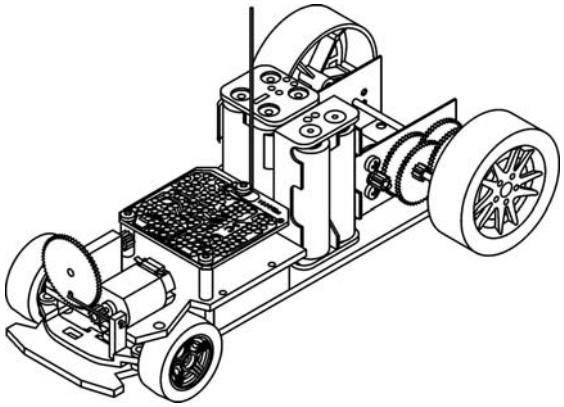
RADIO CONTROLLED VEHICLE (MARK 3)

DESCRIPTION

The *RADIO CONTROLLED VEHICLE (RCV)* is a motorised vehicle, controlled and steered by remote control. There is a Receiver PCB (Printed Circuit Board) mounted on the vehicle and a Transmitter PCB in a hand held control box. This remote control unit controls the vehicle's forward and reverse motion, as well as the steering. The vehicle is driven by a gearbox/motor assembly, and steered by an electric motor through a steering rod and a steering link. The radio transmission distance is approximately 25 metres, and under favourable conditions it could reach 50 metres.



THE PROJECT

The major aspects of this project are the planning, design, construction, assembly and evaluation stages – key competencies or requirements under the VELS and other educational programs.
This project provides a number of different areas which may be investigated, either individually or in pairs or teams. Some ideas are listed below.

- Look at Radio waves (what different types / bands are there?).
- Investigate Radio Transmission and Reception principles and uses.
- What are the Radio Transmission Regulations? Do they affect radio controlled vehicles of any sort?
- Examine the steering design. What other ways are there for steering a vehicle? Have a look at our *FOLLOW WHITE LINE VEHICLE's* steering it uses a different approach to controlling the steering.
- The choice and suitability of various materials (aluminium, PVC, perspex, etc.).
- Calculate the vehicle's turning circle. Can you set up an equation to do this calculation??
- What design elements influence the turning circle? Is a small or large turning circle better?

DESIGN:

The drawings in this unit show the construction of our prototype model. An evaluation may be made of this design, looking at the vehicle's balance, turning circle, component layout, space efficiency.
NOTE: This unit must be used in conjunction with the relevant "*RCV PCB* – Parts List and Assembling instructions". That contains additional instructions, which are not in this unit.

PLANNING STAGE

Before commencing work the student should spend time planning the project. Draw up a plan describing:

- The sequence of work required to complete the *RADIO CONTROLLED VEHICLE (RCV).* This could be set out as a timeline showing the anticipated completion dates for each section of work. This timeline can be used to properly manage classroom time.
- How the *RADIO CONTROLLED VEHICLE* will function.

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

- Completion of a Log Book, recording such items as: the results of individual and team research; Recording progress on a weekly or daily basis etc..
- Detailed information about problems encountered, measurements taken and observations made. These will be used in the evaluation process.
- Assessment on progress and completion in relation to the planned timeline.

At the start, the teacher and student should also pose a number of questions before commencing the project, to be evaluated at the completion of the work. The questions could be in a variety of fields (more ideas in Section 11):

- Technical questions. for example: do the gears mesh well? How well does the steering function?
- Aesthetic questions: for example: can the appearance be improved?
- Practical questions: for example: How can the design be improved?
- Self-critique: for example: is the quality of finish and workmanship satisfactory? How could the execution 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 anything vital missed which would have been of value? (please tell us if you do identify possible improvements)

1. COMPONENTS & MATERIAL REQUIRED

1.1 COMPONENTS SUPPLIED (IN THE KIT)

1 x	Transmitter PCB ***Ref. below	1 x	4x AA Battery holder
1 x	Receiver PCB ***Ref. below	1 x	2x AA Battery Holder
1 x	4.5V Electric motor (Round)	2 x	Axle shafts (Knurled pin 3x20mm)
1 x	Sliding switch – on-off / small (SW1)	2 x	Front wheel knuckle (LH & RH)
2 x	Toggle switch - (SW2, SW3)	1 x	Wheel alignment spring
2 x	Capacitors 473 Z (C15, C17)	1 x	Steering link
1 x	Inductor 15RK – 15µH (L4) ** below	2 x	35 mm dia. Front wheels
1 x	50Tx10T Spur gear (yellow/2.6mm hole)	2 x	52 mm dia. Rear wheels
1 x	60Tx10T Spur gear (white/2.4mm hole)	4 x	Self- tapping screws M2.6 x 4mm long
1 x	12T Pinion gear (1.9mm hole)	7 x	Self- tapping screws M3 x 10mm long
1 x	12T Pinion gear (2.4mm hole)	2 x	M3 x 8mm long bolt
1 x	2.5 mm dia x 70 long Steel rod	2 x	M3 Nut
1 x	9 Volt Battery clip	2 x	Washer (3mm ID / 0.5mm thick)

1x MULTI-RATIO GEARBOX kit for kits, containing:

1 x	Multi-ratio Gearbox case	2 x	50Tx10T Spur gears (white/2.4mm hole)
1 x	4.5V Electric motor (Round)	1 x	50Tx10T Spur gear (yellow/2.6mm hole)
2 x	2.5 dia x120 mm long steel rod	2 x	12T Pinion gears (2.4mm hole)
1 x	Washer (3mm ID / 1.0mm thick)	1 x	10T Pinion gear (1.9mm hole)
2 x	M2.6x 4 self-tapping Screws		

** The Inductor 15RK is only used with the Level A PCB

*** Depending on the student's skill level and available time, there are two PCB variations:

1) TYPE A: the Receiver and Transmitter PCB's are fully assembled.

2) TYPE U: the PCBs and their electronic components come in unassembled form, with all the components for both PCBs loose. Parts have to be identified, located and soldered to the PCB's.

Notes:

- if buying a class set of RCVs, we recommend that one set of assembled PCBs is purchased, to allow testing of student assembled PCBs.

- if not specified when ordering, the un-assembled PCBs will be supplied as standard.

1.2 ADDITIONAL REQUIREMENTS

1.2.1 Available from us are 2.3mm, 2.6 mm and 3.5mm diameter drill bits, and if required, need to be ordered seperately.

1.2.2 The additional requirements are: fine electric wire (different colours), 6x AA batteries and one 9 volt battery (Alkaline batteries are recommended).

1.3 COMPONENTS TO BE MADE

In addition, a variety of materials are required to allow fabrication of the items listed below.
Note: Refer to the exploded drawing for pictorial information.

- The upper Plate & and lower Platform
- Support (platform to upper plate)
- Antennas (for both PCBs)
- Insulated PCB Spacers
- Control unit housing & Battery mount
- Alignment Spring retainer bush
- Steering alignment lever
- Transfer shaft mounting
- Lug for the steering rod
- Steering rod (1mm wire or a paper clip)

Comments – about the material for the platform and other components:

- for our prototype we used 3.0 and 4.5 mm thick PVC sheet. Do they need to be that thick, or are thinner sheets of PVC just as effective (and lighter)?
- Acrylic was found to be undesirable for the Platform and plate, due to its brittle properties (and thus the use of self-tapping screws is not suitable for acrylic)
- Aluminium seems to be suitable because of its lightness, but care needs to be exercised with wiring, due to its electrical conductivity. Note: if a metal base is used care must be taken when mounting the receiver PCB.
- Plywood may be worth investigating, as it is thin and a non-conductor of electricity.
- What other materials are available, that may be suitable?

2. DESIGN STAGE

The design stage is crucial. At this stage the locations of all the components must be worked out. This allows the optimum size and shape of the vehicles platform and chassis to be developed on paper. This layout affects the functionality and the ease of assembly.

For information to help with design, please read the entire unit first for ideas – as many sections have useful information, including the sections on the Steering / clearance to the front wheels, and the Gearbox and motor. Some of our others units have other useful information, for example: *DRAGSTER* has sections on Speed and acceleration and Gearing; the *FOLLOW WHITE LINE VEHICLE* has other steering possibilities, and a brief section on calculation of the turning circle.

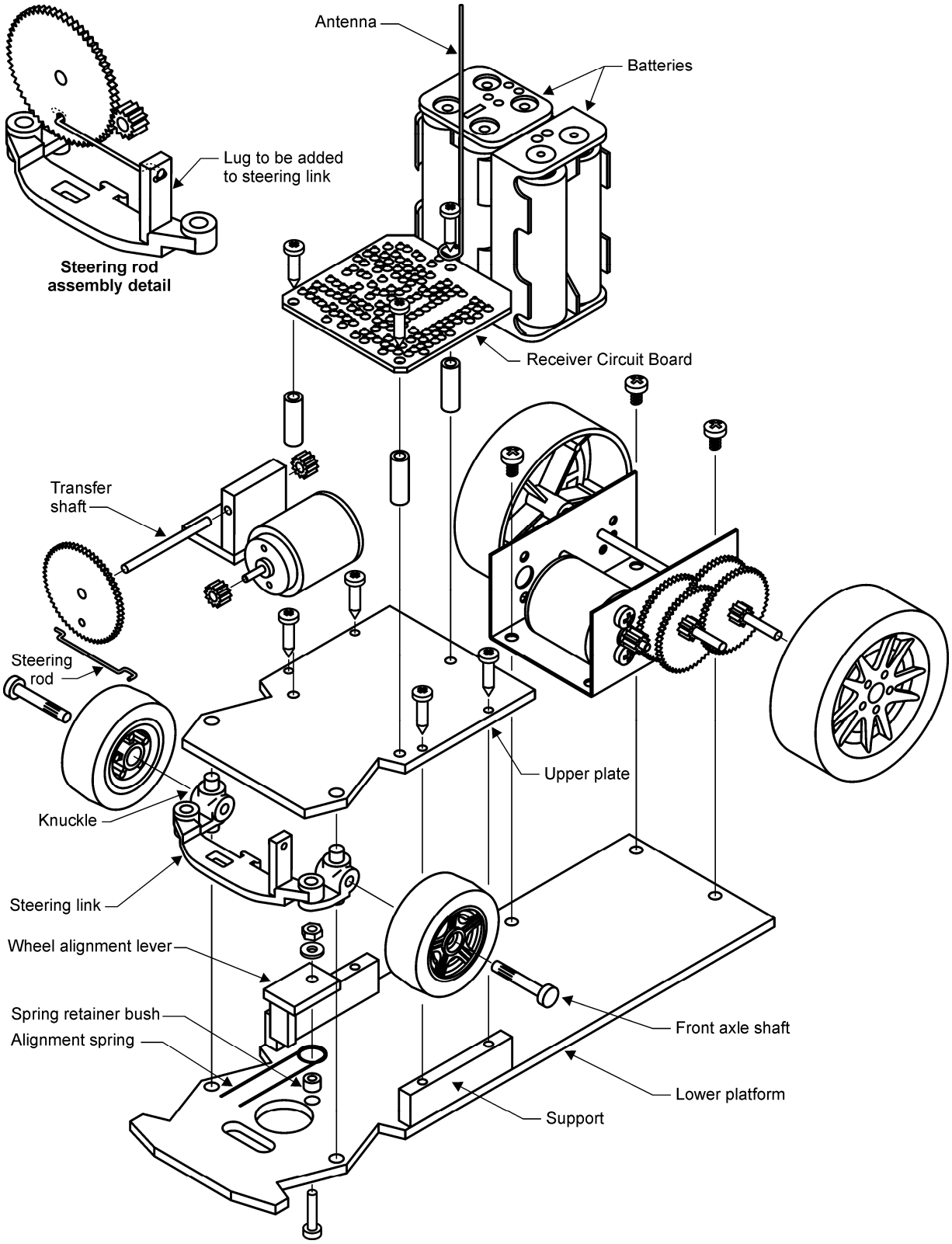
The following points are given as pointers to be taken into consideration during planning.

2.1 PLATFORM DESIGN

- The *RCV* consists of a platform / chassis on which the components are mounted. Before starting, the component location needs to be carefully planned and layed out. For best

functionality of the vehicle, the designer must look at the vehicle as a complete unit - not just as a collection of separate parts.

- The exploded view shows the overall design of our vehicle, although each designer has scope for originality and innovation in their design. Note: the drawings at the end of the unit, are meant as a guide only, and are not drawn to scale. Apart from a few critical dimensions, the size and shape of the vehicle is up to each designer.
- When designing the platform and upper plate, the size of the P.C.B., battery holder and the gear box assembly must be considered.



- The vehicle's front end and steering measurements are critical and should be maintained as accurately as possible. This will ensure the steering mechanism's proper operation. Some measurements also need to be taken from the supplied components. Note: the drawing at the end shows spacers for the optional steering link. These are also worth considering for the supplied link, to provide positive vertical location of the link to the steering knuckles.
- Sufficient clearance must be provided for the wheels – refer section 2.2.

2.2 CLEARANCE TO THE FRONT WHEELS

The platform needs to be designed, so as to provide clearance to the front wheels. This is to allow the wheels to turn approximately 20 - 25 degrees in either direction. During the design stage allow adequate clearance for the wheels, and at the construction stage add turn limiters to restrict the amount the wheels can turn.
Note: if a longer steering link is to be used, the dimensions defining the wheel cut-outs also need to be increased by the same amount (refer section 6 Steering link).

2.2 MECHANICAL COMPONENTS / DESIGN

- The Gearbox offers a choice of 4 ratios to choose from, depending on the desired reduction speeds. The one to be used must be decided upon, prior to assembling it. For this decision to be made, the vehicle's desired speed will be need to be considered. Refer to Section 7 on „Assembling the Gearbox" for more information, in relation to motor speed, and the gearbox reduction ratios.
  - For driving our vehicle, we chose the Third reduction gearbox
- The higher the gear ratio, the lower the vehicle's speed.
- The motors are low power units, therefore to minimize friction all clearances should be liberal.
- To increase the steering motor's effectiveness, the hole for the steering rod needs to be located reasonably close to the centre of the spur gear. As the motor supplies a given torque, the force available at a smaller radius is larger.
- The method of attaching various items, such as eg. the transfer shaft's mounting, need to be decided upon. Suitable methods of attaching include screws, hot glue (roughen both surfaces first), or a foam backed double-sided tape. Note: normal double-sided tape is too thin to be effective.
- Spacers need to be attached to the platform, for mounting the Receiver PCB. The length of these spacers is affected by which way the PCB is mounted – track side up or track side down.
- Decide how best to mount both the Receiver PCB and the antenna – the 3rd hole in the PCB is the antenna's mounting hole as well.
- The control box for the transmitter unit is not shown, and the size and design of that is up to the designer.

3. ASSEMBLY INSTRUCTIONS – GENERAL

3.1 REQUIREMENTS

Before you commence ensure that you have ALL components – both those listed in Section 1.1, as well as all the additional requirements listed in Sections 1.2 & 1.3.

3.2 GENERAL:

- When cutting wires, make them slightly longer than you need - but avoid making them too long, as it will look untidy.
- When soldering, hold the wire still while the solder cools, otherwise the solder may fracture, causing a *dry joint.* A dry joint may look OK, but it is a poor electrical connection. This could cause your model to not work, or not work properly.

- While connecting the wires to the switches, it is necessary to clamp the switches to hold them still (a printed circuit board holder is ideal). If you don't have access to one of these, a small vice or a pair of pliers, with an elastic band around the handles, may be suitable - but be careful not to damage the switch.
- If you experience solder blobs between the terminals, carry out the following: unclamp the switch and hold it upright. Heat the solder blob with the tip of the soldering iron until it melts. Then lower the soldering iron away from the switch (gravity should pull the solder away with the soldering iron).

3.3 CONVENTION:

It is best to follow standard wiring conventions for all battery connections: that is **RED** for **POSITIVE** and **BLACK** for **NEGATIVE**.

3.4 TOOLS and MATERIALS:

- When wiring the switches, use six different colour wires. This avoids confusion and makes it easier to follow the wires when connecting them, and it's easier to trace if you experience wiring problems.
- Use multi stranded wires for all connections. Single stranded wires are not suitable: after they have been bent a couple of times, they will break off.
- It is suggested that you use 0.7l mm solder. Thicker solder will cause problems when soldering small connections (eg. the switches).

3.5 WARNING:

- When soldering wires to the switches, take care not to overheat the switch terminals (Overheating could cause the plastic part of the switch to melt).
- Before connecting power to either PCB, double check to make sure you have the positive and negative wires connected correctly.

NOTE: If the wires are incorrectly connected, and power is applied, you could damage some of the circuitry.

4. ASSEMBLY INSTRUCTIONS – THE PCBs

4.1 ASSEMBLING THE PCBs

If you have a set of un-assembled PCBs, you will need to refer to the relevant "$\mathcal{RCV}$ $\mathcal{PCB}$ – Parts List and Assembling instructions" for instructions and component information.
Note: even if you have assembled PCBs, there is useful component information in that unit.

4.2 WIRING UP THE PCBs

For information on wiring switches etc to the PCBs, you will need to refer to the relevant "$\mathcal{RCV}$ $\mathcal{PCB}$ – Parts List and Assembling instructions", for drawings and instructions.

5. ASSEMBLY INSTRUCTIONS – ELECTRONICS / ELECTRICAL

5.1 WIRING UP THE TRANSMITTER AND RECEIVER

Wiring up the transmitter and receiver is fairly straight forward. This should present no problems if, before beginning any wiring up, you carefully read through, and follow, all the instructions in this section.

5.2 THE TRANSMITTER

5.2.1 THE CONTROL UNIT consists of:

- The Toggle switch to control Forward-Stop-Reverse
- The Toggle switch to control Right –Straight Ahead- Left
- The Transmitter PCB

- The Antenna (refer section 5.4)
- One 9 Volt Battery and battery clip
- Battery Mounting (this can be made from a variety of materials. We used a short length of rigid plastic pipe, which has a section removed along its length to allow it to clamp the battery in place, while still being easily removable.

5.2.2 THE HOUSING

- The PCB, switches, batteries and antenna need to be installed in a housing.
- The Control Unit's housing is not drawn or described in this unit, as the design (appearance / size / shape) of this plays no part in its function. However, the preferred material should be either plastic or wood - as ferrous materials may affect radio transmission.
  Note: If you make a metal box for the housing, it is especially important that the antenna does not touch the case, as this will affect its ability to transmit.

5.2.3 WIRING INSTRUCTIONS:

- Use the 9 volt battery clip for the battery connection to the transmitter PCB.
- For detailed information, on what is connected to the PCB, refer to the "$\mathcal{RCV}$ $\mathcal{PCB}$ – Parts List and Assembling instructions"

5.3 THE RECEIVER:

5.3.1 The Receiving unit mounted on the vehicle consists of:

- The Receiver PCB
- A sliding Two-way switch (Power On/Off)
- The Antenna (refer section 5.4)

And the PCB is connected to the 4 x AA and 2 x AA Battery Holders

5.3.2 WIRING INSTRUCTIONS

- For detailed information, on what is connected to the Receiver PCB, refer to the "$\mathcal{RCV}$ $\mathcal{PCB}$ – Parts List and Assembling instructions"

5.4 THE ANTENNAS & CONNECTIONS

This section applies for the antennas – ie. for both the Transmitter and Receiver antennas:

5.4.1 MAKING THE ANTENNAS

- Both antennas should be made from stiff wire, and should be about 300 mm long.
  Note: Spring steel wire 0.7mm diameter (approx.) is commonly used. Thin brazing rod is also suitable.
- Bend a small ring 3mm in diameter, on the end of the antenna, for attachment to the PCB.

WARNING: For safety, the antennas' ends should be doubled over or bent into a small loop

5.4.2 ATTACHING THE ANTENNAS

- For the Transmitter: use a M3 x 8mm bolt to fix the antenna to the bracket on the transmitter PCB.
- For the Receiver there are a few choices:
  - attach the antenna using a M3 x 8mm metal thread bolt, washer and nut in the appropriate hole, in the PCB. Consider how this affects the 3rd PCB mounting and mounting point
  - attach the antenna to the PCB and PCB mounting spacer, by using a long self tapping screw.
  - Solder the antenna to the track side PCB pad, and use the hole as a mounting point.

NOTE: regardless of the antenna fixing method, the contact between the antenna pad and the antenna needs to be very good.

6. ASSEMBLY INSTRUCTIONS – FRONT END & STEERING

The Steering mechanism's assembly can be tricky and requires some planning and care. For the layout and assembly, refer to the exploded diagram.

The parts supplied in the kit are designed to work as shown in the exploded diagram. Using these parts, the designer has some scope for variation (detailed below), or can design a different method of setting up and controlling the steering.
- Determine whether the supplied steering link, or a fabricated one will be used. If using the supplied link, cement a lug on to the steering link (refer to the exploded diagram for a picture).

NOTE: the measurements shown for the vehicle's front end are critical and should be maintained as accurately as possible. This will ensure the proper operation of the steering mechanism. Some measurements will also need to be taken from the actual components supplied.

6.1 THE STEERING LINK

6.1.1 USING THE SUPPLIED STEERING LINK

By assembling the steering, using the supplied steering link, a neat steering set-up is achieved. However, when using these parts, the front wheel track (i.e. the distance between the wheels) is rather narrow.
- a lug needs to fabricated and glued to the steering link (as shown in the steering rod assembly detail, of the exploded diagram – compare the steering link to the drawing)

6.1.2 FABRICATING A STEERING LINK

Depending on the vehicle's front end design, the designer may choose to fabricate their own steering link. The design of a simple, straight link is shown in the drawings at the end of this unit.
Note: the dimensions shown are for a steering link, which provides the same track as the supplied link, and allows eg. a shorter front on the vehicle, or a body to be installed.

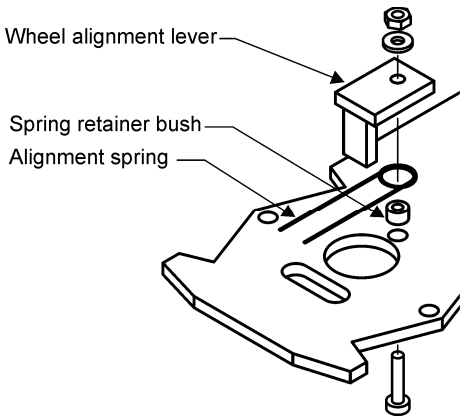
6.1.3 FABRICATING A LONGER STEERING LINK

For the vehicle to have a wider track, a longer steering link can be fabricated.
The design of a simple, straight link is shown in the drawings at the end of this unit. To make a longer link, the 49mm dimension needs to be increased, together with the corresponding 49mm dimension on the lower platform and the upper plate, as well as any other dimensions affected.

6.2 THE STEERING SET-UP

6.2.1 WHEEL ALIGNMENT / CENTERING MECHANISM

- Make the bushing to fit inside the alignment spring's "eye"
- Fabricate a wheel alignment lever as shown in the drawing at the end of the unit: the hole is to suit a 3mm bolt, and the 7mm wide part is to fit between the legs of the alignment spring
- Assemble the front wheel alignment spring, bush and lever to the platform, with the spring straddling the lever's leg. Use the M3x12mm bolt, nut and washer - at this point, leave the nut finger tight.
- When the rest of the front end is assembled, ensure the legs of the spring straddle the lower lug on the steering link.



CENTERING MECHANISM

Note: ensure that the spring remains engaged in the extremes of movement: i.e. not only at the centred position, but also at the limits of travel in both directions.
Note: The legs of the centering spring act on the steering link 's lug. During design, adequate clearance must be provided for movement of the lug, when the wheels are turned. A slot must be cut in the chassis to allow adequate travel of this steering lug. (The slot can be cut with a routing tool or the careful use of a 4 or 5 mm drill bit, coping saw and files).

6.2.2 GENERAL STEERING SET-UP

- Assemble the wheels, knuckles and the axle shafts, and mount them onto the lower platform.
- Assemble the steering link to the steering knuckles.
- Install the upper plate.
- Using the wheel alignment lever, adjust the wheels to point straight ahead. Tighten the nut, to hold that position

6.1.3 STEERING MOTOR AND TRANSFER SHAFT

The steering motion is supplied by the motor through the transfer shaft, gears and steering rod.

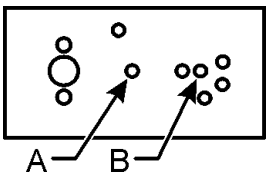
- In the 60 Tooth gear, a 1.5 mm diameter hole must be drilled approximately halfway between the gear centre and the teeth.
  Notes:
  - The force applied by the 60 tooth gear increases, the closer the hole is to the centre
  - If the hole is too close to the centre, an 'over centre' condition occurs, and the steering 'locks' in one position.
  - If desired, experimentation can be carried out to determine the best position of the hole relative to the centre (i.e. in regard to steering response and effectiveness). This can be done by drilling a number of 1.5 mm dia holes in the 60 Tooth spur gear, for the steering rod, in various locations, each progressively further out from the centre, and testing each position.
- Make the steering rod - from 1 mm diameter wire (or a paper clip).
  Install the steering rod, to go between the transfer shaft's gear and the lug on the steering link. This must be connected before the transfer shaft and its mounting are fastened to the platform. It is recommended that the mounting is attached using double sided foam tape, to allow dismantling if required.
- Make the transfer shaft mounting.
- Assemble the transfer shaft mounting, 2.5mm diameter transfer shaft and both gears. Note: the 12 tooth (2.4mm hole) pinion gear is used as a locator, to prevent the transfer shaft from sliding out of the mounting – there should be enough free-play, to allow the shaft to turn freely, but not enough to allow the 60 Tooth gear to dis-engage from the motor's gear.
- Mount the transfer shaft assembly, which should be as low as possible, so that the gear and the platform have a minimal clearance.
- Assemble the 12 tooth (1.9mm hole) Pinion gear to the motor. Hint: Place the gear on the bench, insert the motor's shaft into the pinion gear's hole and gently tap the end of the shaft (where it exits the motor) with a small hammer. Stop when the gear is 3mm from the motor's body. WARNING: Don't just push the motor down by hand as this can push the motor armature out of its bearings and jam the motor.
- Locate the steering motor, on the platform. When satisfied that the steering motor's and transfer shaft's gears operate smoothly, and with the location of both parts, attach the motor to the platform. Foam double sided tape, or hot glue are both suitable for this.

7. ASSEMBLY INSTRUCTIONS – DRIVING GEARBOX & MOTOR

The *MULTI-RATIO GEARBOX* kit provides a choice of 4 gear ratios to choose from. Before starting assembly, the desired gear ratio must be chosen for the driving speed, as this defines the parts to be used and the assembling procedure.

Also refer to the Design Stage section for our gearbox ratio choice.

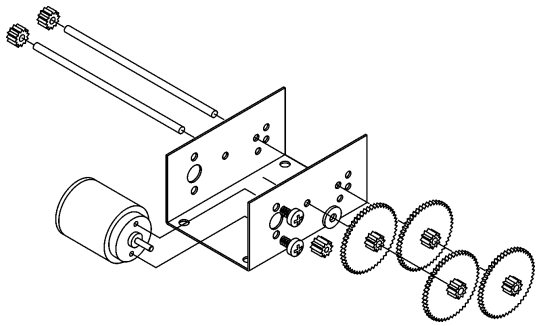
7.1 GEARBOX OPTIONS

GEARBOX STAGE / Reduction ratio	OUTPUT SHAFT	RATIO	
Single reduction	Hole A	1:5	
Double reduction	Hole B	1:25	
Triple reduction	Hole A	1:125	
Fourth Reduction	Hole B	1:625	

Standard Motor (S18) - Rated at 4.5V	Performance
3 Volts: ie. Powered by 2xAA batteries	6,500 rpm ##
6 Volts: ie. Powered by 4xAA batteries	12,600 rpm ##
Torque	17.9 g.cm

Motor speeds quoted are approximate rpms under load

WARNING: Using a higher voltage increases the speed of the motor, but can reduce the life of the motor.



7.2 ASSEMBLING THE GEARBOX

GENERAL:

- for this Gearbox, the holes marked 'A' & 'B' in the drawings are to be used - the available gears will not function if fitted to any other holes
- the 10T pinion gear (which has a 1.9mm hole) is press fit on to the electric motor's 2.0mm shaft
- the 12T pinions are used as locators.
- the white spur and 12T pinion gears (which have a 2.4mm hole) are press fit on to the 2.5mm shafts while the yellow spur gears are free wheeling on the shaft and have a 2.6 diameter hole.
- the outside two 50T spur gears (ie one on each shaft) must be white 50T gears, and are press fit, while the inner (closer to the case) are yellow 50T, which are free spinning .
- the gears can be assembled onto the shaft/s with a help of small hammer.

7.2.1 GEARBOX SELECTION

Before starting assembly, and depending on the intended speed of the vehicle:

- determine the desired gearbox ratio – as this will define which output shaft will be used as the axle
- define the length of the axle shaft, and cut (and de-burr) the steel rod to that length.

7.2.2 ASSEMBLY PROCEDURE:

Assemble the steel rods, and all the gears, to the gearcase - as shown in the appropriate drawing– Single, Double, Triple or Fourth reduction. Also refer to the exploded diagram.

7.2.3 SINGLE REDUCTION

- Fit the shaft to the hole nearest the motor (Hole A), add the 12T pinion gear (locator), with the 1.0mm washer between the case and the (white) 50T spur gear.

7.2.4 DOUBLE REDUCTION

- Start by fitting the first shaft to the hole nearest the motor (Hole A), add the 12T pinion gear (locator), with the 1.0mm washer between the case and the (white) 50T spur gear

- Add the second shaft to Hole B, and add the 12T pinion gear (locator) and the (white) 50T spur gear.

7.2.5 TRIPLE REDUCTION

- Start by fitting the first shaft to the hole nearest the motor (Hole A), add the 12T pinion gear (locator), with the 1.0mm washer between the case and one (yellow) 50T spur gear
- Add the second shaft to Hole B, and add the 12T pinion gear (locator) and one (white) 50T spur gear.
- Install a (white) 50T Spur gear on the shaft nearest the motor.

- for the THIRD reduction ratio, this shaft is the output shaft.

7.2.5 FOURTH REDUCTION

- Start by fitting the first shaft to the hole nearest the motor (Hole A), add the 12T pinion gear (locator), with the 1.0mm washer between the case and a (yellow) 50T spur gear
- Add the 2nd shaft to Hole B, and add the 12T pinion gear (locator) and the second (yellow) gear
- Install a (white) 50T Spur gear on the shaft nearest the motor.
- Install the second (white) 50T Spur gear on the second shaft.

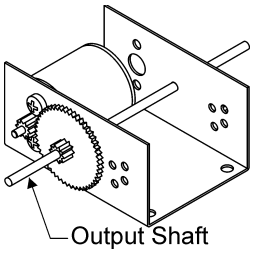
- for the FOURTH reduction ratio, this second shaft is the output shaft.

7.2.6 ASSEMBLING THE MOTOR

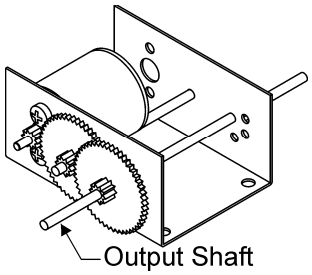
- Press the 10T pinion onto the motor shaft. Stop when the pinion gear is 3mm from the motor's body.

HINT: Place the gear on the bench, insert the motor shaft into the pinion gear's hole and gently tap the end of the shaft (where it exits the motor) with a small hammer.
WARNING: Don't just push the motor down by hand, as this can push the motor armature out of its bearings and jam the motor.

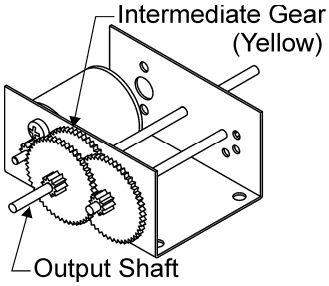
- Secure the motor to the gearbox case using the two self-tapping screws.
- Solder a suitable length of wire to each of the motor's terminals. The length will be dictated by the planned usage / location of the Gearbox and the other components



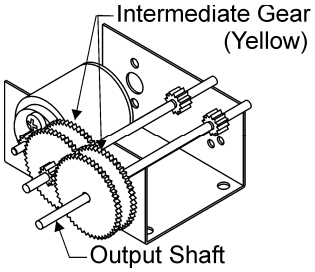
SINGLE REDUCTION
(Low ratio = high output shaft speed)



DOUBLE REDUCTION



TRIPLE REDUCTION



FOURTH REDUCTION
(High ratio = low output shaft speed)

8. ASSEMBLY OF THE *RADIO CONTROLLED VEHICLE*

8.1 GENERAL

For drilling the pilot holes for the 2.6mm self tapping screws, use a 2.3 mm drill bit, and for the 3mm self tapping screws, use a 2.6 mm drill bit.

8.2 MOUNTING THE GEARBOX AND MOTOR ASSEMBLY

- Locate the gearbox and motor assembly on the platform.

- With the gearbox in place, mark the location of the attaching holes and drill them (2 diagonally located holes are a minimum). 2.6x4mm self tappers are supplied for this.
- Make sure the gearbox shafts are at 90 degrees to the body, to ensure that the vehicle travels straight.
- Press the wheels on to the shafts. The rear wheels may also be hot glued for additional strength.

8.3 MOUNTING THE P.C.B.

- When the gearbox is in place, use the Receiver PCB as a template and mark where to drill the mounting holes for the PCB.
- Care must be taken when mounting the Receiver PCB, to ensure that neither the antenna nor the attaching screws and spacers can short across any tracks. This is done by the use of insulated spacers between the P.C.B. and the platform - fibre, plastic or wooden spacers should provide sufficient insulation. This prevents the soldered side of the P.C.B. from shorting out if the base is made from a conducting material, such as aluminium. Attach the PCB, using the 3mm x 10mm long self tappers, or in some other way (refer Section 5.4).

8.4 FINISHING THE VEHICLE

- Mount the battery holders, and wire them up.
- Mount the On-off switch (SW1) to the vehicle. Locating it towards the vehicle's rear is suggested, to provide easy access to the switch.
- complete anything else left uncompleted

At this stage, testing should be carried out, prior to fitment of any optional / additional bodywork etc (such as eg. a vacuum formed body shell).

9. TESTING

After completing the design, manufacture and assembly of the RCV vehicle, a number of tests and adjustments still need to be carried out. These are detailed below.

9.1. BEFORE TESTING:

WARNING: CHECK ALL WIRING THOROUGHLY BEFORE CONNECTING 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).

9.2 WHAT TO EXPECT IN YOUR TESTING

When both motors are driven, they will draw up to 800 mA (milli-Amps) from the batteries. The drive motor's current useage is normally between 400 to 500 mA and for the steering motor it is 250 to 300 mA. The effective range of the transmitter is approximately 25 metres, and can reach 50 metres (if the conditions are favourable. Because of the large currents drawn, Alkaline batteries are recommended for the motors. Low battery voltage can cause erratic performance.

9.3 TESTING THE *RADIO CONTROLLED VEHICLE*

9.3.1 TESTING:

Insert the batteries, move the Receiver's On-off switch to the "ON" position, and check that the following occur:

- the wheels turn and the *RCV* moves forward
- when the Transmitter's direction-controlling toggle switch (Forward-Stop-Reverse) is operated, the *RCV* 's rear wheels turn in the selected direction.

- when the Transmitter's steering toggle switch (Right-Straight ahead-Left) is operated, the $\mathcal{RCV}$'s front wheels turn in the same direction.
- if the switches operate the RCV, but in the wrong direction, the wires to the relevant motor should be removed, swapped over and re-soldered.

9.3.2 TROUBLESHOOTING:

If any of the above are not achieved, turn off the power **immediately** and check the following:

- that the batteries have adequate charge
- that all the PCB components are correctly located and oriented
- that the +ve (red) and –ve (black) from the battery connectors go to the correct positions on the P.C.B.
- bare wire ends do not touch other wires or connections on the PCB
- 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: in this section, one set of pre-assembled PCBs is useful, as it helps to quickly identify which PCB is faulty, and what the correct component placement is.

10. EVALUATION OF THE RADIO CONTROLLED VEHICLE

The evaluation report is based on the vehicle's function and operation. During the Evaluation stage, those questions posed before starting the project should be evaluated. Students should also include an outline of any modifications they made during construction, that differ or were not included in their original plan. It also seems reasonable for some self evaluation, by commenting on the construction processes and the skills the students have learnt or need to improve.

Some questions which could be evaluated are.-

- What new skills have you learnt?
- What skills do you need to work on improving?
- Does the vehicle operate as expected?
- Does the vehicle steer as well as you expected?
- What is the maximum distance of the transmitter's effective control?
- Is the (electrical) current consumption as anticipated?
- Is the hand control ergonomic?
- If you made modifications from your original plan, give reasons why they were necessary.
- If you had to make repairs, what was the cause of the problem?
- If you were to make the vehicle again, what areas of your design would you change to make it better?
- What suggestions for improvement, would you make to the kit designer (please e-mail us)

11. FURTHER THOUGHTS

The transmitter and receiver have been designed for use as a remote control system for a vehicle. If you use your imagination, you should be able to think up lots of other uses for them. For example:

- A model garage door opener
- A control to operate a device for a disabled person
- Model Rocket launcher control
- Volume control for a stereo

Experiment with other methods to operate the transmitter (instead of using the switches). For example:

- Light sensor
- Sound sensor
- Moisture sensor
- Temperature sensor
- Replace the motors with another type of device. For example: solenoids, globes, relays, buzzers

---

THE THEORY BEHIND THE *RCV* – AN OVERVIEW

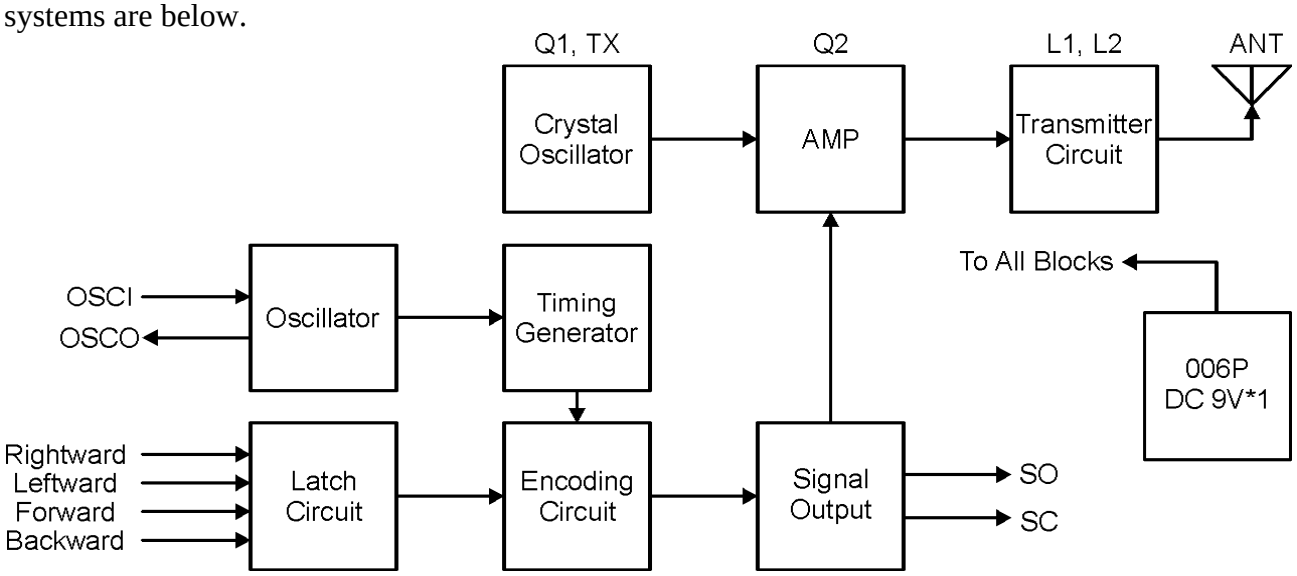
1 HOW THE *RCV* OPERATES

The *RCV* is a four-wheeled vehicle. The rear wheels are driven by a gearbox and motor, with another motor actuating the steering. Both of these motors are controlled by the Receiver PCB, allowing the vehicle to be driven forwards, reversed and steered.

2 HOW THE ELECTRONICS WORKS

2.1 THE TRANSMITTER

Each switch in the Transmitter is connected to an encoder, which produces a different frequency for each switch position. The encoded signal output is modulated (mixed) with the RF oscillator signal. This modulated signal is transmitted via the antenna. Block diagrams showing the sub-systems are below.



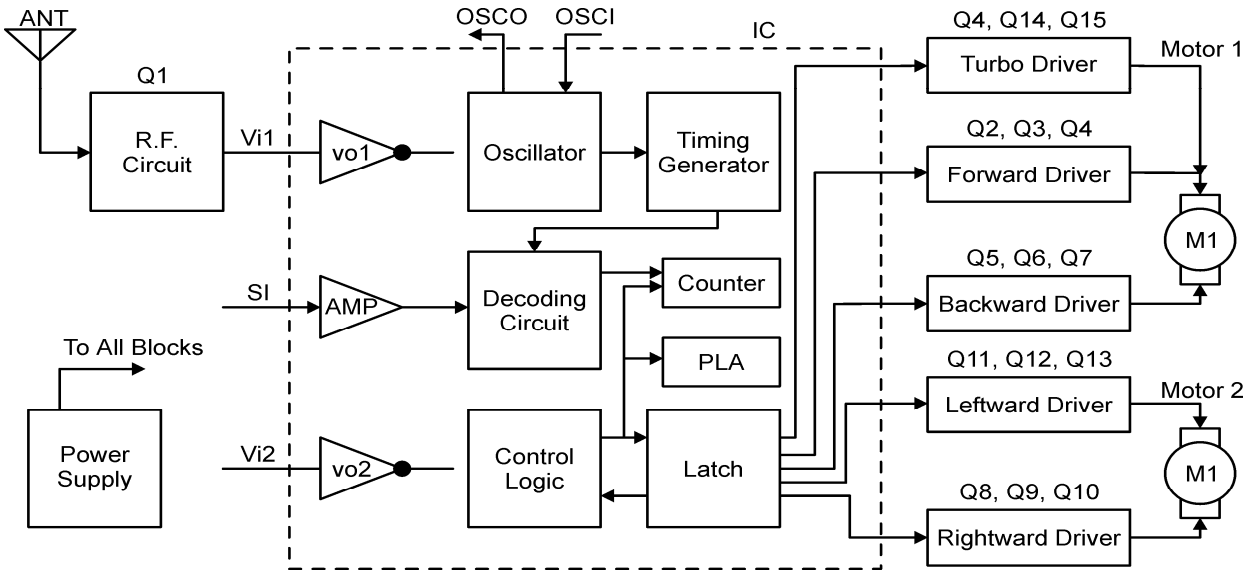
BLOCK DIAGRAM—TRANSMITTER

2.2 THE RECEIVER

The receiver's antenna picks up the radio waves, which are then fed to the RF circuit. There the waves are increased in strength (amplified), and sent to the oscillator, where the information encoded in the radio wave is separated from the RF signal (demodulated). This signal is then decoded into the separate signals used to control the direction of the steering and driving motors.

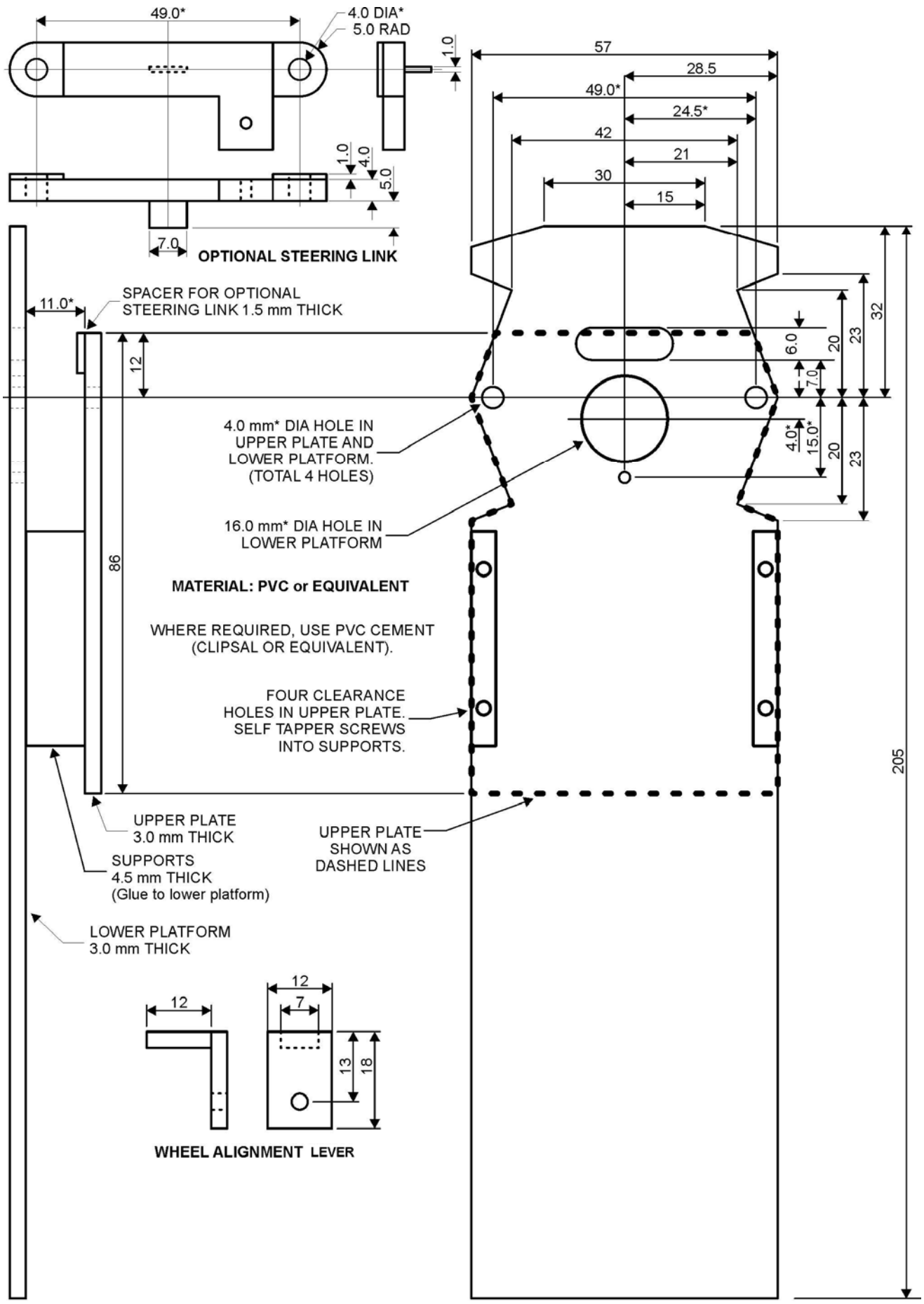
NOTES:

- The Radio control operates on 27.125 or 40 MHZ frequency (as chosen) - preset by the factory.
- The Vehicle requires 9 volt power (6 x 1.5 volt batteries), and the Transmitter uses a single 9V battery
- The control unit (Transmitter PCB) requires a 9 volt battery.



BLOCK DIAGRAM -- THE RECEIVER

****



This is the prototype vehicle built for the RADIO CONTROLLED VEHICLE.
The size and location of the holes for the steering linkage are critical. (These are marked with a "*").
In all other respects, the student may change this design as required.