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Function : Gear Shift

Version : 1.0

This quick reference document is drawn up with the aim to be simple and fast for user consultation, assisting the user or technician in their calibration work.

Will not be in-depth concepts considered fundamental, technical control, PID logic and procedures for writing data or parameters.

This document is the reference for the STRATEGIES section of the control firmware only.

Mectronik not be responsible for all the effects resulting from the calibrations performed by the user using the tools provided, of not achieved competitive results or not achieved goals. The user is always suggested to verify through simulation, the effect of the calibrations on control algorithms.

IN THE DRIVE BY WIRE SYSTEM, THE INCONSISTENCY OF CERTAIN PARAMETERS REGARDING THE MANAGEMENT OF THE THROTTLE BODY, MAY DETERMINE NOT ITENDED AND UNCONTROLLED EVENTS. THE USER ASSUMES THE FULL RESPONSIBILITY WHEN USING ANY TOOL ABLE TO MODIFY CALIBRATION PARAMETERS.

In cases where it is deemed useful to verify through simulation actions resulting from the changes made to the data, and not being in possession of the appropriate tools, contact technical service.

INTRODUCTION

An advanced Gear-Shift strategy is included in this applications .

All applications support Gear Shift UP , and Gear Shift DOWN is supported only by World Super Sport , KIT and STOCK firmware.

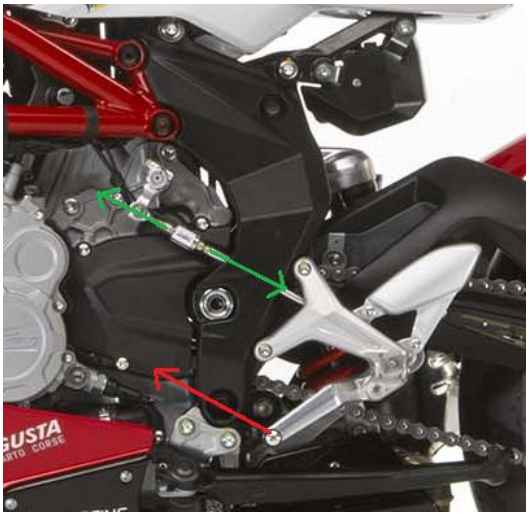
ECU is able to work with many different kind of sensors , and many different leverage .

To complete Your setup You need to follow this simple steps :

1. Install Your sensor and leverage (in case You change the leverage)
2. Configure Your sensor
3. Configure the strategies

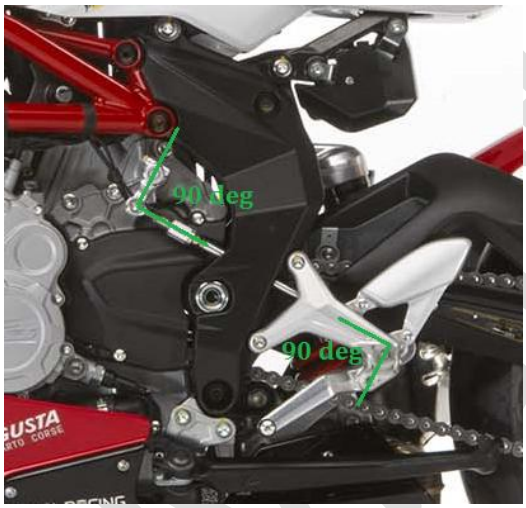
1 INSTALL YOUR SENSOR AND LEVERAGE

Here You have and image of standard leverage with standard sensor .

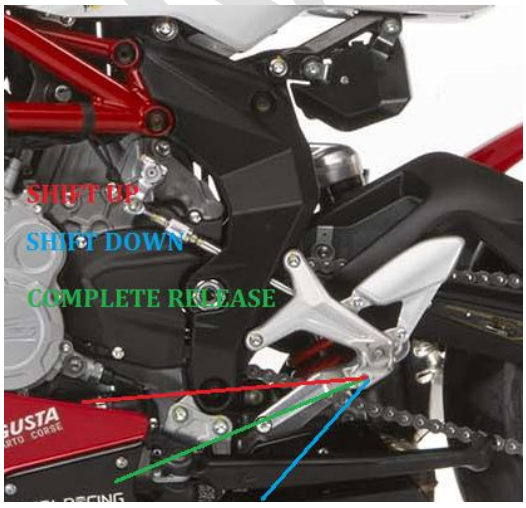


If You would like to change the leverage using a “reverse racing” version , using standard ***SINGLE SWITCH*** sensor , You must consider that sensor must continue to work in the same way (extension) . In case You have a ***DOUBLE SWITCH*** sensor or a ***LOAD CELL*** sensor , You are free to mount sensor how You like , You will configure inside the software the correct force type (extension or compression) for both gear shift UP and DOWN .

For a correct installation of leverage , You can follow 2 simple rules . This will prevent many problems during strategy setup .



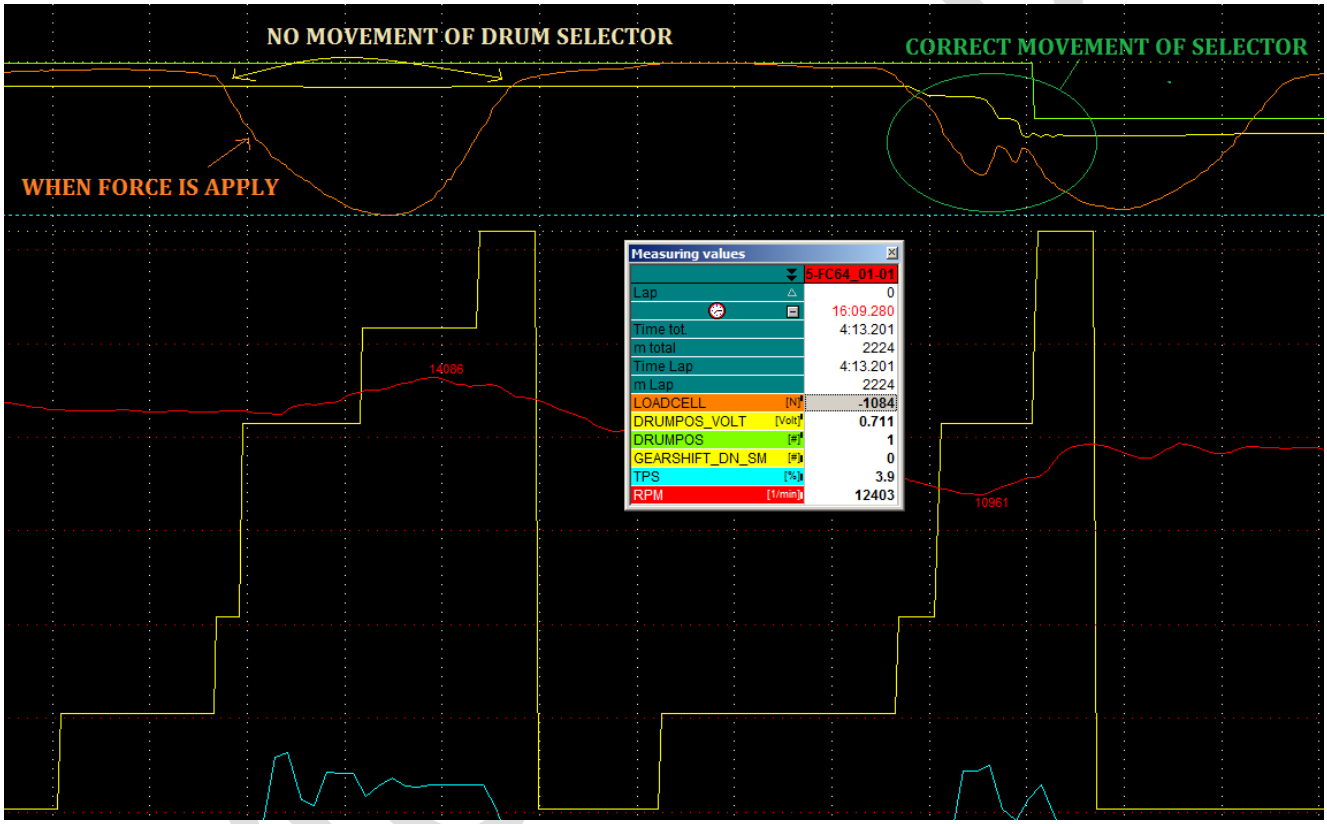
1) To have maximum torque on gearshift shaft (internal to engine) , with minimum rider force on leverage , the shaft where is mounted the sensor must work at 90 degree with both upper and lower leverage .



2) The leverage must be mounted for best raider comfort . It’s important to remember that the leverage position at complete release , must permit to rider to release completely it after a gear shift . If it’s not , the internal shift shaft , will not engage mechanism for next shifting .

Here below , You can see a typical example of leverage not completely released (first gear shifting) , compared with correct engagement of mechanism , because of fully released leverage (second gear shifting) .

On first gear shifting , You can see that the raider apply force on leverage , but no movement can be detected on drum selector . Also the force signal is continuous and this means that no mechanical movement is present .



This is a good example of how easy it is to diagnose some problems if you use all of the available information .

In other situations , without the logged channels , this kind of problems are very difficult to detect . It's easy in this case also to show to raider , the reason of miss shifting , and detect with him best way to solve it .

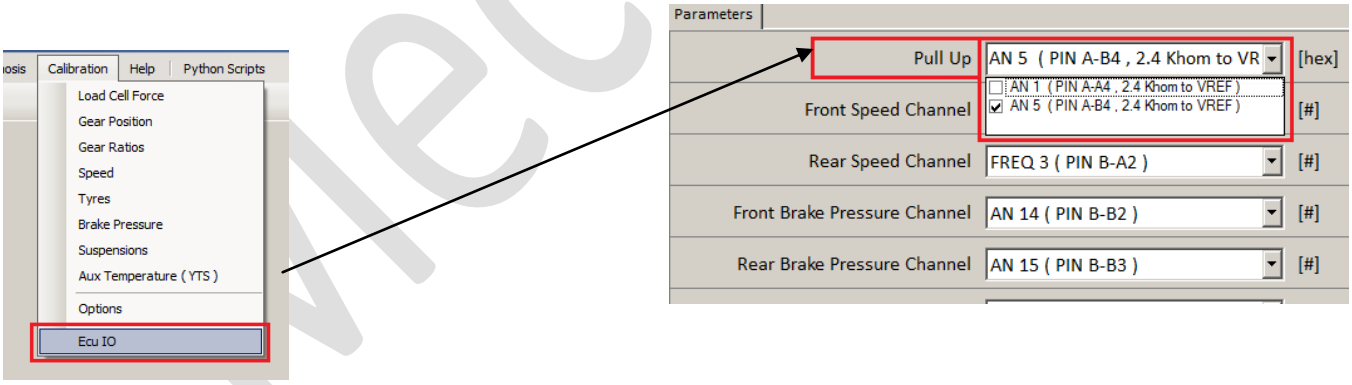
2 CONFIGURE YOUR SENSOR

For an entry level solution , it's possible to use SINGLE SWITCH (the sensor used on road motorbike is a single switch that work with extension force) . A medium level solution is a DOUBLE SWITCH (extension and compression switch) . With a top level solution , Your will get advantage of all features included , in this case best sensor is a LOAD CELL (extension/compression force sensors) able to measure force applied in both direction . We advise to use a sensor able to read in range +- 1000 N .

Sensor	Gear Shift UP	Gear Shift DOWN
Single Switch	Supported (Check compatibility with Your leverage)	NOT SUPPORTED
Double Switch	Supported	Supported
Load Cell	Supported	Supported

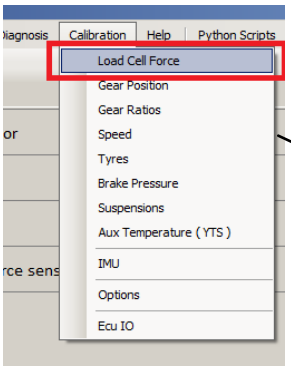
For a correct configuration of sensor , First step is to ENABLE or DISABLE the PULL-UP for AN5 input . The PULL-UP is a configurable resistor , that can connect an ECU PIN , directly to VREF (5 Volt) without need to use external resistors . The MKE7 have 2 pins (AN1 and AN5) that can be connected (by software) to VREF . This function permit to keep the signal for the input , to 5 Volt when PIN is in open circuit (ex. an quick shift released) .

It's possible to access parameters to setup the pull up from menu **Calibration -> ECU IO .**

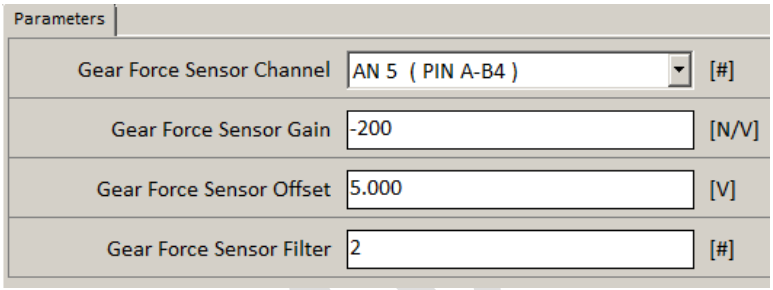


You must ENABLE the PULLUP for AN5 , ONLY in case You're a using a SINGLE SWITCH sensor . You must DISABLE it for all other kind of sensor .

Second step is to configure parameters for conversion from voltage to force .



It's possible to access parameters to setup the sensors from menu **Calibration -> Load Cell Force .**

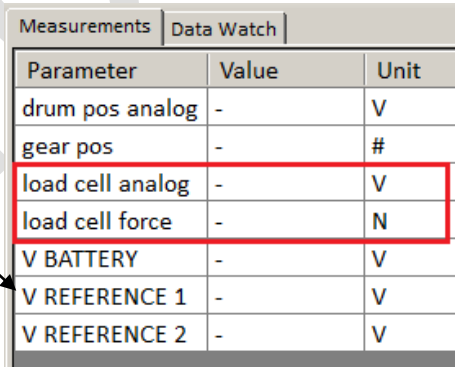


The gear shift sensor , on the wiring KIT/OEM , is connected to AN 5 of the ECU (Analog input N. 5) . You must be sure that Your setting for ***GEAR FORCE SENSOR CHANNEL*** is correct .

Following 2 parameters define the conversion from voltage to force . For all sensors , the ECU will convert input voltage on AN5 , to force expressed in Newton [N] , 9.81 [N] is 1 [Kg] . For SINGLE or DOUBLE SWITCH sensor , this force is virtual , because this sensors are not able to measure forces ,and this configuration is a conventional setup . This parameters are ***GEAR FORCE SENSOR GAIN*** and ***GEAR FORCE SENSOR OFFSET*** .

For a simple setup , take a look to right side of Your screen ,

at measurements of ***Load cell analog*** and ***Load cell force .***



Note that the software use name LOAD CELL for everyone of the 3 different sensor supported .

To setup the ***GEAR FORCE SENSOR OFFSET*** , for all kind of sensors You can follow steps below :

- release the leverage
- read the value of ***Load cell analog***
- copy this value in ***GEAR FORCE SENSOR OFFSET*** .

To setup the ***GEAR FORCE SENSOR GAIN*** , the procedure is different for each sensors .

For ***SINGLE SWITCH*** sensor :

- Set it to -200 (it's a negative value)

For ***DOUBLE SWITCH*** sensor :

- Press the leverage with force for a Gear Shifting Up until You see ***Load cell analog*** value changes
- In case the ***Load cell analog*** decrease the voltage , set it to -200
- In case the ***Load cell analog*** increase the voltage , set it to +200

For ***LOAD CELL*** sensor :

- Take a look to datasheet of Your sensor , and search for the SENSITIVITY , or calculate it . The unit of measure of this value is [N/V] , so describe how many N for voltage variation of 1 Volt .
- Press the leverage with force for a Gear Shifting Up until You see ***Load cell analog*** value changes
- In case the ***Load cell analog*** decrease the voltage , set it to - SENSITIVITY
- In case the ***Load cell analog*** increase the voltage , set it to + SENTIVITY

Now , send Your setting to ECU (storing it on flash memory) , then switch OFF and ON again the ECU .

To check if Your configuration is correct take a look to ***Load cell force*** measurement , at right of the screen .

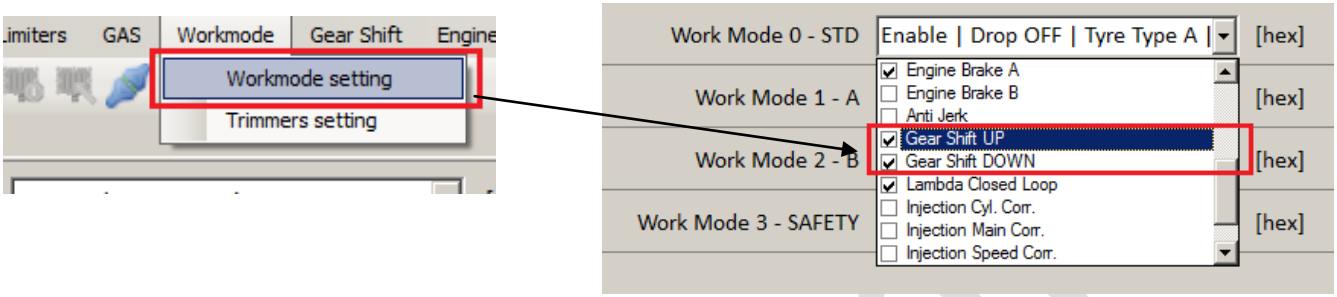
For every sensors You have installed , You can follow below checks :

- Release the leverage → You must read a force of ~0 [N] , less than 10 [N] in absolute value
- Apply a force for gear shifting up to leverage → You must read a positive force , above 200 N
- Apply a force for gear shifting down to leverage → You must read a negative force , below -200 N

3 CONFIGURE THE STRATEGIES

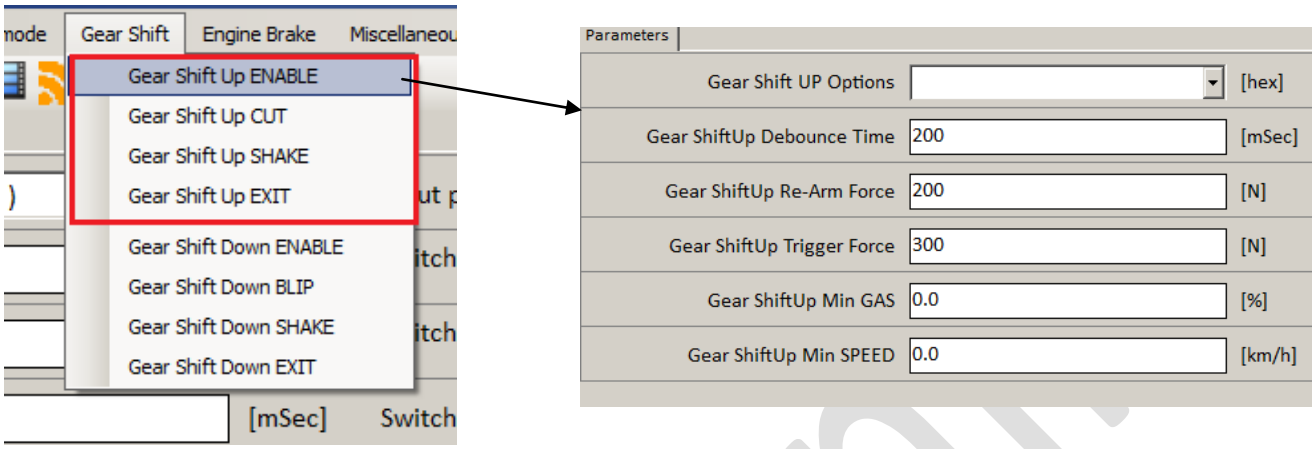
After installing and setting the sensors , You can configure the strategies . The British Superbike application don't allow Gear Shift Down blipping , so on following pages , for this applications , You will have few less items to setup . For all other applications You can use both gear shift up and down .

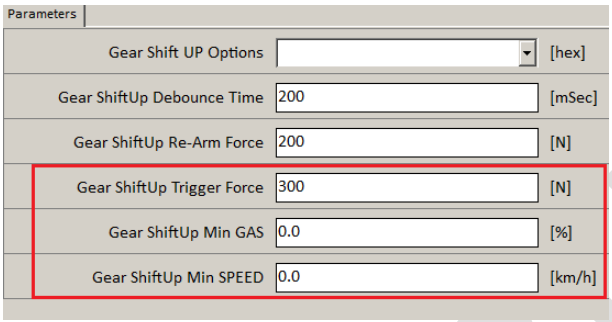
To enable Gear Shift Up and/or Down strategies , must be switch ON the flag inside working modes . To access Working modes , select it from menu **Workmode -> Workmode setting** . This is possible for each of 4 available working modes .



3.1 CONFIGURE THE GEAR SHIFT UP

To Setup the details about Gear Shift Up , select it from menu **Gear Shift .** From **Gear Shift Up Enable** item , You can setup conditions for ***TRIGGER*** , ***RE-ARM*** and enable ***OPTIONS .***





It's possible to define few conditions that will enable the trigger , first one is the minimum Rider Grip Position (GAS) and second one the minimum vehicle speed . Default values for this conditions are :

Gear ShiftUp Min GAS 10 [%]

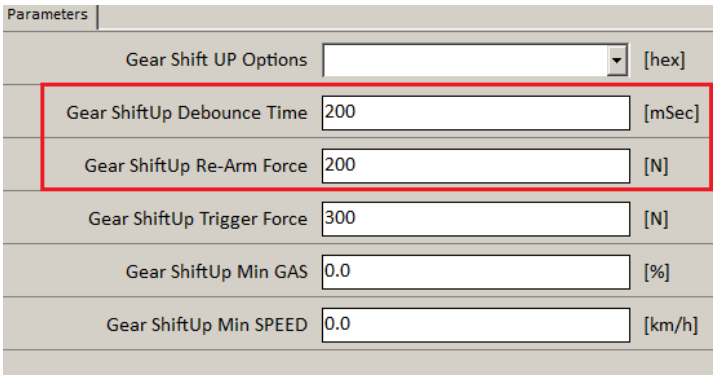
Gear ShiftUp Min Speed 30 [Km/h]

One of most important condition is ***Gear Shift Up Trigger Force*** , this define the force that rider must apply to trigger the strategy . This value don't depend from Your lower leverage , this force depend only from upper leverage (that usually is not changed) .

This trigger force must not be too low , We advise to use values from 300 to 600 [N] . In case You need to reduce this force below 200 [N] , maybe You need to check for some leverage or gearbox problems .

An higher force is also better to prevent partial gear engagement , and faster quick shift .

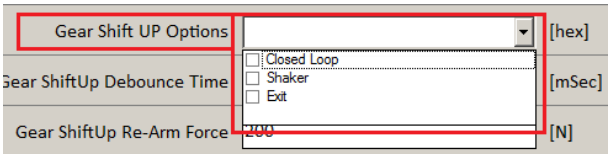
After gear shifting , to be ready for the next trigger , the strategy must be re-armed . To do it , the leverage must be release for a while . The leverage is considered released , if force is below the parameter ***Gear Shift Up Re-Arm Force*** , and must be below this value for minimum a time defined by ***Gear Shift Up Debounce Time*** (usually a time of 200 [msec] can be considered for this parameter) .

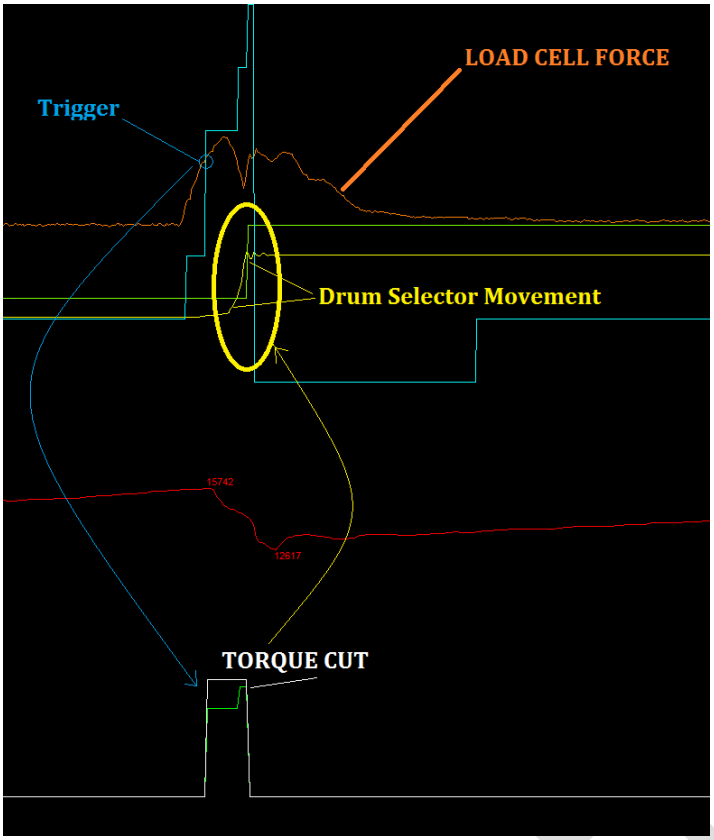


The Re-Arm force must be lower than Trigger force , with a good gap , good value can be defined like this :

Re-Arm Force = Trigger Force / 2

Last parameter to set are the ***Gear ShiftUp Options*** .





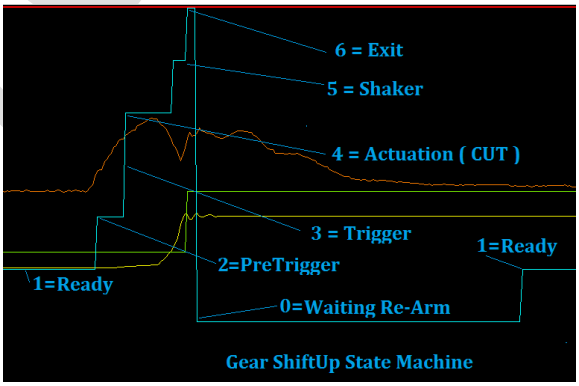
Here We take a look to recorded channels , that describe a typical gear shift up event .

First of all You can see the force applied by rider to leverage , the orange line .

As soon as the force increase up to the ***TRIGGER*** value , the ECU begin to apply a ***TORQUE CUT*** for a while (We will see details below) .

The channels You see , are very usefull to understand how the gearbox is working , and it's very important to acquire it at very hi speed (>= 500 Hz) .

One of most important channel is the ***GEAR_SHIFTUP_SM*** (gear shiftup state machine) . This channel describe every millisecond , what is the actual state of the gear shifting process .



The ECU is ready for gear shifting when state machine is = 1 . After the gear shifting , the state is = 0 , and the ECU is whaiting that force go down (less then ***Re-Arm Force***) for the time required (more than ***Debouce Time***) . If a new trigger is caming during this state (=0) , the event will be ignored .

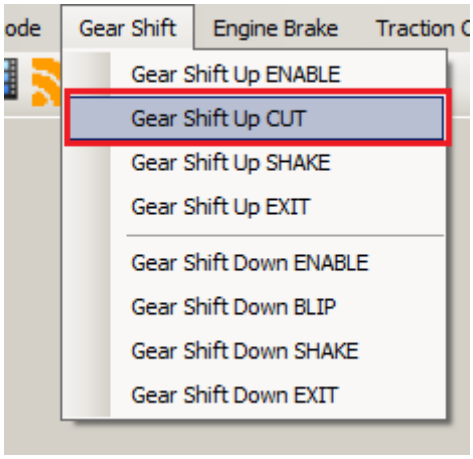
States from 0 to 4 is present for every configuration You have , states 5 (shaker) and 6 (exit) are present only in case You enable flags for it . From the ***Gear Shift UP Options*** parameter .

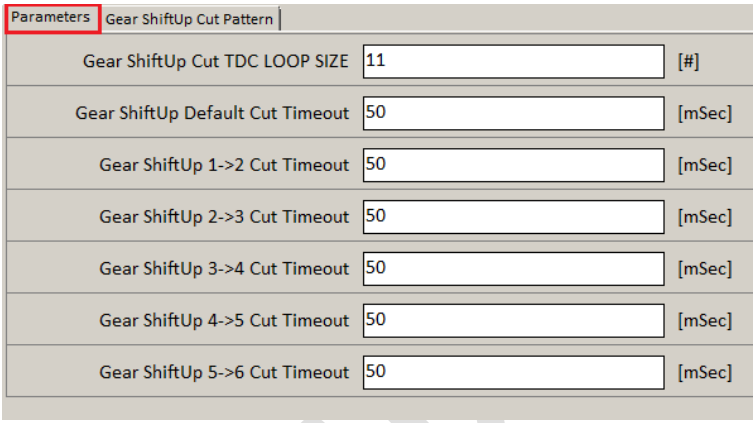
Here You have 3 different flags :

1. Closed Loop
2. Shaker
3. Exit

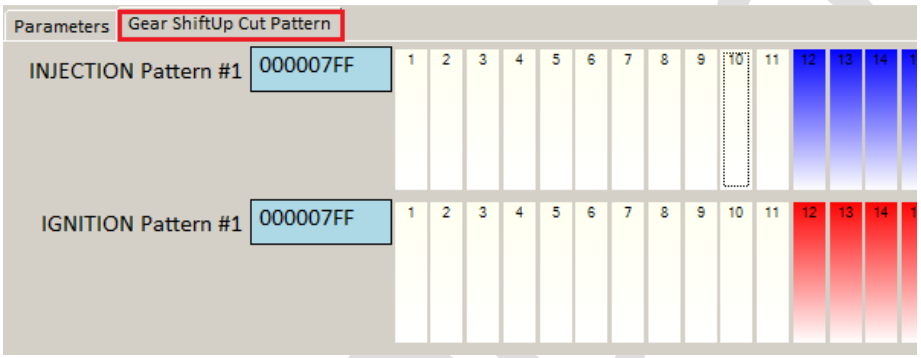
In shorts (We will cover in datails below) , the ***Closed Loop*** , enable the ECU to check the DRUM SELECTOR position every msec , and interrupt the TORQUE CUT in case the gear is engaged before the maximum allowed time . This can speed up the gear shift process . The ***Shaker*** , begin immediatly after the CUTs , using an hard RPM limiter , the ECU equalize the speeds of shafts and generate a "shake" movement on the gear dogs . This will makes the complete insertion easier . The ***Exit*** is at the end , after all other previous states (mandatory or

optional) , the goal of this part of gear shifting , is to introduce a transition from TORQUE CUT (complete or partial) , to full power .





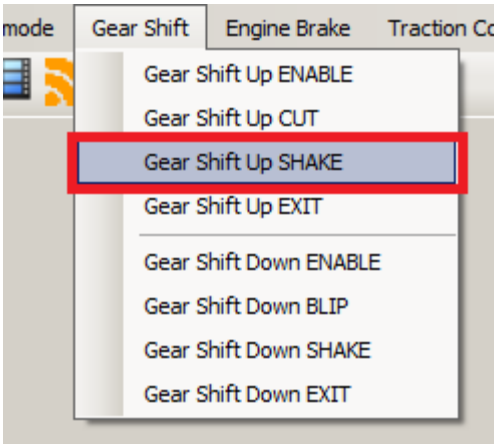
To Set-up the CUT times , select it from menu **Gear Shift .** From **Gear Shift Up CUT** item .

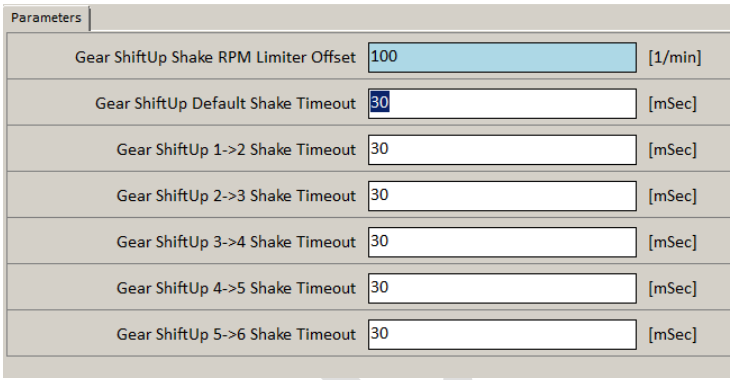


At first page , It's possible to define CUT times for each gear shifting , from 1' to 2' up to 6' gear . The ***Default Cut Time*** is used in case the ECU is not able to know what is the actual engaged gear . In case You enable the ***Closed Loop*** option , this time became timeout (so maximum time) and this will be reduced by ECU , interrupting the CUTs as soon as next gear is detected .

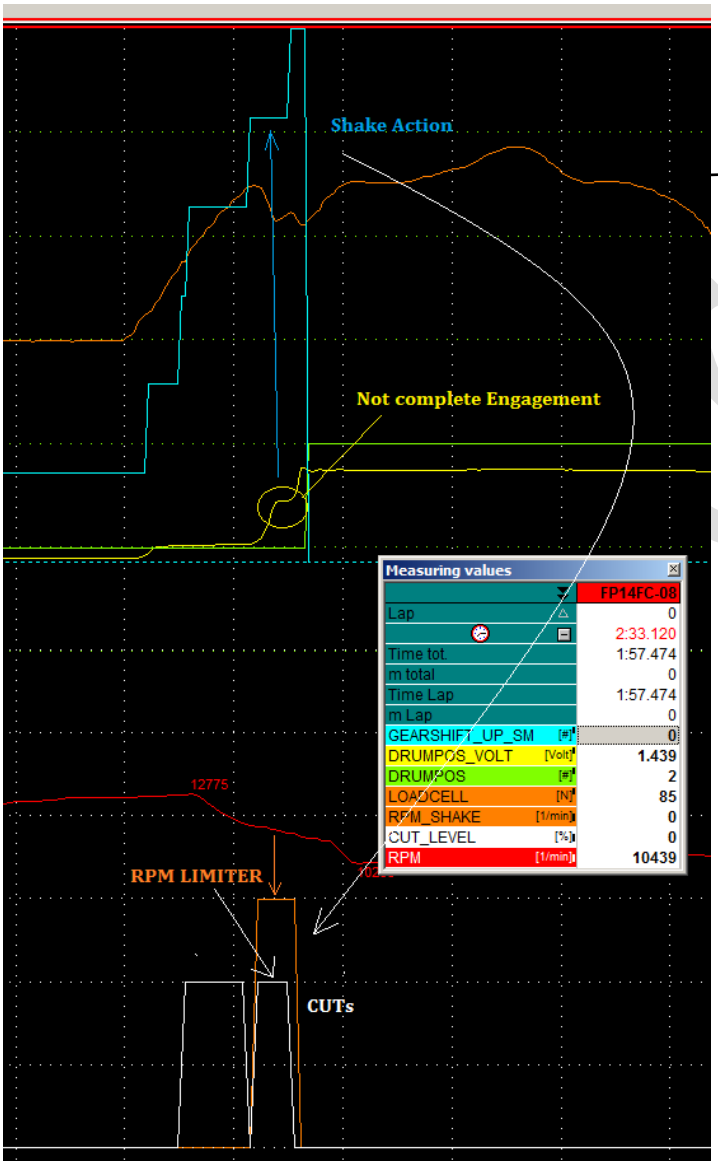
How to CUT TORQUE , is defined on second page (Gear Shift Up Cut Pattern) .

For details We advise to check document about how CUT PATTERN works .





To Setup the SHAKER , select it from menu **Gear Shift .** From **Gear Shift Up SHAKE** item .

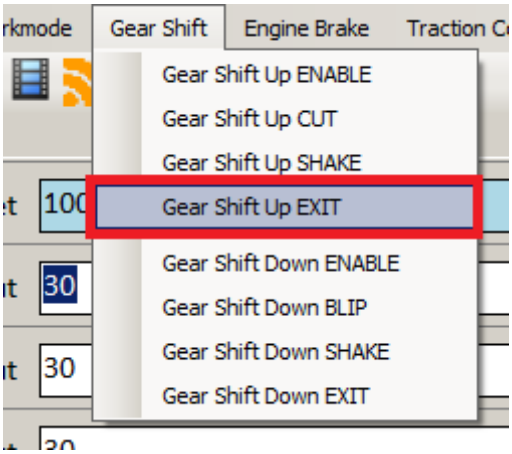


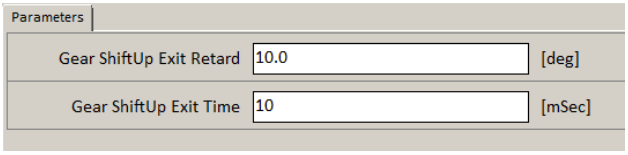
To enable the SHAKER inside the gear shift sequence , this must be flagged ON inside the ***Gear ShiftUp Options*** parameter , defined on previous pages .

Here You can define timeout for SHAKE , in similar way You did for CUT , It's possible to define SHAKE times for each gear shifting , from 1' to 2' up to 6' gear , and default time too .

Also for shake times , You can consider it like timeout in case You enable the ***Closed Loop*** option .

The first parameter is ***Shake RPM Limiter offset*** , this is an offset over the RPM limiter that ECU recalculate in function of ***REAR WHEEL SPEED*** . The result is the channel ***RPM_SHAKE*** , that You can check in data acquisition .





To Setup the EXIT , select it from menu **Gear Shift .** From **Gear Shift Up EXIT** item .

To enable the EXIT inside the gear shift sequence , this must be flagged ON inside the ***Gear ShiftUp Options*** parameter , defined on previous pages .

The goal of this part of gear shift sequence , it to restore full torque smoothly , after complete engagement .

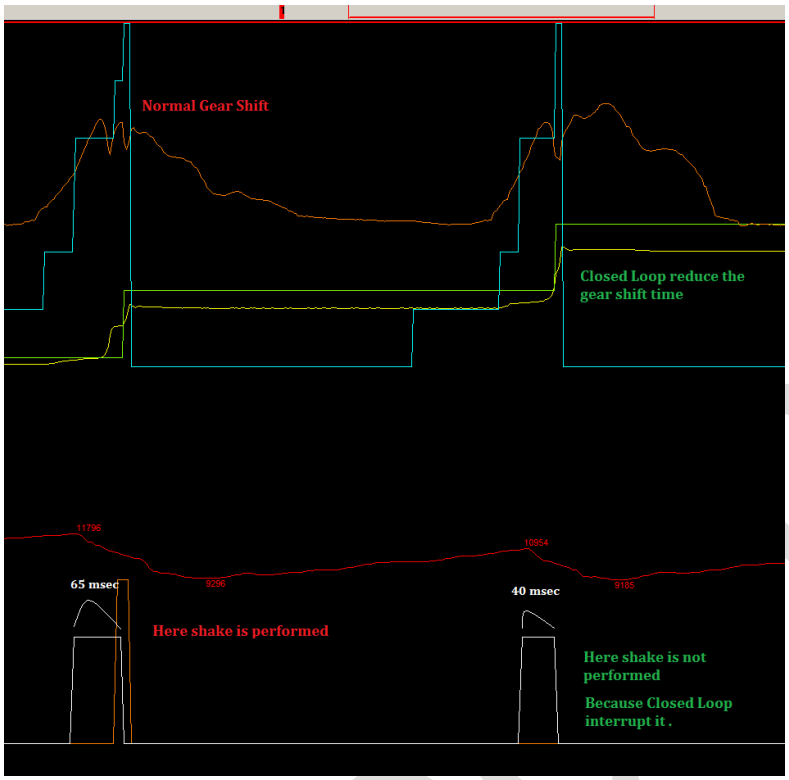
This is performed introducing and ignition correction , that reduce the ignition spark advance , using the first parameter , the ***Gear Shift Up Retard*** , and restoring the correct ignition spark advance , in linear way , during the time defined by ***Gear Shift Up exit time*** .

When You set the time , You must consider how many [msec] is 1 engine revolution , and that on a revolution You have 2 firing .

REV_TIME = 60000 / RPM [msec]

So for example at 15000 RPM , You have 4 [msec] , and on 10 [msec] (like on image above) there are 5 firing , because 2 ½ revolutions over 10 [msec] .

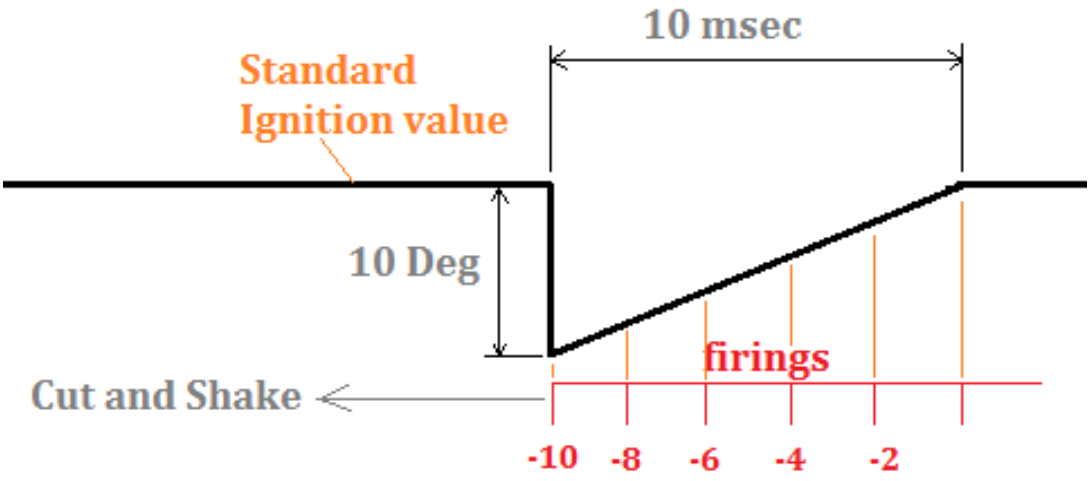
On the same example , every [msec] is reintroduced 1 degree on ignition spark advance , so every fire 2 degree are reintroduced .



Last but not least , is the ***Closed Loop*** option . This can be enabled switching ON the flag inside the ***Gear ShiftUp Options*** parameter , defined on previous pages .

In case You don't switch ON this flag , the sequence is performed using full times You setup for steps described on above pages (CUT , SHAKE and EXIT) .

In case You switch ON this flag , the ECU will check every 1 [msec] the Drum Selector Position , to understand when next gear can be considered fully engaged . If this became before all CUT and SHAKE timeout ends , the CUT and/or SHAKE will be stopped , and the ECU will continue with EXIT step .



On this logged data , it's possible to see a perfect example of closed loop that reduce total CUT + SHAKE time .

On first shift up , the dog engagement is more difficult , and also shake sequence is performed (or partially performed) for a total of 65 [msec] . Here the shake solve the situation , giving some more cuts .

On second shift up , the dog engagement is more fast , the shake step is not performed , and also the CUT time is reduced .

On this example , was used following parameters :

CUT times	=	50	[msec]
SHAKE times	=	30	[msec]

In case You don't use ***Closed Loop*** function , the total time will be 50 + 30 = 80 [msec] , but in this example the ECU , on first gear shift apply the full CUT step (50 msec) + partially the SHAKE (15 msec over 30) . Total save time is 15 msec .

On second gear shift the total time is the same (80 msec) , here the CUT is performed partially (40 msec over the 50) and SHAKE step is discarded . Total save time is 40 msec .

It's important to know that in case ***Closed Loop*** option is enabled , the CUT and SHAKE times can be keep little bit more hi , so to be sure that in Unlucky cases , there is more time to perform full engagement . In the same time this times will became timeouts , so used only in extreme cases .

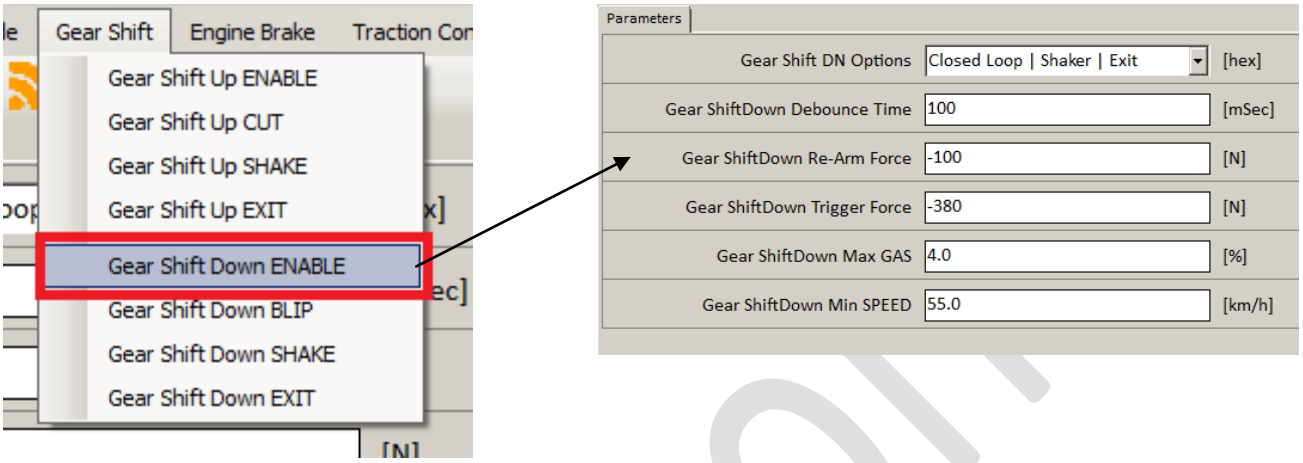
To have closed loop working fine , it's very fundamental the perfect setting of gear position sensor . Please check the related user manual for a detailed procedure .

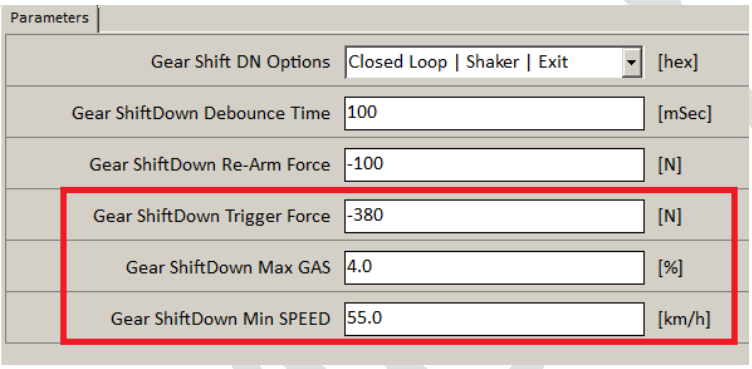
3.2 CONFIGURE THE GEAR SHIFT DOWN

In similar way You setup the gear shift up , it's possible to setup the gear shift down .

First of all , this is possible only if You are using a sensor able to detect both direction .

To Setup the details about Gear Shift Down , select it from menu **Gear Shift .** From **Gear Shift Down Enable** item , You can setup conditions for ***TRIGGER*** , ***RE-ARM*** and enable ***OPTIONS .***





It's possible to define few conditions that will enable the trigger , first one is the maximum Rider Grip Position (GAS) and second one the minimum vehicle speed . Default values for this conditions are :

Gear ShiftDown Max GAS 10 [%]

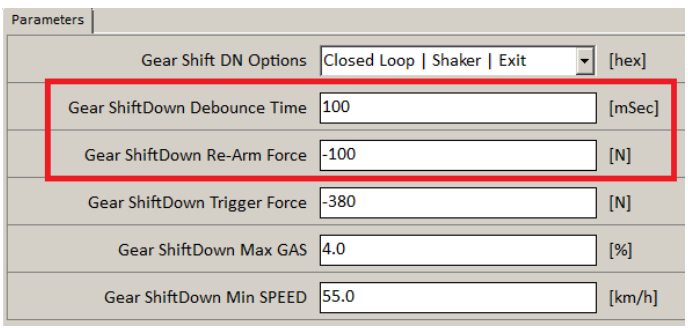
Gear ShiftDown Min Speed 30 [Km/h]

One of most important condition is ***Gear Shift Down Trigger Force*** , this define the force that rider must apply to trigger the strategy . This value don't depend from Your lower leverage , this force depend only from upper leverage (that usually is not changed) .

This trigger force must not be too low , We advise to use values from -200 to -400 [N] . In case You need to reduce this force below -200 [N] (in absolute value) , maybe You need to check for some leverage or gearbox problems .

An higher force is also better to prevent partial gear engagement , and faster quick shift .

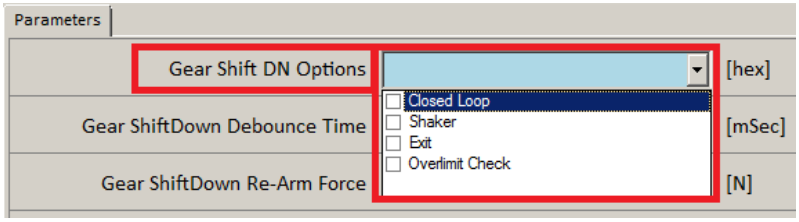
After gear shifting , to be ready for the next trigger , the strategy must be re-armed . To do it , the leverage must be release for a while . The leverage is considered released , if force is below the parameter ***Gear Shift Down Re-Arm Force*** , and must be below this value for minimum a time defined by ***Gear Shift Down Debounce Time*** (usually a time of



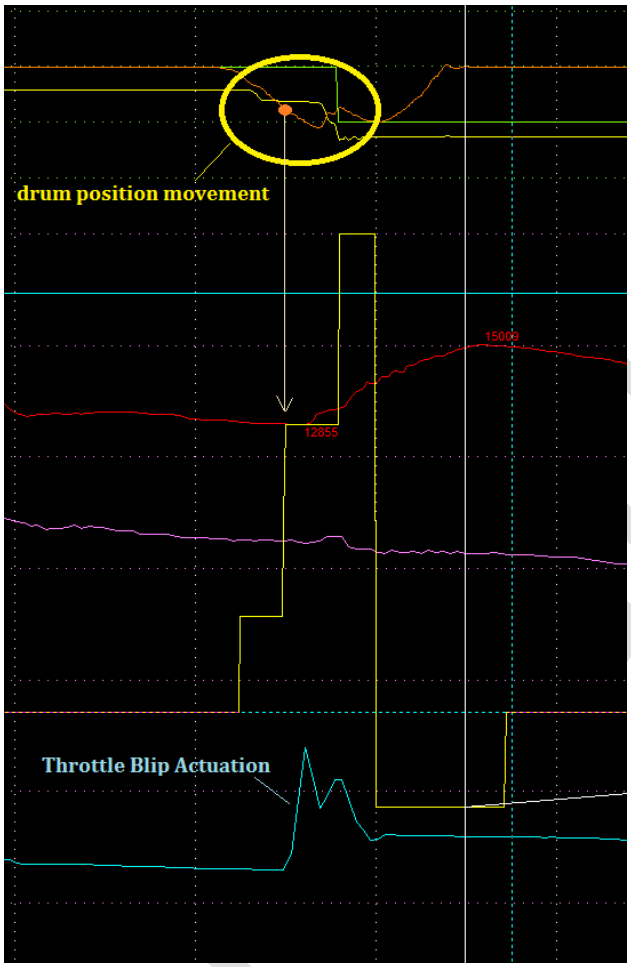
100 [msec] can be considered for this parameter) .

The Re-Arm force must be lower than Trigger force , with a good gap , good value can be defined like this :

Re-Arm Force = Trigger Force / 2



Last parameter to set are the ***Gear ShiftUp Options*** .



Here We take a look to recorded channels , that describe a typical gear shift up event .

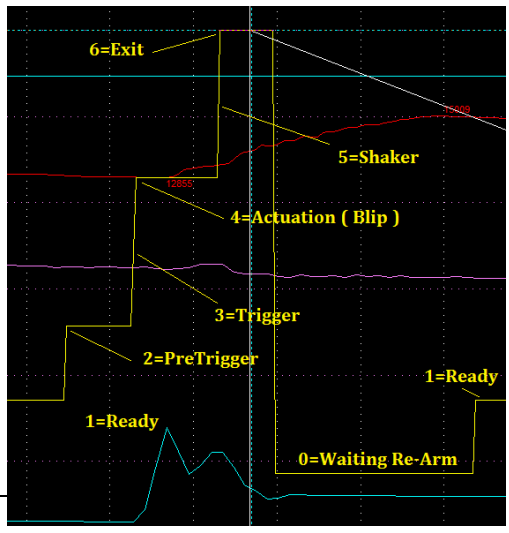
First of all You can see the force applied by rider to leverage , the orange line .

As soon as the force increase up to the ***TRIGGER*** value , the ECU begin to actuate a ***BLIP*** command to the Thorttle for a while (We will see details below) .

Like for Gear Shift Up , the channels You see , are very usefull to understand how the gearbox is working , and it's very important to acquire it at very hi speed (>= 500 Hz) .

One of most important channel is the ***GEAR_SHIFTDN_SM*** (gear shiftdown state machine) . This channel describe every millisecond , what is the actual state of the gear shifting process .

The ECU is ready for gear shifting when state machine is = 1 . After the gear shifting , the state is = 0 , and the ECU is whaiting that force go down (less then ***Re-Arm Force*** in absolute value) for the time required (more than ***Debouce Time***) . If a new trigger is caming during this state (=0) , the event will be ignored .

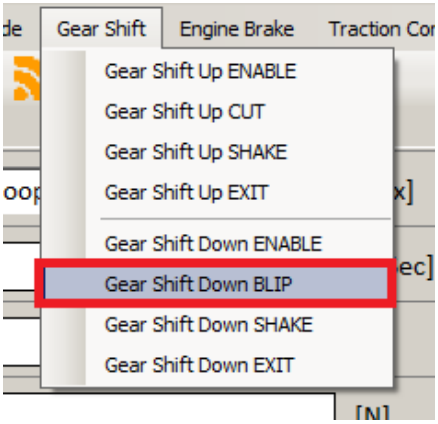


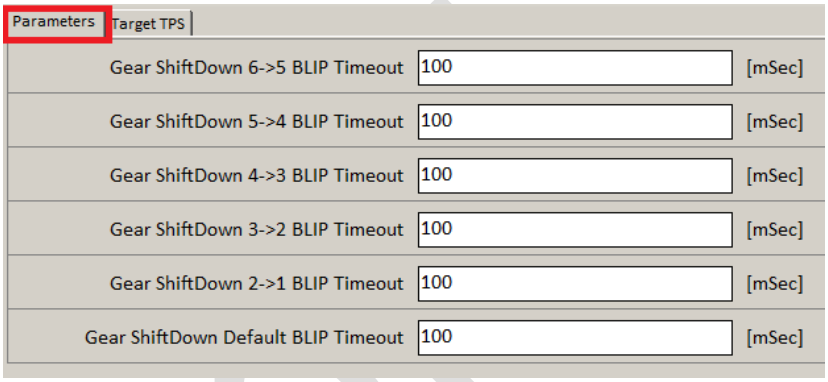
States from 0 to 4 is present for every configuration You have , states 5 (shaker) and 6 (exit) are present only in case You enable flags for it . From the ***Gear Shift DOWN Options*** parameter .

Here You have 4 different flags :

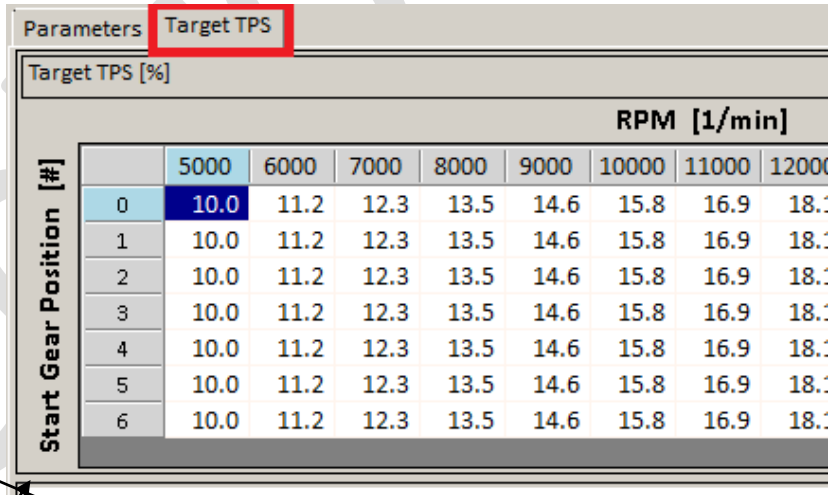
1. Closed Loop
2. Shaker
3. Exit
4. Overlimit Check

In shorts (We will cover in datails below) , the ***Closed Loop*** , enable the ECU to check the DRUM SELECTOR position every msec , and interrupt the BLIP command in case the gear is engaged before the maximum allowed time . This can speed up the gear shift process . The ***Shaker*** , begin immediatly after the BLIP , continuing to keep throttle open , and using an hard RPM limiter , the ECU equalize the speeds of shafts and



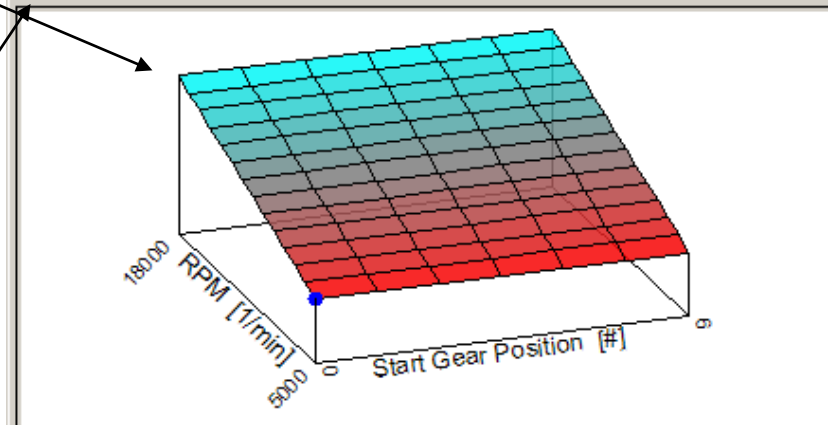


generate a “shake” movement on the gear dogs . This will makes the complete insertion easier . The ***Exit*** is at the end , after all other previous states (mandatory or optional) , the goal of this part of gear shifting , is to prevent positive torque from rear wheel , waiting the throttle is closing after the BLIP actuation .



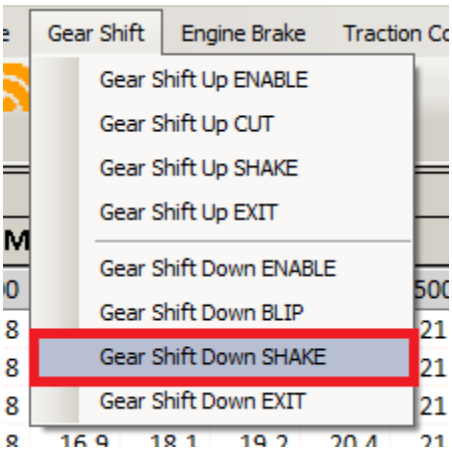
To Setup the BLIP times , select it from menu **Gear Shift .** From **Gear Shift Down BLIP** item .

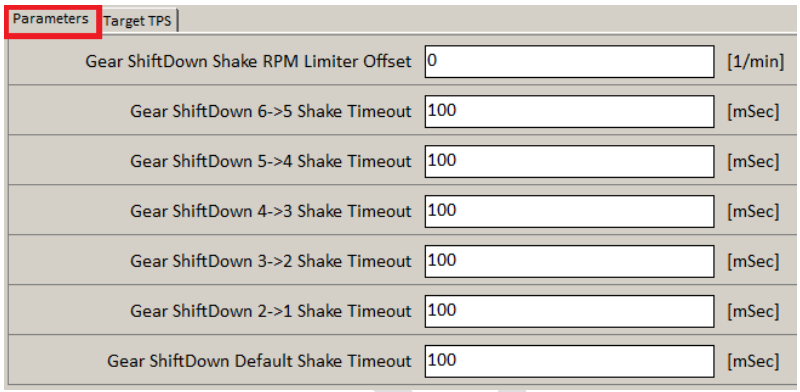
On ***Parameters*** page , must be defined the BLIP times for each gear shifting , from 1’ to 2’ up to 6’ gear . The ***Default BLIP Time*** is used in case the ECU is not able to know what is the actual engaged gear .



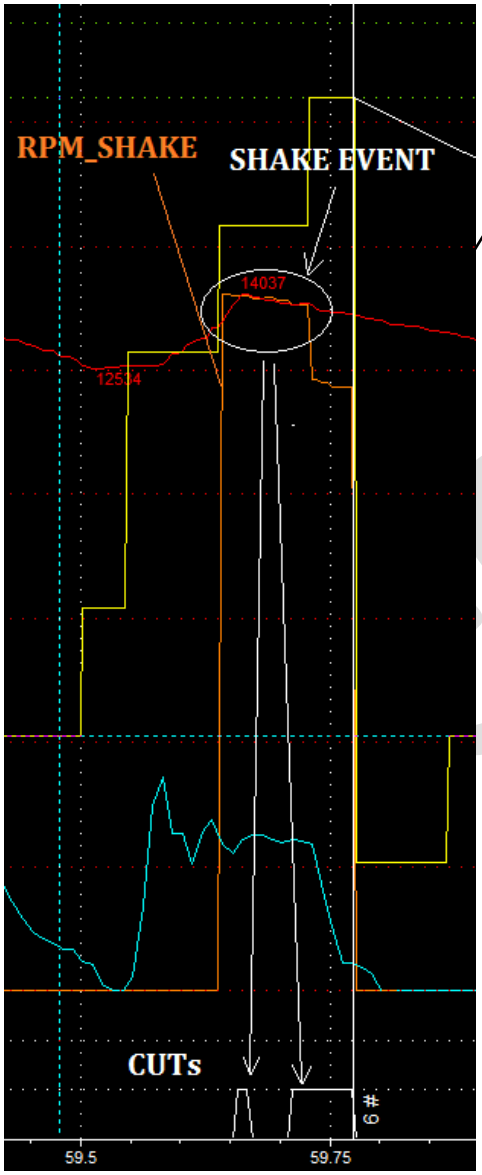
In case You enable the ***Closed Loop*** option , this time became timeout (so maximum time) and this will be reduced by ECU , interrupting the BLIP as soon as next gear is detected .

On ***Target TPS*** page , must e defined how much open the TPS , this in function of the actual engaged gear , and RPM . Usually more hi are the RPM , more open must be the TPS .





To Set-up the SHAKER , select it from menu **Gear Shift .** From **Gear Shift Down SHAKE** item .



To enable the SHAKER inside the gear shift sequence , this must be flagged ON inside the ***Gear ShiftDown Options*** parameter , defined on previous pages .

On first page , ***Parameters*** , must be defined timeout for SHAKE , in similar way You did for BLIP , It's possible to define SHAKE times for each gear shifting , from 1' to 2' up to 6' gear , and default time too .

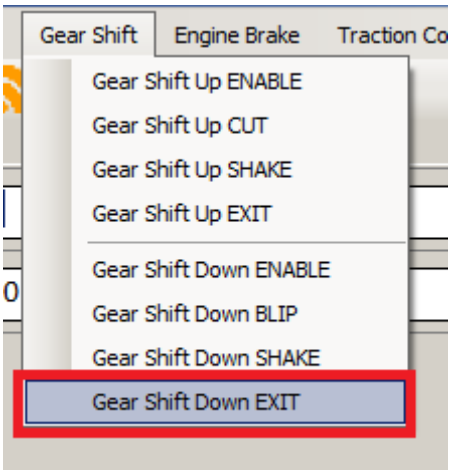
Also for shake times , You can consider it like timeout in case You enable the ***Closed Loop*** option .

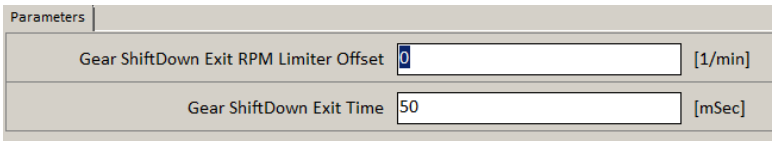
The first parameter is ***Shake RPM Limiter offset*** , this is an offset over the RPM limiter that ECU recalculate in function of ***REAR WHEEL SPEED*** . The result is the channel ***RPM_SHAKE*** , that You can check in data acquisition.

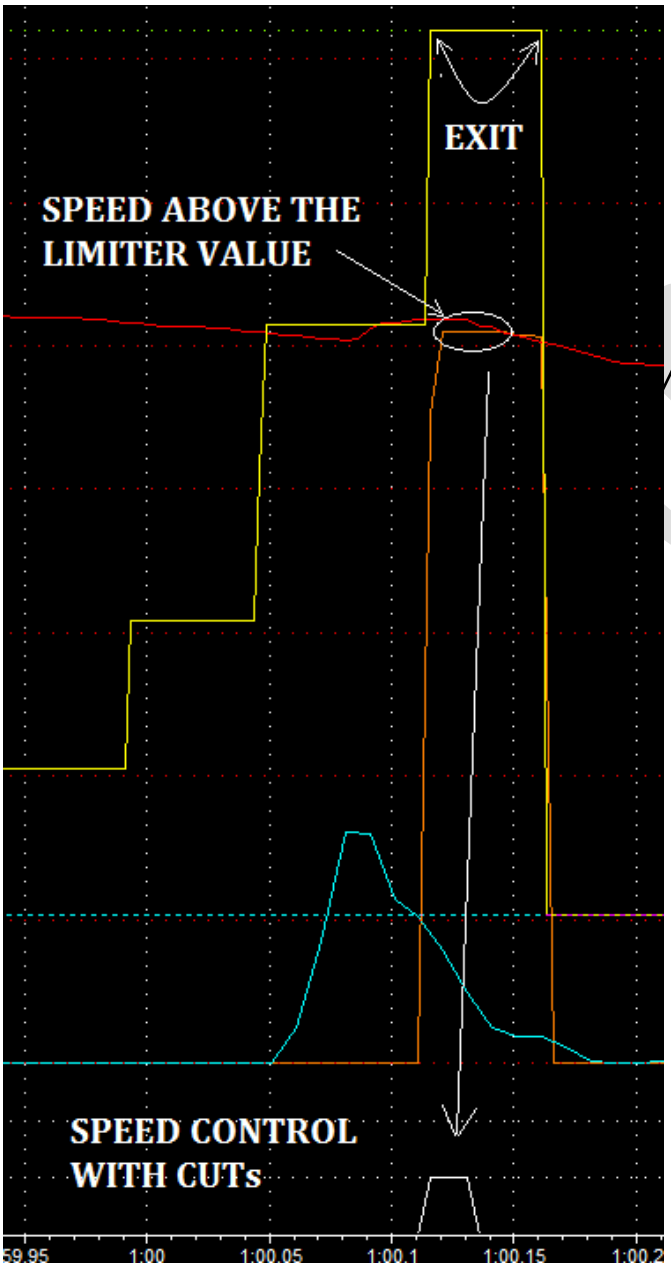
The ***Target TPS*** , don't change respect the table defined in BLIP section , You have the same table also here only for a double check .

Here , on this example , You can see the bottom ORANGE line , that represent the ***RPM_SHAKE*** , this is the RPM limiter calculated by ECU , from ***REAR WHEEL SPEED*** and transmission ratio . As soon as the ENGINE SPEED (RPM is the RED LINE) go over the RPM_SHAKE , the ECU will actuate an hard RPM limiter , the goal is to synchronize the shafts speed , controlling the engine speed (like You can see on example on the left) .

This is possible only in case the clutch is closed , if Your clutch is open , the engine speed probably will be very low re-spect the imposed RPM limiter , so no CUT actuation will be present .







To Setup the EXIT , select it from menu **Gear Shift .** From **Gear Shift Down EXIT** item .

To enable the EXIT inside the gear shift sequence , this must be flagged ON inside the ***Gear ShiftDown Options*** parameter , defined on previous pages .

The goal of this part of gear shifting , is to prevent positive torque from rear wheel , waiting the throttle is closing after the BLIP actuation .

This is performed at the end , after all other previous states (mandatory or optional) , setting a new RPM limiter for engine speed . The value is again defined by ***RPM_SHAKE*** , but the value can be different , because Yiu can define a different value for parameter ***Exit RPM Limiter Offset*** .

This RPM limiter is introduced to control the engine speed (and the REAR WHEEL SPEED as a consequence) , waiting that the throttle will close after the BLIP and SHAKE sequence .

Also for gear shift down (like for shift up) it's possible to enable the ***Closed Loop*** option . This can be enabled switching ON the flag inside the ***Gear ShiftDown Options*** parameter , defined on previous pages .

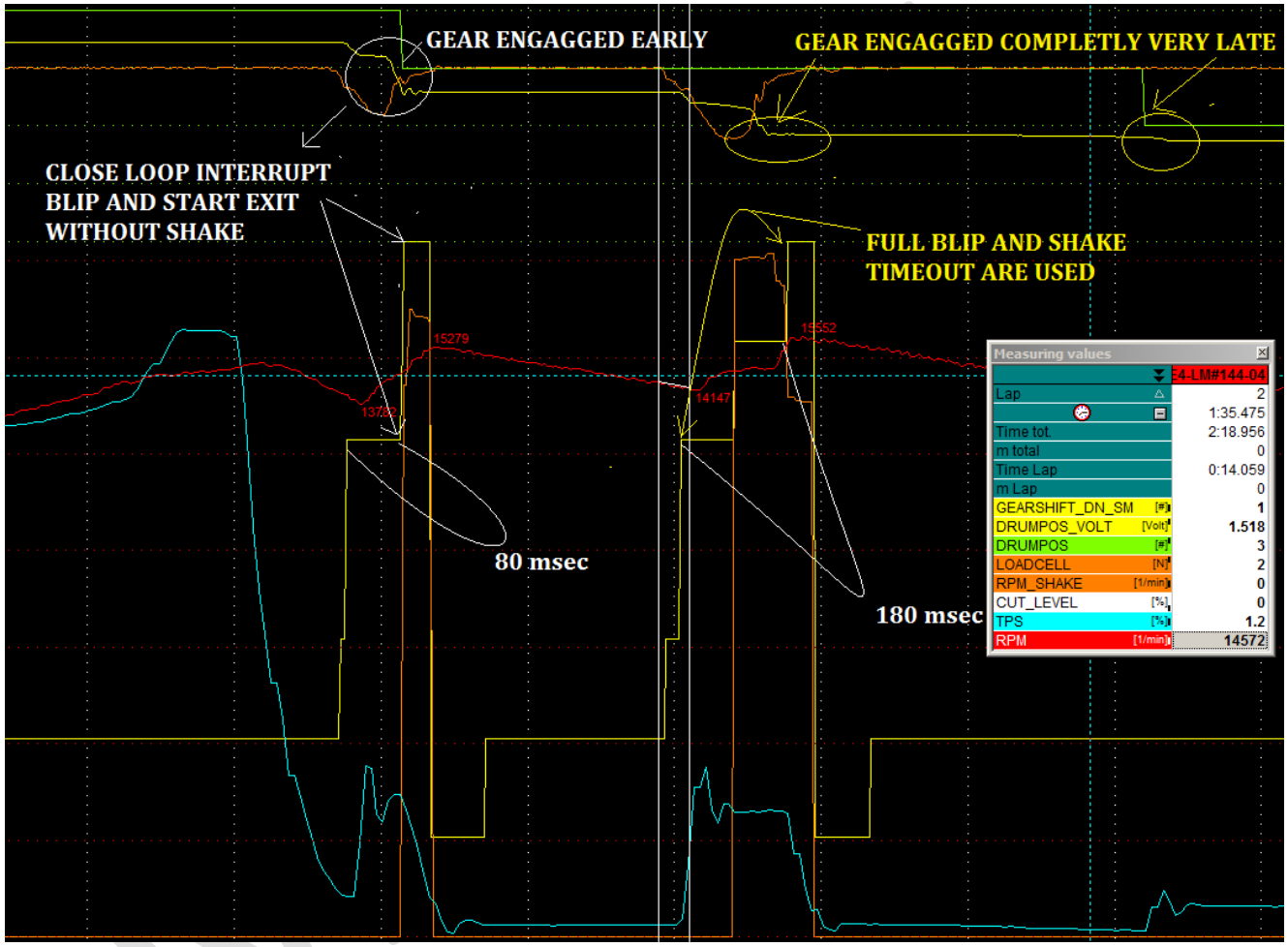
In case You don't switch ON this flag , the sequence is performed using full times You setup for steps described on above pages (BLIP , SHAKE and EXIT) .

In case You switch ON this flag , the ECU will check every 1 [msec] the Drum Selector Position , to understand when next gear can be considered fully engaged . If this became before all BLIP and SHAKE timeout ends , the BLIP and/or SHAKE will be stopped , and the ECU will continue with EXIT step .

On this logged data , on first gear shift down , the gear is engaged very early , and the total BLIP + SHAKE time is reduced to 80 msec (shake is not performed) .

On second gear shift down , the full engagement is very late , and the total time for BLIP and SHAKE is used , for a total of 180 msec .

For down shifting , the closed loop is more important than for up shifting , because the result is not only a little bit lose of performance , but result is a big improvement on time to stop the bike .



To have closed loop working fine , it's very fundamental the perfect setting of gear position sensor . Please check the related user manual for a detailed procedure .

Last possible options that can be used is the ***Overlimit Check*** . Like for other options , it's possible to enable it checking the flag inside the ***Gear ShiftDown Options*** parameter , defined on previous pages .

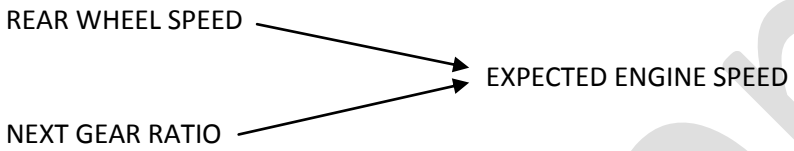
Switching ON this option , the ECU will introduce one more check before trigger the BLIP event . This check is about MAXIMUM RPM LIMITER imposed by manufacturer .

This check is not only about current RPM value , and next gear to engage , this is a little bit more complex .

The main problem to prevent is excessive increase of engine speed , after one or more gear shift down .

The worst case is when the rider try to down shift to many gear keeping the clutch pressed , and release it completely before enter on the corner .

To prevent this situation , the ECU , before each BLIP actuation , calculate what will be the engine speed from rear wheel speed (and not simple from actual engine speed and gear ratios) .



This expected ENGINE SPEED is compared with MAXIMUM RPM LIMTER , imposed by manufacturer , and in case the expected value is ABOVE the imposed limit , the trigger for BLIP is ignored .