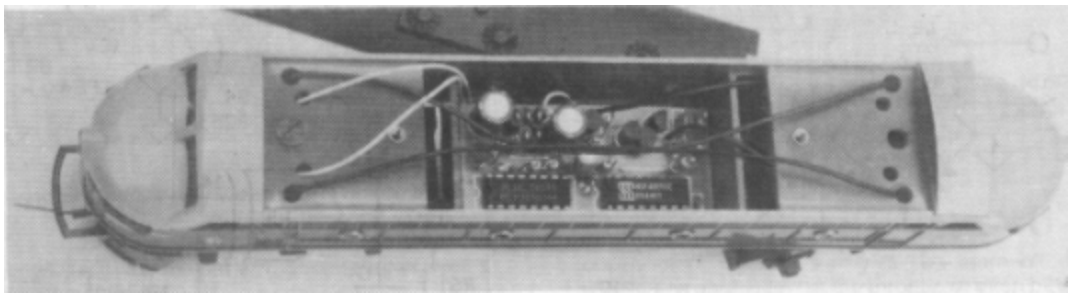
DIESEL SOUND

This project is available on 3 different PC boards:

Diesel Sound 1 -long board

Diesel Sound 2 -short board

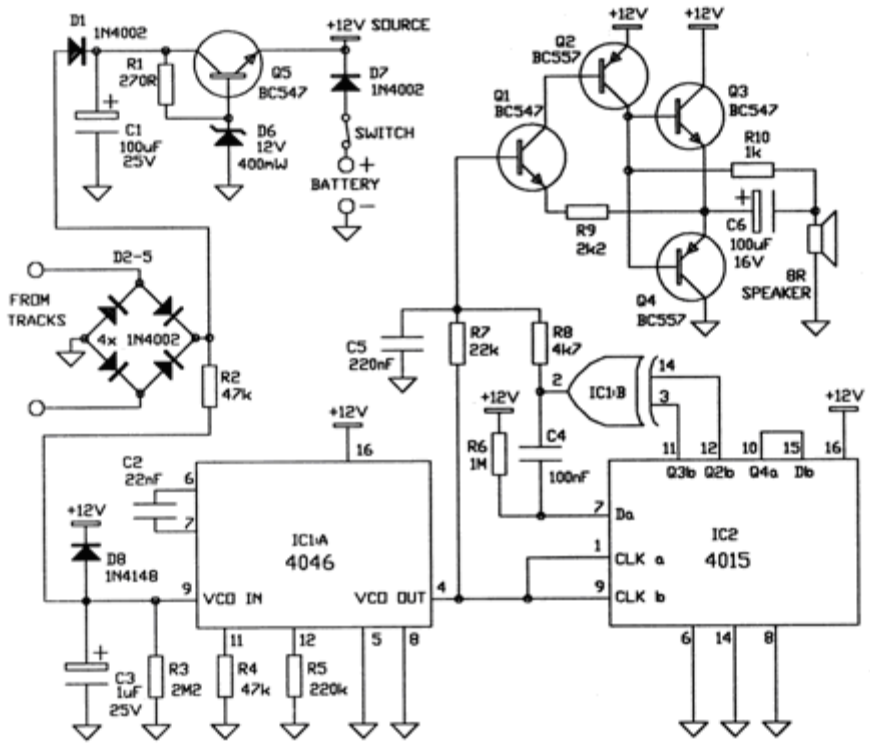
Diesel Sound 3 - called Diesel Sound 4 watt



**The tiny Diesel Sound Generator easily fits into this OO scale locomotive.
The battery is in the space over the non powered bogie,
while the speaker is below the PCB,
in a small plastic compartment, facing downwards.**

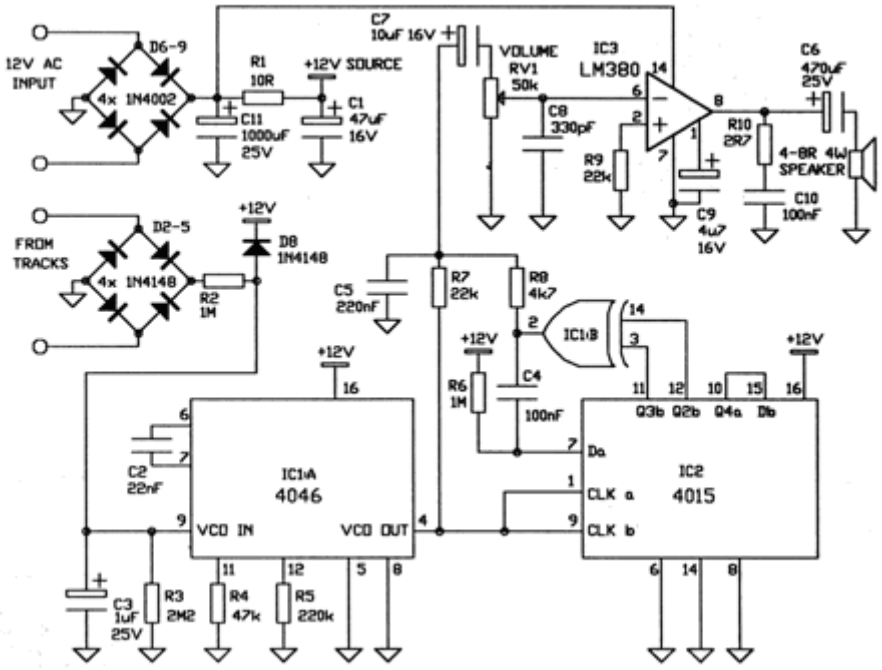
Imagine having a long goods train hauled around your layout by a beautifully detailed diesel locomotive that sounded like the real thing. No longer do you have to tolerate the tinny whine of the electric motor that is the real source of the locomotive's power, because here is a project that generates a convincing diesel engine sound.

There are three versions of the diesel sound generator so the one most suited to your needs can be selected. Two of them are small enough to be coaxed into HO and OO engines, or vans and box cars, helped by different shaped PCB designs to allow for different space limitations. One of them is long and thin, and should fit into the narrower bodies used on some diesels. The other is for fitting into wider but shorter spaces.
Both of these printed circuit boards are very compact and use a lot of very thin tracks. These tracks are susceptible to over or under etching and are very easy to damage while soldering. This makes them highly unsuitable for an inexperienced hobbyist to build. Good construction skills are essential, as are a fine tipped temperature controlled soldering iron and a pair of good quality side cutters.
For those who don't think you can manage the project, there is a third version, designed to be easier to construct. The third design is considerably larger than the other two, and is not meant to installed in a train, but rather back at the controller. I figured as there was little chance of coaxing a unit into an N scale loco, construction could be made easier by spreading the components out and using thicker printed circuit tracks. I also took the opportunity to do away with the battery the other units require, and to install a more powerful amplifier. I have run these diesel simulators through twelve inch speakers to great effect.



DIESEL SOUND 1 & 2

The circuit diagram of the on-board Diesel Sound Generator. There are two different PC boards (long - called Diesel Sound 1 and short - called Diesel Sound 2) but the circuit is the same.



DIESEL SOUND 3 - 4 watt version using LM 380 chip

HOW IT WORKS

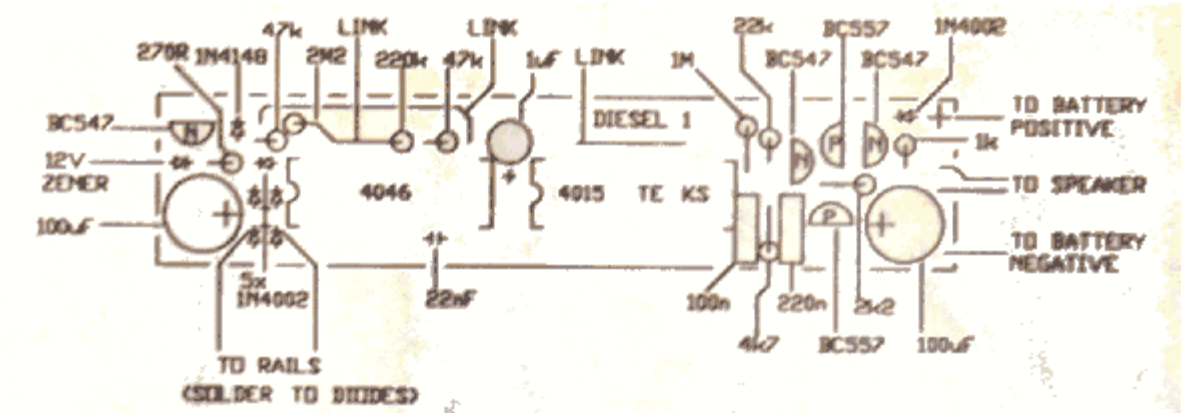
The circuit can be looked at as several parts. Some areas will differ depending on the version. First we will consider the circuit designed to be carried in the locomotive.
The first part is the input bridge rectifier. This makes sure power of the correct polarity is always fed to the diesel sound generator. It feeds power to two circuit sections. The first is the 12 volt zener voltage regulator. C1 smoothes the output of pulse type throttles into a usable constant voltage. D1 prevents any voltage held in the capacitor from being fed back to the second circuit section that is connected to the input bridge.
The second section is the speed detector. The voltage from the track is fed to the control pin of the voltage controlled oscillator in the 4046. As the track voltage is varied to control the speed of the locomotive, it will also modulate the frequency of the VCO, changing the simulated diesel's revs. So the faster the train goes, the faster the engine will sound. As a real diesel engine contains a lot of rotating mass, the rate at which it can rev up or slow down is limited. C3 along with its discharge resistor R3, simulates this inertia effect.
The next section of the circuit is the pseudo-random noise generator. It is this section that actually generates the characteristic diesel throb. It consists of a seven stage shift register with its two last outputs Exclusive-ORed together and fed back into its input.

The square wave output of the VCO is used to clock the 4015 shift register. On each positive transition of the square wave, the data that is on pin 7 of the shift register is clocked into its first stage. At the same time the data in the first stage is clocked into its second stage, the data in the second stage is clocked into its third stage and so on. The data is eventually lost when it is clocked out of the eighth stage. The 4015 is really a dual 4 stage shift register with each stage having its own output pin. By feeding the last output of the first shift register into the data input of the second one, we have made an eight stage shift register. In this circuit, the outputs are taken from stages six and seven. The eighth stage is not used.

The Exclusive-OR gate compares outputs six and seven of the shift register, its output reflecting what is at the input pins. If either input is high, the output of the Exclusive-OR gate will also be high, but if neither or both inputs are high, the output will be low. This output is fed back into the shift register, and will soon be clocked through to outputs six and seven again. This results in an almost random stream of logic levels at the output of the Exclusive-Or gate. It is in fact a repeating cycle. Varying the number of stages in the shift register will vary the pattern. Seven stages seems to be the most suitable.
C4 and R6 are there to kick start the generator. It is possible that the shift register will start with all of its stages containing lows. And as a low compared with a low always gives a low, the pseudo-random sequence will never start. C4 and R6 hold the input high long enough for one or two highs to be clocked into the shift register. If your unit fails to start, reduce the value of R6.
The frequency of the VCO controls the rate at which the shift register is driven, thereby modifying the "throb" rate according to speed.
R7, R8 and C5 form a simple mixer and filter. The output of the pseudo-random noise generator is mixed with a little of the VCO's direct output and then the higher frequency component of the signal is shunted to the common rail via C5, while the remaining signal is amplified and sent to the speaker.
The VCO's direct output is used to simulate the whine of a supercharger. If you do not require the effect, leave out the 22k resistor R7.
The battery is there to provide power when there is not enough being picked up from the rails. D7 prevents the battery from being back fed. The switch is there so you can shut off the battery when you have finished running the train for the day.
If you cannot tolerate the thought of using a battery, replace C1 with a 1000uF electrolytic. The diesel sound generator will still work, but its performance will be adversely affected. It will no longer idle and slow speed performance will be poor, but you will never need to replace the battery!
The other version of the diesel sound generator differs primarily in two areas. The first is its power supply. It is fed from the rectified output of a transformer, and because of this requires no battery.

Secondly, it uses an LM380 audio amplifier chip, giving a possible 4 watts out. With a decent speaker connected, your neighbours may think you are playing with a REAL diesel.
Some cunning modelers will be able to graft this unit directly onto the simple throttle presented in this book (before the reversing switch!), and do away with the need for both bridge rectifiers and a separate transformer. However, I recommend that a separate and isolated transformer winding be used to power each sound generator
constructed. Usually, trying to run them off the same winding as each other or the throttle, or even other circuits from the book, is a recipe for disaster for the unwary. There are too many ways in which an unexpected connection can occur, and when one does happen, either a diode in one of the bridges, or the transformer winding itself, will be damaged.

Diesel Sound 1

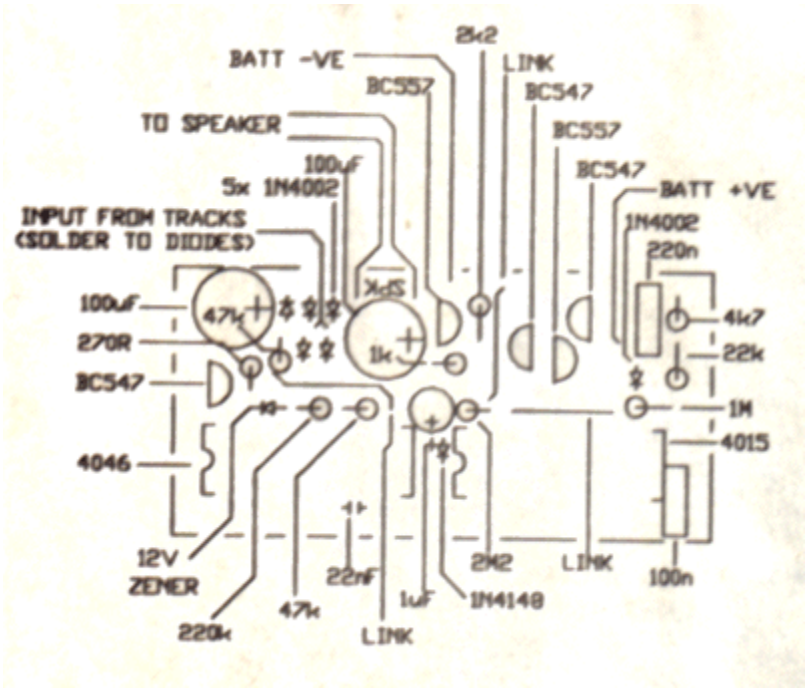


Diesel Sound 1 - parts placement

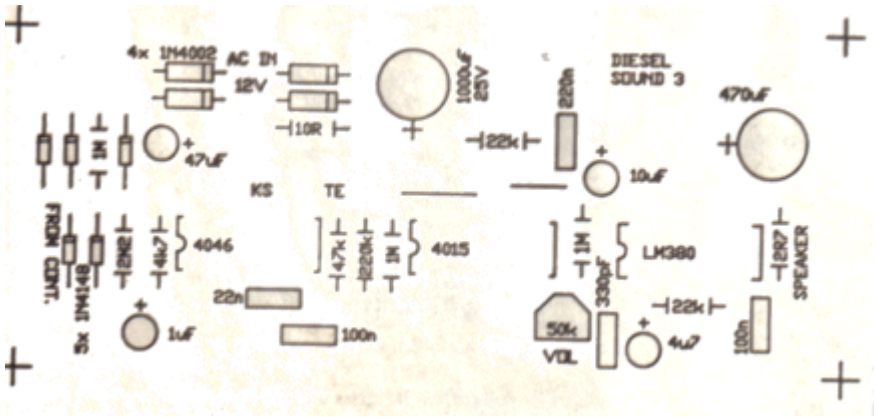
Diesel Sound 1 - photo is reverse to layout above

Diesel Sound 2

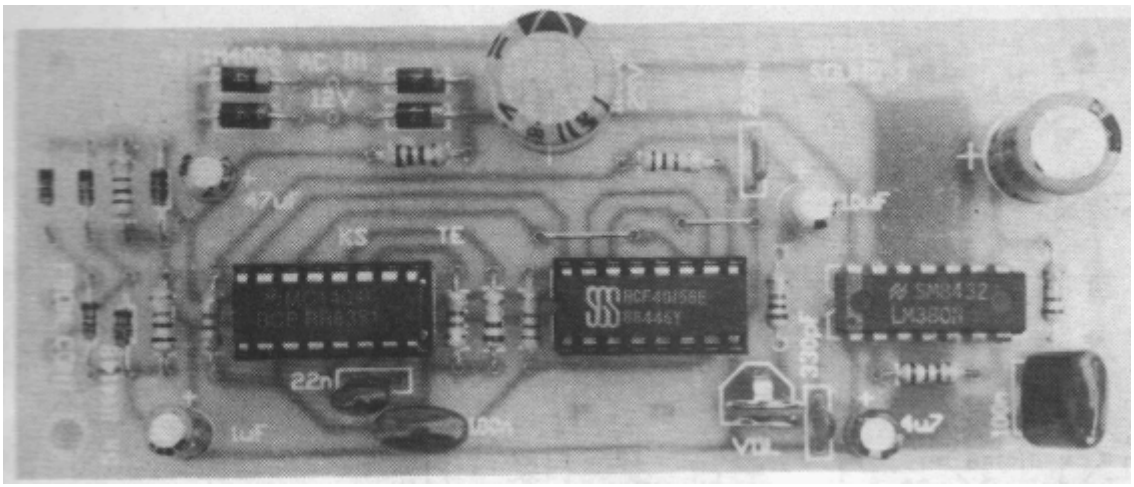
Diesel Sound 2



Diesel Sound 2 - parts placement



Diesel Sound 3

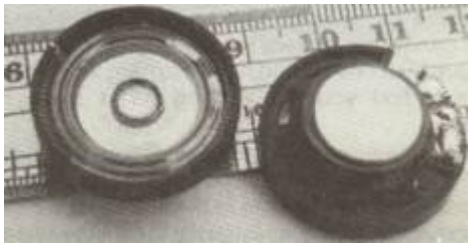


Diesel Sound 3

CONSTRUCTION

The first step is to select which board is more suited to your needs.
If you refer to the construction drawings you will see that there are several links. The shorter ones can be tinned copper wire. The longer ones will need to be insulated. On one version there is a link that is actually soldered between two resistors on the top side of the board.
The chips must be soldered directly to the board. Sockets take up too much space in a project this small. All resistors and diodes are stood on end to conserve space. The overlay on the board shows which end the body of the resistors should be placed. Refer to the photographs for the physical orientation of the diodes. Only their electrical orientation is on the overlay. The diode described as 12V is the 12 volt zener used in the regulator.
The capacitors should all be of the monolithic ceramic or monoblock type, once again to conserve space. Try to use small canned electrolytics too. The size of the 100u capacitors varies a lot depending on manufacturer and age.

The connections to the board have been put where they fit without taking up space. The connections to the diode bridge can be made by soldering either to the pads on the solder side of the board, or directly to the leads of the diodes.
This version should present no problems to any constructor, as it is neatly laid out with reasonable spaces between components. Do not use a socket for the LM380, as it uses the copper on the printed circuit board as a heat-sink. The copper provided for the job is really not enough to dissipate the heat generated if the amplifier is run flat out for extended periods of time, but I doubt anyone will. Besides, the supply voltage is a little on the low side to allow full output power to be attained.



The mini speakers used in this project

COMPATIBILITY WITH THROTTLES

The diesel sound generator responds differently to various types of throttles, I have tried it on all that were available to me at the time of writing. As it stands, it works well on pulse type throttles. It is also completely compatible with variable voltage throttles like that presented in Electronics for Model Railways.

However, old current controlling throttles, that is any that use a rheostat to control speed, tend to make the diesel sound generator over-rev. Some juggling with the input voltage divider would cure the problem, but I have found the simplest and most effective method to be reducing the battery voltage to six volts. The unit will be a little quieter at idle, but will otherwise behave normally.

FITTING THINGS INTO SMALL SPACES

Obviously, if the diesel sound generator is to be built into a train, a small speaker is required. And obtaining suitable speakers has always been a problem too, until recently. Some companies have produced sound effect generating key-rings, equipped with a range of bizarre "revenge" effects, such as machine gun, death ray and grenade bomb! These gadgets are loud. Loud enough to be heard across a sizable warehouse over the background noise. Their secret is in their 27mm 8 ohm speaker. These speakers are only about 9.5mm deep, too, making them almost ideal. The good news is that these key-rings are cheap enough to buy just for the speaker alone. As for the sound generating module, hit it with a hammer, or toss it into the junk box, but whatever you do, don't wire it up to a big speaker and give it to your kid I

Finding a suitable battery can be a problem too. I have found that the diesel sound generator works best when run off a combination of power from the rails and an internal nine volt battery. Otherwise the sound effect stops when the locomotive does. If space is really tight, a row of button cells could be used, but as often as not, there is plenty of space, ft is just that the space is usually of the wrong shape to put a standard nine volt battery into. The solution is to buy an alkaline battery. The Duracell alkaline battery contains six very small pencil cells that can easily be separated and tucked into odd corners through the locomotive. Replacement will be infrequent too. There is one thing to be careful about when using these cells. While they look similar to "AA" cells their terminals are backwards. The negative terminal is the stud, while the plain flat end is positive.

OBTAINING MAXIMUM VOLUME

If you are going to go to the effort of building a diesel sound generator, you will want it to be easily heard. Once you have built one up and have it driving that tiny speaker, you may find yourself wishing for a more powerful amplifier.

There is an alternate way to getting more volume from the unit. For demonstration purposes, take an empty 35mm film canister and cut a hole in the lid. The diameter of the hole should be nearly as large as that of the speaker.

With the diesel sound generator running, place the speaker, facing up, on your workbench. Now place the canister onto the speaker, so that the speaker is facing into the hole. You will notice a tremendous increase in volume as well as an increase in bass response. If you think that the bench is playing a part, lift the speaker and canister, and you will find it just as loud.

What you have just done is to provide the speaker with a resonant cavity, or simply put, a speaker box. I will not give any further details on how to arrange a suitable cavity in your locomotive. Undoubtedly, you won't find space for the canister! Experiment with building boxes to suit your locomotive from some plastic card. You may have to settle for less than optimum results due to space limitations.

PARTS LIST

Diesel Sound 1 & 2

1 - 270R
1 - 1k
1 - 2k2
1 - 4k7
1 - 22k
2 - 47k
1 - 220k
1 - 1M
1 - 2M2
1 - 22n monoblock
1 - 100n monoblock
1 - 220n monoblock
1 - 1u 16v electro
2 - 100u 16v electros
1 - 1N4148
6 - 1N4004
1 - 12v 400mW Zener
1 - 4015 Shift Register
1 - 4046 VCO
3 - BC547 transistors
2 - BC557 transistors
1 - mini switch
1 - 9v battery snap

1 - DIESEL 1 PCB
or DIESEL 2 PCB

EXTRAS:
1 - MINI SPEAKER

PARTS LIST

Diesel Sound 3

4 watt version

1 - 2R7or2R2
1 - 10R
1 - 4k7
2 - 22k
1 - 47k
1 - 220k
3 - 1M
1 - 2M2
1 - 50k mini trim pot
1 - 330p ceramic
1 - 22n greencap
2 - 100n greencap
1 - 220n monoblock
1 - 1u 25v electro
1 - 4u7 16v electro
1 - 10u 16v electro
1 - 47u 16v electro
1 - 470u 16v electro
1 - 1,000u 25v Electro
4 - 1N4004
5 - 1N4148
1 - 4015 Shift Register
1 - 4046 VCO
1 - LM380 Audio Amp IC
1 - DIESEL Sound 3 PCB

EXTRAS:
1 - 4-8R 4 Watt Speaker

28/1/08