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| http://www.talkingelectronics.com/projects/Voyager/images/Voyager-Head.jpg  **800m (2400ft) FM transmitter that fits on top of a 9v battery.**  **Page 1** [**P2**](http://www.talkingelectronics.com/projects/Voyager/Voyager-P2.html)  **http://www.talkingelectronics.com/projects/Voyager/images/Pop-line440x2.gif**  This is one of the smallest and neatest FM transmitters to be presented as a construction project and it has the advantage of being available as a complete kit of parts. This will save going to a number of suppliers as no single supplier has all the necessary components.  The circuit has been specially designed to demonstrate the techniques of FM transmission and to start you in the world of surface-mount assembly.  FM transmission is the best mode for transmitting a signal as it does not suffer from interference such as electrical noise from car engines or electrical appliances etc. It also achieves the greatest range with the least power. With just a handful of components and a few milliwatts of output power you can produce an FM transmitter with a very impressive range and perfect clarity. The **Voyager MkII** kit and **LED Power Meter** is available from Talking Electronics   http://www.talkingelectronics.com/projects/Voyager/images/Voyager-Cct.gif  **The circuit diagram for Voyager Mk II.**   |  | | --- | | **SUMMARY OF SPECIFICATIONS** | | Supply: 9 volts Current consumption: 7mA Battery life: 50 hours ZnC    100 hours alkaline Tuning range: 80 - 110MHz (by stretching or compression the oscillator coil) Fine tune by adjusting the air trimmer (2MHz adjustment) Stability - Low. Bug to be left in-place and not to be moved or handled. Antenna length - 175cm (5ft 9in) |   http://www.talkingelectronics.com/projects/Voyager/images/top-voyager.jpg http://www.talkingelectronics.com/projects/Voyager/images/voyager-underside.jpg  **Enlarged views of the completed Voyager MkII**  With a 175cm (5ft 9in) (half-wave antenna) supplied in the kit, the range has been conservatively rated as 800 metres (2400ft) under normal working conditions. In many countries you must reduce the maximum range to 30ft (10metres) by cutting the antenna to 10 inches. If this is the case, you must abide by it. Some countries totally ban these brilliant devices. You need to find out the situation in your own locality.  To introduce surface-mount technology to our range of projects, we have started with resistors. These are the easiest of the surface-mount components to identify and fit.  Some of the other components such as capacitors and transistors are so small they are almost impossible to solder by hand and surface-mount capacitors are not marked in any way so they become easily mixed up if you are not very careful.  Surface-mount technology is entirely different to normal through-hole placement and some of the differences are explained in this article.  The major difference is size and if you are having trouble soldering 1/4 watt resistors, you will have ten times more difficulty with surface mount. SM items are so small it takes the keenest eyesight to read the figures on the component and the nimblest of fingers to pick them up and place them. But until you buy a kit and see what the parts look like, you will have no idea if you will be able to cope. Nevertheless surface mount has arrived and is here to stay. Most modern designs already include surface mount components and many are already entirely surface mount. Take pocket cameras, watches, pendant transmitters, toys, video recorders, video cameras and computers for example. Their miniaturisation has been almost entirely due to using smaller componentry. Surface mount is very easy to implement on a large scale as the components are available in large quantities on reels or in tubes but when it comes to a one-off project, things are different. Few suppliers sell individual surface-mount components and some sell them in lots of 10 or 100. The normal purchase for surface-mount is on a reel of 1,000 to 5,000 pieces. The only solution is to provide a kit and to make it easy for everyone to put together, we have just converted the resistors to surface-mount. Some of the other components are not available in surface-mount (such as the coil) and there is no real advantage in converting everything to surface mount as the battery cannot be reduced in size without reducing the number of hours of operation. The main difficulty with surface mount is placing them on the printed circuit board and holding them in place while soldering. There are a number of aids to help you do this, such as solder pastes and solder creams, silicon and infra-red setting glues but most of these come in syringes and cost as much as $20 for a 1oz (30gm) tube. For a simple project, this additional cost is out of the question. To keep costs down we are going to hand solder each resistor without the aid of glue and the technique we use is called RE-FLOW SOLDERING.  Re-flow soldering only requires two hands. Normal soldering requires three hands - one to hold the component in place, one to hold the soldering iron and one to hold the solder. If you have three hands available, (such as the help of an assistant), you can use the normal soldering method. Basically re-flow soldering consists of heating up the solder on the board AND THE END OF THE RESISTOR AT THE SAME TIME so that the resistor makes a perfect connection to the board. This is discussed fully in the soldering section.  **HOW THE CIRCUIT WORKS** The circuit consists of two stages - an audio amplifier and an RF oscillator. The electret microphone contains a FET transistor and can be counted as a stage, if you wish. The microphone detects audio in the form of air vibrations that enter the hole (at the end of the mic) and move the diaphragm. This diaphragm is a thin piece of metallised plastic such as mylar and is charged with electrical charges during manufacture.  Next to this is a metal plate containing a number of holes so that the air readily passes through. The relative distance of the mylar diaphragm to the metal plate makes the charges move on the diaphragm (remember static electricity theory: like-charges repel and unlike-charges attract). Some of the charges pass down a lead that touches the metal plate and into a FET amplifier - it looks like a three legged transistor. The FET amplifies the charges and gives a reading on the output lead.  The output must be connected to a supply via a resistor called the load resistor. The FET draws a varying current during its operation and this creates a varying voltage on the output (across the load resistor).  The reason why a FET has been used is due to it having a very high input impedance and does not have any loading effect on the charges. The output waveform from the microphone will be typically 3 - 30mV in our case, depending on how close it is to the source of the sound. The circuit is capable of detecting a whisper at 10ft (3M) and only very sensitive microphones have been included in the kits.  You can also get medium and low sensitivity devices from suppliers so you have to be careful as they are not labelled.  A 22n capacitor on the output of the microphone couples the signal to the input of the first audio amplifier stage. This capacitor is designed to separate the DC voltage on the microphone from the base voltage on the transistor.  The first transistor stage consists of transistor and two biasing resistors.  The stage is said to be "AC coupled" as it has a capacitor on both the input and output so the DC voltages of the other stages do not influence the voltage on the stage.  The stage is also said to be "self-biased" with the 1M base resistor turning the transistor on until the collector voltage drops to about half rail voltage. The value of the base resistor is chosen so that this occurs.  The value can be chosen by experimentation. If the value is too low, the voltage on the collector will be below half rail. If it is too high, the collector voltage will be too high. The AC gain of the stage is about 70 and the signal is amplified and passed to the oscillator stage via a 100n capacitor.  The signal is now typically 200mV to 2,000mV in amplitude and this is adequate for injection into the oscillator stage.  The oscillator stage is designed to operate at about 100MHz and this frequency is set by the value of inductance of the 5 turn coil and the capacitor(s) across it. The 39p and air trimmer can be considered as a single capacitor. The frequency is also determined to a lesser extent by the transistor, the 10p feedback capacitor and also the 470R emitter biasing resistor and the 47k base bias resistor. The supply voltage also has an effect as the oscillator can be classified as voltage controlled.  There are a lot of things that set the frequency and even though the parts have a 5%, 10% or even 20% tolerance, they are STABLE at their present value. The 10p and 39p are NPO types and this means they are stable even when the temperature changes a small amount. The frequency is firstly set by pushing the turns of the coil closer together to lower the frequency or pulling them apart to raise the frequency and then the air trimmer is adjusted to obtain the precise frequency required. The air trimmer has a range of about 2MHz.  The circuit will stay at the desired frequency providing the supply voltage remains constant and the temperature of the parts do not rise appreciably (such as when the project is left in the sun etc).  Voyager MkII is not designed to be handled and is not suitable to be worn on the body. It is designed to be placed on a shelf and left in position.  The most important components in the oscillator stage are the coil and capacitor(s), making up the parallel tuned circuit.   They do almost all the work in setting the frequency and generating the waveform. The transistor merely turns on at the correct instant in each cycle to deliver a small amount of energy to the tuned circuit.   How this is done: The transistor is firstly turned on via base-bias resistor and it injects a small amount of energy into the parallel tuned circuit.  A few low-amplitude cycles now take place and we pick up the operation when the tuned circuit is operating at full amplitude and producing a sinewave at about 100MHz. This frequency is called the CARRIER.  The parallel tuned circuit is also called a TANK CIRCUIT and the name was coined during the development of the earliest transmitters where it was found a coil and capacitor in parallel would smooth out electrical pulses like filling a **water tank** in bursts so that it delivers an even flow of water.  This name has stayed with us and is an ideal way of describing a coil/capacitor combination.  The waveform from the tank circuit is passed to the 10p and this modifies the voltage on the emitter of the transistor.  There are two ways of turning on a transistor. One is to raise the voltage on the base while holding the emitter fixed and the other is to hold the base rigid while lowering the voltage on the emitter.  The second method is used in this circuit and the 10p moves the emitter up a very small amount at the rate of 100 million times per second to turn the transistor off.  The base is held rigid via a 1n capacitor and this value is sufficient to hold the base rigid at 100MHz but allows it to move up and down at audio frequencies so that audio being processed by the first transistor can be passed to the oscillator.  The oscillator transistor does not determine the waveshape of the signal, it mainly delivers a pulse of energy to the tank circuit at the correct instant where the coil and capacitor do all the work in creating the carrier signal. There is one more feature of the tank circuit. Even though it is injected with a pulse of energy of only a few millivolts, it is capable of producing a higher amplitude waveform on its output. In other words the tank circuit is capable of amplifying the voltage supplied to it. This is called its **Q-factor**.  The other two components in the stage are the 47k base-bias resistor and 470R emitter resistor. The 47k turns the transistor on when the power is first applied and sets the operating point for the stage. The 470R emitter resistor acts as a current limiting resistor and allows the transistor to be injected via the emitter.  The voltage produced by the tank circuit is monitored by the 10p and passed to the emitter of the transistor. During a portion of the cycle, the voltage it delivers, turns the transistor off. This effectively removes the transistor from the circuit and allows the waveform from the tank circuit to be passed to the antenna.  When a waveform at 100MHz is passed into a wire (such as an antenna) the signal is very easily radiated as electromagnetic energy. This is how the signal is radiated to the surroundings.  The 22n supply capacitor across the battery is designed to tighten up the power rails. The power rails have also been kept tight by connecting the battery directly to the printed circuit board.  Note: The circuit will not operate from a power supply without generating a lot of "mains hum" - the annoying 100 or 120 cycle hum from the mains - you must use a battery to get a crystal clear, hum-free, output.  Test voltages have been provided on the circuit diagram to help with servicing. They are only approximate and apply to our prototype. They show how each transistor has a voltage on the base of about 0.6v, with respect to the emitter, to turn it on. The voltages around the oscillator stage cannot be measured with an ordinary multimeter when the circuit is operating as the leads of the multimeter will act as an antenna and kill the operation of the circuit. This is certainly the case on the emitter of the second transistor, where the leads of a multimeter will draw off so much energy that the stage will stop working.  Because you cannot detect the operation with a multimeter, we have developed a piece of test equipment called a LED POWER METER. This is covered below and shows how the output of the high frequency RF oscillator stage can be measured without loading it too much.  http://www.talkingelectronics.com/projects/Voyager/images/voyagerMKII-circuit_boards.gif**Enlarged overlay and the trackwork for the Voyager MkII circuit board**  **HOW FREQUENCY MODULATION IS ACHIEVED**  The audio from the microphone is amplified by the first audio stage and injected into the RF stage via a 100n capacitor. This waveform increases and decreases the voltage on the base of the first transistor by a small amount and modifies the "set point" or "bias point" for the stage. This has the effect of slightly altering the timing of the stage (the time it takes for one cycle to occur) and the resulting frequency of the stage is altered very slightly by an amount equal to the frequency of the audio. The result is frequency modulation of the carrier.  http://www.talkingelectronics.com/projects/Voyager/images/Chips.gif **The 5 chip resistors used in this project are: 470R, 10k,  47k,  68k and 1M**  **RESISTOR AND CAPACITOR VALUES**  **5% TOLERANCE The following refers to values with 5% tolerance:** With the size of resistors and capacitors getting smaller and smaller, the space for identifying the value is getting less and less. To make things simple, a uniform numbering system has been adopted for both resistors and capacitors, consisting of three digits. The first two digits give the value of the capacitor in p or the value of resistance in ohms and the third digit is the multiplier. This brings both capacitors and resistors into the same code and once you can read the code, you can identify everything. As an example, we will use a 47k resistor. See the third chip in the diagram above. The digits are 4 - 7 - 3. The digit "3" represents the number of zeros to put after the number "47." Thus we get 47,000 ohms. A 470 ohm resistor is "47" and one zero, thus we get 471 on a chip. A 10k is "10" and three zeros, thus 103 is written on the chip. A 68k is written "68" and three zeros, thus 683 is written on the chip and 1M is written "10" and five zeros. Thus the chip has 105 on it. These are the five values used in the Voyager Mk II. A 10 ohm resistor is "10" and NO ZEROS, so the marking is 100. I know, I don't like it either but 150 on a chip is 15 ohms and not 150 ohms. 150 ohms is "151." Surface mount resistors start at 10 ohms and go to about 1M or 2M2. A zero ohm resistor (used as a "bridge") is labelled "000." It's only the range from 10 ohms to 100 ohms that will cause problems. When you see markings such as 120, 180, 470 etc it is best to check the resistance with a multimeter, to make sure the resistances are 12 ohms, 18 ohms and 47 ohms. The tolerance for the above resistors is 5%.    **1% TOLERANCE** Chip resistors are also available in a complete range of 1% values. Full details for reading these value can be found in our Basic Electronics Course.   If any 1% resistors are included in the kit for the Voyager, they will correspond to the values shown in the following diagram:  http://www.talkingelectronics.com/projects/Voyager/images/Chips-1%25.gif  Keeping this in mind, we go to the markings for capacitors. The basic unit for surface mount capacitors is p (sounded `puff'). Very few surface mount capacitors are marked but those that have identification follow the p rule. This means 101 is 100p, and 102 is 1,000p. Another name for 1,000p is 1n (1 nano). 103 is 10n, 104 is 100n and 105 is 1u. For those who have to convert from the old system, 1n is 0.001u, 10n is equal to 0.01u and 100n is 0.1u. For surface mount capacitors, you must think in p. This will allow you to build any surface mount project in the future. One point to note: With surface mount capacitors, the size of the chip is no indication of capacitance. The structure of the chip can be single layer or multilayer and this affects the size. Also the voltage rating of the capacitor affects the thickness of the dielectric and thus the size.  **ASSEMBLY** Before you do anything, prepare the workbench for a completely different approach to work. Lay out two sheets of clean white paper and place the kit of parts on one. Don't take the resistors out of the carriers until you are ready - a resistor dropped may be a resistor lost. Study the board and note that all the components are identified by the printing on the top of the board, called the overlay or legend. You really don't need any instructions at all, but since this may be your first attempt at surface-mount, we will provide some helpful advice. Note how the board stands on top of a 9v battery, with the battery snap soldered to the edge of the board. The positive and negative lands on the board are large so that the connections to the snap will be strong. The microphone fits on the top of the board with two short wires and overhangs the board. Some microphones come with wires attached and this makes them easy to fit. Others may need to have wires attached and these can come from the leads of the capacitors. The only 4 components that have to be fitted around the correct way are the two transistors, the microphone and battery snap. All the other parts, including the capacitors, coil and resistors can be soldered around either way. The air trimmer is best soldered so that the lead going to the screw is connected to the positive rail. Once you have studied the photos, the PC board and components, you can start. Here is the order for assembly: 5 surface mount resistors  6 capacitors  2 transistors  air trimmer (variable capacitor)  coil  battery snap, wire to hold the battery snap to PC board  microphone  (test the circuit with LED power meter)  antenna lead.  http://www.talkingelectronics.com/projects/Voyager/images/Voyager-kit-layout.jpg **The Voyager MkII components**   |  | | --- | | **PARTS LIST** | | **SEMICONDUCTORS** 2 - BC547 or PN2222   (NPN transistors) **RESISTORS** (All are surface mount 1/10th watt) 1 - 470R marked as 471 1 - 10k    "          "   103 1 - 47k    "          "    473 1 - 68k   "          "     683 1 - 1M    "          "    105  **CAPACITORS** 1 - 10p ceramic-disc NPO type 1 - 39p ceramic-disc NPO type 1 - 1n ceramic-disc 2 -22n ceramic-disc 1 - 100n monoblock  1 - 2p to 10p air trimmer  **ADDITIONAL PARTS AND MATERIALS** 1 - 5 turn coil .020in (0.5mm) enamelled wire 1/8in (3mm) dia 1 - electret microphone insert 1 - 9v battery snap 12in (30cm) fine solder 5ft 9in (175cm) hook-up wire. **1 -  Voyager MkII** **PC Board** |   **SOLDERING** Now for the finer points: The surface mount resistors required a fair degree of skill and you have to be good at soldering if you want to make the board look neat.  Read the notes on resistor identification and make sure you understand the 3 digit code.  Place the strip of resistors on the work-bench and take one out of the carrier strip, keeping the code numbers on top. Turn the resistor around so that the numbers make sense (make sure you don't read the numbers around the wrong way!) and place it on the board as shown in the diagram below, so that it is square with the sides of the board.  http://www.talkingelectronics.com/projects/Voyager/images/VoyagerSMonPC.gif  **The SM resistors on the underside of the board**  **Standard soldering**:  There are two ways of soldering the chip. One is to sit it in place and heat one end with a soldering iron while applying solder and then repeat with the other end. The other method is called RE-FLOW.  **Re-flow Soldering**: In this method you add a little solder to each land on the board and tin the ends of the chip while holding it in your fingers. Yes! you can actually hold the chip while soldering the other end. If you can't, you are taking too long. When both the lands on the PC board and the ends of the chip are tinned, it is placed in position and held with a piece of wire such as an opened-out paper clip while touching one end with a soldering iron. This is repeated with the other end. If you have added enough solder in the pre-tinning stage you will not have to add any more, otherwise a little solder can be added to make the connection neat and shiny. It is important not to put any force on the chip during the soldering process as the ends can be easily detached from the ceramic substrate and the resistor will go open circuit. A hairline crack will be produced and the only way to check that the resistor has not been damaged is to measure it with a multimeter set to ohms range. The other 4 chips are placed on the board in exactly the same way, making sure they are covering the lands and sitting flat on the board.  Double check the codes and if everything is correct you have carried out your first surface-mount placement! The rest of the assembly is a lot easier. It's just a matter of doing things in the correct order. All the other components are mounted on the top of the board and when two formats are combined like this, the assembly is called HYBRID.  Refer to the layout diagram for the placement of the 6 capacitors. These are soldered in place, one at a time. Some of the leads may have to be bent slightly to allow the component to fit down the holes as it is almost impossible to get all components in either .1" or .2" spacing. Next, the two transistors are soldered in place. Push them down until they are 1/8" from the board as we want to keep the profile low. In addition, we have designed the circuit with the transistor leads as short as possible. If you place the transistors high off the board, the performance of the oscillator will be different to our prototype.  Solder the leads quickly so that you don't heat up the transistor too much. The air trimmer is next. This must be soldered very quickly otherwise the plastic insulation between the plates will melt or buckle. Keep a finger on the trimmer to act as a heatsink and everything will be ok. The coil is made from enamel coated wire and this coating must be scraped off with a knife or burnt off with a hot soldering iron so that the two ends are bright and shiny and tinned before fitting the coil to the board. The kit comes with a pre-wound coil but if you are making it yourself, here are the details: Wind 5 turns of 24B&S (.020in or 0.5mm) or 21B&S (.028in or 0.7mm) wire on a 1/8" (3mm) diameter shaft such as a small Philips screwdriver and space the turns as shown in the photo. The coil determines the frequency of the oscillator and the turns will be stretched apart or squashed together after the project is complete. At this stage it does not matter about the spacing, as long as the ends fit neatly down the holes in the board. Make sure the ends have been tinned by firstly scraping off the red enamel insulation with the back of a knife, then adding solder to the wire so that it covers the end of the wire fully and thinly. Push the coil up to the board and solder it in place with the turns evenly spaced. Now the battery snap. If you want this project to produce the highest output power, the battery snap must be fitted directly to the board.   The project does not need an on/off switch as the battery is simply unclipped when not required. To fit the battery snap, take it out of its plastic jacket and solder it directly to the edge of the board. The crown and cup on the snap will be loose when the plastic is removed and they will have to be tightened by tapping the rivet with a centre-punch. The "crown" terminal is soldered to the positive land on the board by fitting a piece of tinned copper wire through the two holes in the board. The ends are twisted together and fitted through the centre of the crown and cut short so that they don't interfere with the terminal on the battery.  Use plenty of solder as it is necessary to make a good mechanical connection as well as an electrical connection. The terminals must not be able to be rotated and if they can be turned, they should be soldered again. Use very little solder inside the crown as the positive terminal of the battery must be able to fit inside to make a firm contact. Repeat with the other terminal. One of the last components to fit is the microphone as its two leads are very fine and any unnecessary bending will cause them to break.   The microphone in the kit comes with two short wires attached and if you look at the solder-lands on the back of the device you will see one goes to the case. This is the negative terminal and must be soldered down the negative hole on the board. Finally the antenna. This is soldered down the hole market "ant."    But before fitting the antenna you can check the output of the transmitter with a LED power meter. This is fitted to the antenna point on the board (without the antenna wire connected). By using this piece of test equipment you can determine if the project is delivering an output. You will also need an FM radio to make sure the output is on the FM band.   **THE LED POWER METER**  http://www.talkingelectronics.com/projects/Voyager/images/VoyagerToLEDPwrMeter.gif **The Voyager MkII connected to the LED Power Meter**    http://www.talkingelectronics.com/projects/Voyager/images/The-led-power-meter-circuit.gif  The LED power Meter is a simple RF detector using diodes to charge a capacitor. The voltage developed across the capacitor is indicated by a multimeter set to a low voltage range. The circuit is soldered together without the need for a PC board, as can be seen in the diagram above and paper clips are used for the positive and negative terminals of the multimeter.   It will only take a few minutes to put this circuit together. The power from the output of the Voyager MkII is indicated by the illumination of a LED and the voltage reading on the multimeter gives a further indication of the output. The reading is not calibrated and does not represent milliwatts output. It is only a visual indication.   |  | | --- | | **LED Power Meter Parts** | | 1 - 470R 1 - 100p ceramic 1 - 100n ceramic 2 - 1N 4148 diodes 1  -  5mm Red LED 1 - 2in (5cm) hook-up wire 2 - paper clips No PC board required |   **USING THE LED POWER METER**  Connect the 2in (5cm) lead to the antenna point on the Voyager MkII board as shown above and turn the project on. The lead of the LED Power Meter will act as an antenna, so place a radio nearby and tune it to about 88.5MHz or somewhere at the low end of the band. Move the turns of the 5 turn oscillator coil either together or stretch them apart until a feedback whistle is picked up by the radio. This is the frequency of transmission. When the turns are pushed together the frequency decreases and when moved apart, the frequency increases. You must not use any metal objects near the coil when moving the turns. If you do, the reading will be upset. The best item to use is a match or plastic knitting needle as you should keep your fingers and hands away from the coil while adjusting it. The multimeter will show a reading of about 2v and this voltage will depend on the quality of the transistors. Once you are satisfied the project is working, remove the LED Power Meter and solder the antenna lead to the board. Move the radio a short distance away and tune across the band to make sure the output is coming through and to see if you have picked up the main frequency of transmission.   Carry out some experiments yourself and you will be very impressed with the performance. By moving the Voyager MkII further away you will be able to pick up the sounds it detects. Make sure the frequency of transmission is well away from any radio stations as the signal from a station will swamp the Voyager MkII when you are testing it for range. You can do this by adjusting the air trimmer. You can see the vanes moving in and out of mesh with the stators and the meshing should be mid-way at the start of the test so you can raise or lower the frequency by turning the trimmer. As the vanes move out of mesh, the capacitance of the trimmer decreases and the frequency of the output increases. When adjusting the trimmer you must use a non-metallic instrument. The best is a plastic knitting needle filed to make it into a flat screwdriver. If you do not get a squeal from the radio you can assume the frequency is lower than the band (we have designed the output to be very close to the bottom of the band) and it may be just a little too low.  In this case you will have to raise the frequency by expanding the turns of the coil. This will bring the output onto the FM band and you can shift it slightly up or down with the air trimmer to get it away from other stations. To get the maximum range the antenna should be stretched out straight and placed either horizontally or vertically. The receiving antenna must be in the same plane to get the maximum range and both antennas should be as high as possible. The signal is generally not affected by brick walls, glass or plaster but it will not pass through metal of any kind such as aluminium foil or metal cladding. Trees can also have an effect due to the amount of moisture they contain. The signal will also find it difficult to get out of a car and you must place the antenna near a window but away from the metal frame-work as this will almost totally absorb the signal. The range from a car will be a lot less than the 800m we stated at the beginning.  **IF IT DOESN'T WORK** If you cannot detect an output on the LED Power Meter, you can safely assume the oscillator stage is not working. Measure the current for the project. It should be about 7mA. If it is only about 3mA, the oscillator transistor may be damaged or not being turned on. You cannot measure any of the voltages around the oscillator transistor and expect to get an accurate reading as the leads of a multimeter will upset the operation of the circuit. However if you measure the voltage on the emitter of the second transistor and find it is zero, it is not being turned on and you should check the 47k base-bias resistor. If it is 9v, the transistor may be shorted or the 470R resistor may be open circuit. But the most likely cause of the project not working will be a soldering fault, such as a bridge between two tracks, poorly soldered joints, or two components that have been swapped - such as the 47k and 470R. The best thing to do is give the project to someone else to check as it is very difficult to check your own work. If you have used your own parts to build the project, the fault could be in the markings on the components (or incorrect reading of the values) or the wrong size coil. The only solution is to buy a kit and put it together - you can then compare one project against the other. If you are picking up a blank spot (called the carrier) on the dial but no audio, the fault will lie in the first stage or the microphone.   Check the voltage on the collector of the audio transistor. It should be about 2.4v, however if it is above 6v or less than 1v, the transistor will not be biased correctly and the 1M base-bias resistor may be at fault. The electret microphone needs only about 50mV across it to work and the only real way to check it and the audio stage is to use a CRO or audio amplifier (our prototype had 200mV DC across the microphone). By whistling into the microphone at a distance of about one foot (30cm), you will get an output of about 10 - 30mV. The audio transistor will provide a gain of about 70 and produce an output of about 700mV - 2,100mV, as mentioned previously. If the microphone does not produce at least 10mV, it may be around the wrong way, damaged, or have very low sensitivity. Reducing the 68k load resistor may help if the microphone is a low sensitivity type.  **FITTING THE BATTERY** The Voyager MkII is designed to fit on top of a 9v battery and doesn't need any case or potting. The safest thing is not to enclose it at all as heatshrinking can squash the coil and change the frequency of operation. Fully-assembled devices **SB-800** are available from Talking Electronics, for those who are not good at soldering or want a built-up unit.  They are covered with heat-shrink so they can be handled and easily fitted to a battery. You can heatshrink your own model by buying a short length of heat-shrink tubing and placing it over the board and shrinking with a candle or gas torch. Crimp the ends with a pair of pointed-nose pliers so they stick together and make a good seal. Cut around the two battery terminals and make a smaller hole for the air trimmer so the frequency can be adjusted, and the project is ready for use.  That's the complete story. I hope you get as much fun out of the Voyager MkII as we did in designing it.  http://www.talkingelectronics.com/projects/Voyager/images/PC-on-battery11.jpg  **Voyager MkII fitted to a 9v battery with 1.75m (6ft) antenna**  **LOCATING A TRANSMITTER**  If you are trying to find a transmitter such as the Voyager MkII, when it is transmitting, you can turn on a transistor radio and tune across the dial. You will get a feedback whistle (when you are in close proximity) and this will indicate a transmitter is present.  But the job of actually locating the transmitter with a radio is very difficult. A radio has no directional ability and it will need two people to do the searching. One will need to hold and listen to the radio while the other searches through the room looking for the bug.  If the searcher makes very low level sounds, the person with the radio will be able to detect when the searcher is getting close to the microphone. The problem with this is most transmitters are so sensitive that it is difficult to know when the searcher is getting really close to the microphone. Two employees of Talking Electronics tried for 15 minutes to find a hidden bug with this method and failed to locate it, so the chances of tracking it down are slim. The other method is to use a Bug Detector. Talking Electronics has designed a very simple-to-operate device called **Bug Detector 2000**. It is extremely easy to use and only needs to be switched on with the antenna extended and the volume turned up. It is a broad-band receiver and picks up the whole FM band at the one time so you don't have to tune across any of the frequencies.  This means you can't miss anything and by simply moving around the room with the antenna outstretched like a probe you will get a feedback whistle from the built-in speaker, if a transmitter is present.  By turning the volume down, the meter on the front of **Bug Detector 2000** will come into operation and register field strength.  It's simply a matter of moving around the room again, this time observing the deflection of the needle on the meter.  The needle will fully deflect at a distance of about 3 metres (10ft) from most transmitters and to get closer you must make **Bug Detector 2000** less sensitive by reducing the length of the telescopic antenna. This will allow you to "home-in" and get right up to the bug, which may be hidden under a book or shelf. Using the radio method described above will get you close to the transmitter but then you will have to do a lot of tapping around to try and find the bug itself. **Bug Detector 2000** achieves a result almost silently so that once the bug is located, it can be left in place or removed, according to the circumstances. |