BATTLER *PROJECT SHEET*

CONTENTS:

DESCRIPTION

The *BATTLER* is a small agile vehicle that is controlled and steered by infrared remote control. There is a receiver PCB assembly mounted on the vehicle. The Transmitter PCB is mounted in a hand held controller.
The *INFRARED CONTROL UNIT (IRCU)* can transmit on 6 bands, which allows 6 *BATTLERS* to be operated at the same time, by selecting one of the bands.
The *BATTLER* is used in a simplified version of Robot Wars.
The *BATTLER* has two independent motor driven gearboxes, each driving one wheel. The remote control unit controls the vehicle through the use of push button switches – for each motor there are 2 push button switches, one to apply forward and the other to apply reverse motions. If both forward motion buttons are pushed simultaneously the vehicle travels forward in a straight line. However, if one forward push button switch and one reverse switch are pushed, the vehicle turns on the spot!
The infrared controls are for indoor use only – it is not suitable for outdoor use. It works best on a smooth polished floor. It requires line-of-sight and can operate up to a distance of approximately 20 metres.

ACKNOWLEDGEMENT

Scorpio Technology would like to thank Stephen (Steve) Hick of James Sheahan Catholic High School in Orange, for sharing the concept of the *BATTLER* with us, as well as photos, information and very many interesting discussions about what he and his class did, including ideas about possible weapons.

SECTION 1: COMPONENTS & MATERIAL REQUIRED

1.1 COMPONENTS REQUIRED

The following components are required to make this project, and are available from Scorpio Technology. Before starting we suggest that you check all components using the checklist below - tick off each component as you identify it.

☐ 1 x ***IRCU*** with: OPTION 1: ASSEMBLED PCBs (IRCU with PCBIR6 -A) or OPTION 2: UN-ASSEMBLED PCBs (IRCU with PCBIR6-UN)	Infra Red Control Unit

☐ 2 x Motor / Gearbox (Yellow gearbox) ☐ 2 x 63mm Wheels (Yellow hub)	Code: BUGWANDM
☐ 2 x Gearbox / motor Mounting brackets ☐ 4 x M3x30 Bolts ☐ 4 x M3 Nuts ☐ 4 x M3x7mm Bolts	Code: BUGMOTMNT Motor / gearbox mounting
☐ 6 x 8mm PCB Spacer (SPACER8) ☐ 6 x 3mm Bolts 16mm long (BOLT16) ☐ 6 x 3mm Nuts (NUTM3) ☐ 2 x 3x16mm Self Tappers (STSC3x16)	

NOTE: If buying a class set of *IRCUs*, we recommend buying one set with assembled PCBs, for visual comparison and testing purposes.

NOTE: this is NOT sold as a kit, but can be bought as components. If you order a *BATTLER-A (assembled PCBs)* or *BATTLER-U (un-assembled PCBs)* set of components, you will get an assembled PCB set and the normal sale quantity of parts, which means that SPACER8 is in a bag of 12, and nuts and bolts in bags of 100 .

1.2 ADDITIONAL REQUIREMENTS

The following items are required Several are available from Scorpio Technology, and can be ordered separately if required (item codes in brackets):

- ☐ 6 x Battery – AA (BATTALK)
- ☐ Multi strand hook-up wire – in a variety of colours (WIREHU10)
- ☐ Material for construction of the vehicle's body and hand held controller. The material needs to be strong, robust and light. The prototype vehicle was made from 3mm plywood.
- ☐ 50mm wide Gaffer tape or some way to hinge the body to open to change batteries or swap bands (TAPEGFBK / TAPEGFBL / TAPEGFW)
- ☐ Wood glue or hot glue

1.3 TOOLS REQUIRED

- ☐ The following tools are required. Several are available from Scorpio Technology, and can be ordered separately if required (item codes in brackets):
- ☐ Assorted hand tools and cutting tools – depending on the choice of materials to be used, such as:
    - Scroll saw or hand saw
    - Ruler / square and pen / marker
    - Craft knife
- ☐ Phillips screwdriver #1 point (SCREWDRPH1/80)
- ☐ Small spanner (MULTITOOL)
- ☐ Soldering Iron (SOLDIRN) and Soldering Iron Stand (SOLDIRNSTD) or Soldering Station (SOLDSTN)
- ☐ Solder: a good quality soldering iron, with a fine tip and the use of 0.71mm 60/40 solder is recommended (SOLD250/SOLD500)
- ☐ Drill Bit – 3.5mm (DB3.5) – for 3.0mm bolts
- ☐ Wire strippers (WIRESTR)
- ☐ Side cutters (SIDECUT or SIDECUTM)
- ☐ Mini Bolt Cutters (BOLTCUTM)

In addition, these tools may be useful and are available from Scorpio Technology, but need to be ordered separately if required:

- ☐ Component lead forming tool (for resistors, diodes etc.) (COMPLFT)
- ☐ IC Inserter (ICINSERT) / IC remover (ICEXTRACT) / IC straightener (ICSTRAIT)
- ☐ PCB Holder (PCBHOLD)

SECTION 2: GENERAL AND PLANNING INFORMATION

2.1 GENERAL

The *INFRARED CONTROL UNIT (IRCU)* consists of the Transmitter and the Receiver assemblies (the PCBs with all their electronic components soldered in place), and all other parts required to operate the unit. The *IRCU* can transmit on six (6) bands, so that 6 different devices can be operated at the same time, by selecting different bands, using the band selection switch.
The *IRCU* is for indoor use only and will not operate outdoors. It can operate up to a distance of approximately 20 metres.
On each band the Transmitter can send up to four signals, e.g. to control 2 motors to go forward and reverse. *IRCU* consists of the Transmitter and Receiver PCBs, switches and battery holders.

The major aspects of this project are the planning, design, construction, assembly and evaluation stages of the vehicle.
Before commencing work the student should spend some time planning their project. Draw up a plan describing:

- ☐ The sequence of work that will be necessary to complete the *BATTLER*. This could be incorporated into a timeline showing the anticipated completion dates of each section of work. The student can then use the timeline to properly manage their classroom time.
- ☐ How the *BATTLER* operates.

These plans should also take into account what items should be recorded throughout the life of the project. These could include:

- ☐ Maintaining a Log Book:
- ☐ Recording progress on a weekly or daily basis.
- ☐ Detailed information about problems encountered, measurements taken, and observations made. These will be used in the evaluation process.
- ☐ Assessment on progress / completion in relation to the timeline.

In addition, before commencing the project the teacher and student should pose a number of questions. These should then be evaluated by the student after the project is completed.

2.2 ITEMS FOR INVESTIGATION

This project provides a number of different areas, which may be investigated. Some ideas are listed below.
The teacher and student should pose a number of questions before commencing the project. These should then be evaluated by the student at the completion of the work. The questions could be in a variety of fields:

- ☐ Technical questions, for example: do the gears mesh well? Does the *BATTLER* travel straight ahead? If not: Do the axles line up, or is there a slight angular offset?
- ☐ How can the design be improved?
- ☐ Aesthetic questions: for example: can the appearance be improved?
- ☐ Self-critique, for example: is the quality of finish and workmanship satisfactory? How could the production of the project be improved? Would a different design be created second time around?
- ☐ Assessment of the project: what difficulties were experienced? What caused them? Can they be reduced or eliminated in future projects? How long did the project actually take?
- ☐ Critique of the Teaching unit: was it missing anything vital? What information did it miss out on, which would have been of value?

- ☐ What is the smallest turning circle of the *BATTLER?* Do the calculation and then measure the actual turning circle. Explain any differences between the calculated and measured distances.
- ☐ What sort of tactics would work the best in competition.

SECTION 3: DEVELOPING RULES OF ENGAGEMENT

Developing the Game rules should be done at the start, so that the students can consider those when designing the project.
See "Section 13: Competition Rules" for further ideas.

Developing the competition's rules, or "Rules of Engagement", becomes part of the design process – especially if eg. a test board or arena needs to be constructed.

What form of "Robot Wars" can you invent? There have been a variety of "Robot Wars" films made – maybe you can get some ideas from those.

Possibly:

- Make the body to flip the opponent?
- Pushing the opponent (from the side) through a trapdoor

WARNING: whatever you decide, do NOT go "head-to-head" like Sumos and have a pushing contest – if the vehicles are stationary and straining, you could overheat transistors and damage the circuit.

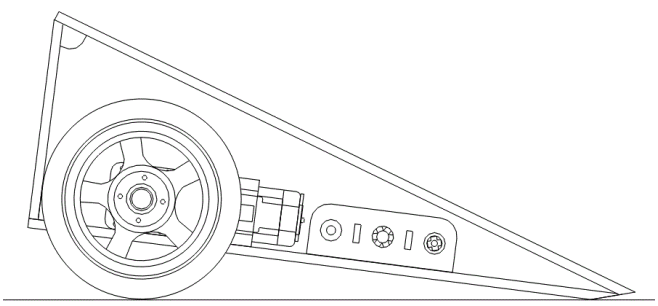
SECTION 4: DESIGN

One of the aims of the *BATTLER* competition can be to flip over your opponent. The easiest design to accomplish this is a wedge shaped *BATTLER.*

MATERIAL:

The material used for your design should be light and strong. Often the material you use is determined by the tools and equipment at your disposal.

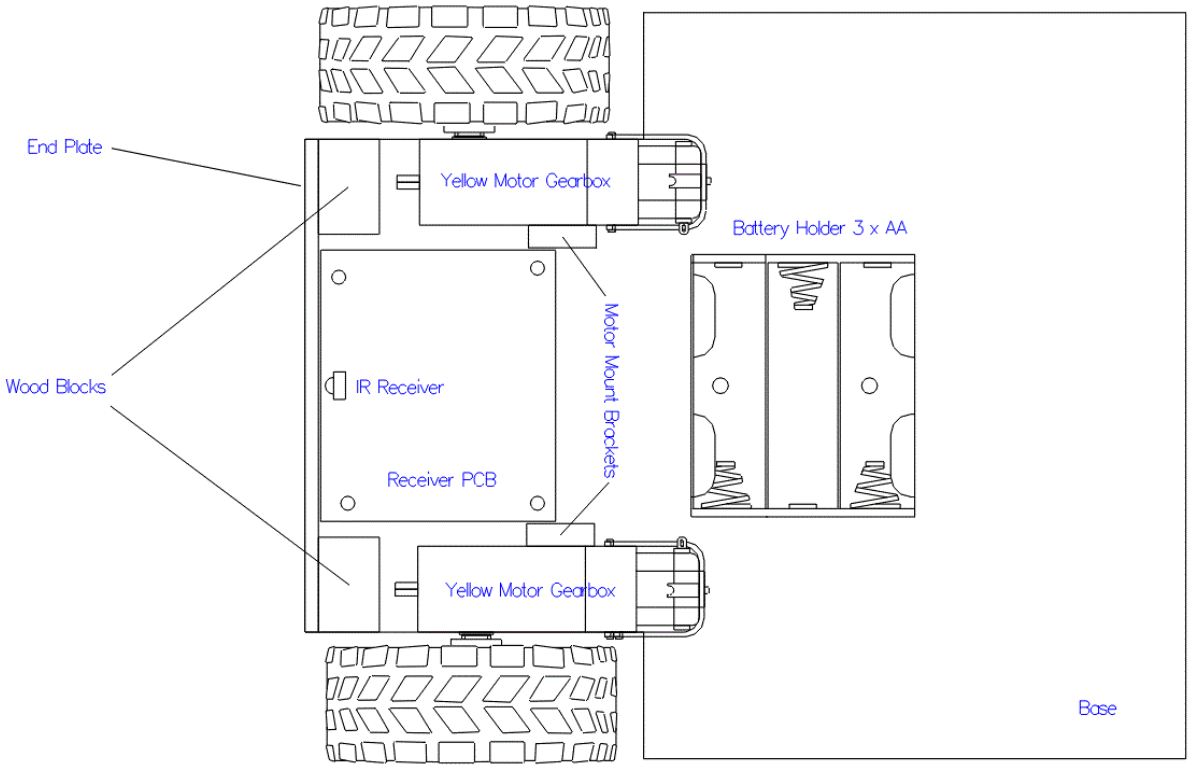
- The prototype used plywood as it is relatively cheap and easy to shape.
- You could also try acrylic plastic sheet, aluminium or steel. All these materials have some advantages and disadvantages:
  - Acrylic is brittle and is relatively heavy and expensive.
  - Aluminium or steel is reasonably easy to work with if you have the appropriate equipment for working with sheet metal.
  - The big drawback with using metal for the body work is that the Infra Red (IR) signal does not pass through metal. This means that the IR Receiver will have to be removed from the Receiver PCB and re mounted somewhere on the outside of the body.

☐ Once you have decided on the material you will use, the next step to design your project. ☐ You should complete your own drawings showing the placement of component and measurements of all parts, including hole sizes and their placement	

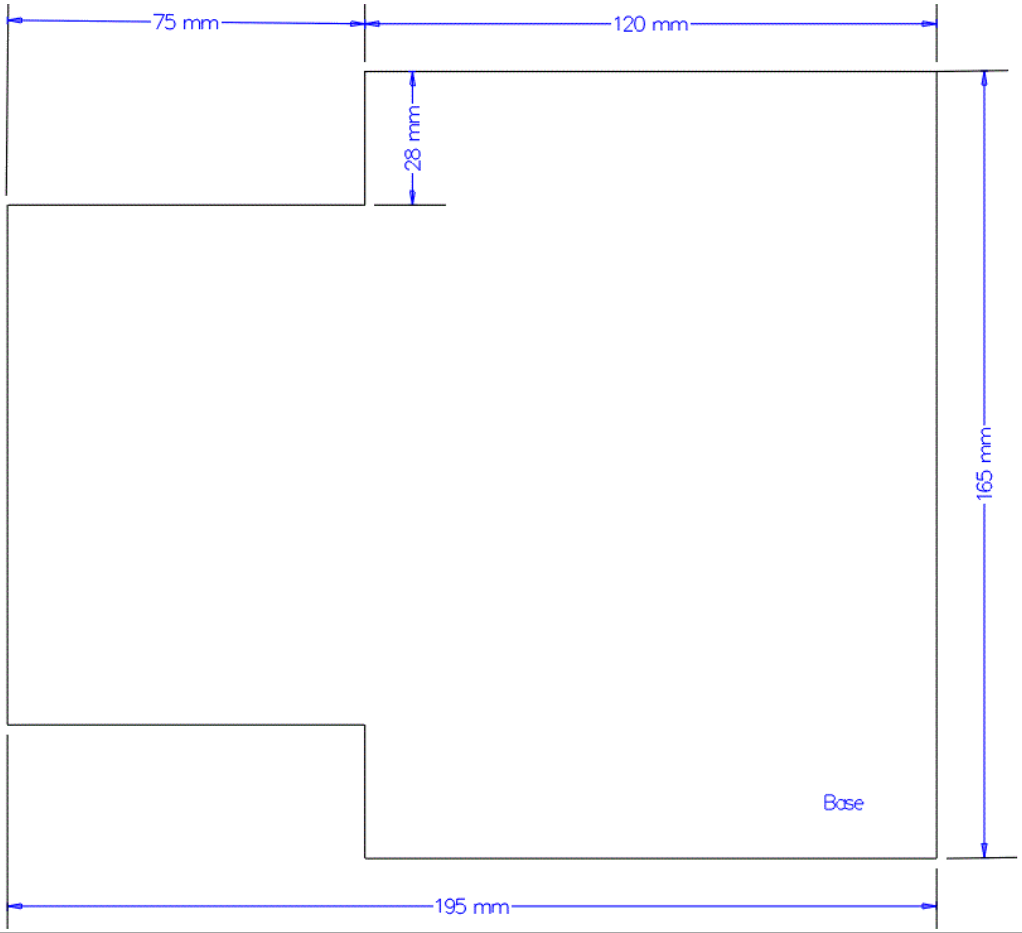
The following drawings of our prototype are provided to give you an idea of a possible layout.
NOTE: No measurements are shown for gearbox location etc. on the drawing. This is something you will have to work out for yourself.

For our prototype, the Base, Top and Back were all made from 3mm plywood.

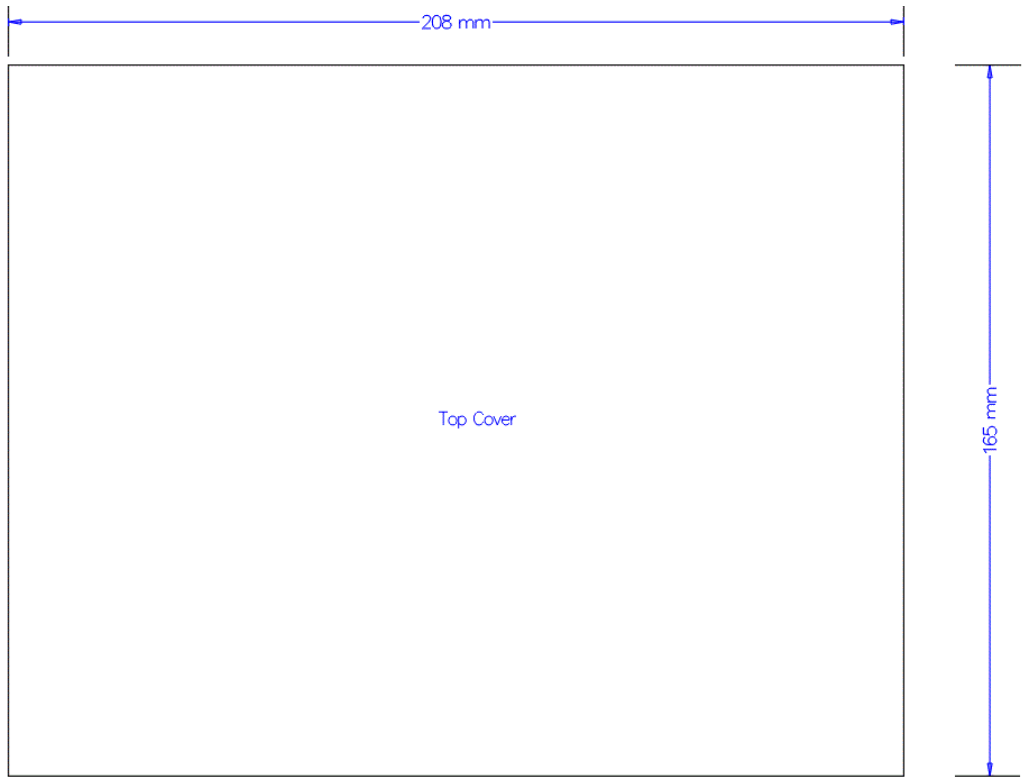
BASE - COMPONENT LAYOUT



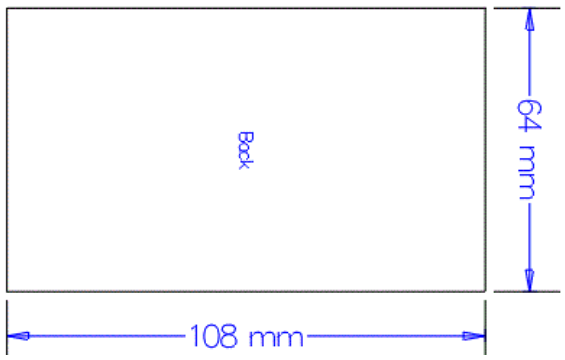
BASE - WITH DIMENSIONS



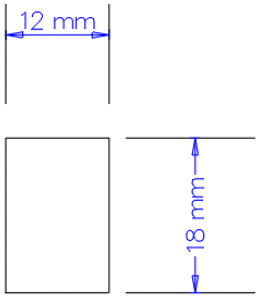
TOP COVER



BACK



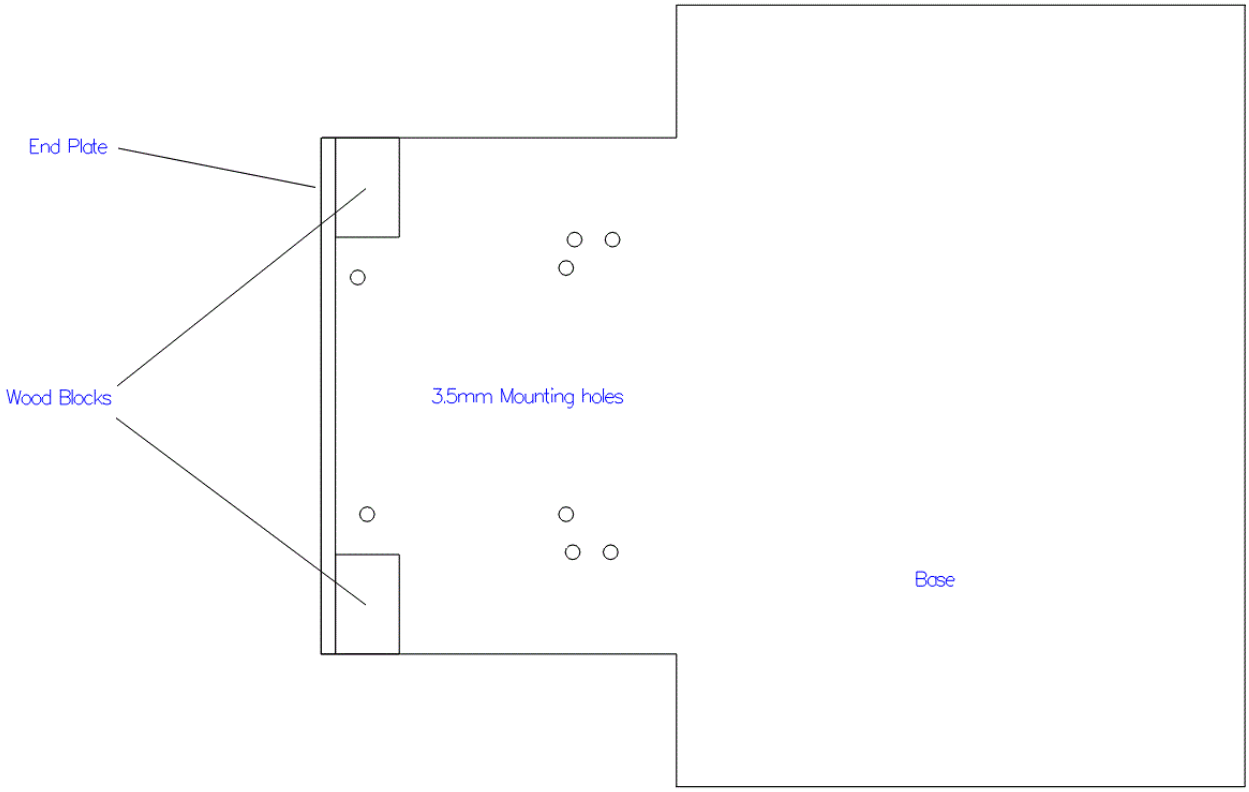
BLOCKS - FOR FIXING THE BACK TO THE BASE
Material - Wood 12mm thick

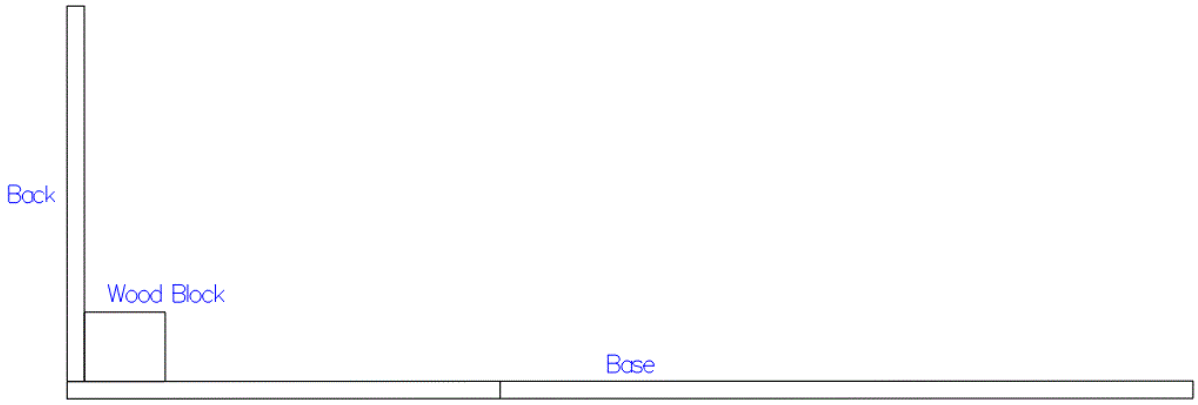


SECTION 5: MAKING THE BODY

Once you have completed your drawings with measurements, you need to mark out the material you will be using.

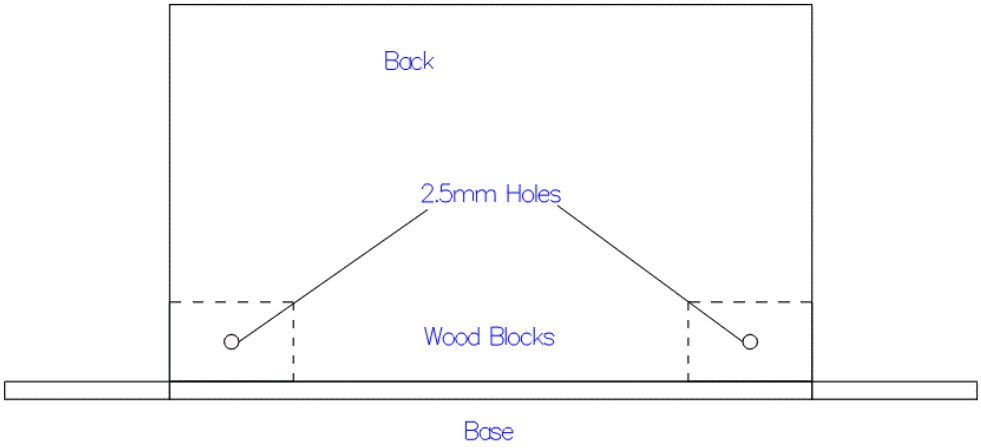
- ☐ Cut out the Base, Top and Back parts of the body.
- ☐ All holes should be drilled prior to the assembly of the body:
  - Use the PCB to locate the position of its mounting holes
- ☐ Carefully mark out the hole locations for the Gearbox / motor mounting brackets. The holes are exactly 8mm apart.
- ☐ Drill the 8 x 3.5mm holes:
  - 4 for mounting the PCB
  - 4 for the Gearbox / motor mounting brackets
- ☐ The next step is to locate and glue the two wood blocks in place in the positions shown in the drawing below.





☐ Place the Base flat on the workbench.
- Sit the back on top of the Base so it is level with the end of the Base.
- Glue the wood blocks in place in the positions shown in both drawings. You can either use hot glue or wood glue.
  NOTE: Hot glue is quicker but isn't as strong as wood glue. The disadvantage of wood glue is it takes at least 3 hours to dry.

NOTE: Make sure you don't glue the wood blocks to the back.

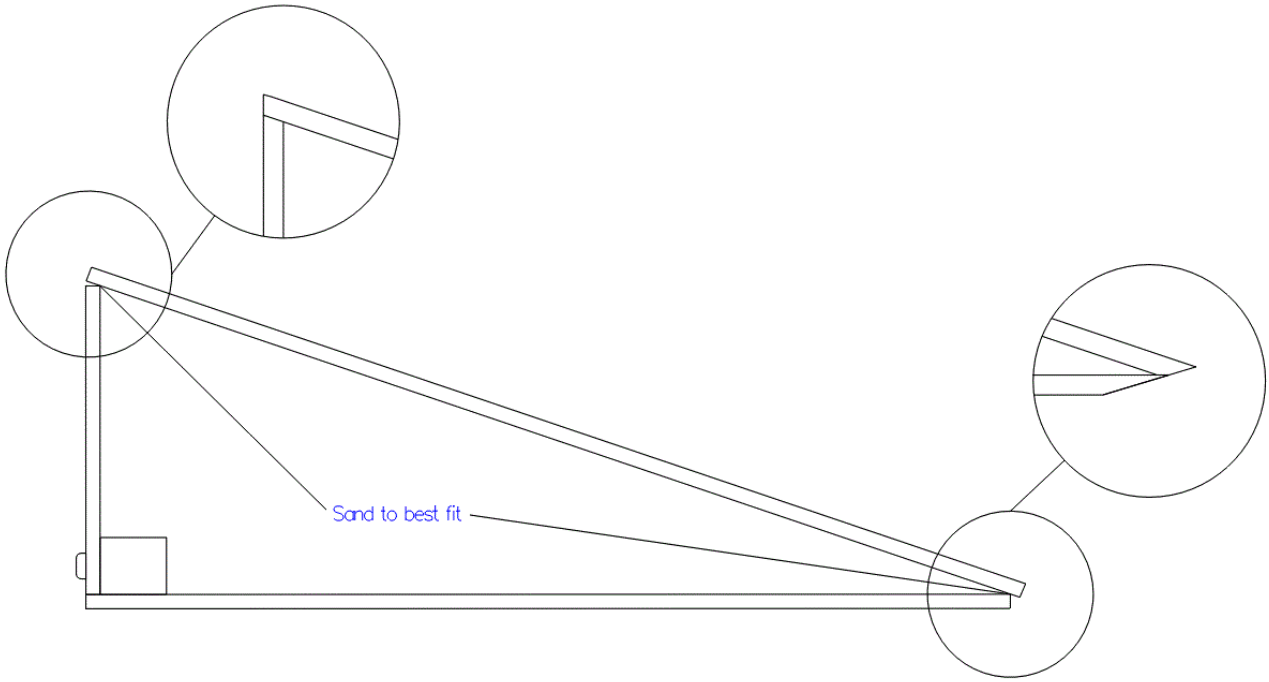


- ☐ Once the glue has fixed the wood blocks down you need the mark out and drill holes for the screws that will hold the back in place.
- ☐ Drill a 2.5mm hole through the back and all the way through the wood blocks.
- ☐ Remove the Back and enlarge the two holes in the back to 3.5mm.

NOTE: DO NOT enlarge the holes in the wood blocks. They MUST remain at 2.5mm so the self tapping screws have something to screw into.

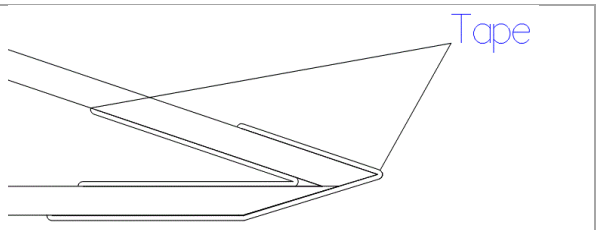
When assembled, this is what it will look like:

- ☐ Put the back in place and using the two self tapping screws fix the back onto the base and snug up against the wood blocks. Do not over tighten the self tappers.
- ☐ Place the top onto the back and base as shown in the following drawing.
    - Use sandpaper to sand an angle onto the top of the back and on the top and base as shown in the diagram.

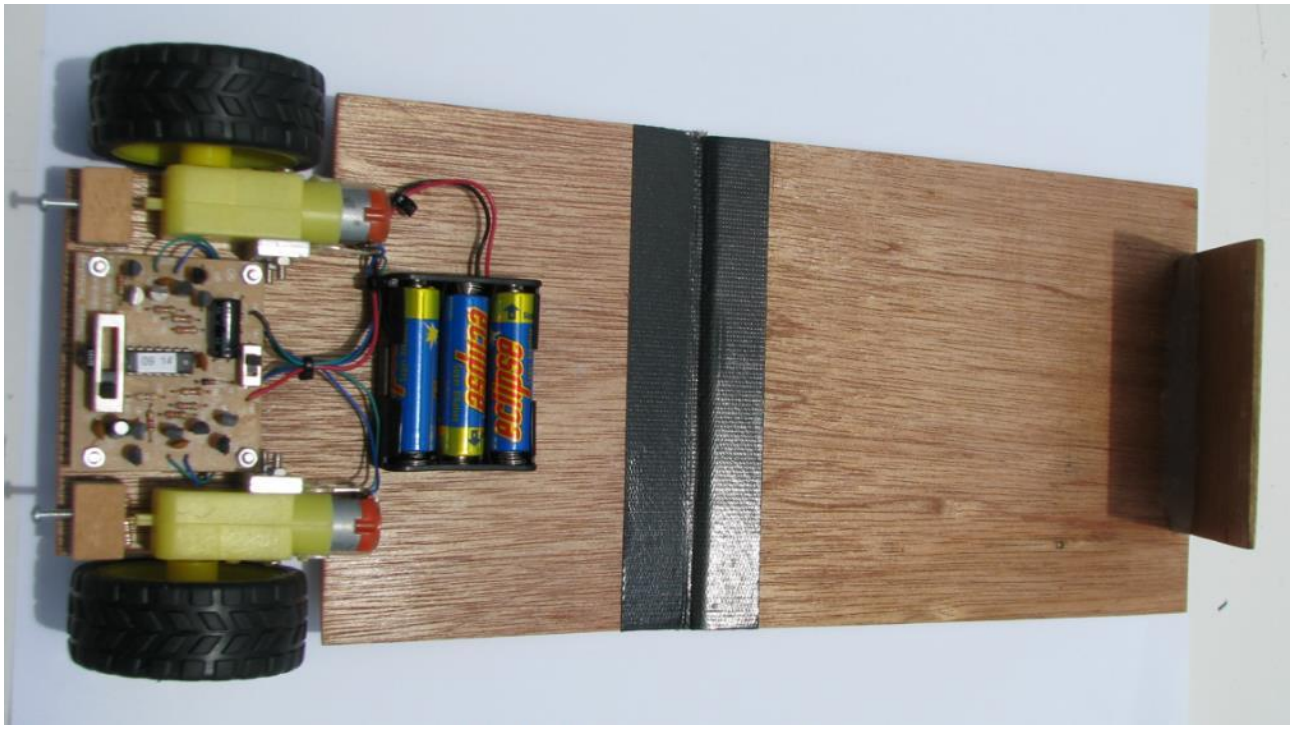


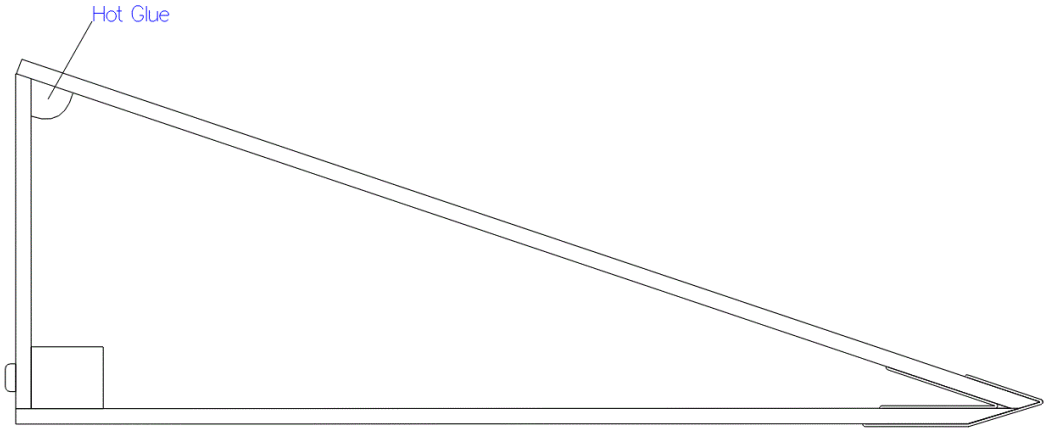
- ☐ Once the sanding has been completed use 50mm wide gaffer tape or similar to fit the base and top together.
    - Cut off a tape to suit the width of your vehicle and fix a 25mm wide width of the tape to the front end of the Base.
    - Place the top back in place on the Base and Back.
    - Fold up the tape around the front, up onto the Top and then press the tape down onto the Top.

- ☐ Fold out the Base and the Top, flat onto the workbench.
  - Apply tape across the ends of both.
  - Trim the Tape neatly and fold the top back in place onto the back.



- ☐ Either use wood or hot glue to fix the Top onto the back.
- ☐ Unscrew the self tapping screws and carefully fold back the Top with the Back attached flat onto the workbench.
- ☐ Use hot glue and fill in the inside junction between the Top and Back to strengthen the joint between them.





NOTE: The tape acts as a "hinge" allowing the top to be opened allowing you access to the PCB to turn the *BATTLER* on and off and to select a matching band to your transmitter.

Once the vehicles body is completed and you feel it is sturdy enough for combat, you will need to assemble and wire the Receiver PCB, Battery Holder and Yellow Motor/Gearboxes.

NOTE: Before you bolt the PCB in place you will have to solder in place the 4 wires that connect the PCB to the motors and the positive and negative wires from the Battery Holder.

SECTION 6: ASSEMBLING THE PCBS

REFER to the Teaching unit supplied with the *INFRA RED CONTROL UNIT*

SECTION 7: MAKING THE HAND HELD CONTROLLER

REFER to the Teaching unit supplied with the *INFRA RED CONTROL UNIT*

SECTION 8: ASSEMBLING THE BATTLER

GENERAL

- ☐ When drilling holes, the following is worth noting - a 3.5mm drill bit is used for the 3mm bolts. Thus, the holes for the Transmitter PCB, Receiver PCB and Motor/Gearbox mounting holes should all be 3.5 mm diameter.

8.1 VEHICLE BASE AND BODY

See Section 5.

- ☐ Use different colour wires to connect to the motors as you will find it less likely to confuse the wires when making the connections.
- ☐ Solder the wires to the Receiver PCB before bolting it to the base. Make sure they are long enough to comfortably reach the motors.

8.2 MOUNTING THE PCB

- ☐ Before you bolt down the PCB, refer to SECTION 9: WIRING.

NOTE: You should solder the wires to the PCB first.

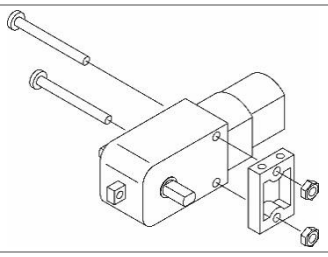
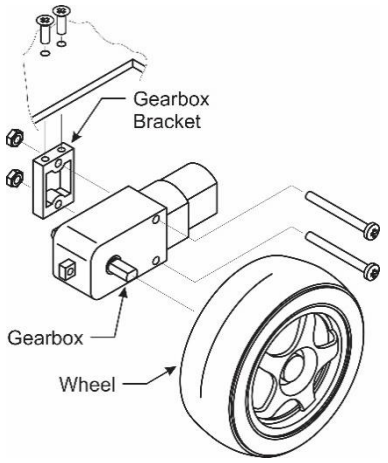
HINT: Allow extra wire for each and use different coloured wires to make easier to identify where a wire comes from and then goes to – the wires can be trimmed to length when soldering to the various components.

- ☐ From underneath, begin by placing four, 3mm x 16 mm long bolts through holes for mounting the PCB. Carefully place the base onto the workbench. This will prevent the bolts from slipping out of the holes while you complete the Receiver PCB mounting.
- ☐ Use spacers between the PCB and the platform. This prevents the PCB from shorting out if the base is made from a conducting material, such as aluminium.

☐ Place the four spacers onto the bolts and then place the Receiver PCB onto the bolts. Use four 3mm nuts to fix the Receiver PCB to the Base.

The next step is to fix the motor/gearboxes to the Base

8.3 MOUNTING THE GEARBOXES

☐ Fix the mounting brackets to the motor/gearboxes as shown in the diagram. **NOTE**: The holes for fixing the mounting brackets to the base are spaced 8mm apart.	
☐ Accurately mark out the position of the holes for the mounting brackets and drill through the base with the 3.5mm drill. ☐ Use the M3x7mm bolts to fix the motor/gearboxes to the base. Make sure that when the motor/gearboxes are fixed to the base they are parallel to each other. **NOTE**: If either of these is not correct your vehicle will travel in a circle. ☐ Use the mounting brackets to fix the motor/gearboxes to the platform.	

8.4 OTHER COMPONENTS

☐ Assemble the battery holder to the platform using hot glue or other suitable adhesive. It should be located in position as designed. The surfaces, which are to be glued, should be roughened with sandpaper, to allow the hot glue to adhere properly to its surface. Alternately, self-adhesive Velcro (hook and loop tape) is suitable, however, hot glue will be more secure and less likely to come loose during competition.
NOTE: Before mounting the Battery Holder check to see if the position you have chosen to mount the Battery Holder does not interfere with the Top closing properly. If the Battery Holder is located too close to the front it may prevent the Top from closing properly.

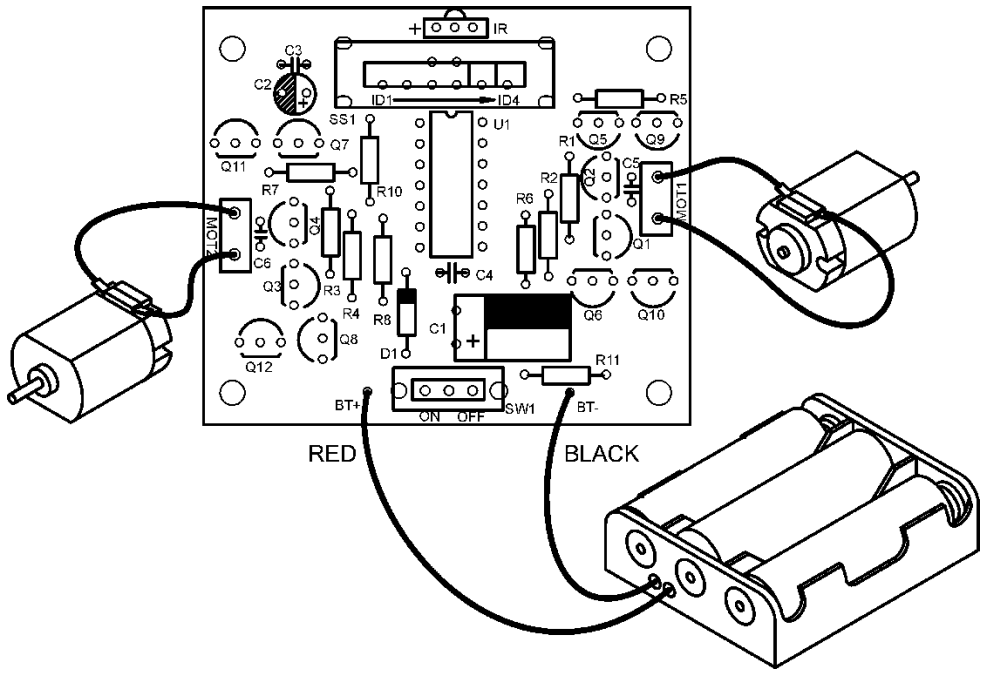
☐ The two driving wheels are assembled to the shafts.

SECTION 9: WIRING

RECEIVER PCB

The last thing to do is to wire up the Receiver PCB to the motor/gearboxes.

☐ Follow the wiring exactly as shown in the following drawing to ensure that the motors travel in the correct direction.
- If you find a wheel turns backwards when you are pressing the forwards push button, simply unsolder the wires to the motor and reverse them. (This is where having different coloured wires makes it much easier).



TRANSMITTER PCB

REFER to the Teaching unit supplied with the INFRA RED CONTROL UNIT

SECTION 10:TESTING AND TROUBLE SHOOTING

After completing the *BATTLER*, you need to test the units.

10.1 BEFORE TESTING

WARNING:

Check all wiring and connections thoroughly before inserting the batteries.

It is worth spending a bit of time and give the wiring and soldering a thorough visual check. If you experience any problems, recheck the wires and soldering (if another working unit is available, compare it to yours).

10.2 WHAT TO EXPECT IN YOUR TESTING

When both motors are driven, they will draw up to 2.0 Amps from the batteries. Because of the large currents drawn, alkaline batteries are recommended for the motors. Low battery voltage can cause erratic performance.

10.3 TESTING THE *BATTLER*

- ☐ Check that the switch settings of the band control switches for both the Transmitter and Receiver PCB's are both set to the same band number.

NOTE: There are 6 Bands to select from. If the bands on both the Transmitter and Receiver are not set to the same number Band they will not work.

- ☐ Insert the batteries, move the Receiver's On-off switch to the "ON" position, and check that the following occur:
- ☐ When the Transmitter's switches are pushed The *BATTLER's* wheels turn in the desired directions (either forward or reverse). If not reverse the wiring direction of the switch on the hand held Control unit.
- ☐ If the transmitter's red indicator LED does not glow when the pushbutton switches are operated or the motors don't operate, turn off the power immediately

10.4 TROUBLESHOOTING

If either of the above don't happen, turn off the power immediately and check the following:

- ☐ That the batteries have adequate charge.
- ☐ That all the Transmitter and Receiver components are correctly located and oriented.
- ☐ That the +ve (red) and –ve (black) from the battery connectors go to the correct positions on the transmitter's PCB and the receiver's PCB.
- ☐ Bare wire ends do not touch other wires or connections on the Transmitter and Receiver.
- ☐ Check that there are no solder bridges between the terminals.
- ☐ That all the wiring is connected as per instructions.
- ☐ Make sure there are no dry joints - the soldering may look dry or lumpy or you may notice the solder does not actually connect to the wire. This will look like a dark ring around the wire: try pulling the wire to see if the lead comes out or moves (a magnifying glass or eye piece will help).

NOTE: At this stage, one set of pre-assembled units wired up as shown previously is useful, as it helps to quickly identify which unit is faulty if operating problems are experienced. They can also be used to cross check the component placement and orientation.

SECTION 11:THEORY – HOW DOES IT WORK?

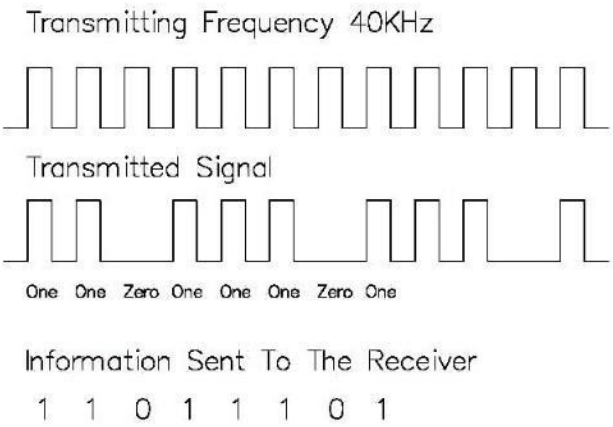
Light is a form of electro-magnetic radiation. Light can be visible or invisible to the naked eye, depending on the wave length. For example, red light is visible light. On the other hand, Infra-red light has a longer wave length, of between 390 to 740 nm, and is invisible to us.

Infrared controls are widely used to control TV's/VCRs/DVD etc. and many other devices.

The signal from the controller only operates on the "line of sight" principle. In other words unless you can see the object you are controlling, the signal from the controller (Transmitter) will not be received. For example, if your Infrared Controlled vehicle turns behind a couch and you can no longer see it, the controller will no longer control the vehicle.

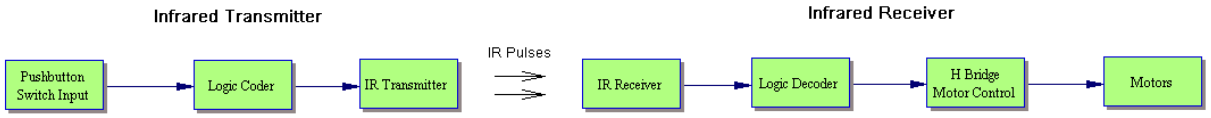
The signal sent from the transmitter is a series of pulses sent at around 40KHz. The band selector switch allows the frequency to be either slightly higher or lower than 40KHz. Once the transmitter's band selector switch is set to a particular value it will only work with the receiver if the receiver's band selector switch is set to the same position.

The pulses sent by the transmitter are in the form of pulses of infrared light. When infrared light is sent this represents a logic level of 1. The spaces when no infrared light is sent, represent a logic level of 0.



Using this method of information it is possible to have 256 different commands. The controller with this kit has only 4 commands to allow you to control the forward and reverse operation of 2 different motors.
This information is sent to the infra-red Receiver (the actual component). The receiver then sends the signals to the Receiver's IC, which interprets the signals and sends commands to the circuitry controlling the output devices (eg. the motors).

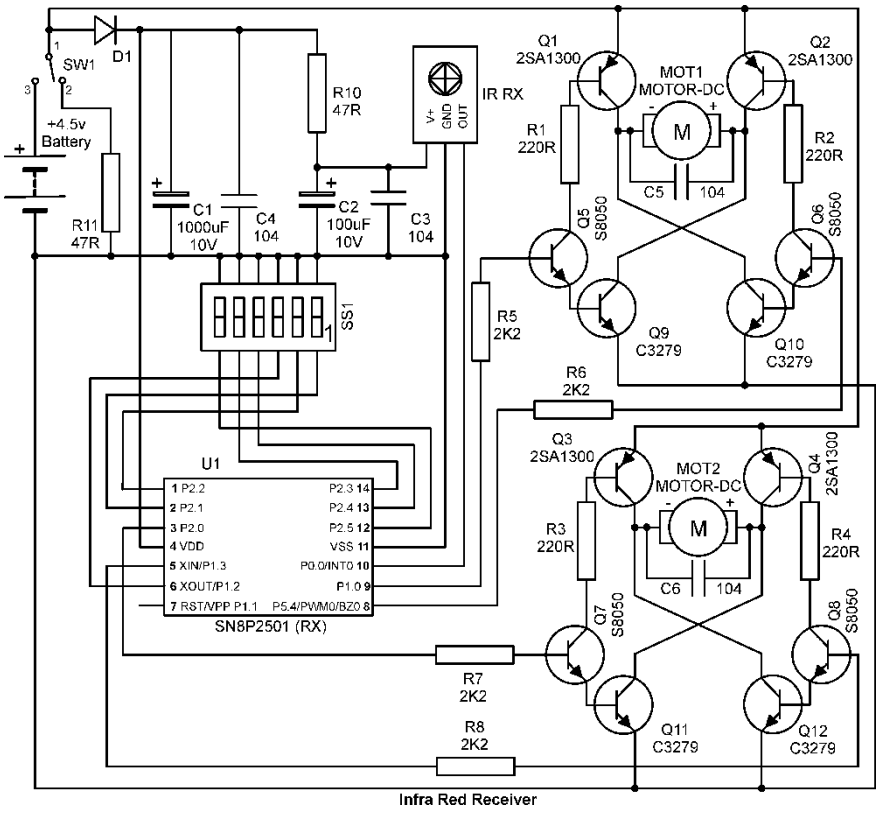
Block Diagram Showing Major Sub-Systems



System Description
When power is applied to the circuit (that is, when one of the pushbuttons is pressed), it causes a coded series of pulses to be generated by the logic controller. These pulses are sent to the IR Transmitter LED, which sends the signal to the IR Receiver. The IR Receiver picks up the IR pulses. These are sent to the Logic Decoder where the signals are decoded and logic signals are applied to the H Bridge's input. The H Bridge is made up of a number of power transistors. These transistors are used to control the presence and polarity of the voltage applied to the output devices. If no voltage is present the output device is stopped. When a voltage is present the output device will operate. If the polarity of the voltage is reversed the output device's direction of rotation will also reverse.

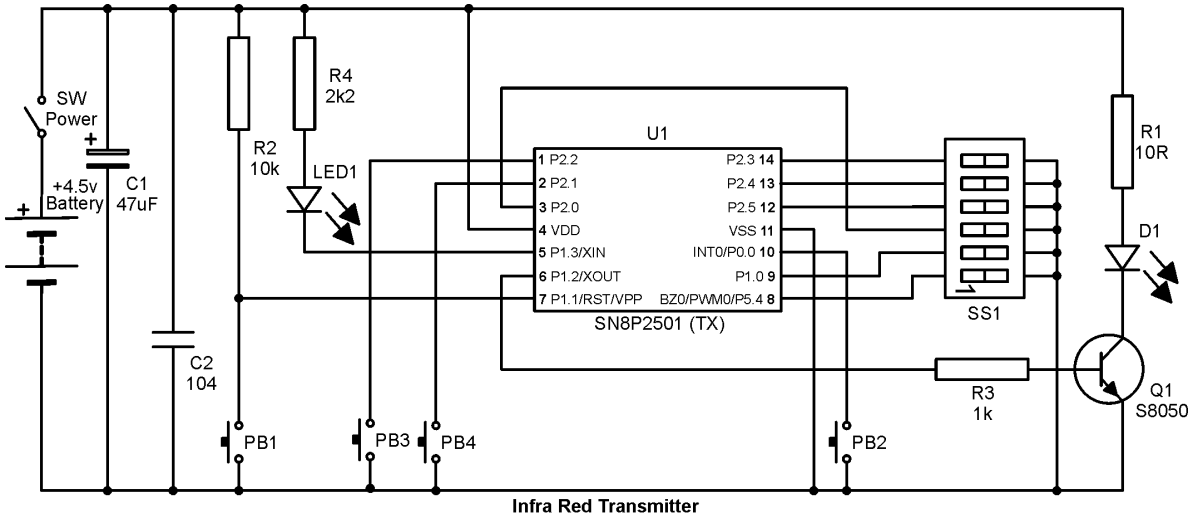
SECTION 12: SCHEMATIC DIAGRAMS

SCHEMATIC DIAGRAM - INFRA-RED RECEIVER



Infra Red Receiver

SCHEMATIC DIAGRAM – INFRARED TRANSMITTER



Infra Red Transmitter

SECTION 13: COMPETITION RULES

It is up to the students to work out the rules of competition.
The following is a suggestion for a starting pointy to work from.

- Two robots compete in a head-to-head match. Robots are not allowed weapons, but can either flip or push an opposition *BATTLER* out of the arena.
- Set a time for the length over which an event can be conducted.
- Determine and area that will be used for the arena. This can be as simple as an area marked on the floor or a purpose built arena. It could be round or square, whatever suits the area to be used.
- If this project is one that will be repeated a number of times you should consider building an arena that can be pulled apart easily and put back together when needed. Gaps could be spaced around the fence where opponents could be pushed out and eliminated.
- Students can compete one on one, gradually eliminating their opponents, with the winner going on to the next round.
- Students can compete in teams against other teams of students.
    - This could be done in two ways. One type of team event could be just one student competing against another with their team mates battling against other members of the opposition team. The team with the most wins, wins the competition.
- Or everyone is in the arena at the same time with free for all with the winning team being the last team with the remaining vehicle.
- Having an odd number of students in a team would make scoring a little easier as one team will always have more wins than the other team.
- If no result is obtained a judge could rule the winner of the competition.
- If an arena is marked on the floor a rule will have to be determined to cover what happens if a vehicle drives out of the arena but not pushed out. A penalty of some kind could be applied. It could be either a points penalty or a restating position that puts them at a disadvantage. If a purpose built arena is constructed this will not apply.
- Determine the starting positions of the two vehicles. This could be marked in the centre of the arena with oppents vehicles facing each other a short distance apart.