

GENIE ROCK STAR

An intelligent, microcontroller-based electronics and CAD/CAM project



**WITH
REAL
MIDI*
MUSIC!**

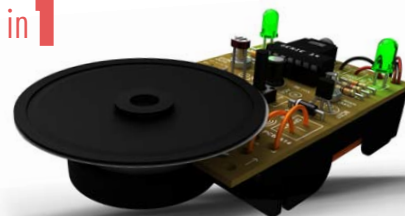
* Learn about MIDI music on page 20.

▲ A 3D rendering of a project created with GENIE Rock Star. The design shown above has a single-panel acrylic guitar body on which has been placed some custom artwork.

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2 in 1



▲ **The GENIE Rock Star project is built around the GENIE Audio Kit.**

The GENIE Audio Kit is also used in the GENIE Cuddly Creatures project (which has real sound effects). So if you have the GENIE Audio Kit, you can choose to make either project.

All of the design files for this project can be downloaded from genieonline.com/rockstar





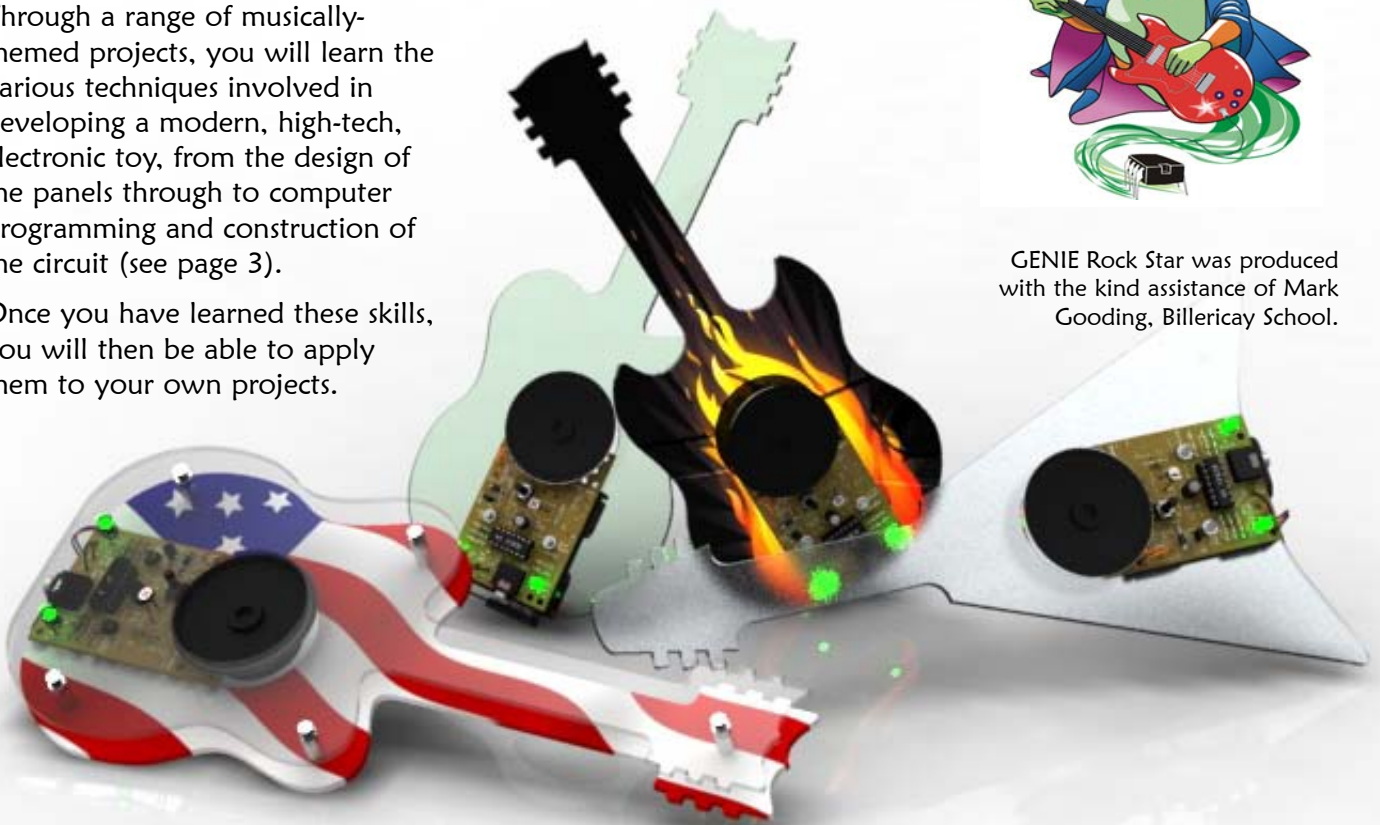
The **GENIE Rock Star** shows how you can use the GENIE Audio Kit to apply computing and embed an intelligent, microcontroller-based electronic circuit into the products that you design and make.

Through a range of musically-themed projects, you will learn the various techniques involved in developing a modern, high-tech, electronic toy, from the design of the panels through to computer programming and construction of the circuit (see page 3).

Once you have learned these skills, you will then be able to apply them to your own projects.



GENIE Rock Star was produced with the kind assistance of Mark Gooding, Billerica School.



▲ 3D renderings of a selection of GENIE Rock Star projects.

Equipment needed

For the GENIE Rock Star project you will need at least the following:

- ✓ A GENIE Audio Kit and download cable.
- ✓ Three AA batteries (new or fully charged).
- ✓ Soldering iron, lead-free solder and wire.
- ✓ Two 3mm (M3) size counter-sunk screws with matching nuts (the screw length will depend on your choice of design) along with a suitable screwdriver.

The materials and equipment needed for the body of the project will vary depending on your own choices, but may include:

- + Cardboard (cheaper, but less sturdy) or acrylic (recommended) for the body.
- + CAD for the design of the body panels and CAM (such as a laser cutter) for manufacturing. These are optional, but will result in a higher-quality end product.





The following list outlines many of the ideas and skills that will be introduced as you step through this GENIE Rock Star project.



Product design

- ◆ Using CAD/CAM in a product design
- ◆ 2-D and 3-D modelling
- ◆ Embedding an electronic circuit into a design
- ◆ Selection of product materials

Computer programming

- ◆ Programming using flowcharts
- ◆ Responding to inputs
- ◆ Controlling outputs
- ◆ Digital and analogue signals
- ◆ Variables and calculations
- ◆ Downloading a flowchart

Science and mathematics

- ◆ Sound waves and frequencies
- ◆ Power, voltage and resistance

Electronic systems

- ◆ Programmable microcontrollers
- ◆ Digital music formats
- ◆ Circuit simulation and modelling
- ◆ Using printed circuit boards (PCBs)
- ◆ Identifying electronic components
- ◆ Soldering components to a PCB
- ◆ Fault-finding and troubleshooting



* STEM is Science, Technology, Engineering and Mathematics.

▲ A 3D rendering of a GENIE Rock Star project created with a single-panel design. The GENIE Audio Kit is mounted on top of the panel, with a battery box underneath.





The GENIE Audio Kit 4

The GENIE Rock Star project is based around the GENIE Audio Kit.

The GENIE Audio Kit, shown on the right, is an intelligent, programmable electronic circuit that can play real MIDI music (see page 19) through its loudspeaker.

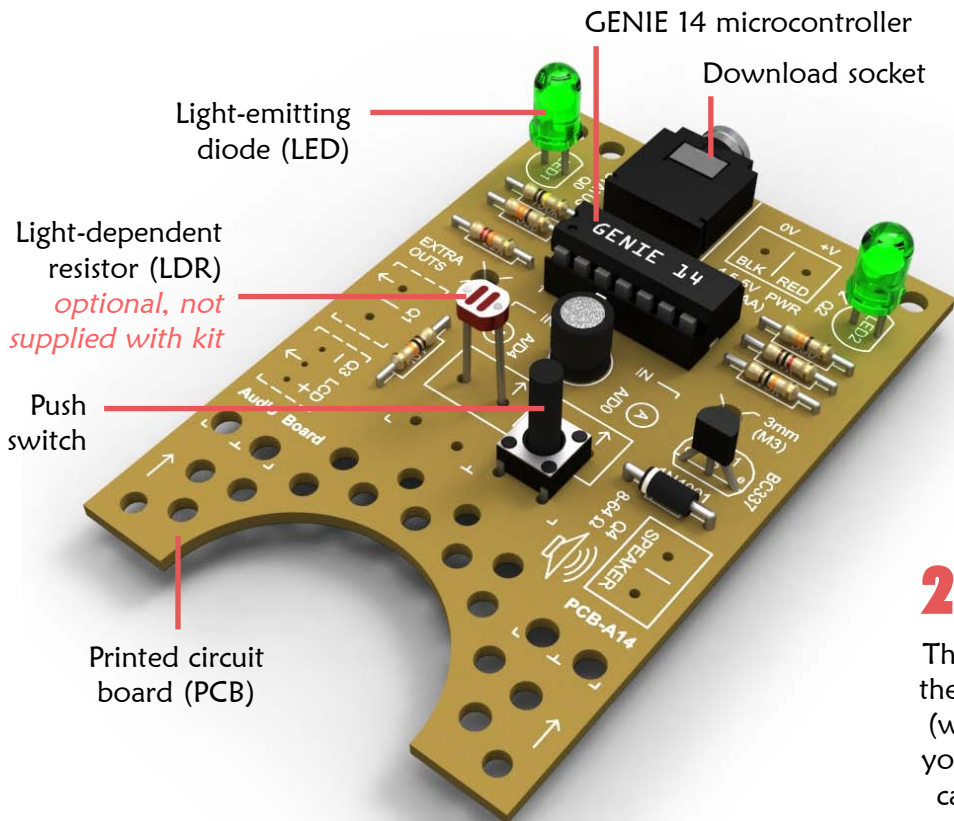
At its heart is a **GENIE 14 microcontroller**.

This is an integrated circuit (or IC) that controls the other components on the circuit. It is programmable, meaning that you can change how it behaves simply by downloading different programs from your computer onto the microchip.



▲ A GENIE Audio Kit (shown on its own, without a product design).

The picture below highlights the major parts of the GENIE Audio Kit. These will be discussed in more detail later. A full list of the parts contained within the GENIE Audio Kit can be found on page 26.



2 in 1 Product Design Tips!

The GENIE Audio Kit is also used in the GENIE Cuddly Creatures project (which has real sound effects). So if you have the GENIE Audio Kit, you can choose to make either project.

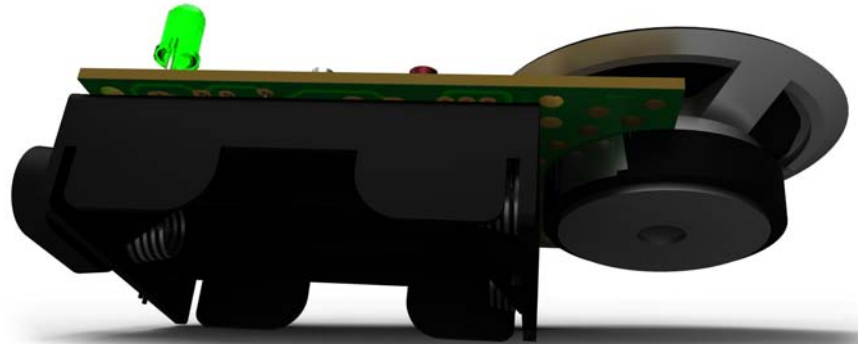




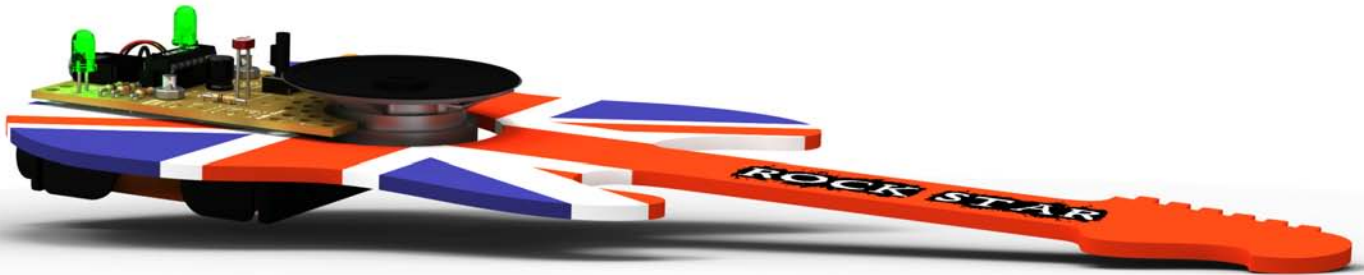
Incorporating GENIE into a product design 5

The GENIE Audio Kit will be incorporated into a product design to create a finished project.

To do this, we will make use of the fact that the GENIE Audio Kit has been cleverly designed so that a battery box can be mounted directly to the back of the printed circuit board (see the picture on the right). ▶

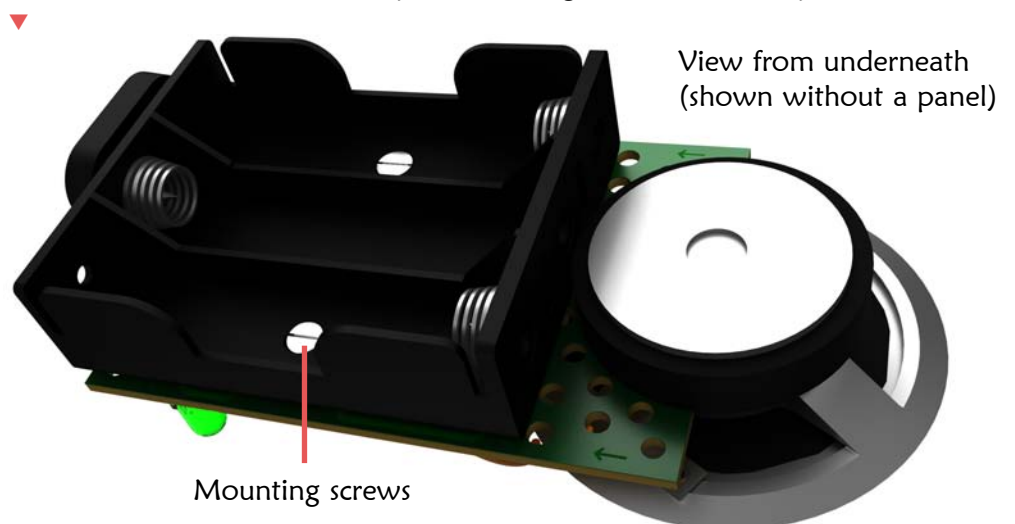


For the GENIE Rock Star, we will extend this idea and place a panel (with similarly designed mounting holes) between the battery box and the electronic circuit. All three will then form a rigid structure.



Top side. ▶

From the underneath of the GENIE Audio Kit we can see the location of the two screws that will be needed to mount the printed circuit board to both the battery box and the panel forming the body of the product:

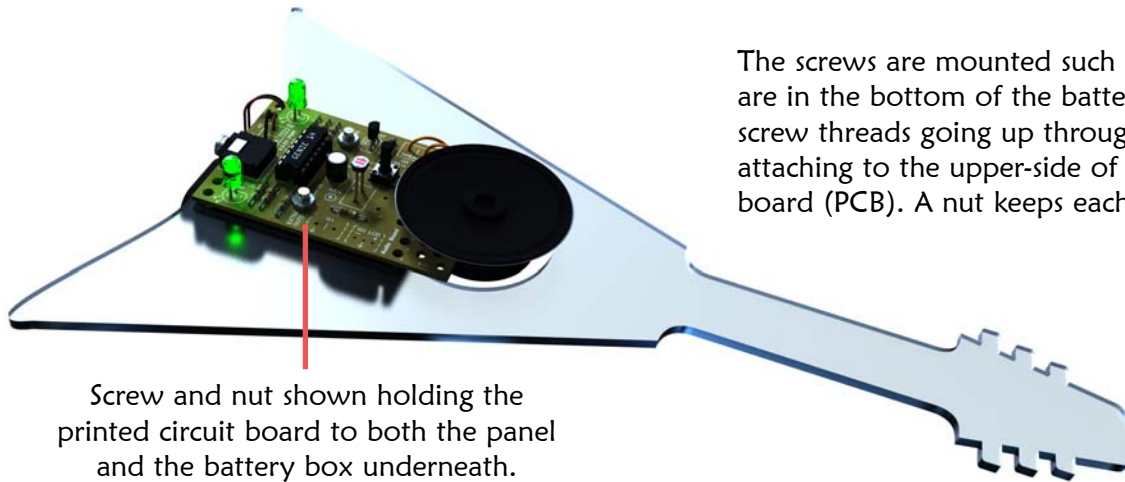


It is recommended that the mounting screws have counter-sunk heads to ensure that they do not obstruct the battery cells when they are fitted.





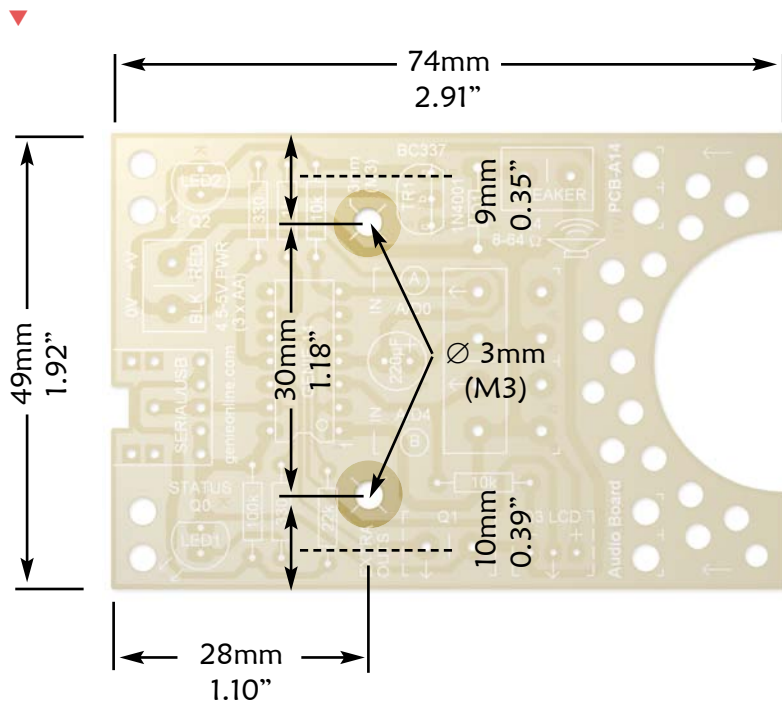
Incorporating GENIE into a product design 6



The screws are mounted such that their heads are in the bottom of the battery box, with the screw threads going up through the panel and attaching to the upper-side of the printed circuit board (PCB). A nut keeps each screw in place.

Screw and nut shown holding the printed circuit board to both the panel and the battery box underneath.

The screws need to be 3mm in diameter (known as M3-size screws). The length of the screw will vary depending on the thickness of the panel used in the design—a length of about 15mm is usually sufficient. From the diagram below you can see the physical dimensions of the printed circuit board as well as the position and size of the two mounting holes. This information is useful when designing your own panels.



Height

The PCB's height including components, legs and soldering, is approximately 15mm (0.6").

Mounting

There are many large holes, but the two indicated by the arrows are designed for mounting the PCB.

These holes have a diameter of 3mm, which makes them suitable for use with M3-size screws/nuts.

The spacing between the two holes is 30mm (1.18").

The other holes were not designed for mounting and are described on the power and loudspeaker pages.

Design Tip!

If you have Circuit Wizard 4, you can use that software's built-in CAD/CAM design tools to automatically calculate all of the necessary panels and mounting holes.



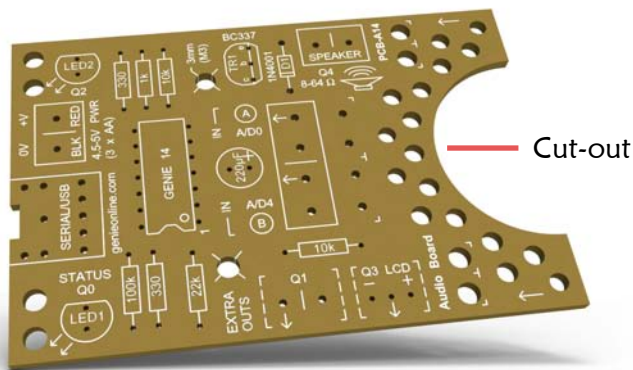
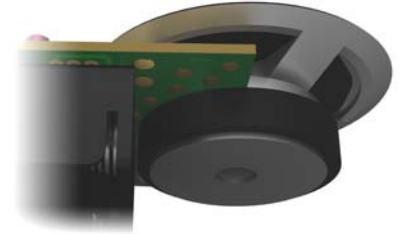


Incorporating GENIE into a product design

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In addition to mounting the battery box, we must also consider how to mount the loudspeaker.

For the GENIE Rock Star project, we will take advantage of another cleverly-designed feature of the GENIE Audio Kit: its useful ability to mount the loudspeaker directly onto the printed circuit board.

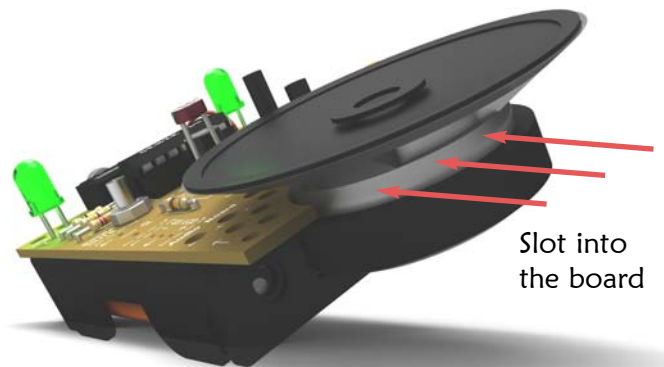


You will notice that the printed circuit board has a large semi-circular cut-out on one side. The size of this cut-out is designed to fit around the central body of a standard 50mm loudspeaker.

The loudspeaker can slot into the circuit board.

Once in position, the loudspeaker will sit over the many sound holes. These holes allow the sound waves to travel through the circuit board.

When finally constructed later on in the project, we suggest adding glue at contact points between the printed circuit board and the metallic part of the loudspeaker body. This will give the loudspeaker even more stability.



A 3D rendering of a finished GENIE Rock Star project, showing the mounted loudspeaker.



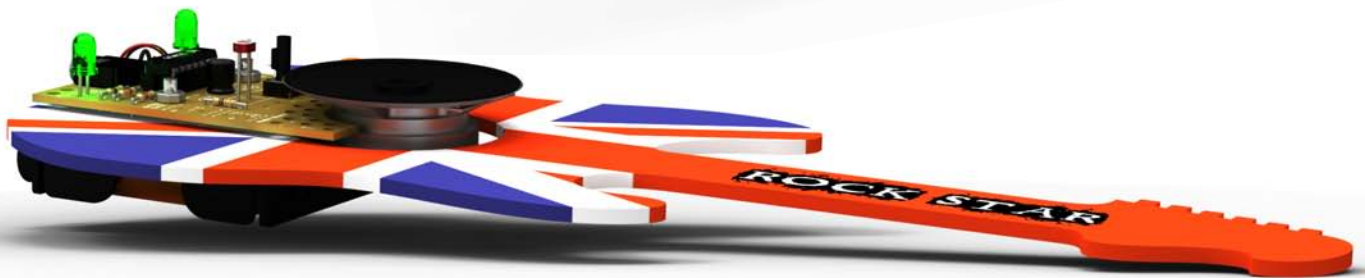
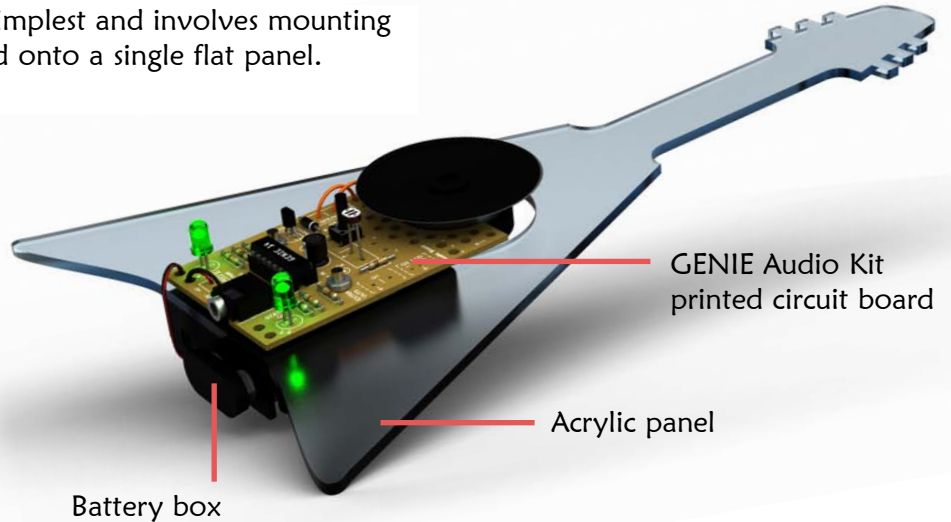


Creating a single-panel design 8

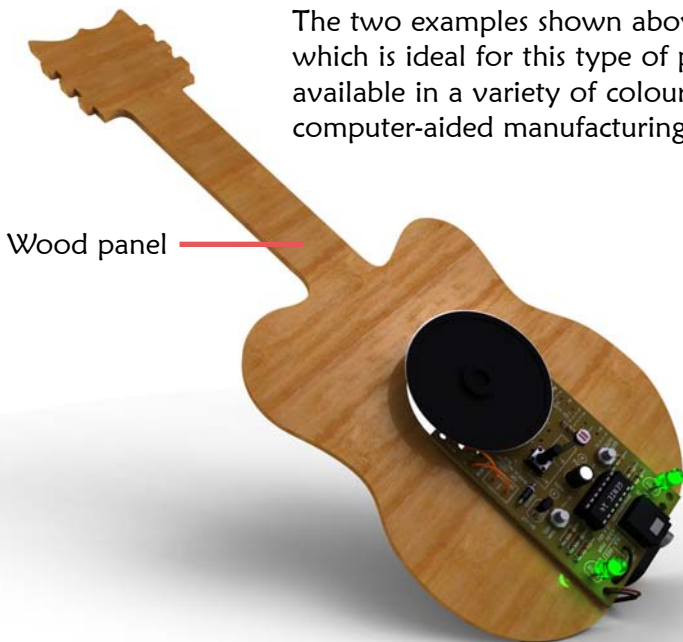
The first suggested design is the simplest and involves mounting the GENIE Audio Kit circuit board onto a single flat panel.

An example of this type of design can be seen on the right. In this case, a clear acrylic panel has been used to form the body of the guitar.

As described previously, the battery pack is mounted on the underside of the panel and attached to the circuit board by two screws.



The two examples shown above have their panels made out of an acrylic material, which is ideal for this type of project as it results in a strong, rigid structure. Acrylic is available in a variety of colours (both opaque and transparent) and is well suited to computer-aided manufacturing (CAM), such as with a laser cutter.



Wood, shown left, is equally suitable.

Metal, although strong, is not recommended as it may result in an electrical connection with the underside of the circuit board (metal is a conductor and will affect the behaviour of any circuit with which it comes into contact).

A lower-cost approach involves selecting a thick cardboard material. Cardboard will be damaged more easily, but is great for quick projects, such as when creating prototypes. You can also draw directly onto the cardboard itself, allowing you to mock-up ideas for any artwork that is going to go on the top of the body as well.

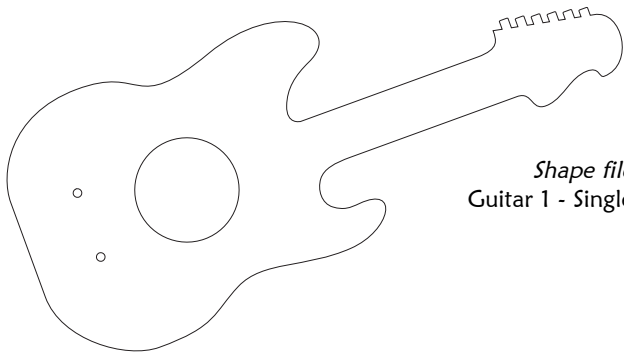




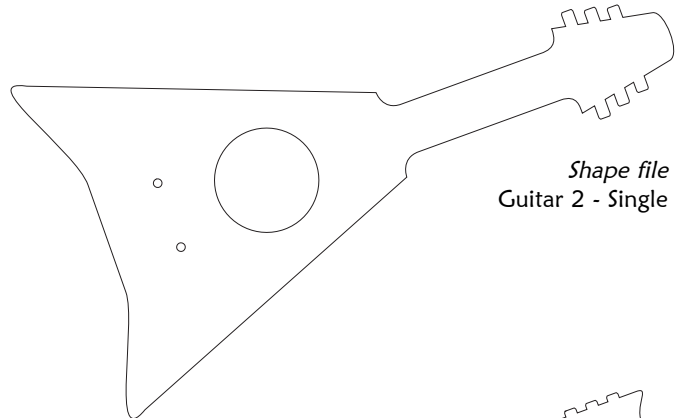
Creating a single-panel design

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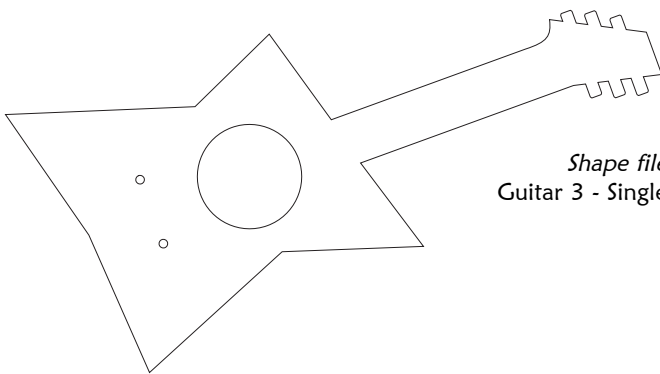
There are six guitar body shapes from which you can choose for the panel. These are shown below, though not to scale. Each has a large hole for the loudspeaker and two smaller holes for mounting the GENIE Audio Kit. These panels were created in Circuit Wizard 4. If you do not have Circuit Wizard 4, you can download the shape files (in .dxf format) from genieonline.com/rockstar



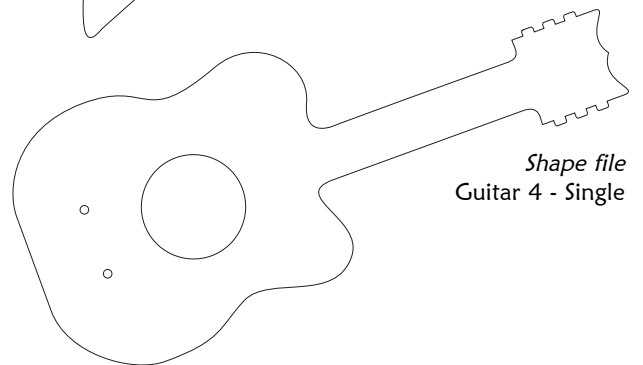
Shape file
Guitar 1 - Single



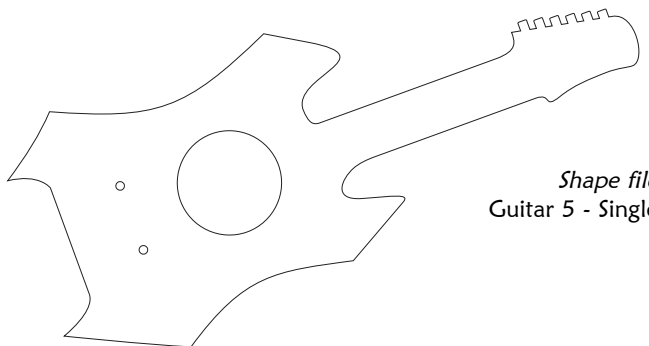
Shape file
Guitar 2 - Single



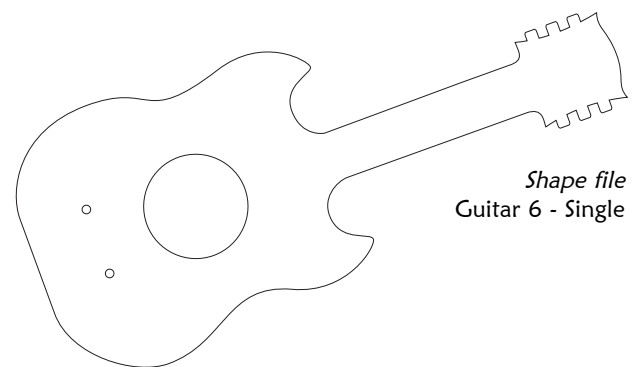
Shape file
Guitar 3 - Single



Shape file
Guitar 4 - Single



Shape file
Guitar 5 - Single



Shape file
Guitar 6 - Single

Product Design Tips!

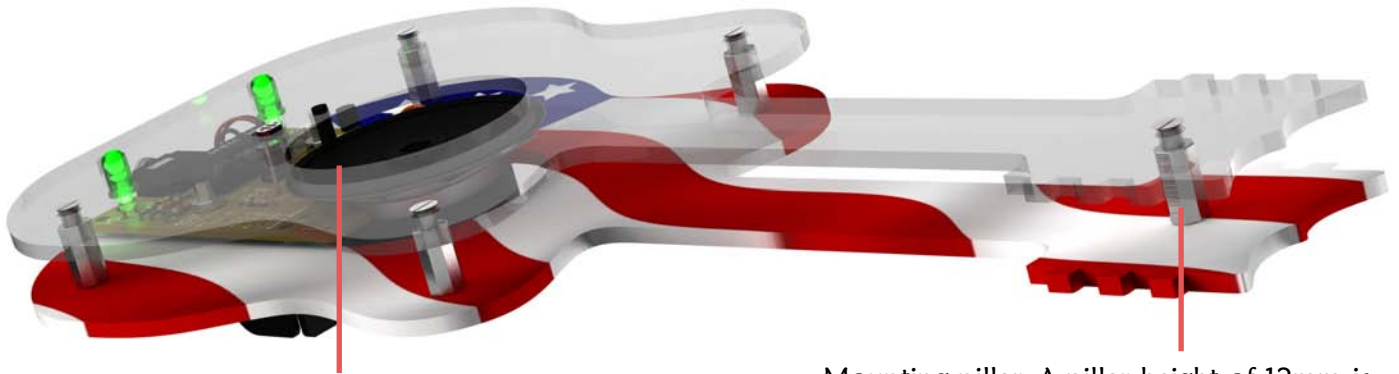
You are not limited to these six shapes. Why not design your own guitar shape? To start, you can use Circuit Wizard 4 to modify one of these existing designs, or alternatively create one from scratch.





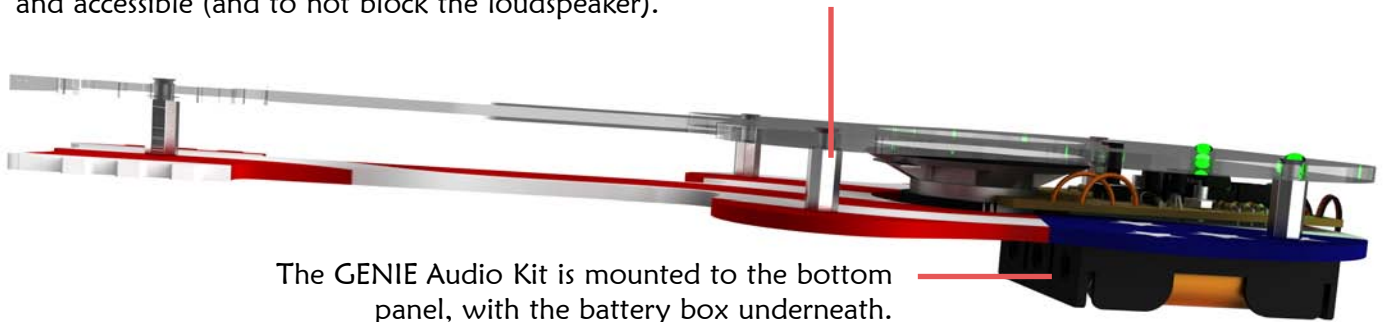
Creating a double-panel design 10

A second, more sophisticated design involves mounting the GENIE Audio Kit circuit board inbetween two panels to form an enclosure. The two panels have the same basic shape, but differ in the number and type of mounting holes that are present. Pillars are used to separate the two panels.



Holes on the upper-most panel allow the printed circuit board's inputs and outputs to be visible and accessible (and to not block the loudspeaker).

Mounting pillar. A pillar height of 12mm is recommended for this type of design. The pillars are fixed in place by screws at each end.



The GENIE Audio Kit is mounted to the bottom panel, with the battery box underneath.

The two panels in this type of design are well suited to both acrylic and wood. Metal, being a good conductor, should not be used for either panel. Cardboard lacks the rigidity required for mounting the pillars and therefore cannot be recommended, even for prototypes or mock-ups.

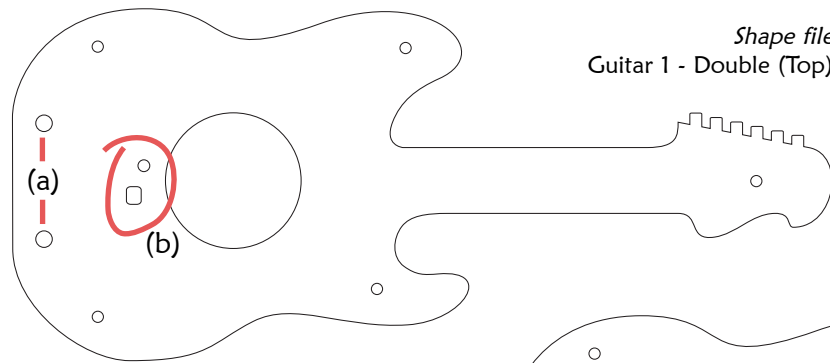
The upper panel is an ideal location for placing more elaborate artwork.





Creating a double-panel design

There are six guitar body shapes from which you can choose. Each guitar is made up of a top panel and a bottom panel. The two panels for the first guitar shape are shown below (though not to scale).



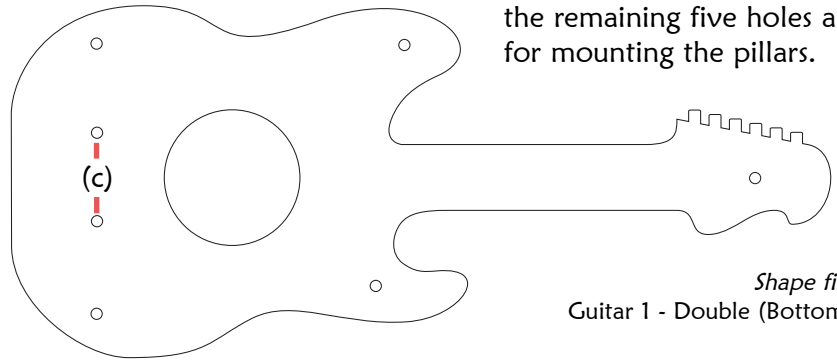
Shape file
Guitar 1 - Double (Top)

The top panel has ten holes in total. The holes marked (a) are to allow the light-emitting diodes (LEDs) to poke through. Similarly, the two holes marked (b) are for the push switch and optional light sensor.

The large hole (or a grille if you have Circuit Wizard 4) is for the loudspeaker and the remaining five holes are for mounting the pillars.

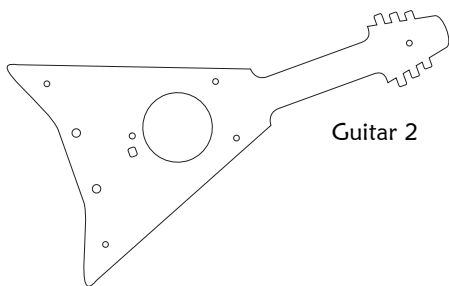
There are eight holes on the bottom panel. Two of the holes (c) are for mounting both the GENIE Audio Kit and the battery box.

As with the top panel, the other holes are for the loudspeaker and mounting pillars.

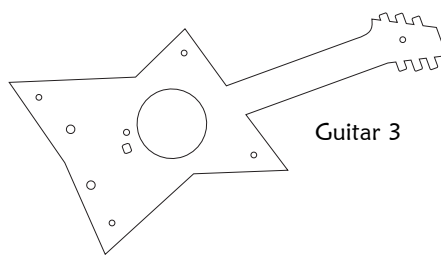


Shape file
Guitar 1 - Double (Bottom)

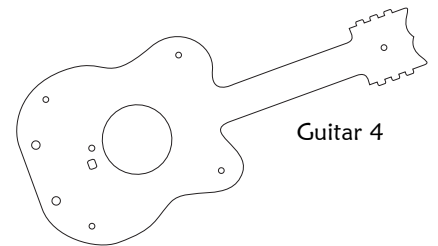
The top panels for the other five shapes are pictured below. If you do not have Circuit Wizard 4, you can download the shape files (in .dxf format) from genieonline.com/rockstar



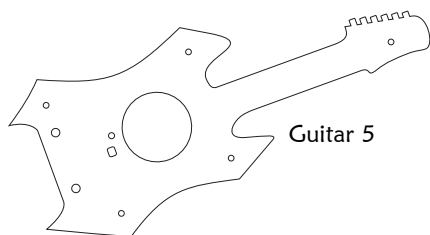
Guitar 2



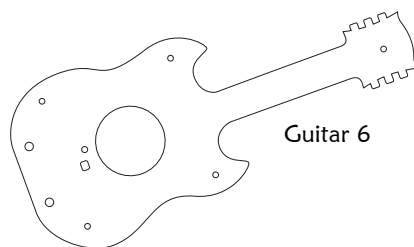
Guitar 3



Guitar 4



Guitar 5



Guitar 6

Product Design Tips!

You are not limited to these six shapes. Why not design your own guitar shape?

To start, you can use Circuit Wizard 4 software to modify one of these existing designs.



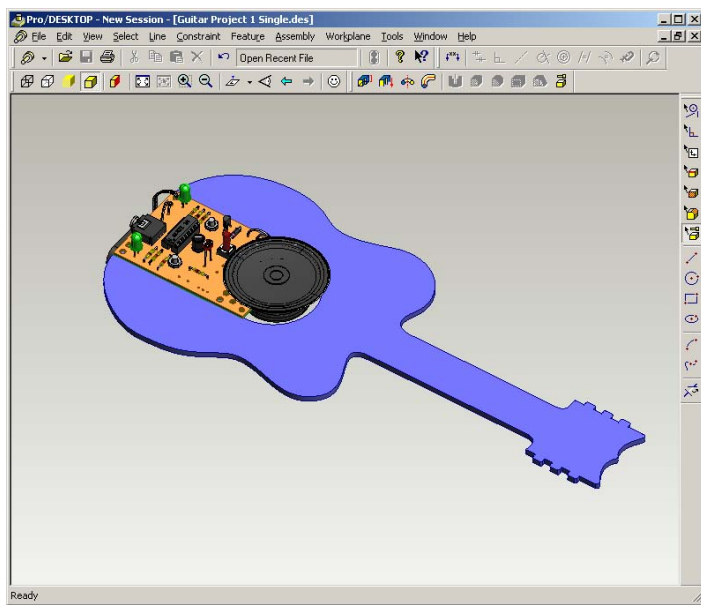


Creating your own designs 12

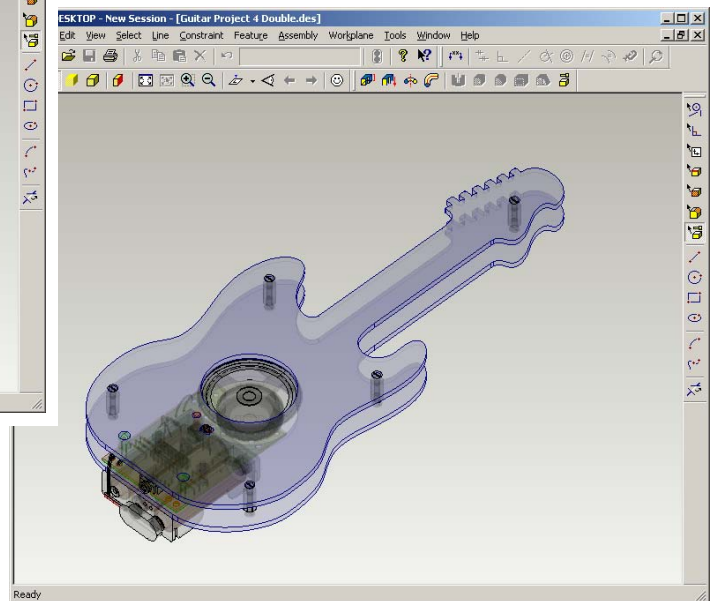
Now that you have seen how the single- and double-panel designs are put together, you may be ready to create your own designs. You may wish, for example, to modify an existing guitar body shape, create a new shape or even create an entirely different type of musical toy!

All of the designs shown in these worksheets were created using the CAD/CAM design tools within the Circuit Wizard 4 software. By combining both electronic circuit design and CAD/CAM panel design, Circuit Wizard 4 was able to automatically calculate and produce all of the necessary mounting holes.

Once created, the design outlines were then exported in .dxf format for further editing and manufacture.



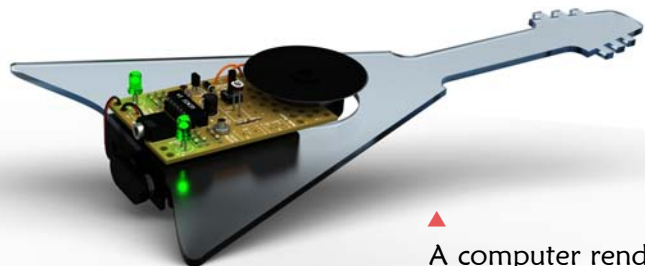
- ◀ The 3D models were all created using the Pro/DESKTOP 8 CAD software. You can download these files from our website at: genieonline.com/rockstar



Product Design Tips!

The designs presented in these worksheets are only intended to act as a starting point for your own creative ideas and product designs.

You can design your own products and then use these instructions to incorporate the GENIE Audio Kit.



- ▲ A computer rendered 3D design.

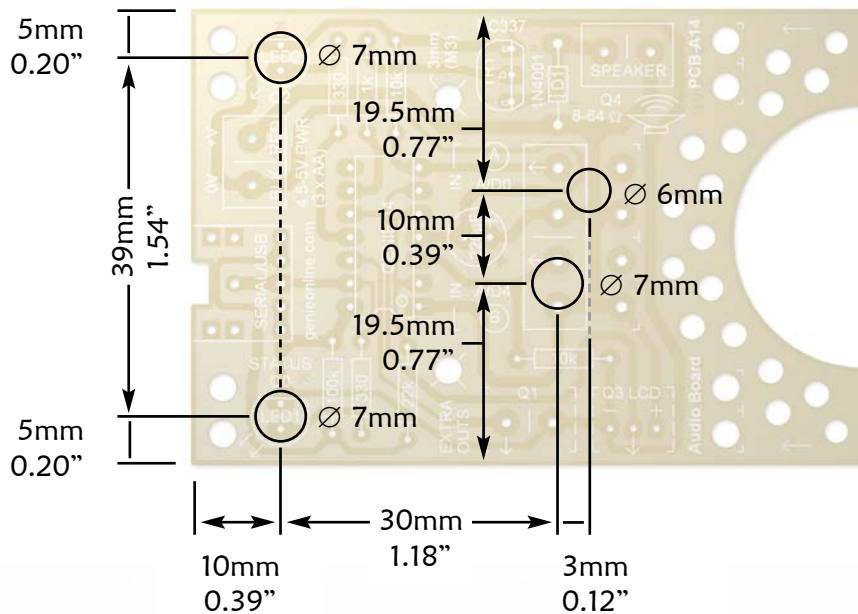




Creating your own designs 13

When creating your own project designs, you may find it useful to refer to the diagram below. It details the precise sizes and locations of the holes needed for the light-emitting diodes (LEDs) and the sensor(s).

If you have Circuit Wizard 4, these holes and mounting details can be created automatically.



◀ A 3D rendering of a single-panel guitar design.





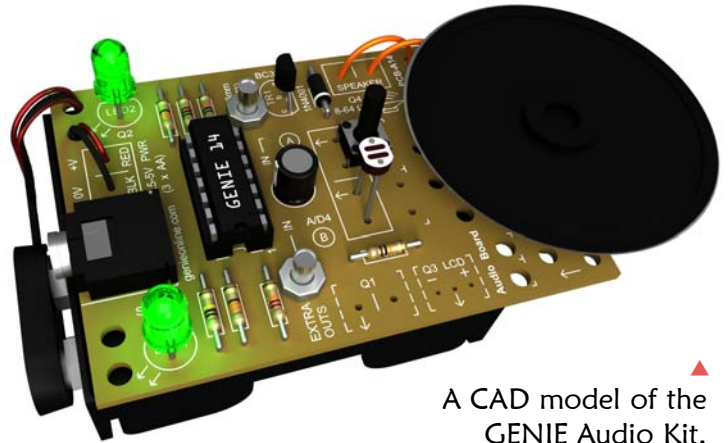
Modelling the GENIE Audio Kit 14

With the product design chosen, we can progress onto the making the project come to life through the GENIE Audio Kit.

The intelligence is provided by a sequence of instructions that are created on a computer and then downloaded to the microcontroller. This process is known as **programming**.

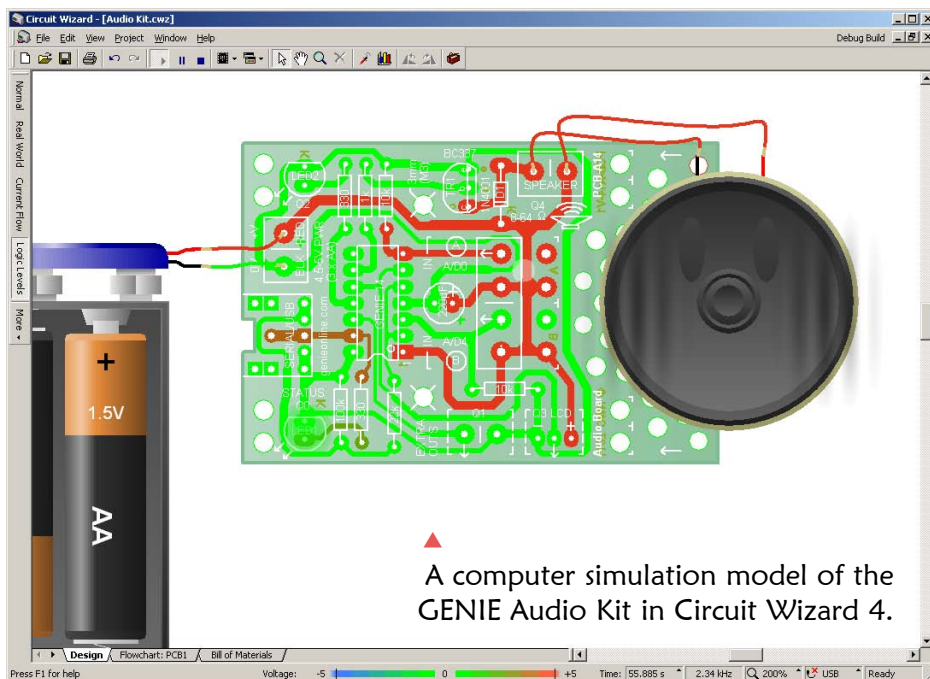
With GENIE, the instructions can be in the form of either graphical flowcharts or (the more advanced) BASIC text commands.

For the GENIE Rock Star project, we will be programming using flowcharts.



A CAD model of the GENIE Audio Kit.

Traditionally, developing these instructions has been difficult, however just as with computer-aided design (CAD), we can take advantage of computer modelling to develop and test a design before it is built.



A computer simulation model of the GENIE Audio Kit in Circuit Wizard 4.

An example of computer modelling is shown left.

Here we are using Circuit Wizard 4 to simulate an electronic circuit model of the GENIE Audio Kit.

Circuit Wizard 4 allows us to run the simulation and see how our flowchart behaves as we interact with it. We can detect mistakes early on, saving time.

One example of this can be seen in the picture. Here we have asked the software to colour each connection a different colour based on the voltage at that point.

You can find the Circuit Wizard 4 design and simulation files within its **Microcontroller Resources**.

For those without access to Circuit Wizard 4, you can instead use the free GENIE Programming Editor available from genieonline.com/editor. This software allows you to write and download your flowcharts, but does not enable you to design, simulate and test your electronic circuits on the screen.





Programming the GENIE to play music

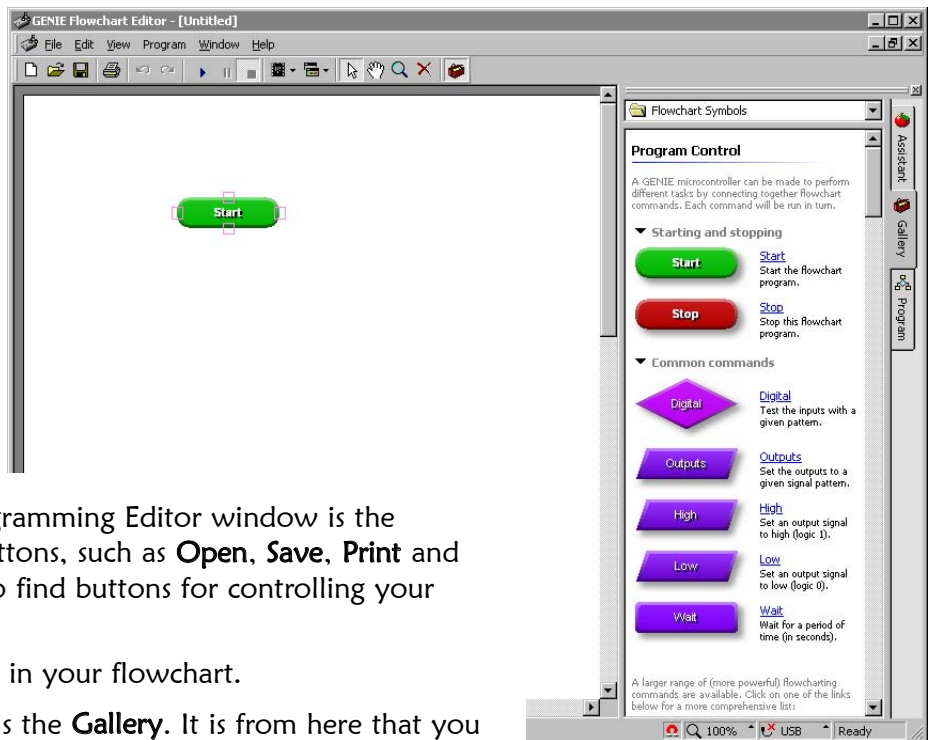
Creating a flowchart to control the GENIE Audio Kit requires either the **GENIE Programming Editor** software or version 4 of the **Circuit Wizard** software. The GENIE Programming Editor software is described here; for information on using Circuit Wizard 4, please see the following page.

Run the GENIE Programming Editor by clicking on its icon. Once it loads, click on the **New** button on the toolbar or choose **New** from the **File** menu. You will then see the screen below.



The GENIE Programming Editor icon.

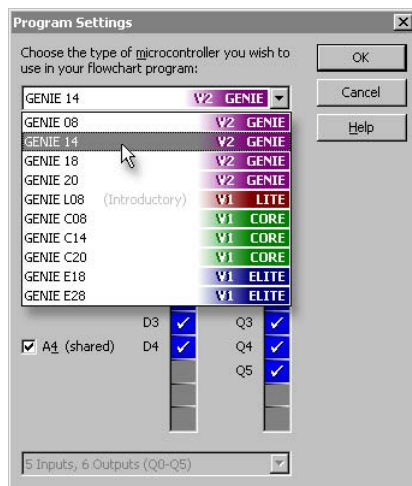
The GENIE Programming Editor software.



At the top of the main GENIE Programming Editor window is the toolbar. Along with the normal buttons, such as **Open**, **Save**, **Print** and **Undo**, on this toolbar you will also find buttons for controlling your flowchart or BASIC programs.

A **Start** command is placed for you in your flowchart.

On the right of the main window is the **Gallery**. It is from here that you will select which other commands you wish to include in your flowchart.



Next, you need to tell GENIE which type of chip you are using. To do this, click on the **Microcontroller** button on the toolbar and choose **Program Settings**.

Select a **GENIE 14** chip from the list. The inputs and output signals for this type of microcontroller are fixed, so just click on the **OK** button to continue.

You are now ready to draw a flowchart. This is described on page 18.





Programming the GENIE to play music 16

Circuit Wizard 4 is our flagship software combining GENIE programming, circuit design and simulation along with the a range of built-in CAD/CAM design tools. The guitar panels, circuits and flowcharts for this project were all created using the Circuit Wizard 4 software.



◀ The Circuit Wizard 4 icon.

To run Circuit Wizard 4, double click on its icon (pictured above).

Once it loads, go to the **Help** menu and choose **Microcontroller Resources**. This opens a window where you can access a wide range of resources that show how GENIE can be used to add intelligence to your designing and making projects.

On the front screen are six areas for you to explore:

'**Lighting and Sensing**', '**Sound and Music**' and '**Motors and Robotics**' all provide information on how to use and control particular inputs and outputs.

'**Design and CAD/CAM**' is where you can learn about the built-in panel design tools and access resources for this project, such as the one shown on the right (this is an example of single panel guitar design within the Circuit Wizard 4 software).

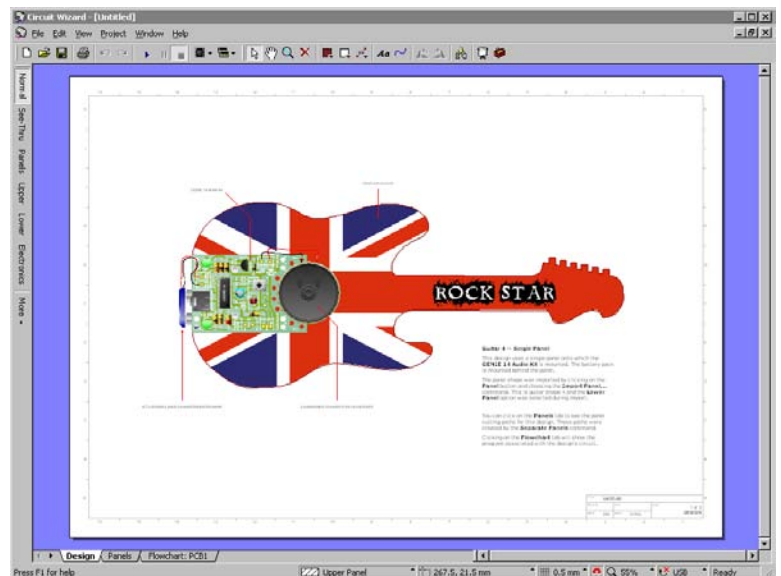
Once you are ready to progress your knowledge, you can access the topics within the '**STEM Activities**' section. Here you will find information on the computing, scientific and mathematical principles behind the GENIE system, as well as starting points for engineering your own electrical or electronic circuits.

The final area, '**Further Information**', provides access to support worksheets for the various kits and components.



▶ Circuit Wizard 4 Microcontroller Resources window.

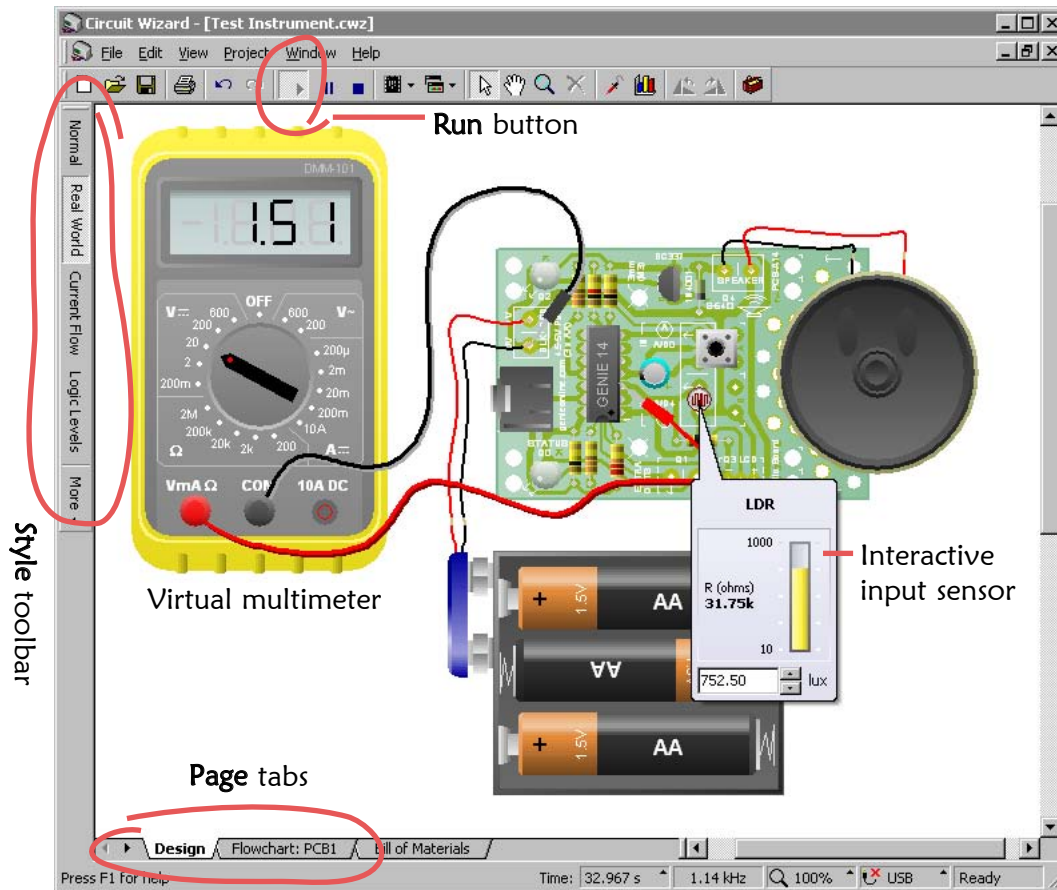
▶ Viewing a guitar design resource.





Programming the GENIE to play music

In addition to simulating just the GENIE flowchart, Circuit Wizard 4 also allows you to also simulate the flowchart in context with the printed circuit board, as can be seen below.



▶ A model of the GENIE Audio Kit.

You can click on the **Design** and **Flowchart** tabs at the bottom of the window to switch between the different pages of the design.

With a GENIE Audio Kit model selected or drawn (as described on page 14), simply click on the **Run** button on the top toolbar.

When you simulate a circuit, Circuit Wizard 4 will model both the flowchart and the circuit's electronics.

Whilst the model is simulating, you can take readings with the mouse (for example, by moving over a track or pad) or control the animation by choosing one of the options from the left-hand **Style** toolbar.

The two most common styles to view when running a simulation are:

- ◆ **Current Flow.** When selected, the software will animate the flow of electrical current in the circuit.
- ◆ **Logic Levels.** Shows the high or low digital logic levels at each part of the circuit.

A wide range of instruments and tools allow you to check your circuit before building (this also applies to circuits you've designed yourself).

In the example above, a virtual multimeter is being used to check the voltage on pin 3 of the GENIE microcontroller. This pin is where the connection to the light sensor (input 'A/D4', see page 23) comes into the chip.

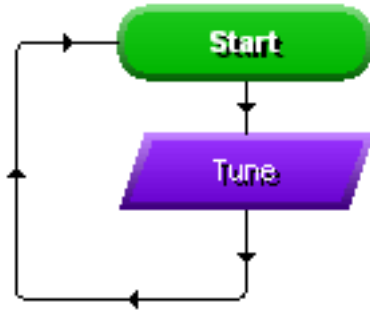
Simulation is able to show that as the light sensor input is adjusted (via the interactive control), the voltage on pin 3 of the microcontroller changes.

Voltage, current, power and charge can all be measured and tested on the screen.





Programming the GENIE to play music 18



- ◀ The first flowchart we will look at is shown on the left. It plays a tune and then repeats. The LEDs will flash in time with the music. All GENIE flowcharts begin with a **Start** command. When running the flowchart, GENIE simply follows the arrows. Each command that GENIE encounters while following the arrows will be run. With most commands, including the two shown here, arrows go both into and out of the command.

When you create a new flowchart, a **Start** command will be placed automatically on the page. To add other commands, you should use the **Gallery**.

If the Gallery is not visible, click on the **Gallery** tab that appears to the right of application's window. From here you can drag commands onto the page.

For the flowchart above, we will want to locate the **Tune** command and drag it below the **Start** command. To locate it, you will need to scroll down through the list of commands.

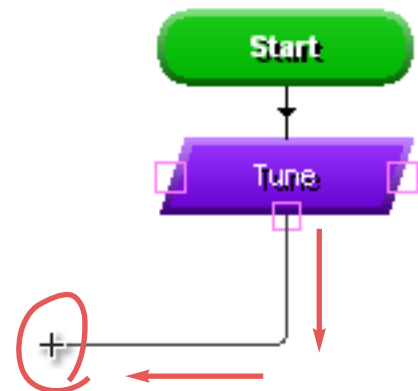
When you drop a command below (and close by) another one, a line and arrow will be placed automatically. To add the second line (the one looping back to the **Start** command), you need draw it using your mouse.



- ◀ Lines can be drawn from any one of the three squares shown on the **Tune** command. Move the mouse over the bottom square then click and release the left mouse button.

Now move the mouse down and to the left. A line will follow your mouse.

Click with the left mouse button to add a bend when you are not over anything. Keep moving the mouse upwards so that it is level with the **Start** command. Click again to add a second bend and then move the mouse right until the square appears. When you are over the square, press the left mouse button a final time to connect line to the **Start** command.





Choosing which music is to be played

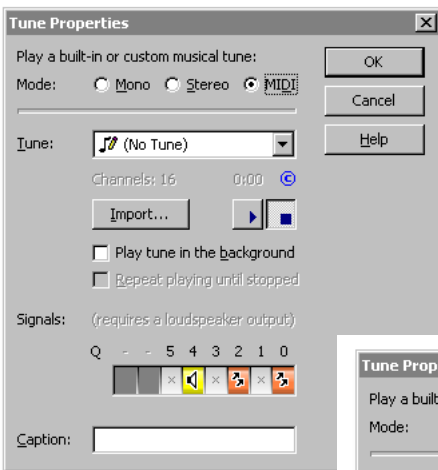
Once you have added a **Tune** command to your flowchart, you must next select the MIDI music that is to be played when the command is run (you can learn more about MIDI on the next page).

For those using Circuit Wizard 4, you can select MIDI tunes through the **Music Centre**.



Click on the **Tune** command that you wish to change (this is not needed if there is only one command).

Once done, open the **Music Centre** and move the mouse to the right-hand edge to reveal a list of available tunes.

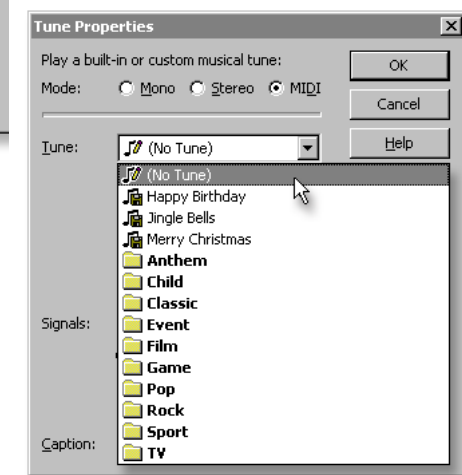


Click on a tune to select it (selecting one with a folder icon will bring up the list of tunes in that folder).



With the GENIE Programming Editor, you should instead double-click with the left mouse button on the **Tune** command.

Finally, click on the **Tune** drop-down box to reveal a list of available tunes. As before, selecting one with a folder icon will bring up the list of tunes in that folder.



First you must select the **MIDI** option.

Next, click on the **Signals** so that they match the ones shown on the far left. If the signals are currently empty, you should click on signal number **4** once, followed by signal **2** and then signal **0**.

These steps are not needed if you are modelling the GENIE Audio Kit within Circuit Wizard 4 because it can select the settings automatically, since it knows which printed circuit board you are using.



Because GENIE uses MIDI, you are not limited to the tunes that come with the software. With both Circuit Wizard 4 and GENIE Programming Editor, you can import MIDI tunes from other musical products, such as **Sibelius** or **Cubase**. To import, simply drag a MIDI file onto the **Music Centre** or **Tune** windows.





Understanding MIDI music and audio

20

The GENIE microcontroller at the heart of the GENIE Audio Kit stores tunes in a musical format known as **MIDI**.

MIDI is short for **Musical Instrument Digital Interface** and is a digital standard developed in the early 1980s, primarily to control keyboard synthesizers (though it later progressed into electronic drum sets and other musical instruments).

Unlike musical formats such as MP3 which store music as a series of waveforms or samples, MIDI instead works by storing numbers representing the actual musical notes being played (with 60 being middle C).

Because MIDI stores just the pitches and durations of each note, it takes up far less space, however it does mean that MIDI cannot record singing voices.

MIDI was used to play music in video games in the 1980s and 1990s and for ringtones on second-generation mobile telephones, from around 2002.

You can learn more about MIDI via the following Wikipedia article: <http://en.wikipedia.org/wiki/MIDI>

▼ A low-cost home MIDI keyboard.



GENIE supports **16-channel** MIDI music, which means that up to 16 notes can be played back at the same time. This allows GENIE to play complex tunes involving chords.

The GENIE Audio Kit works by taking the notes within the MIDI file and then vibrating the **loudspeaker** cone at the correct frequency. These sound frequencies are measured in **Hertz (Hz)**, which is the number of waves per second. Humans can typically hear from about 10Hz to 10,000Hz.

The frequency determines the pitch of the sound. Higher frequencies result in higher (treble) sounds, whereas lower frequencies result in lower (bass) sounds.



▲ A MIDI synthesizer in a recording studio. Image courtesy of Wikipedia.



▲ The loudspeaker cone is controlled by a magnet (which is itself controlled by the GENIE microcontroller) that forces the cone to move. This movement generates compression waves in the air, which are eventually picked up by your ear, forming the sound you hear.





Responding to inputs from the push switch 21

Some types of input signal, such as push switches, can only be either on or off. These are known as **digital** signals.

On the GENIE Audio Kit there is a push switch. It is connected to the input marked by the text 'A/D0'.

This means that it is the input number **0**. The 'A/D' prefix indicates that the GENIE pin to which the input is wired allows both analogue and digital components to be connected). When used for digital within the software, it will be called **D0**.

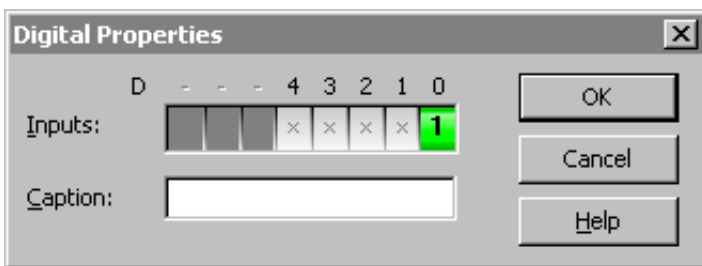


Use the **Digital** command to respond to a digital signals.

The **Digital** command allows you to make a decision based on whether the push switch (or any digital signal) is either pressed (on) or not pressed (off).

When a digital signal is on, it has the value '1' whereas when it is off, it has the value '0'.

Double-click on the command to select which digital inputs you wish to check. GENIE will follow the 'Y' (yes) path when the digital signal matches the chosen pattern, otherwise it will follow the 'N' (no) path. For the GENIE Audio Kit, we suggest clicking on the right-most input until it shows a '1':



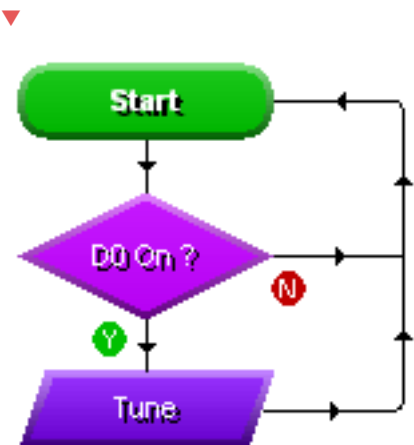
The **Digital** command should be incorporated into a larger flowchart. The flowchart tells the GENIE microcontroller what action to take when it reaches the command.

This can be seen on the right. In the flowchart shown, a tune will be played whenever the switch is pressed.



▲ A view of the GENIE Audio Kit, showing the push switch.

A simple flowchart that plays a tune whenever the push switch is pressed. The **Digital** command has two lines coming out of it, unlike the others.





Responding to inputs from analogue sensors 22

Not all input signals are digital. Some types of signal, such as those for temperature or light, can be at a number of different levels. These are known as **analogue** signals.

On the GENIE Audio Kit an analogue sensor can be connected to the 'A/D4' input. Although not supplied with the kit, an LDR is used in this example.

'A/D4' means that it is the input number 4. As with the push switch, the 'A/D' prefix indicates that the GENIE pin to which the input is wired allows both analogue and digital components to be connected. When used for analogue, it will be called **A4**.



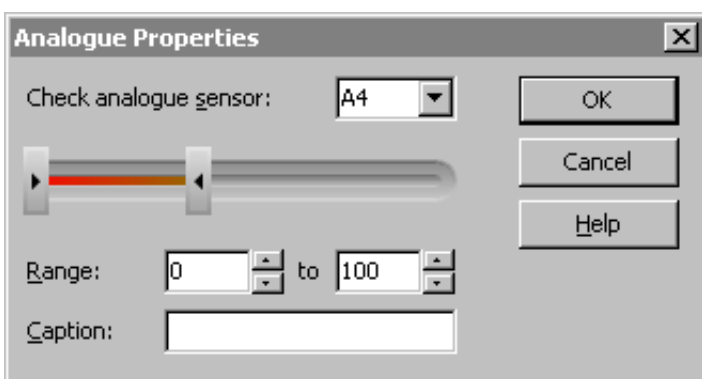
Use the **Analogue** command to respond to analogue signals.

The **Analogue** command allows you to check an analogue signal to see if its value lies within a given range.

With GENIE, analogue levels can vary between **0** (the lowest level) and **255** (the highest). For the light sensor, low values are when less light is detected, and high values when it is brighter.

Double-click on the command to select a sensor to check and a range. GENIE will follow the 'Y' (yes) path when the signal is in range, otherwise it will follow the 'N' (no) path.

For example, to test if the light sensor on analogue signal A4 is between 0 and 100, you should enter the following:



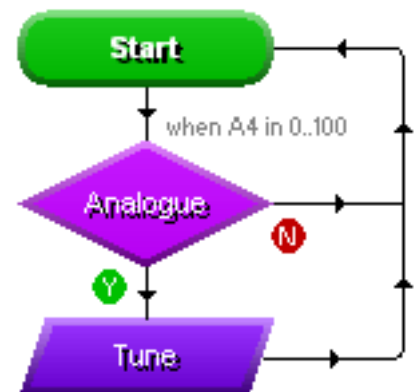
To allow you to fine-tune the sensor values, you can make use of the **Calibrate Sensor** command with a real GENIE Audio Kit.

A view of the GENIE Audio Kit, showing the optional light sensor.



Light sensor optional, not supplied

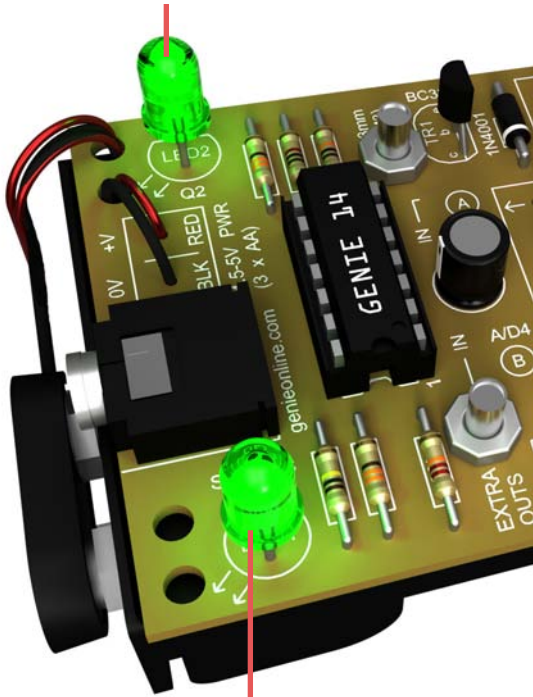
A simple flowchart that plays a tune whenever the light level goes low, such as when the sensor is covered. The **Analogue** command, like the **Digital** command, has two out lines.





Controlling the two light-emitting diodes (LEDs) 23

LED connected to output Q2



LED connected to output Q0

▲ A view of the GENIE Audio Kit, showing the two light-emitting diodes (LEDs).



▲ The first LED (connected to output Q0) has an extra significance when programming GENIE. This output is also referred to as the **STATUS** output because it will flash whenever a program is being downloaded to the microchip (it helps you check that everything is working okay).

The GENIE Audio Kit has two **light-emitting diode**, or **LED**, outputs. These LEDs will light up whenever the appropriate output signal goes high.

Normally the LEDs will flash in time with the music, however when the music is not playing, you can turn the LEDs on or off yourself via flowchart commands.



Use the **High** command to turn a single LED on.



Use the **Low** command to turn a single LED off.

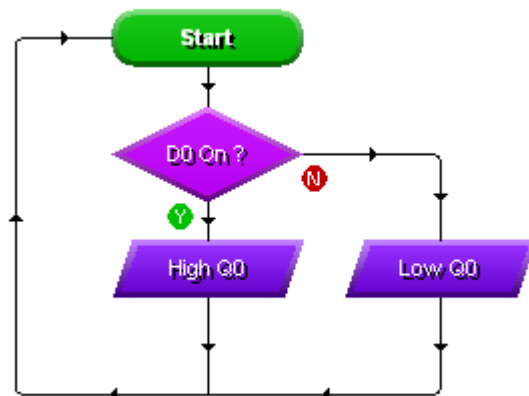


Use the **Outputs** command to control more than one LED.

The two LEDs are connected to the following outputs on the GENIE 14 microcontroller:

- ◆ The first LED is connected to output **Q0**.
- ◆ The second LED is connected to output **Q2**.

An example can be seen below. In the flowchart, the first LED is turned on whenever the push switch is pressed (and turned off again when it is released).

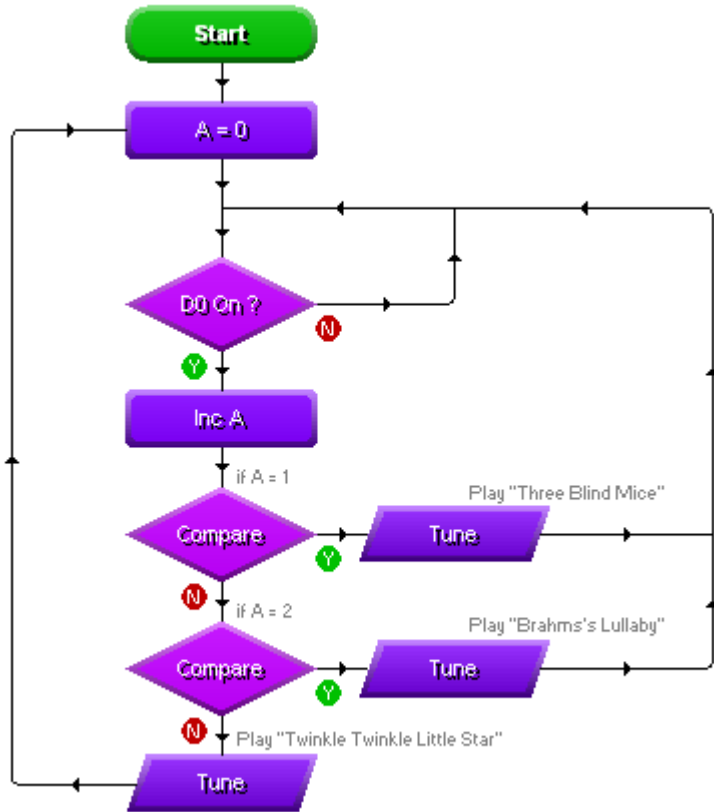


▲ Controlling the LED connected to output Q0.





Playing more than one tune 24



◀ The GENIE microcontroller at the heart of the GENIE Audio Kit allows even more complex flowcharts to be programmed.

One example can be seen on the left. It extends the push switch flowchart so that a different tune will be played (from a list of three) each time the switch is pressed.

The flowchart works by storing the number of the next tune to be played in a **variable**.

Variables are special parts of the GENIE microcontroller's memory that allow you to perform and remember calculations.

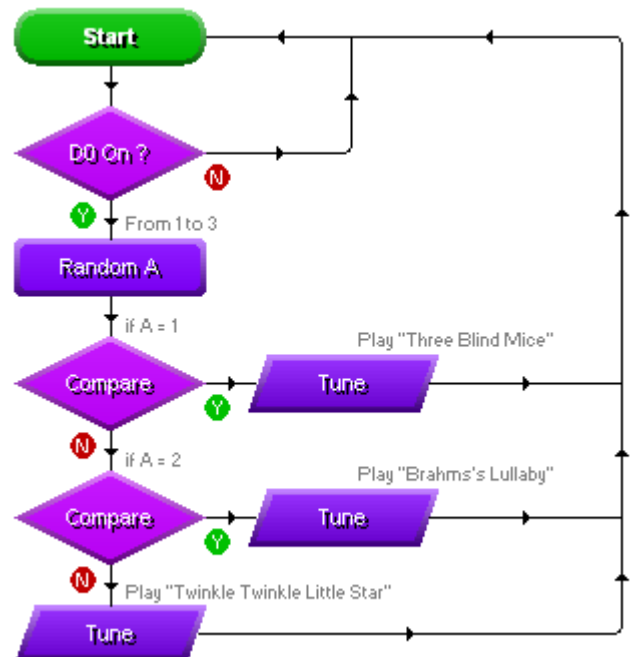
These variables can hold any whole number between 0 and 255 and are referred to by different letters of the alphabet. Here we are using the first variable, named **A**.

The flowchart increases the value stored in variable **A** each time the switch is pressed (this is the **Inc A** command). It then **Compares** the value of **A** to select a tune.

A similar approach is taken in the flowchart on the right. Here, instead of playing the next tune in the sequence, a tune is selected based on the value of a random number between 1 and 3 (inclusive) using the **Random** command.

Because the flowchart does not check to see if the value of the random number generated differs from the one chosen last time, the flowchart will sometimes play the same tune twice in succession.

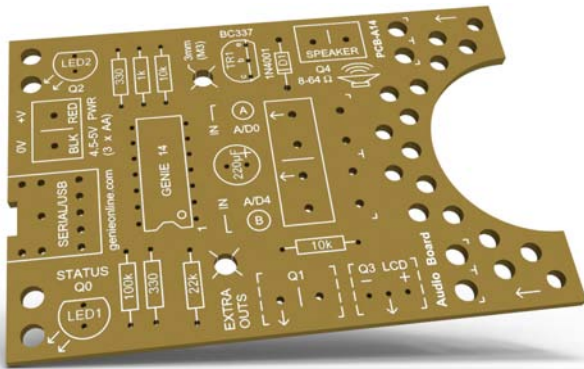
You should also note that because MIDI tunes take up a lot of GENIE's memory, you may need to select shorter tunes when playing more than one.





Building the GENIE Audio Kit 25

With the product casing and flowchart done, we are now ready to build the GENIE Audio Kit.



◀ The GENIE Audio Kit consists of a **printed circuit board (PCB)**, shown on the left) onto which are placed a number of electronic components.

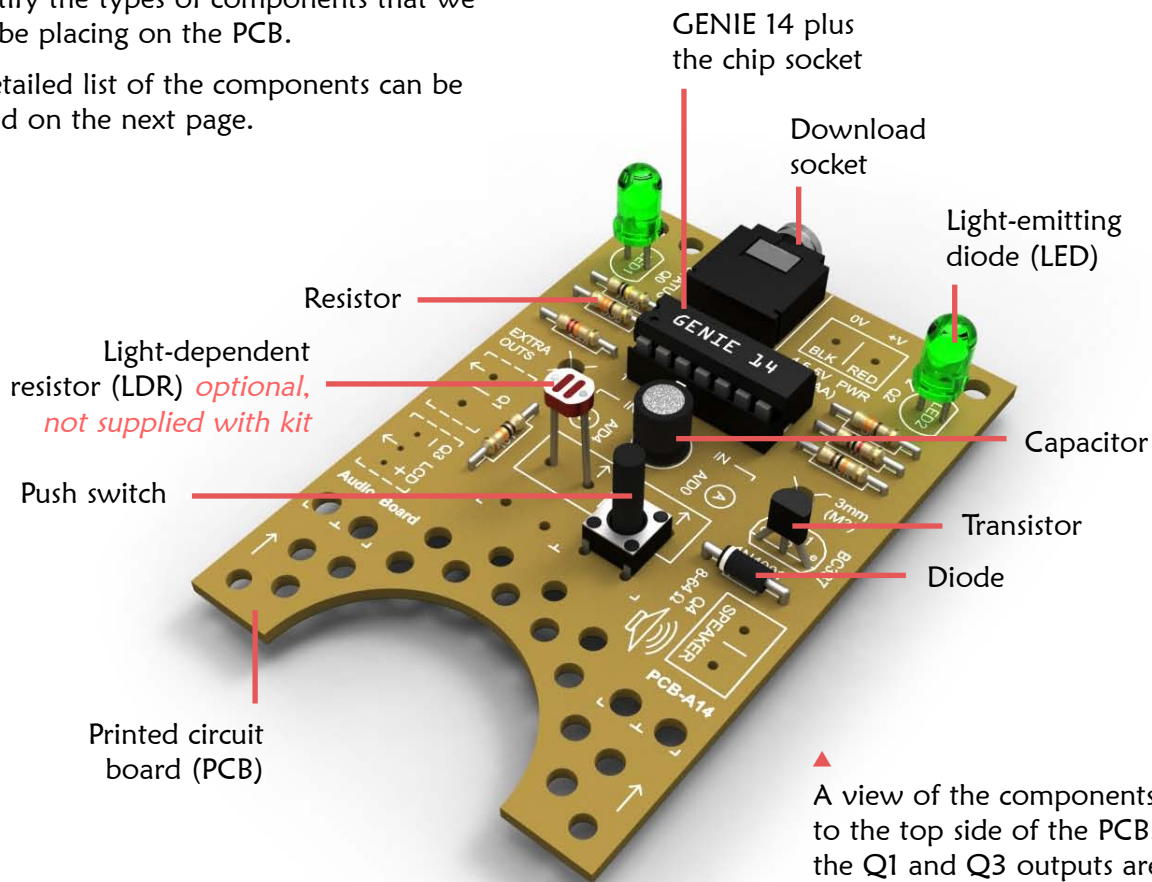
It is these components that provide the kit with the ability to play music.

The components must be placed in specific positions on the PCB. These positions are indicated by a series of markings and labels on the upper-side of the PCB. These markings are known as the **silk screen**.

Once placed, components must then be soldered to the under-side of the PCB so that they make an electrical contact.

The picture below will allow you to identify the types of components that we will be placing on the PCB.

A detailed list of the components can be found on the next page.



▲ A view of the components mounted to the top side of the PCB. Note that the Q1 and Q3 outputs are not used in the GENIE Rock Star project.

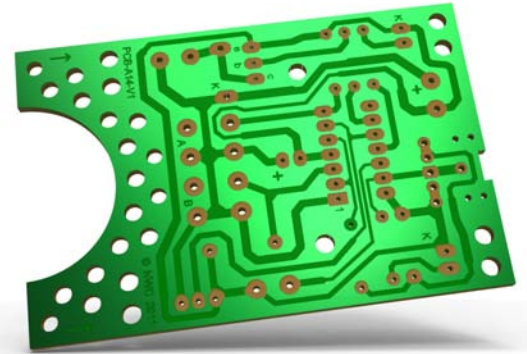




Building the GENIE Audio Kit 26

A GENIE Audio Kit has the following component parts:

Qty.	Component description
1	GENIE Audio printed circuit board (PCB)
1	GENIE 14 (14-pin) integrated circuit (IC)
1	3xAA battery pack
1	Battery clip
1	Loudspeaker
1	14-pin chip socket
1	Download socket
2	330 ohm (330Ω) resistor
1	1,000 Ohm ($1k\Omega$) resistor
2	10,000 Ohm ($10k\Omega$) resistor
1	22,000 Ohm ($22k\Omega$) resistor
1	100,000 Ohm ($100k\Omega$) resistor
1	220 micro-Farad ($220\mu F$) electrolytic capacitor
1	1N4001 diode
1	BC337 transistor
1	Push switch
2	Green light-emitting diodes (LEDs)



▲ A view of the underside of the printed circuit board. The component legs will be soldered to this side of the board.

Most of the components are easy to identify (if you need guidance, see the picture on the previous page). The seven resistors however are more difficult. These need to be identified by their different colour bands.



The resistor values and colour bands are:

- 300 Ω Orange, orange, brown and gold
- 1k Ω Brown, black, red and gold
- 10k Ω Brown, black, orange and gold
- 22k Ω Red, red, orange and gold
- 100k Ω Brown, black, yellow and gold

Ω is the symbol for **Ohm**, which is a measure of how much it resists the flow of electricity. A higher value will result in a smaller electrical flow.

More Information!

More detailed information on the GENIE Audio Kit and printed circuit board can be found in the separate **GENIE 14 Audio PCB** pdf.





The following instructions describe how to solder the different components to the printed circuit board.

First, switch on the soldering iron. It will only take a few minutes for the iron to reach operating temperature. Once the soldering iron is hot, carefully clean the soldering iron tip with a moist (but not too wet) sponge.

Melt some solder at the chamfered end of the soldering iron tip. This is called 'tinning' and it will aid the flow of solder from the soldering iron to the copper track on the printed circuit board and component pins.



The LDR (not supplied) and LEDs are shown mounted above the base of the printed circuit board. This is optional for single-panel designs, but is recommended for double-panel designs (so that the components are not obscured by the upper panel).

Next, solder each component onto the board. We recommend that you fit them in this order:

1. Resistors
2. Diode
3. Download socket
4. 14-pin chip socket (not the GENIE IC)
5. Transistor
6. Capacitor
7. Light-emitting diodes (LEDs)
8. Light-dependent resistor (LDR) *optional*
9. Push switch

Use the picture on page 25 along with the PCB's silk screen as guides when placing the different components. See on the right for further help.

When fitting components such as resistors, we recommend that you use long-nosed pliers to bend the legs through 90 degrees. This will make the components easier to place.

Some of the components need to be fitted the correct way around:

- ◆ The diode should be placed so that the stripe on the diode matches the stripe on the board.
- ◆ The 14-pin chip socket should be positioned so that the notch matches the notch shown on the printed circuit board's silk screen.
- ◆ The flat side of the transistor must match the flat side shown on the board.
- ◆ When fitting the electrolytic capacitor, you need to ensure that the positive side of the capacitor (the side without the stripe) is nearest to the '+' sign on the board.
- ◆ The LEDs should be fitted so that the flat edges on the base of the LEDs line up with the flat edges shown on the board.
- ◆ So that the LDR (optional, not supplied with the kit) and LEDs are visible when used with a double-panel design, we suggest sitting the bottom of those components above the printed circuit board (shown left).

To solder a pin, hold the soldering iron onto the board for a few seconds, then quickly touch the tip with a small amount of solder.

You should always remember to replace the soldering iron back into the stand after soldering and repeat cleaning the tip of the iron with the moist sponge before the start of each soldering operation.

Finally, cut off any excess wire or component legs for a tidy finish.





Building the GENIE Audio Kit 28

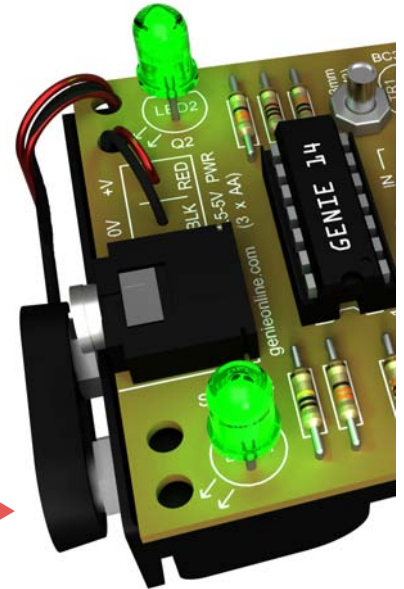
With the components mounted on the printed circuit board, the power and loudspeaker connections can then be soldered.

To wire up the power connections, you need to solder the red (positive) and black (negative) wires coming from the battery clip to the '+V' and '0V' holes on the PCB, pictured on the right.

Before soldering, we recommend looping the wires from the battery clip through the two nearby holes as shown. This acts as a strain relief, helping to protect the wires from damage.



◀ Loudspeaker wired to the board.



▶ Power connections wired to the board.

For the loudspeaker, two wires will need to be soldered to the 'SPEAKER' holes on the PCB, as shown above. The other end of these wires will be soldered to the two solder tabs on the loudspeaker itself.

For neatness, you can run the wires through one or more of the sound holes. A wire length of about 4 to 5 cm is normally sufficient. Remember to strip the wires at both ends before soldering.

The final step required to complete the building of the GENIE Audio Kit is to fit the GENIE microcontroller into the chip socket.

As with the chip socket itself, the GENIE microcontroller must be fitted the correct way around. You will notice that the chip has both a notch and a 'dot' at one end of the chip. These identify which of the chip's pins is number 1. Insert the chip so that these match the notch and '1' shown on the printed circuit board.

Care should be taken not to damage the chip's legs, but you may need to bend them gently as you insert the chip. The chip should be seated flat against the top of the socket.



▶ The GENIE chip inserted into the 14-pin chip socket. The pin 1 'dot' is highlighted.





Powering the GENIE Audio Kit 29

A power cell.

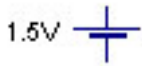


The positive end of an AA cell is usually marked by a '+' sign.

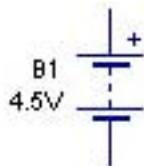
These AA power cells typically produce an electrical potential of about 1.5 volts each.

For the GENIE Audio Kit we will need three of these cells, giving a total of 4.5 volts.

On a circuit diagram this would be represented by the following circuit symbols:



Circuit symbol for an individual power cell.



Circuit symbol for a battery of cells.

With the design completed and the electronic circuit built, the three cells should then be inserted into the battery box.

As with all power cells, it matters which way around the AA cell is inserted: there is a **positive** end and a **negative** end. The positive end is usually marked by a '+' sign.

The cells are placed in **series**, meaning that the negative end of the first cell connects to the positive end of the second, and so on.

The two pictures on the right show how to insert the AA cells into the battery box.

You should now be ready to switch on your circuit. However, for any electrical or electronic circuit to work there first needs to be a source of **power**.

Like most electronic toys, the GENIE Audio Kit gets its power from standard AA power cells, shown on the left. These cells are measured by their **voltage** (voltage is a measure of the cell's electrical potential).



Spring

An empty battery box before the cells have been inserted. The negative end of the power cell should be against the spring. Notice that the middle spring is at the other end, which means that the cell must also go in the other way around:



Battery box showing all three cells inserted and the battery clip connected.

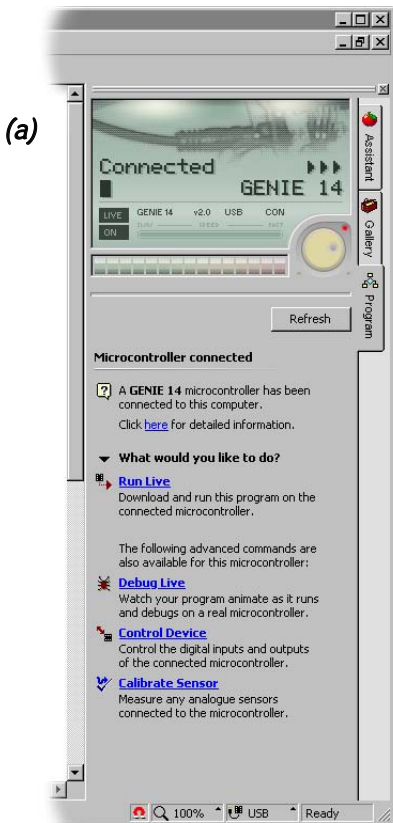




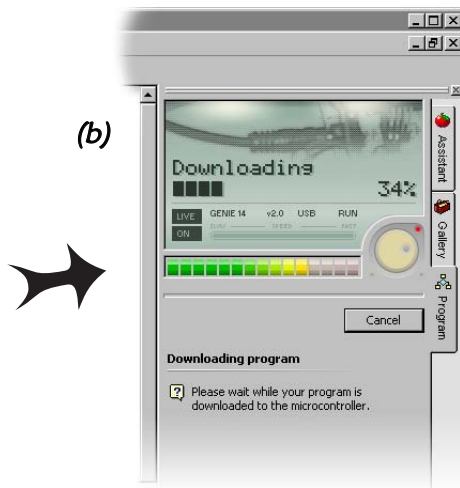
Downloading a program to the GENIE microcontroller 30

Once you have written your flowchart program, you need to store it on the GENIE chip. Here's how you do it:

- 1 Wire-up the built GENIE circuit board and connect up a suitable battery power supply.
- 2 Plug the GENIE cable into the download socket on the GENIE circuit board.
- 3 Once done, the **Program** panel in the software will then show a 'Connected' message (see picture a).
- 4 Click on the **Run Live** option. Your flowchart will be transferred onto the GENIE chip—this is known as **downloading** (see picture b).



The green STATUS LED will flash as the download takes place.
It tells you everything is OK!



If you have problems downloading your flowchart, see the fault-finding and troubleshooting hints and tips on the next page.



As soon as the program has been downloaded you will see the above screen (c) and GENIE will start running your flowchart.

Your GENIE project is now ready to go! You can disconnect the cable and use your GENIE Rock Star away from the computer.

Finished!





Fault-finding and troubleshooting 31

If you are unable to connect to a GENIE microcontroller or download a program, you should go through the following troubleshooting hints and tips.

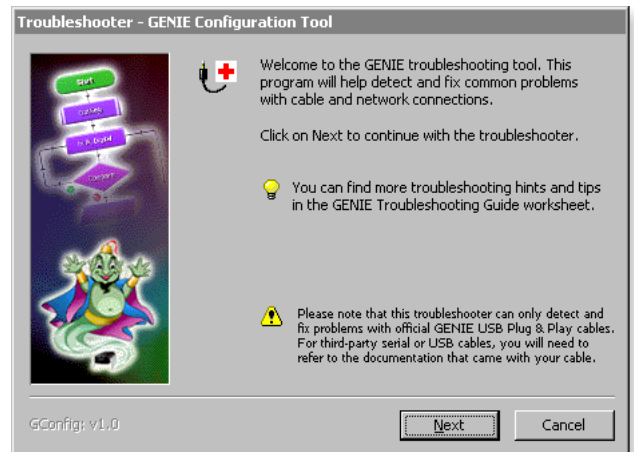
A Run the GENIE troubleshooting tool

The GENIE troubleshooter will automatically check your cable and software to ensure that the computer can access the GENIE cable.

To run the GENIE troubleshooter, choose **Troubleshoot GENIE...** from the **Help** menu of the Circuit Wizard or GENIE software.

If that option is not shown in your version of the software, you can download it separately from genieonline.com/cable.

Step through the on-screen instructions.



B Step through the following checklist of common problems

Cable

- Circuit Wizard, GENIE Design Studio and the GENIE Programming Editor software all check and report problems involving the cable. If given, follow through on the on-screen advice.
- Unplug the cable, wait a few seconds and then plug it back in. Windows can occasionally fail to detect that a cable has been inserted.

Power

- Check that the voltage of the battery is sufficient. For this project, the battery voltage should be in the range of 4.5 volts. You should never connect batteries totalling 6V or more.
- Check the voltage level across the power connections (+V and 0V) on the board. This can identify if there is a problem with the battery clip or battery holder. Ensure that the wiring has not become loose and the batteries are properly seated in the holder.

Circuit

- Try plugging the cable into another GENIE board if you have one available. When powering up this circuit, the green STATUS LED should flash once (when properly connected it will flash repeatedly).
- Try with another GENIE microcontroller if possible.
- Visually inspect the board for bad solder joints or cases where soldering has incorrectly bridged pins together. Note that for the download socket, the two left-most pins should be connected together, as should the two right-most pins.

For more troubleshooting hints and tips, please read the separate **GENIE Troubleshooting Guide**.

