Harman Motor Works
Fluid Drive Bus Mk1 #6683

OPERATOR'S MANUAL

Version 1.0 – July 2014

Contents

1. Purpose of this Manual

This manual has been written to provide an in-depth understanding of the Fluid Drive Bus Mk1 by Harman Motor Works.

This manual is structured to provide a background on the components of the Bus and also cover operation and maintenance tasks.

This manual is not intended to provide:

- ☞ Instruction on modifying the Bus (those who choose to undertake such modifications do so at their own risk)
- ☞ Instruction on performing major maintenance work to the Bus (such as removing major body and mechanical components).

2. Notes about this Manual

Symbols may be provided throughout this manual to direct attention to important information. The meaning of each of the symbols is shown below:

⚠ - this symbol denotes that damage or injury may occur if care is not taken. Pay particular attention to the information provided here.

 - this symbol provides noteworthy information.

3. Components of the Bus

The main components of the Bus can be divided into the following distinct items which are further detailed in this section:

1. Drive Motor
2. Fluid Coupling
3. Transmission
4. Steering
5. Main Battery
6. Remote IR Controller
7. Body
8. Wheels.

Drive Motor

The drive motor is responsible for converting electrical energy from the main battery into mechanical force to move the Bus.

Figure 1: Drive Motor (LEGO E-motor)

Type and Specification

The drive motor is a LEGO 'E'-Motor, rated at a maximum speed of 640 RPM @ 12 VDC. Typically, the main battery voltage of the Bus will be somewhat less than 12 VDC and will be in the region of 7-9 volts. The E-motor's high RPM specification (in comparison to the LEGO M-motor's lower RPM specification) is useful for the application of the fluid drive, as generally, the higher the RPM the fluid drive is spun at, the greater the amount of driving force it can transmit (particularly when the Bus is required to be travelling at high speeds). Other considerations however must be taken into account such torque levels at varying speeds.

Below is a table which states technical specifications of the LEGO E-motor:

Voltage	Torque	Rotation Speed	Current	Mechanical Power	Electrical Power
4.5 VDC	1.32 n/cm	63 RPM	0.17 A	0.087 W	0.76 W
6 VDC	1.32 n/cm	186 RPM	0.17 A	0.26 W	1.02 W
7.5 VDC	1.32 n/cm	300 RPM	0.17 A	0.42 W	1.27 W
9 VDC	1.32 n/cm	420 RPM	0.18 A	0.58 W	1.62 W
12 VDC	1.32 n/cm	640 RPM	0.18 A	0.89 W	2.16 W

Note: the figures quoted in this section have been obtained from the Internet and have not been independently verified nor endorsed for accuracy by Harman Motor Works.

Fluid Coupling

The fluid coupling is a very remarkable key component of the Bus and its faultless operation is required in order for the Bus to drive.

The fluid coupling is a specially-designed unit mounted directly between the drive motor and the transmission. Like a conventional clutch, the fluid coupling transmits the rotational drive forces of the drive motor to the transmission. The manner in which the fluid coupling transmits power from the drive motor to the transmission however is anything but conventional: a smooth, even, power delivery is effected at all times, reducing wear and tear on all parts of the Bus' drivetrain.

To understand the basic principle of operation of the fluid coupling, imagine two electric fans facing each other very closely…one plugged in and the other unplugged. Turn on the plugged-in fan, and the airflow generated strikes the blades of the other fan (which is unplugged) and very soon causes it to also rotate. Increase (or decrease) the speed of the plugged-in fan, and note that the unplugged fan's speed soon follows suit (either increasing or decreasing in speed, respectively).

Now imagine that the fan is not manipulating air, but oil. The driving effect is still gradual, and smooth, but powerful nonetheless. Note however that the fluid coupling is designed to transmit power, and **not** to increase the torque from the drive motor. Torque multiplication is a role fulfilled by the transmission (see next section).

The fluid coupling is essentially comprised of an input shaft, impeller and case (all of which are connected and rotate as one unit), and also an output shaft and turbine (which is completely seperated from the input side of the fluid coupling). The fluid drive case is approximately one half-full of silicon oil.

When the drive motor rotates, it directly rotates the input side of the fluid coupling (along with the case) which causes the oil to be flung around at high speed inside the case, producing the rotational influence required to then rotate the turbine and thus the output

side of the fluid coupling. The output side of the fluid coupling is connected directly to the transmission (and thus rear wheels) of the Bus. There is very little (virtually indiscernable) time between when the drive motor spins and that which the output side of the fluid coupling responds; particularly in LOW gear. In DRIVE, some 'slippage' of the fluid coupling may be observed, but this is generally not excessive, unless mechanical trouble or obstruction exists, or excessive grade or rough terrain is encountered.

The figure below illustrates the basic principles of operation of the fluid coupling.

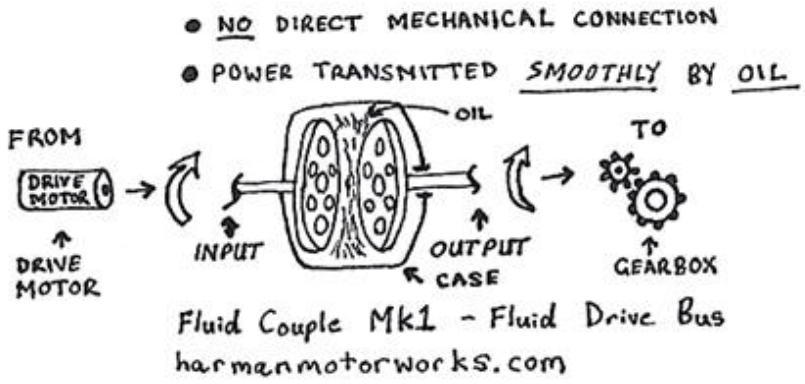


Figure 2: Illustration of Fluid Coupling Operating Principles

It is important to note that whilst the power transmission efficiency of the fluid coupling is high, there are inherently some slippage losses which occur between the input and output sides of the fluid coupling. Slippage is generally more pronounced at higher Bus speeds and particularly when higher-speed gear ratios are in-use.

Transmission

The transmission is connected to the output shaft of the fluid coupling and is responsible for directing the power received from the fluid coupling to the rear wheels. It is also responsible for providing torque multiplication of the drive motor as required (when driving on inclines or driving on uneven terrain). Torque requirements for the Bus will vary greatly and these are dependant on several factors including grade and terrain.

Because the transmission is not directly connected to the drive motor and is in effect instead 'cushioned' from the forces of the drive motor by the intermediary fluid coupling, the transmission receives a smooth input of power at all times. For this reason, acceleration of the Bus is also smooth and gradual and never jerky or sudden.

Type

The transmission is of a manual, two-speed, constant gear mesh type. Two forward gear ratios are provided: *Drive* and *Low*. A *Neutral* range also exists which allows the drive motor to run without driving the Bus and also allows for the Bus to be moved freely without the use of the drive motor*.

***** Note that the neutral range of the transmission can only be selected by means of manually manipulating the shift collar directly on the transmission.

Components

The following components of the transmission control and effect its operation:

Gear Lever

The Bus features a gear lever on the Remote IR Controller which controls the *dog clutches* in the transmission to select gears as appropriate. Note that no direct way of controlling the gears is possible from the Bus, aside from directly manipulating the shift collar underneath the Bus (described in later sections). See the section titled 'Remote IR Controller' for further details on the gear lever and its operation.

Gears and Dog Clutch

The transmission contains an arrangement of gearwheels which effectively transmit power flow according to the the position of the dog clutch. The dog clutch can be controlled through the operation of the aforementioned gear lever mounted on the Remote IR Controller.

Gear-change Motor

The Bus is fitted with a dedicated electric motor for selection of gear speeds in the transmission. Operation of the motor is tied to the movement of the gear lever mounted on the Remote IR Controller. In this way it is possible to drive the Bus using the Remote IR Controller and make gear changes without having to interact directly with the Bus.

☞ If the Bus' main battery is off, gear selection CANNOT be made using the Remote IR Controller

☞ The gear-change motor uses a drive belt to connect it to the gear-change mechanism in the transmission. If this drive belt breaks, gear selection CANNOT be made using the Remote IR Controller, until the drive belt is replaced.

Transmission Modes

The following transmission modes are available for selection:

- **DRIVE**: this ratio is one which is most-commonly utilised when driving the Bus and generally provides sufficient driving force to the rear wheels to drive the Bus in most situations, even when starting from a standstill (on level ground). This ratio provides the optimum balance between speed and torque.

☞ Use DRIVE ratio as far as possible and only switch to LOW if the Bus should stall whilst maneuvering at very low speed, travelling up a grade or over uneven terrain.

- **LOW:** this ratio is to be used only when maxiumum torque multiplication is required from the transmission. For example, when maneuvering at very low speed, ascending grades or traversing difficult terrain. In contrast to DRIVE, the LOW gear ratio will not drive the Bus very fast, however it will ensure successful negotiation of most difficult driving situations.

Gear lever

The transmission is controlled via a lever, located on the Remote IR Controller.

The following colour codes apply:

1. RED knob lever: DRIVE/LOW (selection of either gear speed as needed)

Gear lever Movement (Remote IR Controller)

When moving the gear lever to select a gear, only a short 'tap' of the lever is necessary to effect a gear change. Prolonged holding of the gear lever is unnecessary and can cause undue wear.

Note however that if the transmission is under heavy load, the torque forces in the transmission may prevent or resist the gearbox from shifting normally. In these cases, reduce the power setting or stop the drive motor completely before attempting to shift gears again (in extreme cases you may also need to operate the drive motor briefly in the opposite direction to completely relieve the torque stress from the driveline).

Do not hold the gear lever engaged for prolonged periods of time, as this can cause undue wear of the gear-change motor drive belt.

Selecting Gears

Gear selection is effected using the Remote IR Hand Controller. Note that it is necessary for the Bus' main battery to be turned on in order for the gear selection to occur, as the gear selection is effected via a dedicated gear-shifting motor.

Note that whilst the transmission is 'automated' and shifts are controlled remotely, the transmission is still a manual system and will require shifting from one gear to another as necessary during driving operations.

DRIVE

To select DRIVE, move the gear lever directly backward momentarily and release again. The sound of the gear-shifting motor should be momentarily heard and you may also hear positive engagement from within the Bus' transmission. If the Bus is in motion when you make the up-shift to DRIVE, you will also be able to hear the audible decrease in drive motor RPM as DRIVE is engaged.

LOW

To select LOW, move the gear lever directly forward momentarily and release again. The sound of the gear-shifting motor should be momentarily heard and you may also hear positive engagement from within the Bus' transmission. If the Bus is in motion when you make the down-shift to LOW, you will also be able to hear the audible increase in drive motor RPM as LOW is engaged. Take care to not shift into LOW when the Bus is moving at high speeds as this can cause undue stress on the drivetrain components.

Notes on Neutral and Reverse

To select NEUTRAL, you must manually move the red shift collar under the Bus to the central position so that none of the dog clutches on either side of it are engaged. A small pictogram should be visible under the Bus which illustrates the correct positioning of the shift collar to achieve neutral. Otherwise, it may also be possible to select neutral by very lightly tapping the gear lever, however this is generally quite difficult.

Figure 3: Position of Shift Collar for Neutral Selection (pictogram also visible)

There is no dedicated reversing gear in the transmission. To reverse the Bus, rotate the throttle wheel on the Remote IR Controller anti-clockwise. This will run the drive motor in the opposite direction and allow you to use both LOW and DRIVE gears as necessary whilst reversing, in the same manner as when driving forward.

Steering

The steering system of the Bus is designed to be operated from the Remote IR Controller and acts on the two front wheels of the Bus, which are free-wheeling.

Type

The steering system of the Bus consists of a rack and pinion steering linkage, to which a LEGO M-motor is connected, via a dual-belt pulley system.

Steering the Bus

It must be noted that the steering system of the Bus can only be operated with the main battery ON. Using the Remote IR Controller, rotate the steering wheel control to effect control of the steering system (see the section titled 'Remote IR Controller' for further details).

Main Battery

The main battery is the primary source of power for the Bus and powers functions such as the steering, throttle and gear change actuation. The main battery much be switched on for any of the aforementioned features to function.

Type

The Bus is powered by a LEGO LI-PO battery which is rated at approximately 7.5VDC when fully charged. The longevity of each charge is reasonable with good voltage stability.

Operation

Access to switch on or off the main battery is possible via the recess immediately behind the left hand rear drive wheel, within the wheel arch area. Sufficient space is provided to reach the on/off button of the main battery.

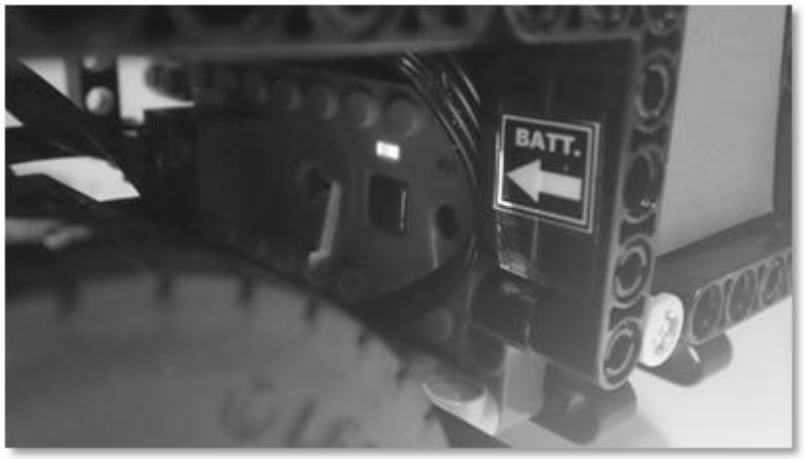


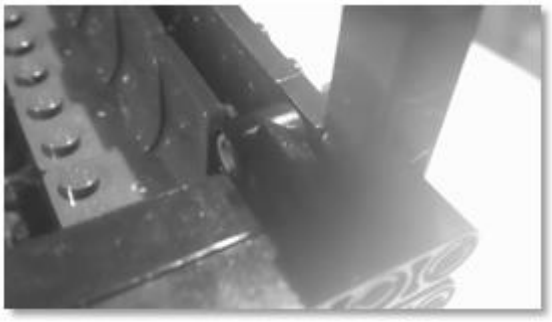
Figure 4: Main Battery On/Off Switch

Removal and Replacement

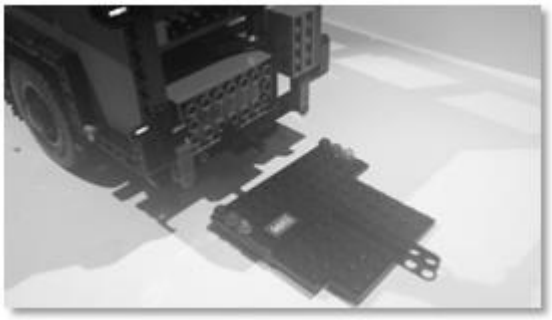
Although charging the main battery without removing it from the Bus may be possible (depending on your dexterity!), you will generally need to remove the main battery from the Bus in order to recharge it. This section deals with removal and replacement of the main battery. The following steps may be used to remove the main battery from the Bus (installation is the reverse of removal):

1. Disconnect the upright stay from its pin at the rear of the Bus:

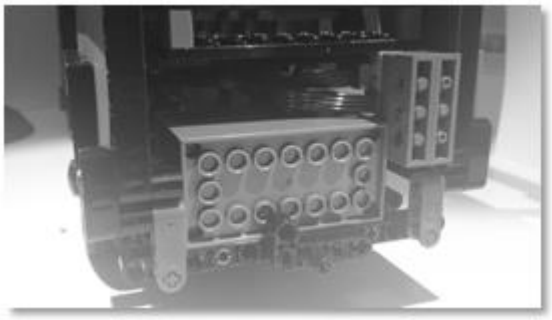
2. Unclip the rear panel from the pin in the rear seat area (left hand side of Bus):



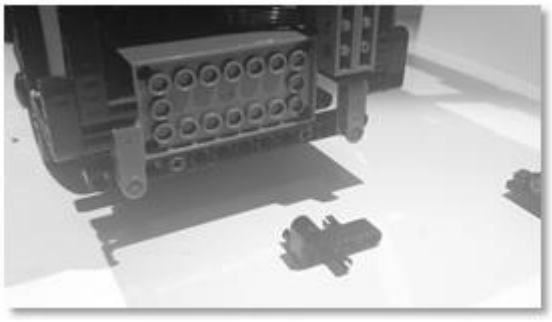
3. The entire rear panel of the Bus should now be able to removed:



4. You will now be looking at the rear of the Bus with the main battery in situ:

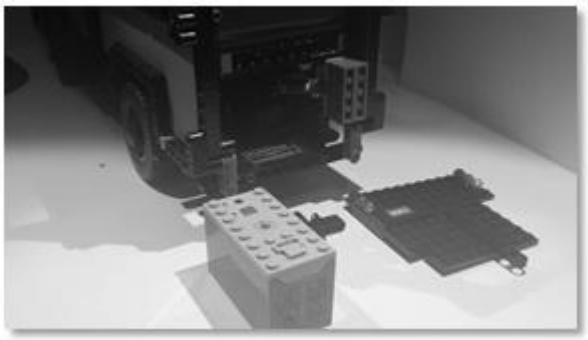


5. Remove the L-shaped battery retainer from the rear of the Bus:



6. Disconnect the main battery power cable connection by pressing gently but firmly downwards on the power connector to snap it free (easiest performed from the right hand side of the Bus):

7. The main battery can now be slid rearward without resistance and removed from the Bus completely (watch for any cables which may obstruct the rearward movement of the main battery):



8. Whilst the main battery is removed and recharging, take note of the maintenance checklist printed on the bottom of the main battery compartment and perform checklist items as necessary:

Remote IR Controller

The primary method of controlling the Bus is via the Remote IR Controller. This unit takes a total of 5 AAA batteries and is comprised of two seperate IR controllers combined together to allow functions of the Bus to be remotely controlled.

The elements of control that the Remote IR Controller provides to the Bus are listed as follows:

1. Steering
2. Throttle
3. Gear change.

Layout and Controls

The following diagram shows the typical Remote IR Controller layout, with numbered call-outs which denote the various functions of the unit. The most critical functions are highlighted in green for convenience.

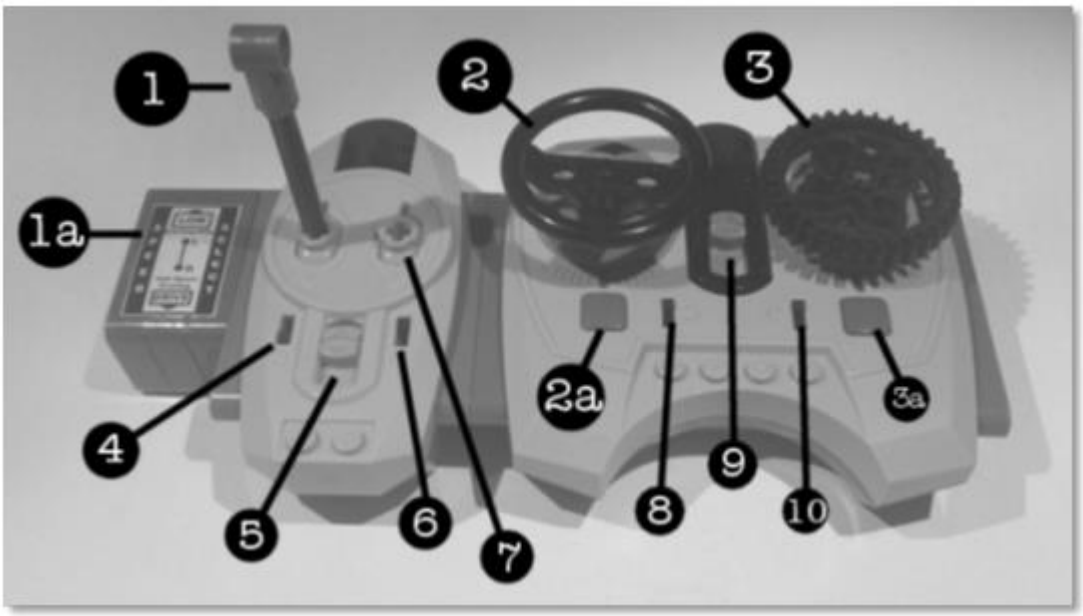


Figure 5: Remote IR Controller

1 – Gear Lever – tap upwards to shift into 'LOW', tap downwards to shift into 'DRIVE'.

1a – Gear Shift Plate – denotes the operation of the gear lever.

2 – Steering Wheel – Rotate to the left or right to steer the front wheels of the Bus. The speed of the steering action can be increased by rotating the steering wheel harder to the left or right. Generally however, rotating to one 'click' in either direction is sufficient to start the front wheels steering in the desired direction at a sufficient rate.

⚠ Excessive rotation with the steering system already at full-lock may cause undue wear of the steering system drive belts.

2a – Steering System Stop – After rotating the steering wheel and obtaining the desired steering angle from the front wheels, press this red button to keep the front wheels at the desired angle.

⚠ Failure to use this button after issuing a steering command may cause undue wear of the steering system drive belts.

3 – Throttle Wheel – This wheel provides analog control of the Bus' drive motor. Seven (7) power settings are available, with the 7th power setting being 'full throttle'. Rotate this wheel either clockwise (to move the Bus forward) or anti-clockwise (to move the Bus backwards). It is not necessary to stop or slow the drive motor when shifting gears, as the fluid coupling absorbs any excessive shocks associated with changing gears.

3a – Throttle Stop – By pressing this red button, the drive motor can be halted immediately, regardless of the power setting it was currently operating at (NOTE: it is not recommended to press this button if the drive motor is operating at a high speed setting, as the sudden halt of the motor may cause damage to the fluid coupling (which operates at 3x the speed of the drive motor) or associated components).

4 – This switch reverses the action of the gear lever; this switch need not be disturbed during normal operations, unless the gear change actuation system gear train has been rebuilt incorrectly.

5 – This switch controls the channel with which the gear change module transmits its IR signal to the Bus. This is normally set to channel 2 and need not be disturbed during normal operations.

6 – Unused.

7 – Unused.

8 – This switch reverses the action of the steering system and need not be disturbed during normal operations.

9 - This switch controls the channel with which the steering and throttle module transmits its IR signal to the Bus. This is normally set to channel 1 and need not be disturbed during normal operations.

10 - This switch reverses the action of the throttle and need not be disturbed during normal operations, unless the differential housing is ever reinstalled in the reverse manner in the Bus.

Body

The body of the Bus comprises a box frame which is mounted upon a ladder-frame chassis containing the motors and running gear. Removal and maintenance of the body and chassis is beyond the scope of this manual.

Figure 6: Typical Body Layout

Entry/Exit Door

The entry/exit door of the Bus can be locked and unlocked as required. To lock/unlock the door, rotate the red latching lever to the appropriate orientation as shown on the lower door frame. If unlocking the door, once unlocked, it may be swung outwards manually by hand. Ensure both panels of the door are fully closed before attempting to engage the lock.

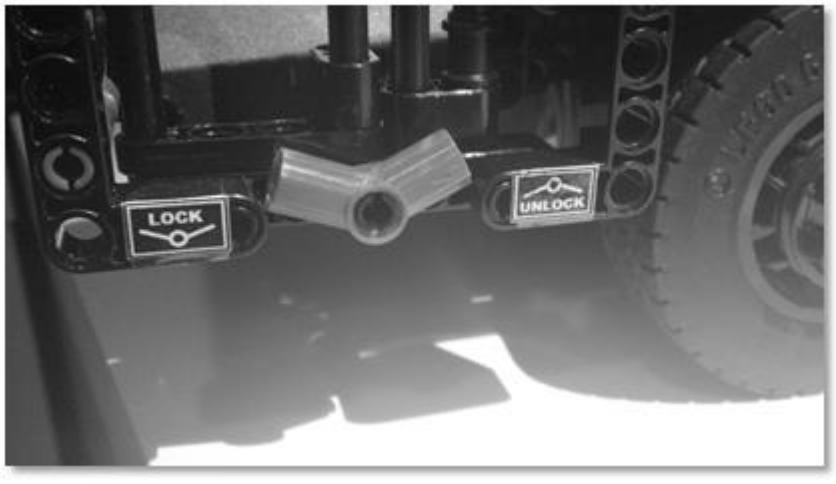


Figure 7: Entry/Exit Door Locking Mechanism

Wheels

The Bus is fitted with four wheels, the front two of which provide steering and the rear two which provide driving force to move the Bus. The front wheels are not driven and can rotate independently of each other. The rear wheels are linked via a standard differential unit to assist in efficient operation around corners.

Removal and Installation

Should it be necessary to remove the wheels, follow the steps described below:

Rear Wheels:

1. To remove the rear wheels, you will generally need to remove the hub unit first by prying it gently off the axle:

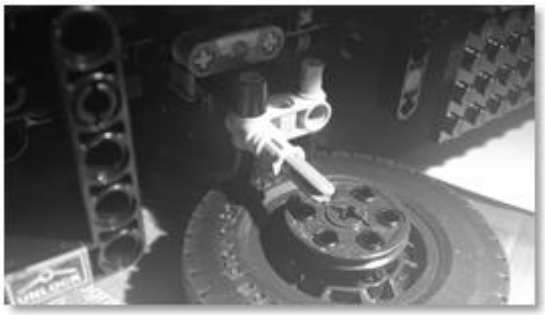
2. Once the hub has been removed, place one finger on the rear axle shaft and apply slight inward pressure and at the same time, pry outwards with your fingers on the outside of the wheel to pull the wheel (both rim and tyre) free from the axle:

Installation is the reverse of removal, noting that you may need to hold the rear axle shaft in position from behind the wheel as you mount it on to the rear axle shaft and press it inwards.

Front Wheels:

1. To remove the front wheels, pry the hub unit outward first so that it clears the stub axle (complete removal from the pins is not required):

2. Gently pry the front wheel evenly outward and off the stub axle:



Installation is the reverse of removal, noting that you will need to place a finger or object behind the stub axle to prevent it being pressed inwards with the pressure when you attempt to re-mount the front wheel.

4. Bus Operating Checklist and Procedure

The following is detailed information on operating the Bus in a safe and damage-free manner.

Prior to Starting

Before starting the Bus, perform a general check to ensure there are no obstacles nearby, and that there are no obstructions in or around the drive motor or running components which may cause binding and subsequent damage. Also ensure the entry/exit door is secured and locked correctly.

Bus Running Procedure

Once you are satisfied that the Bus is ready to run, follow the procedure below to prepare the Bus for operation:

1. If the Bus has previously been sitting for a long period of time before being run again, it is recommended to perform basic maintenance checks on it first per the section titled 'Maintenance' below.
2. Turn on the main battery of the Bus (ensuring it has been sufficiently charged beforehand).
3. Ensure the Remote IR Controller has a sufficient charge of batteries.
4. Select an appropriate gear ratio in the transmission (LOW gear for starting off – however DRIVE may also be used in most cases) by momentarily tapping the gear lever on the Remote IR Controller forward or backward, respectively.
5. Rotate the throttle wheel slowly and smoothly on the Remote IR Controller and observe as the Bus begins to move. If you have chosen to set-off in DRIVE, more power may be required from the drive motor before the Bus begins to move.
6. If you have started in LOW gear, listen as the drive motor RPMs begin to increase as the Bus moves, and shift into DRIVE appropriately. You should notice an audible change (decrease) in drive motor RPM as you initially up-shift to DRIVE. Increase drive motor power as necessary to effect the required amount of speed and acceleration. Note that the fluid drive effects smooth and gradual acceleration
7. The Bus may be steered using the steering wheel located on the Remote IR Controller. Remember to press the red button below the steering wheel once the front wheels have reached their intended steering angle (particularly at full-lock), to avoid excessive wear on the steering drive belts.
8. To slow or stop the Bus, reduce the power setting with the throttle wheel located on the Remote IR Controller until the drive motor slows or stops. If operating the Bus on a down-grade and the speed is increasing undesirably, slow the drive motor to the minimum power setting and engage LOW gear.

Tips and Hints for Efficient Operation

- Where you need to manuever the Bus at very low speeds (e.g. when parking or turning sharply), slow the Bus and engage LOW gear. LOW gear will:
    a. Provide the best control over the Bus at low speeds,
    b. Prevent excessive drive motor power settings/RPM being required to move the Bus,
    c. Ensure there is enough driving torque transmitted to the rear wheels to overcome any parking obstacles and,
    d. Consume the least amount of energy for the work being performed.

- When accelerating, gradually increase power to the drive motor, rather than 'flooring' the throttle to the maximum power setting immediately. The Remote IR Controller has 7 power settings for forward and backward. Make use of these graduated settings to effect the smoothest operation of the Bus as possible. In most situations it is not necessary to advance the power control to setting 7 before shifting from LOW to DRIVE. In fact, in many cases, an early shift to DRIVE, or even starting off in DRIVE is sufficient for comfortable performance. **Remember, passenger comfort and safety is paramount!**

- Because of the nature of the fluid coupling installed on the Bus, acceleration of the Bus will be gradual but nonetheless reasonable, especially when considering the weight of the Bus. Do not however expect race-car-like acceleration, even with the drive motor operating at full power. If whilst operating in DRIVE, the Bus seems to slow excessively or stop, reduce the drive motor power setting and engage LOW gear. Operate this way until you judge that it is time to up-shift to DRIVE once again.

- Avoid operating the drive motor at maximum power settings for prolonged periods of time. In some cases, high power settings may be required due to grade, however in most cases, operating at the 5^{th} or 6^{th} power setting on the throttle wheel will be sufficient. When in doubt, shift to LOW gear to obtain the required torque from the rear wheels.

- Avoid operating the drive motor at maximum power settings with the rear wheels unloaded (such as when spinning freely). This can cause the drive train (and in particular fluid coupling) to spin at excessive RPM which can shorten the life of these components or cause sudden failure. Bearing in mind that the fluid coupling spins at three times the speed of the drive motor, it approaches approximately 900 RPM when the drive motor is at full power setting, with the rear wheels unloaded.

- Similarly, avoid operating the drive motor at maximum power settings with the rear wheels stalled. This may cause excessive torque in the drive train and undue

stress upon the fluid coupling. If the Bus is not moving with full power applied, shift to LOW gear and try again. In LOW gear, the transmission provides a significant amount of driving force to the rear wheels - if the Bus is still not moving, be sure to stop the drive motor immediately and check around the Bus for signs of excessive obstruction or mechanical trouble (see the 'Troubleshooting' section at the end of this manual for further information)

- Whilst the Bus has reasonable ground clearance, always operate the Bus over the smoothest terrain possible to avoid problems.

- If it is necessary to operate the Bus over rough, soft or uneven terrain, engage LOW gear – this will give you the best chance at powering through any obstacles; do note however that there is an increased chance of bogging over soft terrain whilst operating in LOW gear. The front wheels of the Bus carry equal (if not more) weight than the rear wheels and thus the front wheels may be prone to bogging first when travelling forwards.

- Should the Bus become bogged on soft terrain, consider reversing and attempt to choose another path. Should this not be possible, it may be possible to place objects such as sticks or other pieces of wood, etc under the rear wheels to increase traction. It is recommended to use LOW gear with careful amounts of power in such an instance.

- **In an emergency situation, to stop the rotation of the drive motor as quickly as possible,** press the RED button below throttle wheel on the Remote IR Controller.

5. Post-Operation

Following operation of the Bus, shift the transmission into LOW, stop the drive motor and turn off the main battery.

⚠ Shifting to LOW is very important, as otherwise the Bus may begin to roll away if the ground on which it is parked is not level.

☞ It is recommended to drape a suitably-sized clean cloth over the Bus whilst it is in storage, in order to protect it from dust.

☞ If long periods of storage are anticipated, it is also recommended to disconnect the main battery connector from the Bus' electrical circuit. It is also recommended to place a small catch pan or cloth under the fluid coupling to catch any oil which may seep out during long-term storage (see next section for further information).

6. Maintenance

Some periodic maintenance of the Bus is required, depending on both how often and the manner in which the Bus is used.

The fluid coupling is perhaps the most maintenance-heavy component of the Bus, however with careful operation, this component will last a long time with little trouble.

It is important to note that in the case of any lubrication requirements, less is definitely more, and **only silicone-based oil should be used**.

General Notes

- ☞ After each driving session, wipe down the Bus and its components to ensure dust and dirt do not excessively collect. Pay particular attention to the areas around the fluid coupling and the recesses surrounding the wheels of the Bus.
- ☞ Check the alignment of all gears and shafts within the drivetrain and promptly remove any foreign objects which may be present.
- ☞ Check the condition of the drive belts within the steering and gear-change systems.
- ☞ Occasionally, lubricate (very lightly!) the gears in the gear train. DO NOT OVER-LUBRICATE – A LIGHT SMEAR IS SUFFICIENT

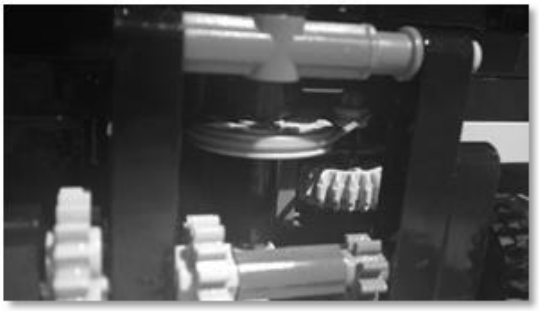


Figure 8: Checking Condition of Gear-change Drive Belt

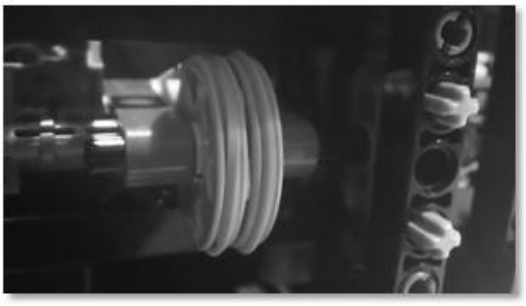


Figure 9: Checking Condition of Steering System Drive Belts

Fluid Coupling

It is normal for the fluid coupling to seep oil over time, particularly if the Bus is subject to rapid temperature changes. The performance of the fluid coupling is such that it can sufficiently operate even with a somewhat low oil level; by design, satisfactory performance is achieved when the fluid coupling is half full. It is NOT recommended to fill beyond this level as excessive fluid leakage via the fluid coupling output shaft will result.

However, depending on the amount of oil lost, it may be necessary to refill any lost oil at periodic intervals to maintain optimum performance of the Bus.

Follow the guidelines below:

- ☞ Depending on the type of fluid coupling case used (transparent or opaque), you may be able to gauge the level of oil in the fluid coupling. If so, try to ensure that the oil level remains immediately under the level of the output shaft at all times. Over-filling will give rise to excessive leaks. Conversely, too-low an oil level will yield poor fluid coupling performance and excessive slippage (normally noticed as poor in-gear acceleration, particularly noticeable when attempting to accelerate in 'DRIVE').
- ☞ If you cannot view or otherwise easily gauge the oil level in the fluid coupling, add oil only when performance of the Bus begins to diminish; e.g. if the Bus no longer 'creeps' forward/backward at minimum drive motor power setting (with the transmission in LOW and on level ground), this may indicate that the fluid-couple oil level is low. Also, if the Bus seems to stall easily whilst operating in DRIVE gear or fail to achieve the speeds it once did over familiar terrain, this may also indicate low fluid coupling oil level.
- ☞ If it's determined that oil needs to be added to the fluid coupling, turn the Bus onto its side, rotate the fluid coupling until the oil fill screw is facing almost vertical, remove the oil fill screw by GENTLY rotating it anti-clockwise with a suitably-sized screwdriver and insert an oil filler tube into the hole in the fluid coupling. USE ONLY 40W SILICON OIL. Using silicon oil of a lower weight may give rise to excessive leaks. Conversely, heavier weight silicon oil will place excessive fluid drag forces on the fluid coupling and reduce its power transmission efficiency.

Figure 10: Removing Fluid Coupling Oil-Fill Screw

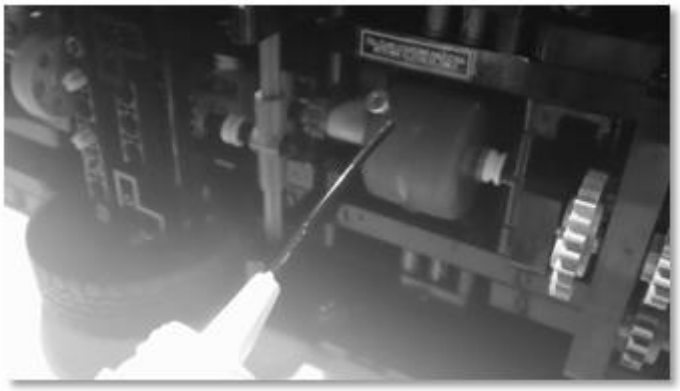


Figure 11: Suitably-sized Oil Fill Container and Nozzle

⚠ **Using a non-silicon based oil (e.g. mineral oil) may cause unpredictable results INCLUDING TOTAL FAILURE OF THE FLUID COUPLING AND SUDDEN LOSS OF ALL FLUID.**

☞ Add oil SLOWLY and watch for excessive leakage from the rear output shaft of the fluid coupling during the fill process. When oil begins to seep out in a steady flow, stop filling immediately and wipe away the excess. Depending on how much you over-filled the fluid coupling, you may need to monitor the leakage for a few moments and repeatedly wipe away the excess which has leaked until the leak stabilises.

☞ Once sufficient oil has been added, replace the oil filler screw by aligning it correctly against the fill hole and GENTLY rotating it clockwise with a screwdriver. 1 – 2 turns of the oil filler screw is sufficient. DO NOT OVERTIGHTEN.

⚠ Before running the Bus, rotate the fluid coupling one complete revolution by hand to ensure that the oil fill screw clears both of chassis

rails either side of it. Always ensure that the oil fill screw is secured fitted before running the Bus, otherwise oil may be flung out of the fluid coupling during operation, causing a great mess and rapid loss of performance.

Tyre Wear

The tyres on the Bus are very robust and should last a very long time. Over time however, and particularly with heavy use, you may notice the tyres wearing on the Bus. In some cases, the inside edge of the tires will wear excessively. To ensure even wear, rotate the tyres appropriately at regular periods and replace any excessive worn or damaged tyres as appropriate.

7. Troubleshooting

Operating troubles with the Bus may be diagnosed and remedied by using the information contained in this section. For best results, follow the steps of the prescribed 'Remedy' in the numbered order with which they appear.

Problem	Remedy
Bus will not move at all	1. Ensure main battery is on and fully charged 2. Ensure Bus is clear of any obstructions 3. Verify correct gear engagement and drive motor power setting (if in doubt, engage LOW gear) 4. Check drivetrain for any binding 5. Add correct oil to the fluid coupling
Bus abnormally slow to accelerate	1. Verify correct gear engagement and drive motor power setting (if in doubt, engage LOW gear) 2. Ensure Bus is clear of any obstructions 3. Check drivetrain for any binding 4. Ensure main battery is fully charged 5. Add correct oil to the fluid coupling
Bus stalls in DRIVE gear – even with full power applied	1. Shift to LOW gear if ground is uneven or not level 2. Ensure Bus is clear of any obstructions 3. Check drivetrain for any binding 4. Add correct oil to the fluid coupling
Bus will not shift gears when gear lever is moved (gear-shift motor can be heard)	1. Ensure main battery is fully charged 2. Operate the drive motor in the opposite rotation direction and try to shift gears again 3. Check drivetrain for any binding 4. Ensure gear-motor drive belt is operational – replace if necessary
Bus will not shift gears when gear lever is moved (gear-shift motor cannot be heard)	1. Ensure main battery is on and fully charged 2. Ensure Remote IR Controller batteries are fully charged 3. Check drivetrain for any binding
Drive motor RPM fluctuates momentarily whilst accelerating, as if the gearbox is slipping	1. Verify correct gear engagement and drive motor power setting (if in doubt, engage LOW gear) 2. Check drivetrain for any binding
Bus will not steer (steering motor can be heard)	1. Ensure main battery is fully charged 2. Ensure steering motor drive belt(s) are operational – replace if necessary
Bus will not steer (steering motor cannot be heard)	1. Ensure main battery is on and fully charged 2. Ensure Remote IR Controller batteries are fully charged 3. Check steering mechanism for any binding