seismic Detector is shown in Fig 1; follow it during the following discussion

The heart of the system is SEN1, a vibration transducer Manufactured by Geophone for use by the oil industry, it is a small can measuring 1 inch in diameter by 1 3 inches in height It has a natural frequency of 10 Hz. If you open up a sensor, you'll find that it consists of little more

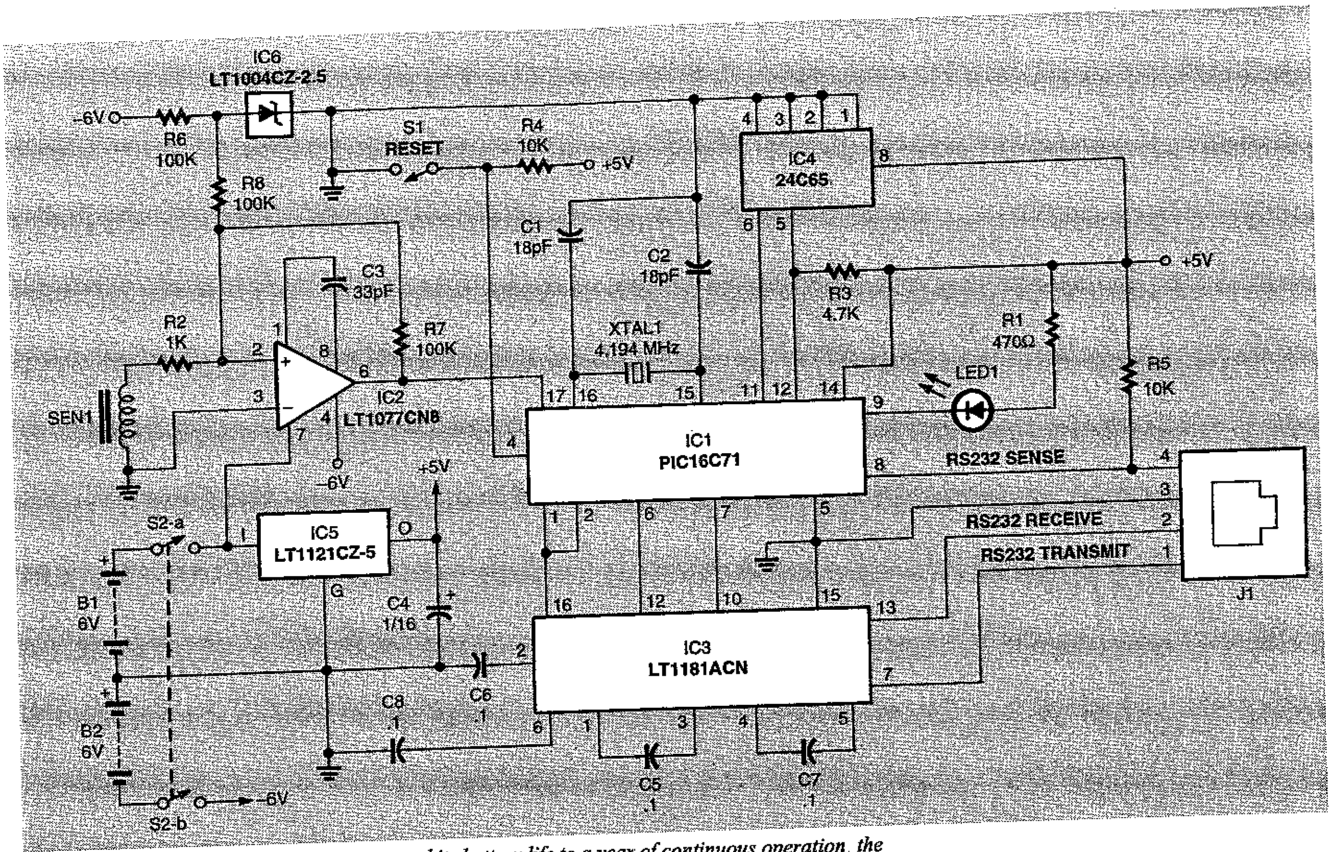
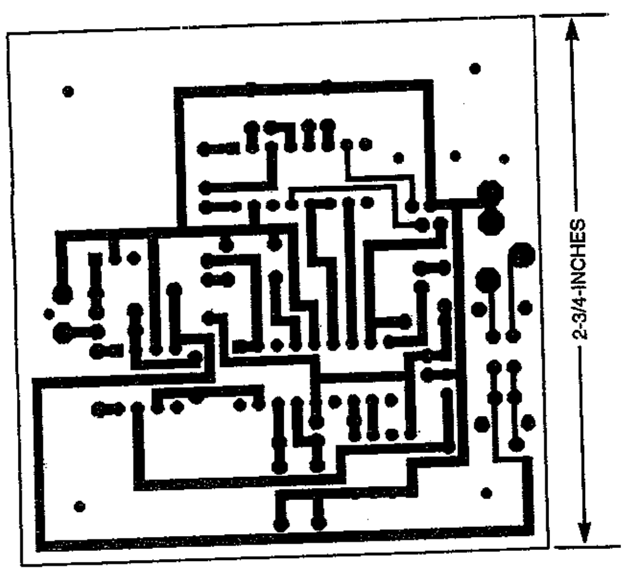


Fig. 1. Using low-power components to extend its battery life to a year of continuous operation, the Seismic Detector can store eight separate seismic events. Enough memory is provided for a minute's worth of samples per event—at 16 samples per second.

than a coil with a magnet suspended by a spring. When the sensor shakes, the magnet moves up and down within the coil. As everyone remembers from basic electricity, an electric current is generated when a conductor passes through a magnetic field. The sensor uses that effect to generate an AC voltage when it is moved. The intensity and shape of the AC signal is related directly to the amount of vibrational shock detected.

The output from SEN1 is very weak; IC2 amplifies it 100 times to boost the Seismic Detector's sensitivity. The amplified signal is applied to one of the inputs of IC1, a PIC16C71. That particular microcontroller features an on-board 8-bit analog-to-digital converter. There is a limitation on the input signal to the A/D converter—it cannot go negative, making measuring an AC waveform a bit difficult. The solution is to raise the voltage level of the signal so that it doesn't exceed the input specifications of the 16C71. Take another look at IC2; it is set up as a summing amplifier. A 2.5-volt offset is added to the sensor signal by using a precision reference diode, IC6. That voltage is at the halfway point on the A/D converters limits (128 on a 0–255 scale). Thus, a negative voltage will read



Here's the foil pattern for the Seismic Detector.

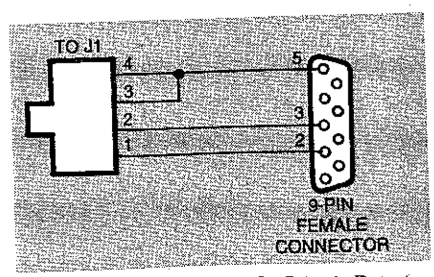


Fig. 2. This cable connects the Seismic Detector to a PC for downloading the recorded data as well as setting up the unit

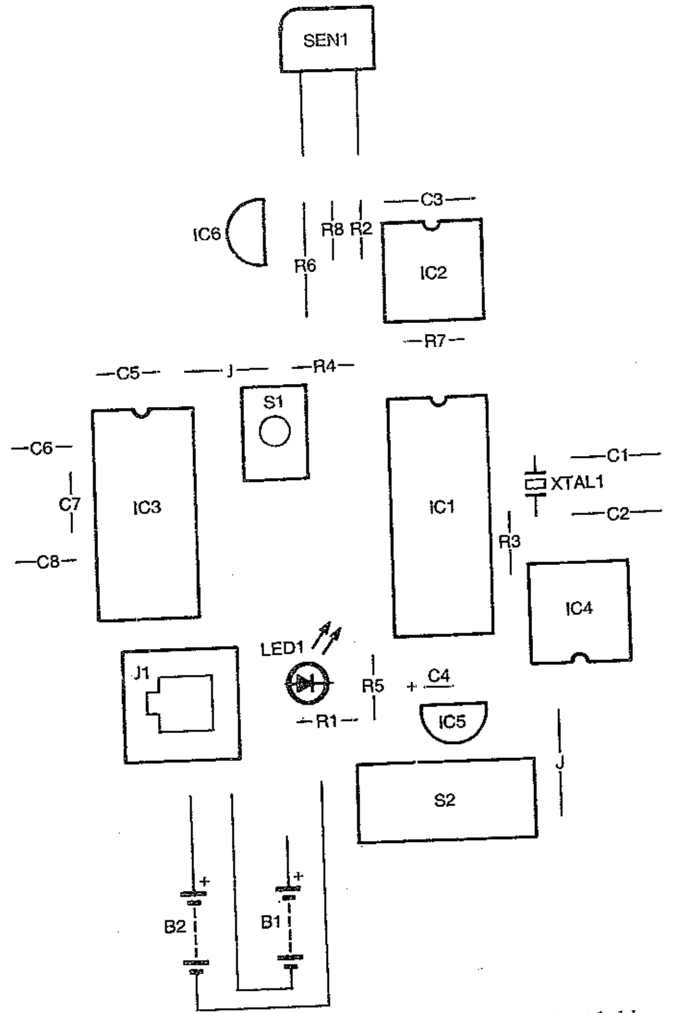


Fig 3. The Seismic Detector is a simple circuit that fits on a small single-sided board Only two jumpers are needed.

between 0 and 127; positive voltages will be between 129 and 255

The frequency of XTAL1 was chosen so that together with the software that is programmed into IC1, precise timing lengths can be generated For example, IC1 samples its analog/digital converter 16 times per second. If the reading is less than 123 or over 133, the software turns on LED1, which will flash every 15 seconds One minute's worth of readings are stored in IC4, a serial memory chip After a total of eight events, the system is set to "go to sleep" without taking any more readings no matter what happens. Due to the nature of how IC4 stores information, no data will be lost if power is lost However, the unit will not take any more readings even if power is restored

A bi-polar power supply is needed because of IC2 The positive side is supplied by four D-size batteries and is regulated to 5 volts by IC5, a low-power voltage regulator A set of four AA cells provides the negative voltage for IC2

Communications to a PC is handled by IC3, an RS232 interface chip To conserve power, IC1 only activates IC3 when an adapter cable is plugged into J1. That adapter cable, shown in Fig. 2, shorts pins 3 and 4 of J1 together; IC1 watches for that condition The Seismic Detector uses a 9600-baud rate to keep it compatible with the oldest of PCs

Construction. The Seismic Detector's circuit is simple enough to build on a piece of perfboard using standard construction techniques However, using a PC board makes for a neater appearance and eliminates most wiring errors

If you choose to use a PC board, a foil pattern for a single-sided board has been included here. Alternatively, an etched and drilled board is available from the source given in the Parts List.

Before beginning assembly, note that IC1 must be programmed with the software that runs the Seismic Detector. The software for the Seismic Detector can be downloaded from the Gernsback FTP site (ftp.gernsback.com/pub/EN/seismic.zip) If you do not have access to a PIC programmer, a pre-programmed chip can be purchased from the source given in the Parts List, but download the software anyway. That package includes the PC software for reading back the information that the Seismic Detector has collected

Start construction by placing the D-cell battery holder upside down with the wires to the left. Mount the AA-cell battery on the right side of the D-cell holder using double-sided tape or other suitable adhesive; the wires for both battery holders should face the same way.

Place the PC board on the left side of the D-cell battery holder Mark the four locations where screws will hold the PC board to the holder Drill those holes in the holder and set it aside

If you are using a PC board that has been purchased from the source given in the Parts List or have etched one from the foil pat-

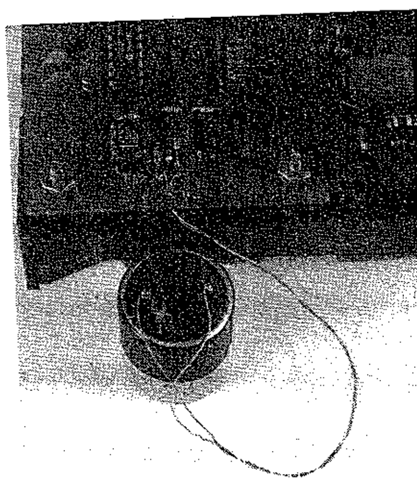


Fig. 4 The Seismic Detector relies on a vibration sensor that is used by the oil industry for exploration.

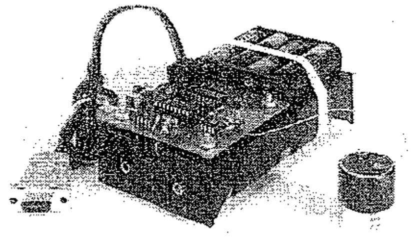


Fig. 5. The completed Seismic Detector is a compact, self-contained unit.

tern, use the parts-placement diagram shown in Fig. 3 to locate the various components. Note that there are two jumpers; they can be made from scrap pieces of component lead. In general, start with the smallest components and work your way up to the larger devices. Before soldering any polarized components, be sure to double-check their orientation. Burned semiconductors let you know that they have been installed backwards by releasing a puff of smoke and a unique odor that is unlike any other smell on Earth. Electrolytic capacitors, when installed the wrong way, have a way of failing that is—in a single word—"thrilling!"

A pair of square wire-wrap posts should be installed where SEN1 will be connected to the board. The integrated circuits can be soldered directly to the board; sockets can be used, but they might cause reliability problems after the Seismic Detector has been out in the field for several months exposed to extremes of temperature and humidity. Note the orientation of IC4; it is the reverse of the other chips.

You might want to consider a socket for IC1, especially if you are using the re-programmable version and might replace the program with one of your own design. Again, reliability and upgradability are the two features that you must choose between when it comes to the use of IC sockets.

When the board is done, look over your work carefully for poor soldering or missing, backwards, or misplaced components.

Note that there is a large strain-relief hole next to J1. Run the battery wires through that hole and solder them to the appropriate pads. The red wire from the AA batteries goes to ground and its black wire to the negative-voltage input. On the D-cell wires, the red goes to the positive-voltage input and the black to ground.

The transducer is connected to the board in a similar way; a strain-relief hole is next to the pads for the transducer wires. That hole is much smaller—use two different colors of wire-wrap wire. Twist the leads together and keep their length less than 12 inches to prevent any electromagnetic interference (EMI). The wiring method used in the author's prototype is shown in Fig. 4.

Mount the board to the back of the battery holder using standoffs, screws, and nuts. That completes assembly of the Seismic Detector itself.

Cut one end off of a modular 4-conductor telephone handset cord. Strip and tin the wires on the cut end. Following the schematic diagram shown in Fig. 3, connect the wires to a 9-pin connector. Use an ohmmeter or continuity tester if you are unsure as to which wire goes to which connector pin. The transmit line goes to pin 2 and the receive line to pin 3. Twist the ground and RS232 sensor wires together and solder them to pin 5

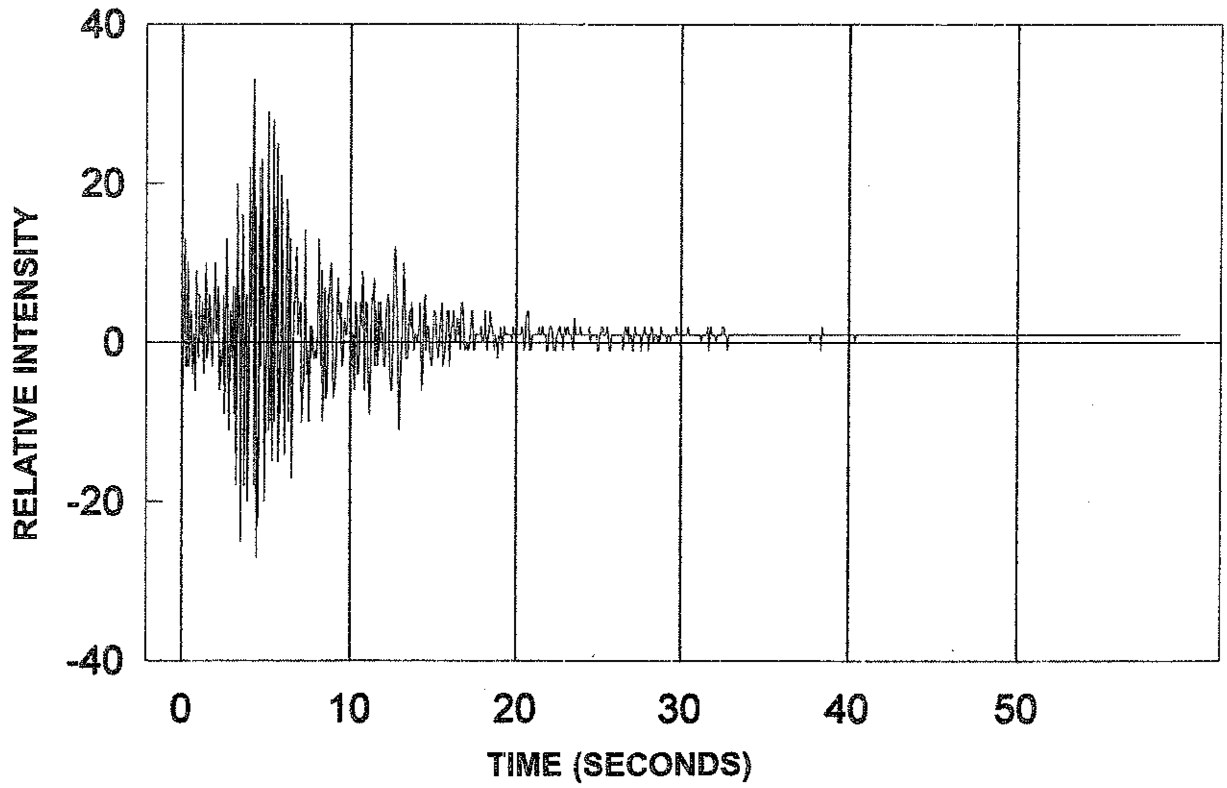


Fig. 6. An example of recorded data from the Seismic Detector is this plot of an earthquake that occurred in Carson City, NV on October 30, 1998.

PARTS LIST FOR THE SEISMIC DETECTOR

SEMICONDUCTORS

IC1—PIC16C71 microcontroller, integrated circuit
IC2—LT1077CN8 op-amp, integrated circuit
IC3—LT1181ACN RS-232 driver, integrated circuit
IC4—24C65 serial EEPROM, integrated circuit
IC5—LT1121CZ-5 low-power 5-volt regulator, integrated circuit
IC6—LT1004CZ-2.5 micropower 2.5-volt reference, integrated circuit
LED1—Light-emitting diode, red

RESISTORS

(All resistors are ¼-watt, 5% units.)
R1—470-ohm
R2—1000-ohm
R3—4700-ohm
R4, R5—10,000-ohm
R6–R8—100,000-ohm

CAPACITORS

C1, C2—18-pF, ceramic-disc
C3—33-pF, ceramic-disc
C4—1-µF, 16-WVDC, electrolytic
C5–C8—0.1-µF, polyester

ADDITIONAL PARTS AND MATERIALS

B1, B2—6-volt battery
J1—modular telephone connector, PC-mount
SEN1—Seismic vibration transducer (see text)
XTAL1—4.194-MHz crystal
9- or 25-pin connector, four D-cell battery holder, four AA-cell battery holder, wire hardware, etc.

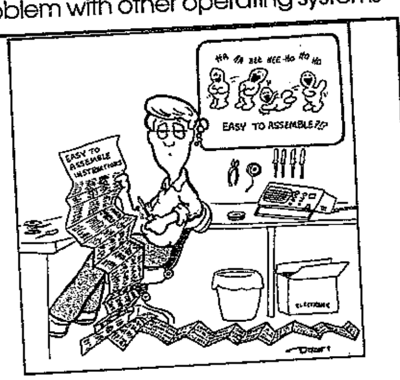
Note: The following items are available from Tahoe Chemical R&D; Tel: 702-885-8842; E-mail: sjnewt@aol.com: Pre-programmed IC1, $10; etched and drilled PC board, $15. Please add $5 for shipping and handling within US and Canada. NV residents must add appropriate sales tax.

SEN1 is available from: All Electronics, PO Box 567, Van Nuys, CA 91408-0567; Tel: 800-827-5432; item GP-1; and from Geo Space Corporation, 7334 N. Gessner, Houston, TX 77040; Tel: 713-939-7093; Web: www.geospacecorp.com; item GS-20DM.

If you need to use a 25-pin connector, pins 2 and 3 are reversed; pin 7 is used for ground.

As a final touch, put a drop of red fingernail polish on the side of S2 next to the battery wires That will be a reminder as to which position is the "on" position. The completed Seismic Detector, with batteries loaded, is shown in Fig 5

Testing. One of the files in the download package is seismic.exe; that is the PC program for setting up and collecting data from the Seismic Detector It is a DOS-based program; it will run under Windows95 and Windows98; compatibility might be a problem with other operating systems



such as WindowsNT, Windows2000, and OS/2 At any rate, running the software from a plain DOS prompt is best to avoid any interference Windows might cause while accessing the serial ports

Make sure that S2 is off; place the batteries into their holders With the Seismic Detector resting on a table, turn it on; LED1 should light. Connect the adapter cable to J1 and the serial port of your computer The LED should turn off Start the seismic.exe program and select the serial port that you have the Seismic Detector connected to

Once you reach the main menu, type "C" for real time Tap the table and you should see the data change When SEN1 is at rest, the data should be centering on 128

Now we'll test the unit's recording ability. Type "D" to clear the Seismic Detector's memory, and then type "E" for field recording Hit the enter key to accept the default delay of one minute Note that the Seismic Detector can be set for a delay of up to 255 minutes—that's four hours and 15 minutes, the approximate driving time between Boston and New York! Remove the cord from J1 and LED1 should blink on and off indicating that it is arming Once LED1 goes out, it is armed. Tap the table and LED1 should go on indicating that it is taking data Tap the table several times for about one minute You can turn S1 off; the unit will retain its data

Downloading. Plug the adapter cable into J1 and turn the unit on At the main menu of the PC program, type "B" to choose the store-to-disk option, then type "A" Collection will automatically stop when all of the available data is downloaded Once you are satisfied that you have stored the data you want, you can erase the memory as detailed above

The data files can be read into any spreadsheet Both Lotus 123 and Excel work well. The first large number is the date and its decimal is the time that the seismic event took place The following data is seismic data Use the spreadsheet's graphing function to display the data. An example of graphing a seismic event is shown in Fig. 6. That event took place in Carson City, NV on October 30 1998 at 1:53 AM. That data file, as well as a text file with further information on using the Seismic Detector, is a part of the full software package that you downloaded

Field Use. For simple seismic sensing in a building, set the unit down on its D batteries on a concrete floor in an area where it won't be disturbed. Place SEN1 next to it The unit can be turned off without disturbing SEN1.

When studying volcanoes or doing other outdoor work, place the unit into a plastic container with a waterproof screw or snap cover. Fix SEN1 to the bottom using double-sided tape; hold the batteries in place with rubber bands or foam rubber Bury the container to prevent vandalism and retrieve the data later Remember that when you go back to dig it up, the shovel will cause the last recorded event! Don't forget to turn off the power when transporting the Seismic Detector Ω