M1 GPRP Guide

Version 1.0 Published: January 2017

TABLE OF CONTENTS

SCOPE

The following document is a description of the Paddle Shift function of the M1 GPRP Package for sequential, dog engagement racing transmissions. This document should be used in conjunction with the Help screens in the M1 Tune application when a GPRP Package is open. The document is based on the release version of GPRP January 2016.

The document is written in several sections based on the suite of sensors available to the paddle shift function. The sensors used for the paddle shift system should be made with consideration to this document at the time of installation.

OVERVIEW

MoTeC have produced a professional motorsport Paddle Shift Package for use with an M1 Engine Management System called GPRP. This Package has taken existing GPR Package with all the comprehensive motorsport features and merging in a tightly coupled Paddle shift system.

By combining the Paddle shift system within the M1 Engine Management System itself, the paddle shift can be more closely timed with ignition, fuel, and throttle events than a standalone system can. This method also allows for all the control and logging of the gear change event to come from one controller.

The GPRP Paddle Shift function is designed to work with switched inputs from driver controls, one input for requesting up shifts and one input for requesting downshifts. The function can also be triggered with analogue paddle position.

The gearbox actuation is via an up-shift output and a down-shift output. The two outputs work independently and only when their specific function is called. There is currently no interaction for a “centring” operation where both outputs work together to rest the gearboxes shift mechanism. There is also no support for “half shifts”, e.g. finding neutral on motorbike style gearboxes.

The actuator outputs can be low side driven to ground or high side driven to the ECU main battery supply. The outputs are not current controlled in any way (no PWM).

The gearbox shift actuator should rotate the gearbox selector barrel for one single gear increase or decrease. The ECU does not have any control over the limits of stroke of the actuator; this should be considered in the mechanical setup of the gearbox shift actuation.

The GPRP Package is designed primarily around an engine with a Drive by Wire throttle. There is currently no support for a cable throttle “blipper” mechanism.

The engine management section of the GPRP Package is the same as the GPR Package so there is no difference from an engine tuning point of view.

FEATURES OF THE GPRP PADDLE SHIFT SYSTEM

The MoTeC GPRP paddle shift system is a sophisticated system that is integrated within the MoTeC Engine Management System. By combining the Engine management and the Paddle shift in one controller, the system can provide high end gearshift features with tight Engine Management controls. Some of the features provided include:

Automatic throttle blipping on Downshift

The GPRP Package has full control over the DBW motor by being built as part of the engine management system. During down shifts, the Paddle shift system blips the throttle to a pre-determined level to unload the gearbox dogs and improve down shift feel.

Engine speed matching on Down and Up shifts

When enabled, the Engine speed matching system controls the engine speed during gear changes. When a change of gear is requested, the current vehicle speed is used to determine what the engine speed is going to need to be at the end of the requested gear change. The ECU uses the Throttle blip or engine cut controls to move the engine speed to the new gears matching engine speed. **Requires working wheel speed sensors.*

Engine Speed over-rev protection

When a down shift is requested, the paddle shift system calculates what the Engine Speed will end up being in the next gear down. If this is going to exceed the Engine Speed limit, then the shift request will be ignored. **Requires working wheel speed sensors*. If you do not have a valid vehicle speed, then *Gear Shift Down engine speed* can be used as a fixed engine speed per gear that ignores downshift requests if the driver tries to shift down above this engine speed.

Closed loop control of gear shift timing

The length of time that a gear shift takes will vary from gear shift to gear shift. Sometimes the gearbox will slip right into the new gear, while at other times it may balk off the next gear dog before going in. The GPRP Package varies the shift time for each gear change by measuring the gear position sensor at high speed, and ending the shift as soon as the new gear has been achieved. The other way to control gear shift timing is an Open Loop system which uses a fixed shift time for the gear change. This time will end up being either too short or too long in most instances. Although this method can be used with an M1, the closed loop method is far better for the gearbox wear and for overall performance.

Automatic gear selection mode

In some instances, a driver may prefer to let the Paddle shift system choose to both up and down shifts at the optimum engine speed. The GPRP Package provides this feature with the ability to set both up and down shift engine speeds for each gear. The auto shifts can always be overridden by a Paddle request. Although this mode can be useful, the downside is that you do not necessarily get the shift happen when you would most like it, so careful consideration of the shift control options needs to be taken.

Configurable engine power reduction strategies

To reduce engine power for a gear shift, the GPRP Package allows for Ignition cut, Fuel cut or Ignition retard. Combinations of the three can also be used to help smooth out changes, and reduce noise on gear changes.

Advanced failure mode control

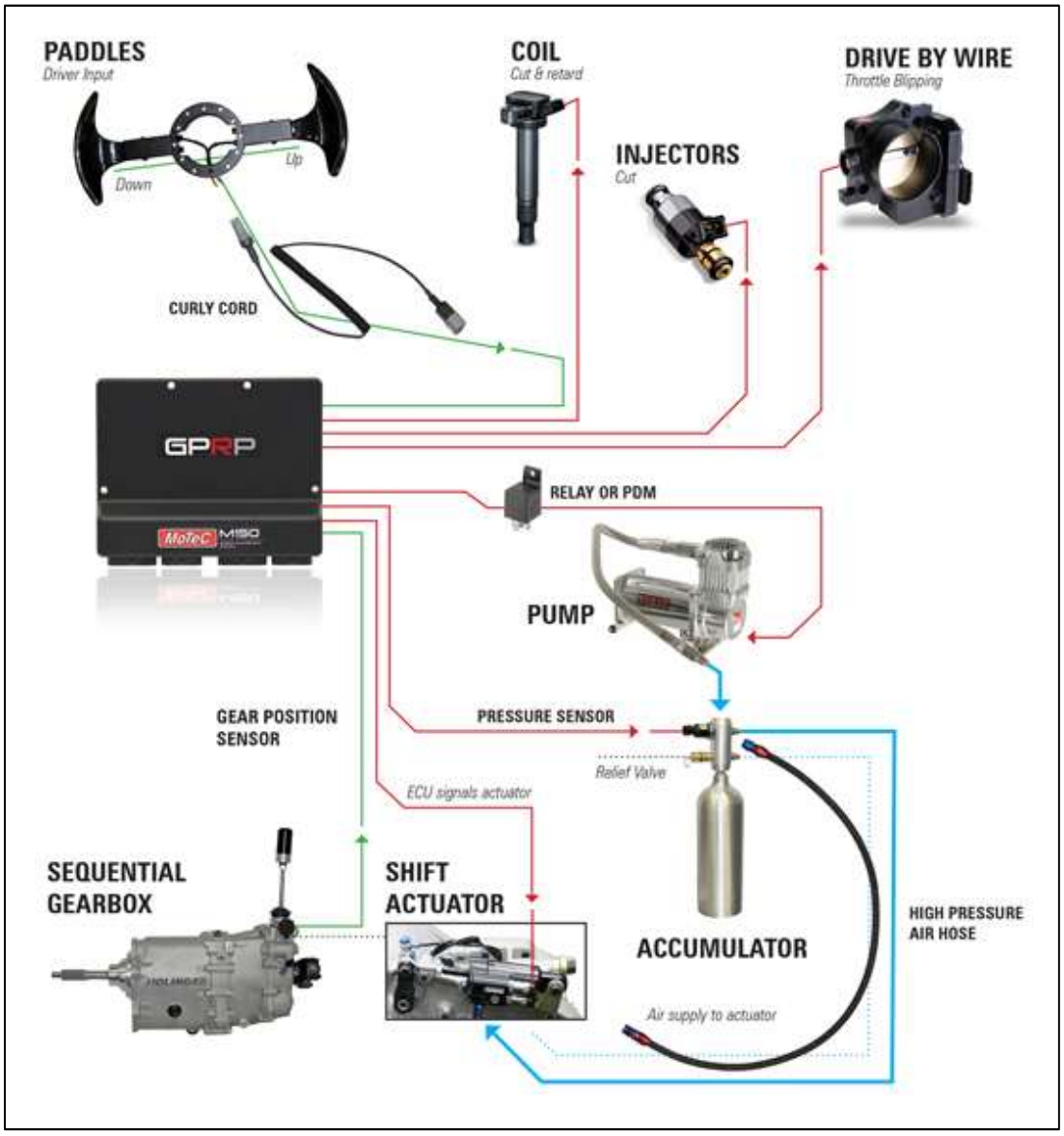
Getting a car to the finish line no matter what has been a corner stone of the GPRP design. The system is aimed at maximum performance when the system is all working properly. When things start to go wrong, such as a sensor or wiring failure, the GPRP system has numerous modes to help the driver get the car to the finish line. Here is a list features, and for what type of failure they are designed to overcome.

- **Redundant gear position sensors** in case of gear position sensor fault
- **Timed air pump control** in case of air pressure sensor fault
- **Automatic shift** mode in case of Paddle fault
- **Paddle fault** mode in case of Paddle trigger fault
- **Fault mode** in case of gear position fault
- **Open loop** fall-back in case of gear position failure

WHAT IS NEEDED?

Diagram of Paddle Shift Components

A Paddle shift system is made up of several components. Some of the parts of this system are mandatory to have a working system. Other parts are Preferable for a quality system, whilst there are some optional parts that if added to the system will improve the overall system operation.



List of Paddle shift components.

Item	Importance	Use of item within GPRP
Up and Down Paddles	Mandatory	Initiate the up or down shift event
Up and Down Actuators	Mandatory	Move the gear change mechanism with compressed air on request
Paddle shift controller (GPRP)	Mandatory	Control the system
Barrel Position Sensor	Mandatory	Measure the gear position
Air pump	Mandatory	Create the air pressure for the shift
Air reservoir	Mandatory	Store the air pressure for the shift
Air Pressure Sensor	Mandatory	Control the pump state to maintain pressure
Clutch Switch	Mandatory	Allow the system to lock out certain changes without a clutch
Drive by Wire throttle	Preferable	Used for downshift throttle blipping
Wheel speeds	Preferable	Used for Engine speed matching
Paddle shift mode dial	Optional	Vary the system between auto, manual and fault modes
Brake State	Optional	Used in Auto shift mode only

Inputs

Gearbox inputs

- **Gear Position Sensor**: This is an analogue sensor that measures the rotational position of a sequential gearbox's selector barrel. Used to determine the exact position of the gearbox selector barrel through the shift process, it is highly recommended that this be fitted. Most modern sequential gearboxes come with these as standard.
- **Gear Shift Mode**: Analogue or CAN input for a multi position switch. Used to change the gearbox operating mode (Manual request to Automatic).

Shift Request inputs

- **Gear Paddle Up Switch**: Digital (on/off) or CAN input used for requesting an up shift
- **Gear Paddle Down Switch**: Digital (on/off) or CAN input used for requesting a down shift.
- **Gear Paddle Position Sensor**: An analogue sensor used to measure the position of a paddle lever that is used for both up and down shift requests.
- **Gear lever**: An analogue strain gauge generally used for measuring the force on the gear lever.

Only one method of requesting a gear shift is required by the Paddle Shift system. If more than one of the above inputs is used the highest priority is placed on the Gear Paddle Position Sensor and the lowest priority is for the Gear Lever channel. These switches can be send over CAN from a MoTeC Dash, but it is recommended that they are directly connected to the M1.

Pneumatic Air Reservoir input

- **Gear Shift Actuator Pressure**: An analogue or CAN input used to measure the pressure in the pneumatic gear shift system. This sensor is used to indicate when the ECU should turn on the Gear Shift Actuator Pump output.

Clutch Input

- **Clutch Pressure**: Analogue or CAN input used to measure the pressure in the clutch system.
- **Clutch Position**: Analogue or CAN input used to measure the position of the clutch pedal or mechanism
- **Clutch Switch**: Digital or CAN switch input used to indicate if the clutch is engaged or disengaged.

Only one method of measuring the clutch is needed for the Paddle Shift system. *This input is required for the correct operation of the **Manual** mode, without a clutch input, only **Fault** mode can be used.*

Brake pressure

- **Brake Pressure Front**: Analogue or CAN input to measure the pressure in the front brake hydraulic circuit.
- **Brake Pressure Rear**: Analogue or CAN input to measure the pressure in the rear brake hydraulic circuit.
- **Brake Switch**: Digital or CAN input used to indicate that the driver is braking

Only one method of measuring the brakes is needed for the Paddle Shift system. The brake state of the vehicle is only used for some automatic shift mode logic and is not required if the shifts are intended to be from driver inputs only.

Wheel Speed inputs

- **Wheel Speed Rear Drive**: Digital or CAN input used to measure the speed from the single source on either the input or output of the final drive.
- **Wheel Speed Rear Left**: Digital or CAN input reading rear left wheel speed directly from that wheel
- **Wheel Speed Rear Right**: Digital or CAN input reading rear right wheel speed directly from that wheel.
- **Wheel Speed Front Drive**: Digital or CAN input used to measure the front drive speed of either a front wheel or four-wheel drive vehicle. Speed measured from either the input or output of the front final drive.
- **Wheel Speed Front Left**: Digital or CAN input reading front left wheel speed directly from that wheel.
- **Wheel Speed Front Right**: Digital or CAN input reading front right wheel speed directly from that wheel.

The most important function of the wheel speeds is to be able to measure the speed of the output of the gearbox for Engine Speed Matching during up and down shifts. While not all sensors are required at once it is highly recommended that at least one source of speed for a driven wheel or shaft is fitted to cars using the GPRP Paddle Shift system.

Wheel Speed Sensor hardware

With the sensors and tone rings, the more teeth on the tone ring the more effectively the wheel speeds will work, as it can detect changes to the wheel speed sooner, and react in a shorter period. GPS Speeds are not suitable for use with the Paddle Shift system, as they are prone to wander when stationary, this can prevent the Paddle Shift system from not operating correctly. These sensors also have a lag in operation when the vehicle speed changes quickly.

If the vehicle originally came with wheel speed sensors and tone rings, then it is recommended that these be used for the sensing of wheel speeds, or retro fitted from another vehicle from the same range that has them. If the vehicle did not have wheel speed sensors standard, and requires them to be manufactured to suit, then the recommendation is to have a minimum of 24 teeth, with 48 or more preferred. The number of teeth that can be used will be restricted by the sensor type used, and the recommended tooth size and spacing for that sensor. The physical space available to mount the sensors and tone rings in will also need to be considered when integrating wheel speed sensors into the vehicle.

If you are adding wheel speed sensors, typically a “Hall Effect” style sensor would be used, as these will give a consistent signal that does not vary in amplitude based on wheel speed.

Warning!

If an existing Antilock Braking System is in the vehicle, the wheel speeds MUST BE generated by the ABS module, not by splicing into the wheel speed sensors directly. Doing so can give false readings to the ABS control module and may result in the failure to operate of the ABS in a braking situation.

Outputs

The ECU will be required to activate outputs to facilitate the actual shifting of the gearbox.

Gearbox Shift Actuator output

- **Gear Shift Actuator Up**: Switched output to activate the up-shift actuator circuit.
- **Gear Shift Actuator Down**: Switched output to activate the down-shift actuator circuit.

The output function for the shift actuators is a timed switch based on control from the Paddle Shift system, no Pulse Width Modulation (PWM) is available.

Actuator Pump output

- Gear Shift Actuator Pump: Switched output for operating the compressor pump. The ECU can control this closed loop with an aim pressure and feedback from the Gear Shift Actuator Pressure sensor or open loop (in case of pressure sensor failure) with a constantly cycling on and off time. This output can also be transmitted over CAN to a PDM if desired.

M1 GPRP Configuration Guide

GEAR SHIFT STATE

This is a quick overview of the different states that the GPR-P Paddle Shift system operates through when the driver requests an Up or Down shift. For a more detailed explanation of the process, and to see the interdependencies that exist in the process, please see the **Gear Shift State** Help section of the **Firmware Help** in M1 Tune.

Upshift Shift Process

Upshift Shift Process - Pre Shift

This state is only active when the **Gear Shift Type** is **Upshift Power Off**. During the **Pre Shift** Stage, the DBW throttle is blipped based on the values set in **Gear Shift Throttle Aim Main** to assist in unloading the gearbox. The **Gear Shift** State will remain in **Pre Shift** for the time specified in the **Gear Shift Timing** table, unless **Gear** changes in this time. If **Gear** changes, the **Gear Shift State** will abort the **Pre Shift** state, skip **Shift**, and go straight to recover state.

No engine speed limiting is used during this state, this is to allow for the engine to effectively introduce a torque change to unload the gears.

With an **Upshift Power On**, the **Pre Shift** state is ignored.

Upshift Shift Process - Shift

This is the actual shift process, when the Actuator is physically moving the selector mechanism of the gearbox. The **Gear Shift State** will remain in **Shift** for either the time specified in the **Gear Shift Timing**, or until **Gear** is changed. The **Gear Shift Throttle Aim Minimum Duration** must have expired. If none of these conditions are met, then retries will be initiated (if greater than 0) until the retries are depleted. Once this occurs, the system will change to **Recover**.

As the M1 is monitoring the voltage output of the **Gear Position Sensor**, and reacts to the change in position shown through this, it is recommended to use a longer than required shift time. Using a shift time such as 150ms, will allow for the M1 to maintain the shift until the gear has changed, and then change S**tate** to **Recover**.

Upshift Shift Process - Recover

During this stage, engine torque is progressively re-applied. The rate that the ignition cut, fuel cut, and ignition retard are phased out is from the **Gear Shift Timing** table on the **Gear Shift Timing Phase** of **Recover**. The Engine Speed limit that was applied during the **Shift** phase is also phased out at this time. The **Gear Shift Engine Speed Limit** phase out rate is configured using the **Gear Shift Engine Speed Limit Ramp** parameter.

Upshift Shift Process - Rearm

This parameter is used to lockout shifts for a period after the shift has completed. Once the timeout period has elapsed, and the **Gear Shift Request** and **Gear Shift Actuator** state are at Idle, **Gear Shift** and **Gear Shift State** return to Idle in readiness for the next shift request.

Upshift Power On

This is an up-shift request made when the **Throttle Position** is greater than **Gear Shift Power On Throttle Position**.

Upshift Power Off

This is an up-shift request made when the **Throttle Position** is less than **Gear Shift Power On Throttle Position**

Idle

The Gear Shift function is enabled with no diagnostic conditions met, and is waiting for an Up-Shift request to occur.

Downshift Shift Process

Downshift Shift Process - Pre Shift

During **Pre Shift**, the M1 is initiating the unloading of the gear box through the use of DBW throttle blip and Ignition timing.

It will stay in this state until the time specified in **Gear Shift Timing** expires, or the **Gear** value changes, as long as the **Gear Shift Throttle Aim Minimum Duration** has expired. If this occurs, then the **Shift** state will be skipped, and the state will become **Post Shift**.

The Fuel and Ignition Cuts, and Ignition Retard setting are active at this point, as long as the current gear is not First, Neutral or Reverse, or the clutch is disengaged. There may also be an engine speed limit in use at this point.

The **Gear Shift Throttle Aim** will change from **Gear Shift Throttle Aim Main** to **Gear Shift Throttle Aim Hold** when the **Gear Shift Throttle Aim Blip Duration** expires, or the Engine Speed reaches the current Engine Speed Limit. This is aborted when **Gear Shift State** changes to **Post Shift**.

Downshift Shift Process - Shift

Gear Shift State remains in **Shift** for the period specified in **Gear Shift Timing**, or until **Gear** changes, **Gear Shift Throttle Aim Minimum Duration** must also have expired for the **Gear Shift State** to change to **Post Shift**.

If **Gear** does not change within the specified period, then the retry process will be initiated, unless the **Gear Shift Mode** is **Fault**.

Engine speed blipping will also be active during this period according to the settings for **Gear Shift Throttle Aim**.

As the M1 is monitoring the voltage output of the **Gear Position Sensor**, and reacts to the change in position shown through this, it is recommended to use a longer than required shift time. Using a shift time such as 150ms, will allow for the M1 to maintain the shift until the gear has changed, and then change S**tate** to **Post Shift**.

Downshift Shift Process - Post Shift

Post Shift is used to reduce the engines torque so that the engine is not pushing the car after a throttle blip event has occurred. This is done using a combination of Fuel and Ignition Cuts, as well as Ignition Retard.

The **Post Shift** period is configured in the **Gear Shift Timing** table.

Downshift Shift Process - Recover

When the **Gear Shift State** is **Recover**, the M1 is reintroducing engine torque in a progressive manner. The **Gear Shift Engine Speed Limit** is phased out using the **Gear Shift Engine Speed Limit Ramp.** The **Gear Shift Ignition Timing Retard** is ramped out to **Ignition Timing Normal.** The Ignition and Fuel Cuts are also ramped out, if they had been active during the **Post Shift** stage.

The Timing for this is set in the **Gear Shift Timing** table.

Downshift Shift Process - Rearm

Rearm allows for the locking out of a further shift request for the time specified, this is to prevent accidental downshifts due to the paddle being bumped.

Downshift Power On

This is a down-shift request made when the **Throttle Position** is greater than **Gear Shift Power On Throttle Position**.

Downshift Power Off

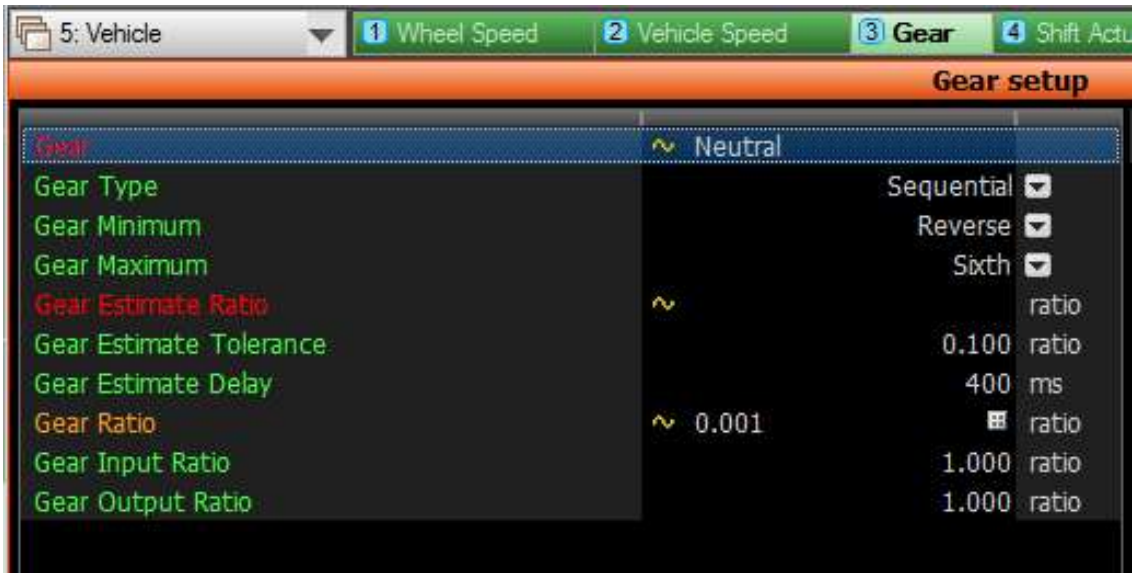
This is a down-shift request made when the **Throttle Position** is less than **Gear Shift Power On Throttle Position**

Idle

The Gear Shift function is enabled with no diagnostic conditions met, and is waiting for a Down Shift request to occur.

GEARBOX DETAILS

There are several parameters specific to the gearbox that must be configured for correct operation of the Paddle Shift system. Failure to correctly setup this information will potentially cause issues with setting up and controlling the Paddle Shift system.



- **Gear Type**: For GPRP the gearbox should always be sequential.
- **Gear Minimum**: The lowest gear the Paddle Shift system is expected to shift to.
- **Gear Maximum**: The highest gear the Paddle Shift system is expected to shift to.
- **Gear Estimate Tolerance**: Part of the whole gear position system is to estimate the gear ratio from Driven Wheel Speed and Engine Speed while in a known gear. The ECU will try to match an estimated gear ratio with one from the **Gear Ratio** table. The tolerance allows some small difference in the ratio calculation. As a starting point calculate the difference between the two closest actual gearbox ratios and then divide by 2. For example, if Fourth gear ratio is 1.220:1 and Fifth is 1.000:1 (the closest two gear ratios) the tolerance would be (1.220 – 1.000)/2 = 0.110, the tolerance would realistically be set to 0.100 or less to give a small break point between the two gears.
- **Gear Ratio**: The individual ratios of each gear in the transmission including reverse. The Default gear can be set to any of the normal forward gears. Neutral can be set to any number as this is ignored in the gear calculations.
- **Gear Input Ratio**: The ratio of any drop gear on the gearbox input. Set to 1 if there is no drop gear set on the gearbox input.
- **Gear Output Ratio**: The ratio of any drop gear on the gearbox output or differential input, this is separate to the differential ratio. Set to 1 if there is no drop gear set.

NOTE: Some gearboxes may have input/output drop gear ratios that do not apply to all gears, e.g. Albins ST6 ”constant mesh” gears. In this case, the Gear Input Ratio or Output Ratio is set to 1 and the actual drop gear ratio is applied to the Gear Ratio table for the specific gears.

GEARBOX POSITION SENSORS

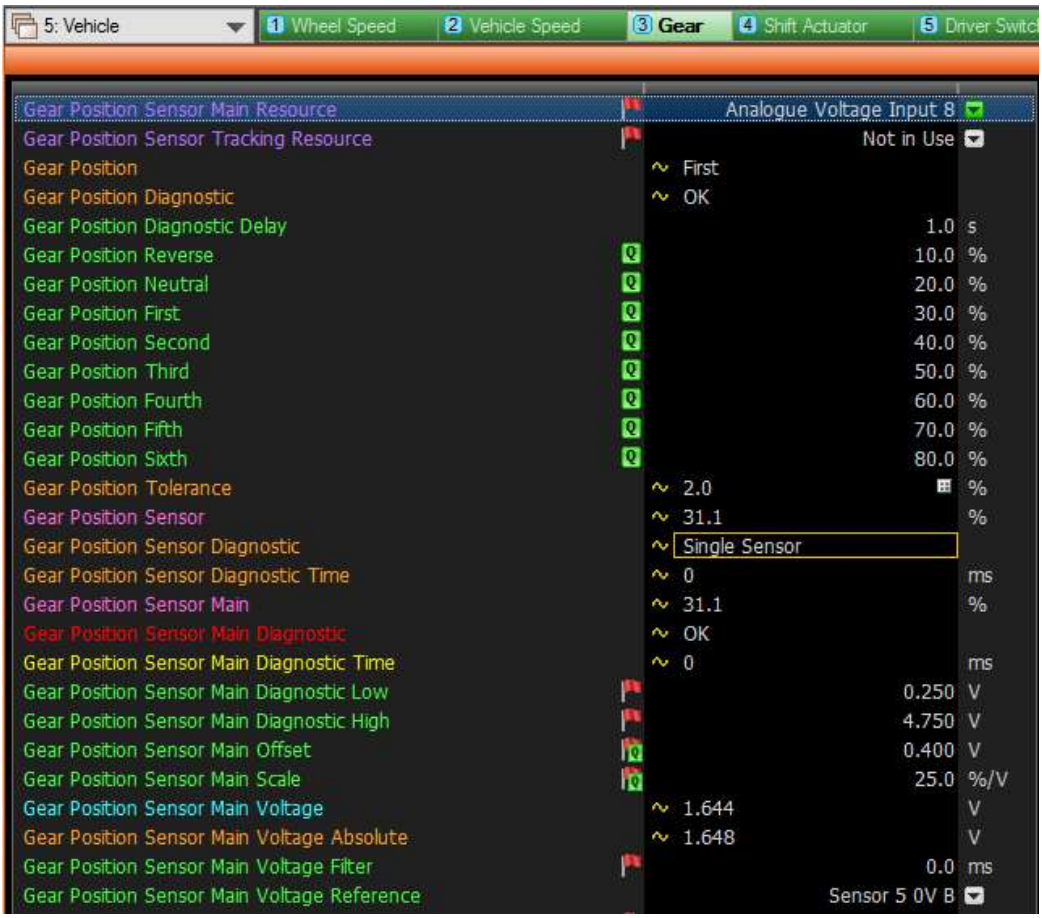
Description

The gearbox position sensor is an analogue rotary position sensor that measures the movement of the selector barrel in a sequential gearbox. The selector barrel rotates when a different gear is being selected and stops once the gear has been fully engaged. The ECU must constantly know where the gearbox selector barrel is, as the paddle shift system times many features based on this position, e.g. the end of a torque reduction event.

In the event of a Gear Sensor Position sensor failure, the M1 will resort back to using the Gear Estimate channel, this is calculated from the available Wheel Speeds and Engine Speed. The Gear Source channel will report where Gear is being generated. If the sensor is working correctly, then Gear and Gear Estimate will be the same.

Installation and calibration

The selector barrel position sensor/s should be wired to Analogue Voltage inputs.



To setup these sensors, physically shift the gearbox to a gear that reads the lowest voltage value (setting the **Gear Shift Mode** to **Fault** will allow for the actuator to be driven directly by the paddle request) and press **Q** in the **Gear Position Sensor Main Offset** parameter, this will set the base voltage for the sensors. Move the gearbox to the gear that reads the highest voltage and then press **Q** in the **Gear Position Sensor Main Scale** Parameter, this will allow the M1 to calculate the percentage scale per volt that the position sensor reads.

Once these parameters have been set, you then setup the individual gears. Preferably starting from either the highest or lowest voltage reading gear in the gearbox, select the matching **Gear Position** parameter and press the **Q** key, this will read the voltage value from the input pin/s, and convert it into a percentage. Do this for each of the gears until all are done.

To accommodate the use of sensors that have dual output channels from the Gear Position Sensor, there is also the Gear Position Sensor Tracking parameters. When this is enabled by the selection of **Gear Position Sensor Tracking Resource**, the Q key function can be used on the Main Offset and Scale values, to also set Offset and Scale for the Tracking sensor. This will also adjust the Diagnostic values for both the Main and Tracking sensors. If the Tracking sensor does not have a linear relationship with the Main sensor, then the **Gear Position Sensor Tracking Linearisation** table is configured to represent this. In the case that there is a difference between the Main and Tracking scales, the Main scale will be given precedence and tracking will be used for diagnostic purposes.

*It is highly recommended that **Gear Position Sensor X Voltage Filter** is left at 0.0ms. Any filtering done on this signal will result in a slower response to the **Gear Position Sensor**. If the signal is noisy, then the cause of that noise should be rectified first.*

DRIVER PADDLES

Description

In general, the shift system will be set up so that the driver can manually request gear changes with paddles mounted on the steering wheel. There are three methods of setting up the paddle system;

- Using two momentary switches, one for up shift requests and one for down shift requests, directly wired into the M1
- Using an analogue sensor (e.g. a linear position sensor) that gives a different reading for up shifts and down shifts.
- CAN into the M1 from a separate device, such as a Dash or CAN Module mounted on a steering wheel.

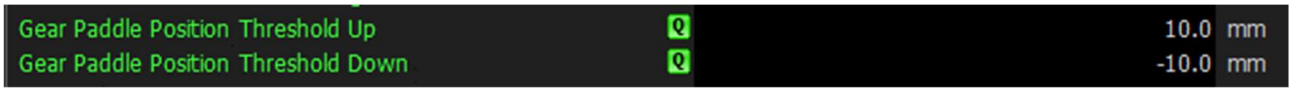
Driver Paddles – Gear Paddle Position Sensor

Gear Paddle Position Sensor Offset: Is the voltage reading of the sensor when the paddles are at rest. The rest value is provided by the **Gear Paddle Position Sensor Target** (This parameter should be set first).

Gear Paddle Position Sensor Scale: Sets how many millimetres travel the sensor does per 1v change in signal. See **Gear Paddle Position Sensor Voltage** live channel. **Gear Paddle Position Sensor Scale** should be set after **Gear Paddle Position Sensor Offset**.

Gear Paddle Position Sensor Target: Is the target reading for the paddles when at rest. In general, this parameter will be set to 0 so, after the Scale and Offset parameters are set, the live channel **Gear Paddle Position Sensor** will read a positive value for one direction of paddle movement, e.g. up shift request and read a negative value for the other direction.

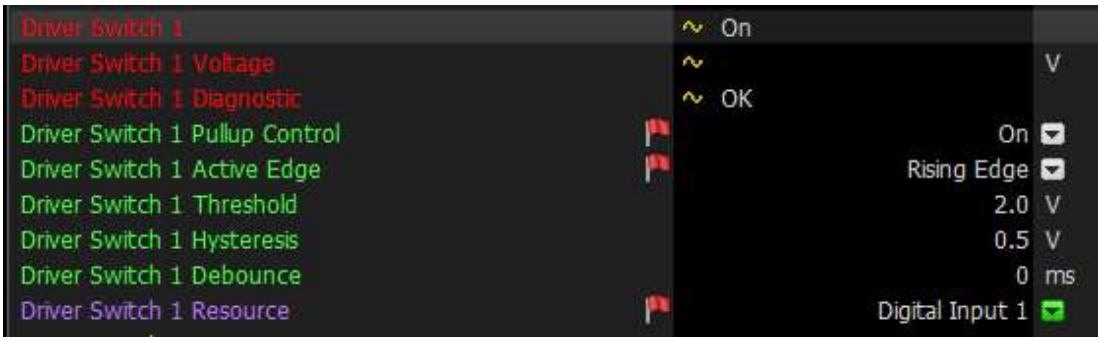
To set the paddle position that will trigger an up shift or down shift. **Search "**paddle threshold" in the same Worksheet.



Gear Paddle Position Threshold Up/Down: Sets the position of the paddle sensor that will request an up or down shift. The live channel **Gear Paddle Position Sensor** can be used to monitor the paddles position to find a comfortable amount of travel to suit the driver and paddle system. This setting also creates the Hysteresis value for the **Gear Paddle Position Sensor Offset**.

Driver Paddles – Separate Up and Down Switch

This method of shift request uses an individual momentary switch, one for up shift and one for down shift. The first step is to start by configuring two Driver Switch channels based on its input type. In this example, the signal input comes from a wired switch on Digital input 1.



This process will need to be repeated for a second driver switch as there needs to be one for up shifts and one for down shifts.

To link these two driver switches to the up and down paddle function go to the **Gear** Worksheet in the **Vehicle** Workbook.

Driver Paddles – Separate Up and Down Switch through CAN

The setup process for the use of CAN inputs is the same as that for the separate up and down switch, with the only difference being that the **Driver Switch *x* Resource** selected is one of the CAN inputs.

For further information regarding the setup of the CAN Inputs, please see the M1 Help for **ECU Receive**

CLUTCH

The clutch channel is used for logic in the gear shift system when entering/exiting reverse or neutral. *While it is not imperative to the system, not having a clutch input will limit the Gear Shift Mode to Fault and not Manual or Automatic. It is highly recommended that a clutch sensor or switch is fitted to be able to access all the features of the GPRP system*. This channel can be transmitted from another device over the CAN Bus if required.

Only one source of clutch needs to be used and can be from **Clutch Switch**, **Clutch Pressure**, or **Clutch Position**. If the user decides to install more than one source for clutch information they will all be considered in the **Clutch State** logic, which ever channel reaches its threshold first will change the **Clutch State**.

Clutch Switch

Clutch Pressure

A clutch pressure sensor can be used to indicate if the clutch is engaged or disengaged in the same way as a clutch switch.

Clutch State Pressure Threshold

The clutch pressure above which the clutch will be disengaged (no clutch drive).

Clutch Position

The clutch position sensor has very similar set up to the clutch pressure so its setup is not specifically detailed in this document.

AIR PRESSURE SYSTEM

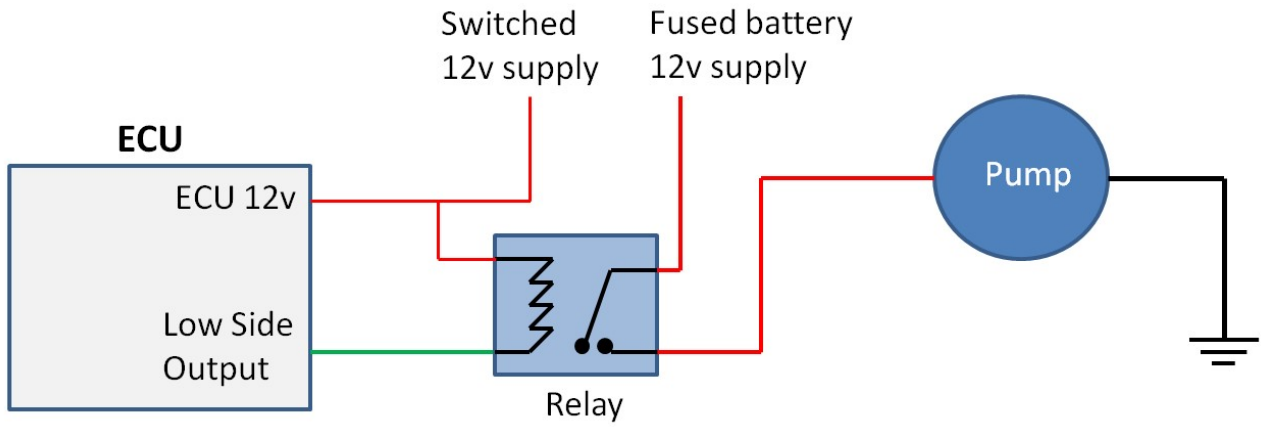
The paddle shift system is generally a pneumatic system so the actuator system pressure is very important to the operation of the system. A pressure sensor for the pneumatic system should be fitted to allow for ECU control of the pressure pump. This channel can be transmitted from a Dash over CAN if required. If another method is managing the pressurized gas/fluid being used for the actuator system this sensor input channel can be ignored.

NOTE: It is important to consult the actuator manufacturer for recommendations as to the pressure threshold that should be used.

ECU OUTPUT SETUP

Actuator pressure pump

The pressure pump output is used to control the compressor/pump used to supply pressurized gas/fluid to the shift actuator system. It is recommended that a relay is used for compressors or pumps that require more than 1.5A continuously. Below is a recommend wiring diagram for the compressor or pump.

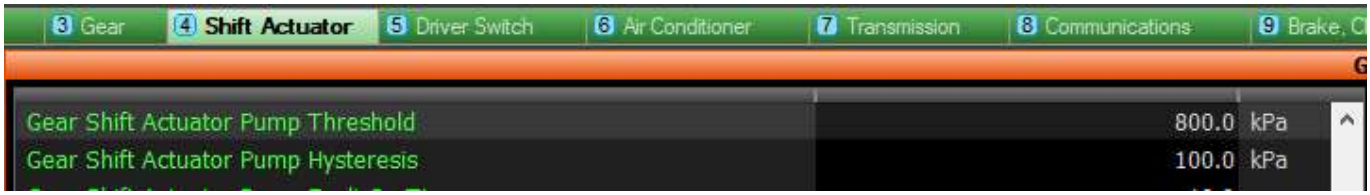


Gear Shift Actuator Pump

The **Gear Shift Actuator Pump Threshold** and **Hysteresis** parameters are used by the GPRP Package to set the aim pressure for the Gear Shift system.

Gear Shift Actuator Pump Threshold sets the lower pressure limit parameter for the pressure system, when the system pressure drops below this point, it will activate the pump.

Gear Shift Actuator Pump Hysteresis is added onto the **Gear Shift Pump Threshold** to generate the upper pressure limit for the pressure in the system, when the value is exceeded, the pump will be deactivated.



Gear Shift Actuator Pressure Fault Pump On/Off Time

If there is a fault with the pressure sensor the ECU will lose the ability to accurately control the on/off switching of the pressure pump. The On/Off Time parameters allow the ECU to cycle the pump on/off to attempt to maintain good actuator system pressure. Logging of the characteristics of the actuator pressure behaviour can be used to gauge what the fault times should be. It is highly recommended that the actuator pressure system should always be fitted with an over pressure relief valve set to just above normal system pressure.

Shift Actuators

The shift system requires two outputs to be setup, one for up shifts and one for downshifts. At the time of writing there is no provision for any clutch actuation.

The commercially available pneumatic shift actuators should only use a small amount of current to activate so can be wired directly to the ECU outputs. As an example, the Holinger shift actuator valves only draw 1A which is well within the capacity of the ECU outputs.

If any other sort of actuator is used, e.g. electric solenoid, the current draw should be tested, anything over 2A should be used with a relay. Solid state relays are recommended to be used to maintain actuation speed.

M1 GPRP Setup Process

GEAR SHIFT SETUP PROCESS

The major part of the setup for a gear shift system will be in the **Gear Shift** Worksheet of the **Race Functions** Workbook. This is the section of the setup where the tuning work will be done to make the shift system work properly.

Gear Shift Timing

The overall timing for the Gear Shift process is configured through the **Gear Shift Timing** tables.

With the **Up Shift Power On** and **Up Shift Power Off** tables, as **Post Shift** is not used in either of these two shift states, the timing values can be set to zero. This also applies to **Pre Shift** for the **Up Shift Power On**. Setting any of the other values to zero will disable them.

You may also want to have a longer recover period specified for the lower gears to slow the transition out of the torque reduction of the **Shift** mode to minimise traction loss that may occur.

The values supplied here are suggested starting values for the various tables. Dependent on vehicle and driver preferences, they may need to be fine-tuned to suit.

Gear Shift Timing - Up Shift Power On

	Default	Reverse	Neutral	First	Second	Third	Fourth	Fifth	Sixth	Seventh
Rearm	100	100	100	100	100	100	100	100	100	100
Recover	100	100	100	100	50	50	30	20	20	20
Post Shift	0	0	0	0	0	0	0	0	0	0
Shift	150	150	150	150	150	150	150	150	150	150
Pre Shift	0	0	0	0	0	0	0	0	0	0

Gear Shift Timing - Up Shift Power Off

	Default	Reverse	Neutral	First	Second	Third	Fourth	Fifth	Sixth	Seventh
Rearm	100	100	100	100	100	100	100	100	100	100
Recover	100	100	100	100	100	100	100	100	100	100
Post Shift	0	0	0	0	0	0	0	0	0	0
Shift	150	150	150	150	150	150	150	150	150	150
Pre Shift	60	60	60	60	60	60	60	60	60	60

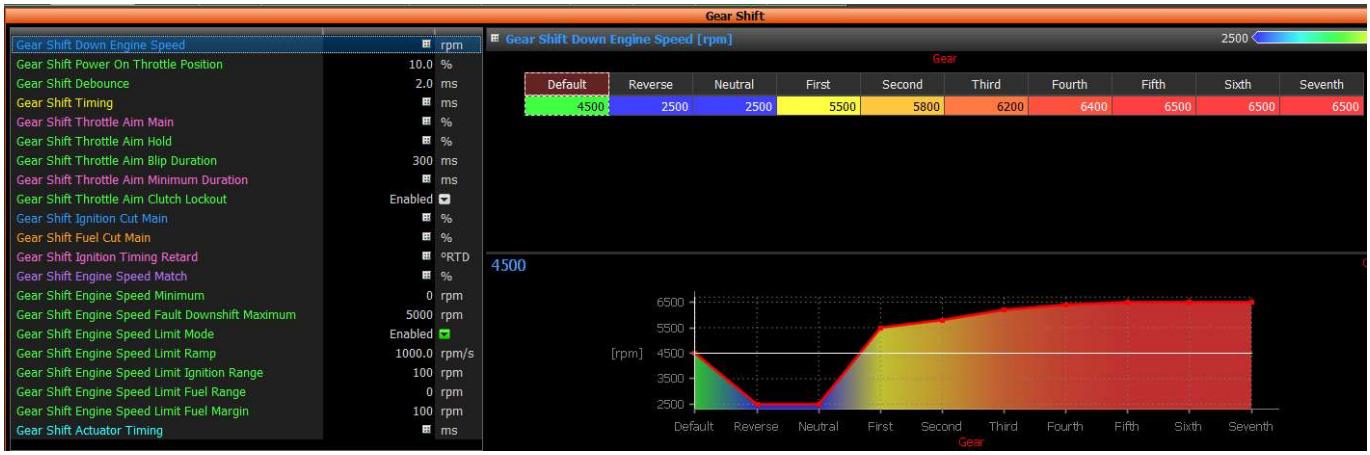
Gear Shift Timing - Down Shift Power On

	Default	Reverse	Neutral	First	Second	Third	Fourth	Fifth	Sixth	Seventh
Rearm	150	150	150	150	150	150	150	150	150	150
Recover	100	100	100	150	133	117	100	100	100	100
Post Shift	40	40	40	40	40	40	40	40	40	40
Shift	150	150	150	150	150	150	150	150	150	150
Pre Shift	60	60	60	60	60	60	60	60	60	60

Gear Shift Timing - Down Shift Power Off

	Default	Reverse	Neutral	First	Second	Third	Fourth	Fifth	Sixth	Seventh
Rearm	100	100	100	100	100	100	100	100	100	100
Recover	100	100	100	150	133	117	100	100	100	100
Post Shift	60	60	60	60	60	60	60	60	60	60
Shift	150	150	150	150	150	150	150	150	150	150
Pre Shift	40	40	40	40	40	40	40	40	40	40

Gear Shift Down Engine Speed



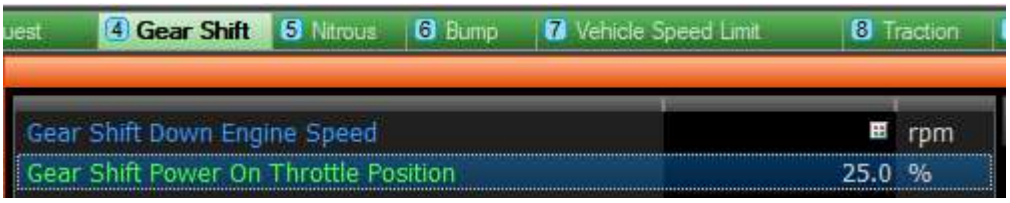
The **Gear Shift Down Engine Speed** table sets the maximum Engine Speed for a down change. If the Engine Speed is above the table value for the current gear a down shift cannot be made, for example, in the above picture the driver is in Forth gear (represented on the table with the yellow arrow) and the table value is 6750rpm, the driver is not able to make the forth to third downshift until the engine speed is lower than 6750rpm.

The table is used to ensure that the driver cannot down change too early and run the engine to high Engine Speeds potentially damaging the engine. Some driver education is necessary as they may feel the paddle system is not working sometimes if they are trying to down change to early.

The **Gear Shift** channel should be logged, if the driver is trying to downshift at too high an Engine Speed for the **Gear Shift Down Engine Speed** the **Gear Shift** channel will report a state of **Lockout**.

A starting point for this table can be calculated from knowledge of the gear ratios and the maximum allowable engine speed.

Gear Shift Power On Throttle Position

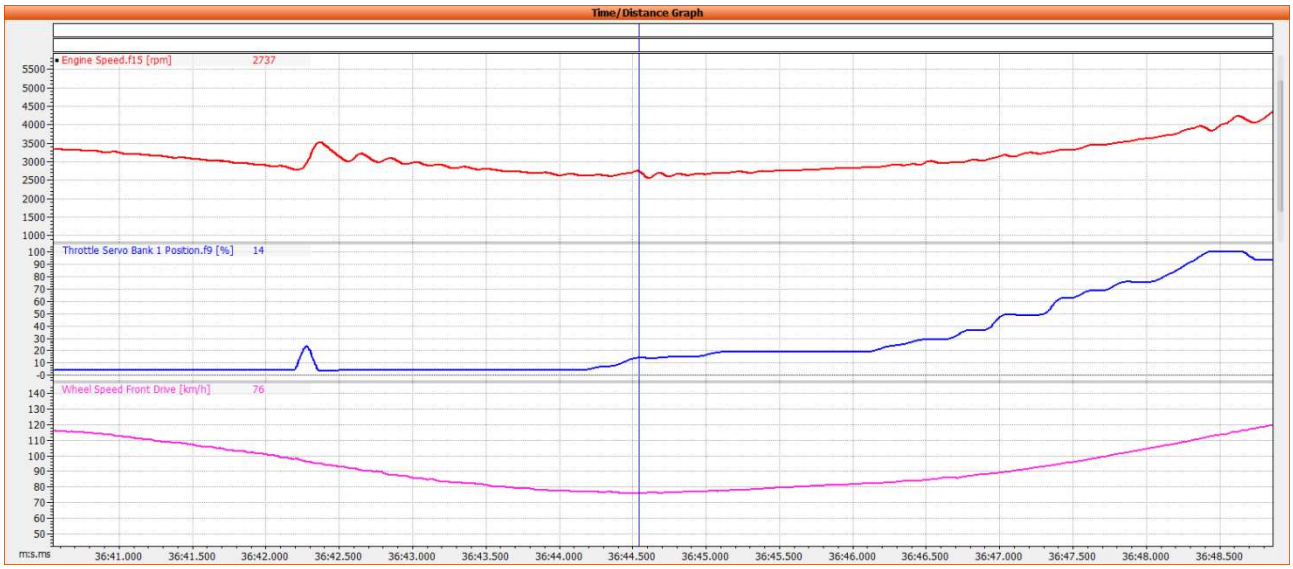


This parameter is used to determine what the **Gear Shift Type** is. The ECU has four types of gear shift:

- **Power On Up Shift**
- **Power Off Up Shift**
- **Power On Down Shift**
- **Power Off Down Shift**

The **Gear Shift Power On Throttle Position** needs to be set so that the ECU will correctly choose between the Power On and Power Off states for the up and down changes.

From logging in this example, the wheel speed (pink trace) begins to climb at 14% throttle (blue trace), there is also a characteristic “bounce” in the Engine Speed (red trace) trace as the gearbox dog teeth change from the overrun side to the drive side.



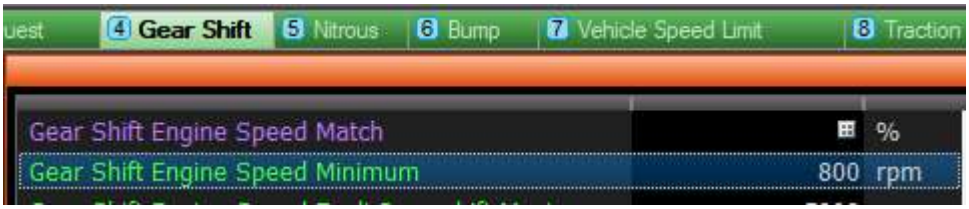
This would be a good starting point for **Gear Shift Power On Throttle Position**, slightly more may be used to ensure a good definition between Power On and Power Off.

Gear Shift Debounce

The Debounce is used as a basic filter to ensure that the driver cannot accidentally request more than one gear shift at a time, e.g. if they still have pressure on the shift paddle and the car is driving on a rough surface.

The **Gear Shift Debounce** should be set so that multiple up shifts cannot accidentally be requested but also low enough that the driver can still short shift two gears if it is needed. The maximum time will need to be longer than the time taken for one complete gear shift. A suggested starting point would be 150-200msecs.

Gear Shift Engine Speed Minimum



The Engine Speed must be greater than **Gear Shift Engine Speed Minimum** otherwise the gear shift request will be ignored. If the engine is not running, Engine Speed is zero, this parameter will be ignored so that shifts can still be made, for example when the driver may have spun and then stalled the engine in a high gear they will still be able to shift down to a more appropriate gear to get back onto the track.

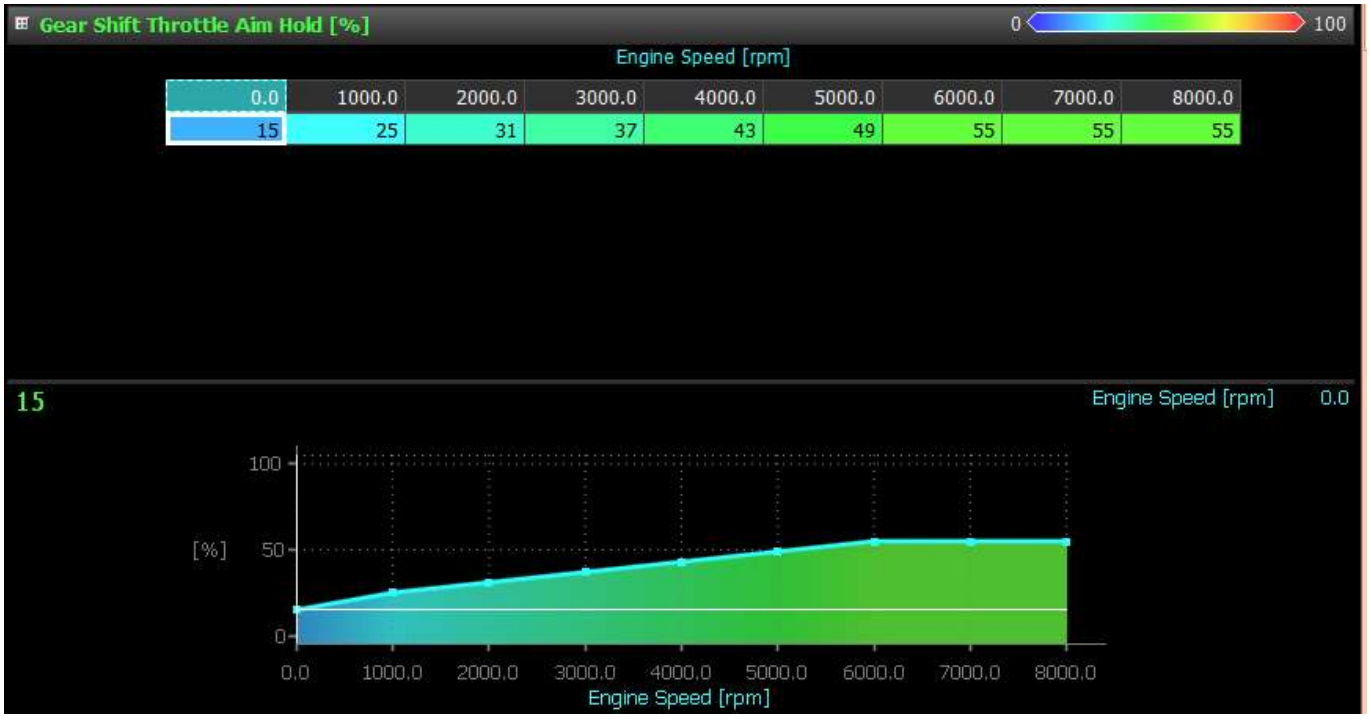
As a suggested starting point the **Gear Shift Engine Speed Minimum** can be set 100rpm below the idle engine speed.

Gear Shift Throttle Aim Main

The GPRP Package is primarily designed to work with Throttle Servos (Drive by Wire throttles) the **Gear Shift Throttle Aim Main** sets where the throttle servo is driven to when torque needs to be added for a shift, generally known as a throttle “blip”.

The amount of throttle opening should be set to ensure the engine can respond quickly enough. If using the **Gear Shift Engine Speed Limit Mode** (detailed in this document) the blip amount can effectively be more than would be necessary to match the Engine Speed on a down shift, the **Gear Shift Engine Speed Limit** would control the Engine Speed to the correct amount. If the **Gear Shift Mode** is **Fault** the **Gear Shift Engine Speed Limit** function will be disabled so the **Gear Shift Throttle Aim Main** table will need to be set more precisely, one suggestion would be use data from a similar engine combination and looking at the amount of throttle the driver was using on downshifts with the “heel and toe” method.

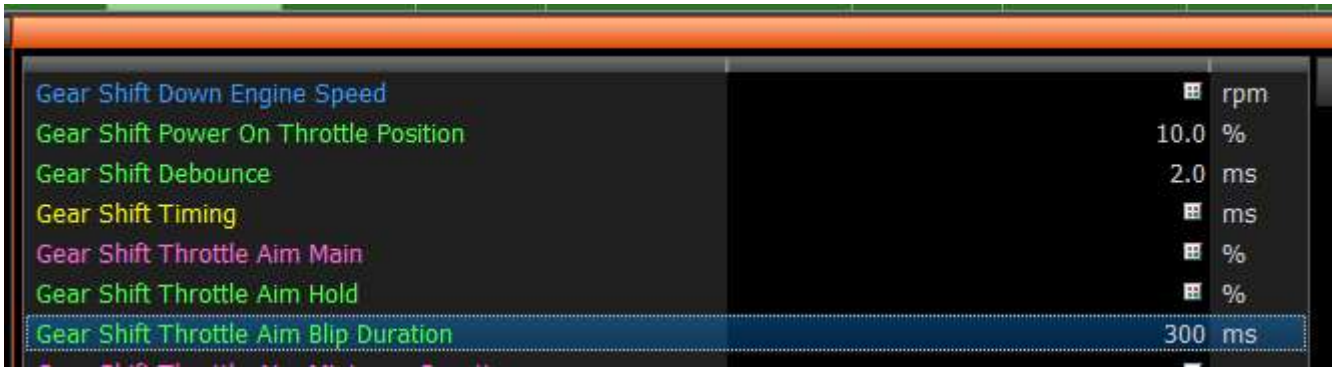
Gear Shift Throttle Aim Hold



In some cases, the initial throttle blip duration may not be enough to complete the shift. The **Gear Shift Throttle Aim Hold** is used when the throttle opening time is extended by the gear shift function. For example, when an initial downshift attempt has failed and the Gear Shift system has retried the shift, the throttle will only blip to the **Gear Shift Throttle Aim** position for a maximum time specified by the **Gear Shift Throttle Aim Blip Duration**. When the **Gear Shift Throttle Aim Blip Duration** has timed out the throttle position will drop to the **Gear Shift Throttle Aim Hold** until the completion of the retries and the **Gear Shift State** goes to **Post Shift**.

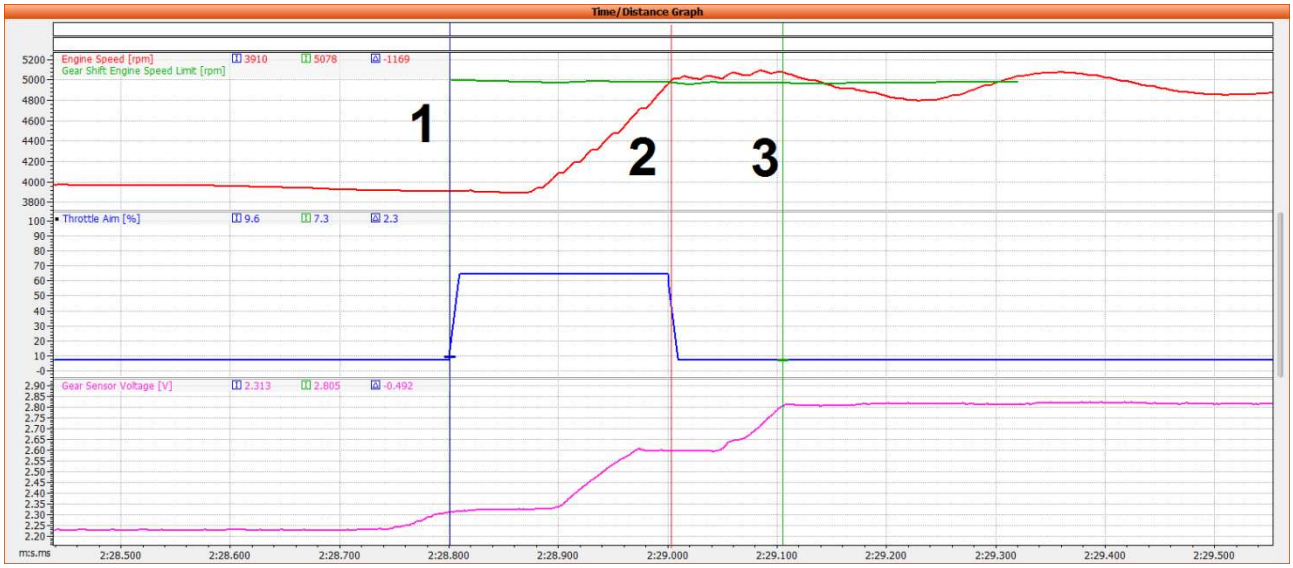
As a starting point, the **Gear Shift Throttle Aim Hold** table can be set to the Throttle Position that maintains the Engine Speed for the specific table site. In the above table, the 25% setting for the 4000rpm Engine Speed site would suggest that 25% is enough to maintain 4000rpm on the engine.

Gear Shift Throttle Aim Blip Duration



When the throttle is blipped for a **Power Off Down Shift** the throttle will move to **the Gear Shift Throttle Aim Main** position for a maximum allowable time as specified by the **Gear Shift Throttle Aim Blip Duration**. The throttle can remain in this position until the new gear is achieved and the **Gear Shift State** has changed to **Post Shift** and will then drop to the normal position as specified by the throttle pedal. The throttle can also remain in the **Gear Shift Throttle Aim Main** position until the Engine Speed reaches the **Gear Shift Engine Speed Limit** if this happens before the next gear is achieved the throttle position will drop to the **Gear Shift Throttle Aim Hold** the next gear is achieved or the gear shift event times out (reaches maximum retries).

The recommended starting point would be a slightly time longer than it takes to achieve the required **Gear Shift Engine Speed Limit**. In the diagram below it can be seen that Throttle Aim (blue trace) at point 1 starts at the beginning of the shift, shortly after the Engine Speed (red trace) reaches the **Gear Shift Engine Speed Limit** (green trace) at point 2. The setting in the ECU was set to finish at point 3 which allows enough extra time for the shift to be completed in the event of any problems, the ECU will automatically shorten the time if the correct Gear or Engine Speed Limit is achieved earlier.

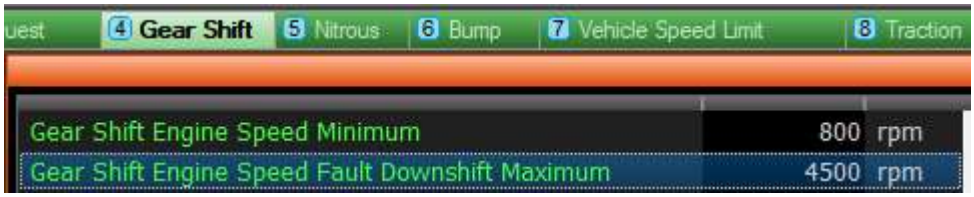


Gear Shift Actuator Retry Maximum

This sets how many times the ECU will retry a gear shift if it fails on the first attempt. 3 retries is a good starting point but if the number needs to be increased it would be advisable to work out where the shifting problem lies, it may be a timing issue for example.

Gear Shift Engine Speed Fault Downshift Maximum

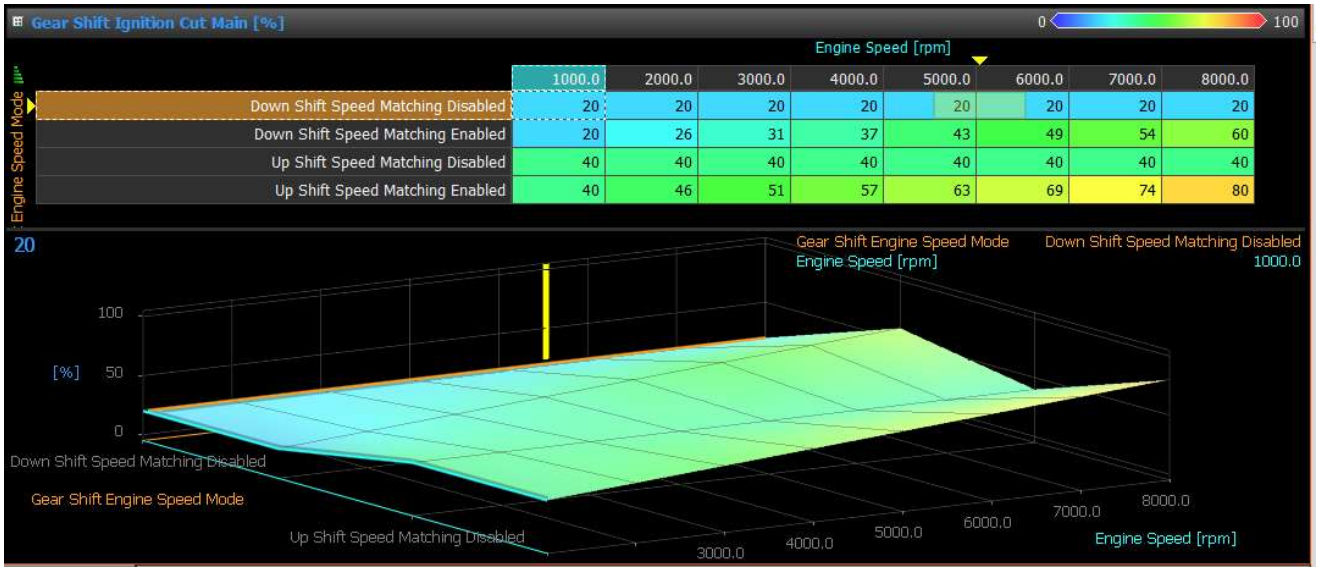
If the **Gear Shift Mode** is **Fault** then the normal gear calculations are ignored so the **Gear Shift Engine Speed Fault Downshift Maximum** is used as the logic for accepting a downshift request. This value should be set at a suitable level to avoid downshifting when the Engine Speed will be well beyond the Engine Speed Limit. Some driver education is recommended to avoid any reports of the shift system not working or being inconsistent.



Gear Shift Ignition Cut Main

This table sets the amount of Ignition Cut that will be used any time it is required for the shift system. This includes Pre-Blip and Post Blip periods.

NOTE: If the **Gear Shift Engine Speed Limit Mode** is active it may request cut levels higher than the **Gear Shift Ignition Cut Calibration** table, this is to maintain the engine speed matching.



Gear Shift Request Delay Reverse

The **Gear Paddle** or **Lever** must be held in the **Down** position for this amount of time before a request to shift from Neutral to Reverse is accepted.

2 seconds is a recommended value.

GEAR SHIFT MODE

The operating mode of the Paddle Shift System.

The **Mode** value is set by the position of **Gear Shift Mode Switch Override.**

Gear Shift Mode is solely defined by the **Gear Shift Mode Switch** when **Gear Shift Mode Switch Override** is **None**. In the case of a fault, such as the gear position sensor or paddles, the **Gear Shift Mode Switch** must be changed to react to the fault condition.

If the **Gear Shift Mode Switch Override** is in **When Fault**, the gear shift control system will automatically react to fault conditions.

- **Gear Shift Mode** changes to **Fault** if **Gear** is **Default**, and the current gear cannot be determined.
- **Gear Shift Mode** changes to **Paddle Fault** when **Gear Paddle Fault** and **Gear Lever** Diagnostic is **No Valid Input** or **Not in Use.**
- And **Gear Shift Request Automatic Mode** is **Enabled**.

When **Gear Shift Mode Switch Override** is NOT **None** or **When Fault**, **Gear Shift Mode Switch Override** sets the mode, **Gear Shift Mode Switch** is ignored and the selected mode will not be changed in case of faults.

When Fault** is the recommended mode for the **Gear Shift Mode** setting, if no **Gear Shift Mode Switch** is installed. If a **Gear Shift Mode Switch** is installed, then the **Gear Shift Mode** should be set to **None.

Description of Modes

Manual

- **Gear Shift Request** is determined by the paddles or lever as reported by **Gear Shift Request Manual**, **Gear Shift Request Automatic** is not considered.
- Closed Loop control of the gear shift is enabled; the gear shift phase will be terminated when the gear has changed (or the **Gear Shift Timing** is expired)
- Actuator performs retries (if set) if gear shift is not successful.

Automatic

- **Gear Shift Request** considers **Gear Shift Request Automatic** as well as **Gear Shift Request Manual**.
- Closed Loop control of the gear shift is enabled; the gear shift phase will be terminated when the gear has changed (or the **Gear Shift Timing** is expired)
- Actuator performs retries (if set) if gear shift is not successful.

Paddle Fault

- **Gear Shift Request** only considers **Gear Shift Request Automatic**, the gear shift paddles and lever as reported by **Gear Shift Request Manual** are ignored.
- It is not possible to shift into Neutral or Reverse
- Closed Loop control of the gear shift is enabled; the gear shift phase will be terminated when the gear has changed (or the **Gear Shift Timing** is expired)
- Actuator performs retries (if set) if gear shift is not successful.

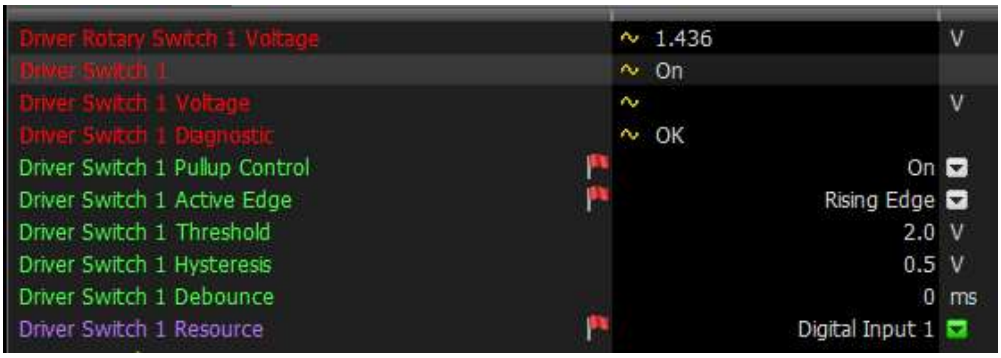
Fault

- **Gear Shift Request** only considers the gear shift paddles and lever as reported by **Gear Shift Request Manual**. **Gear Shift Request Automatic** is not considered.
- Every paddle shift request will be processed, **Gear** information is not considered.
- Neutral and Reverse lockouts are disabled.
- Gear shift Timing is in Open Loop, all timings are based on the **Gear Shift Timing** table.
- No Gear Shift related Engine Speed Limits are enabled.
- No retries are performed.

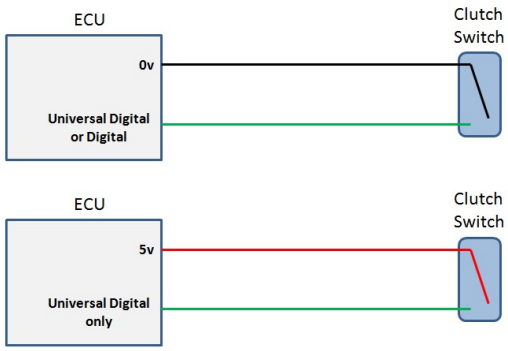
Disabled

- No gear shift will be processed, Gear Lever, Gear Paddle and Gear Shift Request Automatic will be ignored.
- No gear shifts will be processed, Gear Lever, Gear Paddle and Gear Shift Request Automatic will be ignored.
- Gear Shift Request Automatic

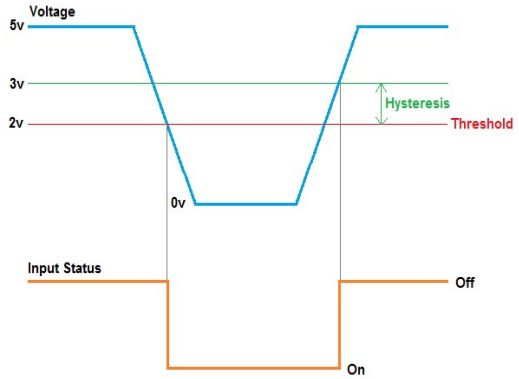
DRIVER SWITCHES



- **Driver Switch 1 Pullup Control**: In general a switch will be wired with a Digital or Udig input switching to 0v. Using this wiring method, the **Pullup Control** must be set to On. The pullup will link an internal 1000ohm resistor to 5v allowing the circuit to work. If the Digital or Udig input is to be switched to a voltage, e.g. 5v or 12v the pullup control can be set to Off.



- **Driver Switch 1 Active Edge**: Sets the polarity of the switching logic. For the example above where the Udig input is pulled up to 5v the input will sit at 5v when the switch/paddle is not being pressed, when the driver presses the switch/paddle the voltage will instantly fall to 0v, this is therefore the edge that should be triggered on. If the pullup control is off and the button/paddle pressed the voltage will instantly rise to the supply level so the setting would be Rising Edge.
- **Driver Switch 1 Threshold**: The input will turn on when the input pin voltage passes this value.
- **Driver Switch 1 Hysteresis**: The input will turn off when the voltage deviates from threshold voltage by this amount. See diagram below.



- **Driver Switch 1 Debounce**: The amount of time the switched signal must exceed before it is accepted. If good quality switches are used and there is no noise induced on the wiring this time can be 0.
- **Driver Switch 1 Resource**: Specifies which input pin is being used for the switched channel.

TROUBLESHOOTING

Problem	Causes	Remedy
Gearbox will not shift in/out of Neutral	• Clutch Switch not installed/configured	• Install/Configure Clutch Switch • Use **Fault** mode
I can upshift, but not downshift	• Traction Control Engine Speed Limit preventing Engine Speed Matching	• Change TC Engine Speed Limit
Gear Position doesn't match actual gear	• Incorrect calibration of Gear Position Sensor/s • Gear Ratio's incorrectly setup • Vehicle Speed incorrect	• Redo Calibration of Gear Position Sensor/s • Ensure that ratios are correct • Calibrate Vehicle speed
Cannot Select Reverse	• Driver is requesting Reverse, but request is ignored as Gear Shift Request Delay Reverse time has not been exceeded	• Driver needs to hold Down Paddle for longer than Gear Shift Request Delay Reverse time.

GLOSSARY

- **XX Sensor Main Voltage Filter**: Filter time constant for the analogue voltage input. It is recommended that this remains at the default setting of 0ms. If the sensor signal is noisy then this number can be increased (10ms-20ms). Over filtering of the signal will delay the reading of the value and will adversely affect the operation of the function.
- **XX Sensor Main Voltage Reference**: 5v sensor supply that was used to power the sensor. The Absolute setting can be used for sensors that have their own internal voltage regulator.
- **XX Sensor Main Resource**: Assigns the input pin that the sensor has been wired to.
- **Gear Position Reverse – Seventh**: Sets the fully engaged scale reading for each specific gear. To set each parameter the laptop must be connected to the ECU in the car. Highlight the desired gear, e.g. reverse, and select that gear then press "Q". This will set the current scale reading to that gear. Repeat this process for each gear. The live reading of **Gear Position Sensor Main Voltage** can be seen if the live channel readings are turned on using by clicking the yellow tilde symbol (~).
- **XX Sensor Main Offset**: This is the lowest valid voltage reading provided by the **XX Sensor Main Voltage**. This is used as a starting point for the **XX Sensor Scale** values and is also used to set the **XX Sensor Main Diagnostic Low** value.
- **XX Main Scale**: This is the highest valid voltage reading provided by the **XX Main Sensor**. This provides a normalised linear reading of %/V so if the highest value read is 4.5V, and the Offset value is 0.5V, then the scale will calculate out to 25%/V. This value is required to be set before setting the Gear Position scales, otherwise the scale values will not set properly. This is used for setting the **XX Sensor Main Diagnostic High** value.
- **XX Sensor Main Diagnostic Low** and **Diagnostic High**: If the sensor voltage is outside the bounds of these two parameters for longer than the Gear Sensor Diagnostic Delay it is considered to be in fault. These parameters may need to be adjusted to suit the specific sensor used on the gearbox.
- **XX Diagnostic Delay**: Used for detecting if either the sensor is faulty or in an invalid position. Use **XX Diagnostic** live channel to look for details on the Sensor channel status.
- **XX Tolerance**: This table sets the tolerance range for a specific gear. For example, if **Gear Position Third** is set to 50% and the tolerance for that gear is 2%, third gear will be considered to be valid from 48% to 52%. The tolerance can be specified for each gear individually. The tolerance should be set so that the dog tooth engagement is still within the bounds of the taper and not the back cut on the top of the dog tooth, i.e. adding engine torque will further engage the gear not push the dog ring out of engagement.

DIAGNOSTIC LOGGING SETUP

It is highly recommended that at least Level 2 Logging is enabled to make setup and diagnostics easier. Below is a list of channels that should be logged. A suggestion would be to log each channel at their highest allowable rate during initial setup.

- Engine Speed
- Gear Shift Engine Speed Limit
- Throttle Pedal
- Throttle Position
- Throttle Aim
- Throttle Aim State
- Manifold Pressure
- Gear
- Gear Estimate
- Gear Sensor Voltage
- Gear Shift Actuator Pressure
- Gear Shift Actuator Pump State
- Wheel Speed Front Drive
- Wheel Speed Rear Drive
- Vehicle Speed
- Vehicle Speed State
- Gear Ratio
- Gear Estimate Ratio
- Clutch State
- Paddle Up Switch
- Paddle Down Switch
- Gear Paddle Position Sensor (if an analogue sensor is used instead of two switched inputs)
- Gear Paddle
- Gear Shift State
- Gear Shift Mode
- Gear Shift Result
- Gear Shift Type
- Gear Shift Ignition Cut
- Ignition Output Cut Average
- Ignition Output Cut Count
- Gear Shift Fuel Cut
- Fuel Output Cut Average
- Fuel Output Cut Count
- Ignition Timing
- Gear Shift Actuator State