

Selectable One-Way Clutch in GM's RWD 6-Speed Automatic Transmissions

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ABSTRACT

This paper described implementation of a selectable one-way clutch in the GM's RWD 6-speed automatic transmission [1] content to replace the current one-way clutch and low/reverse plate clutch. A selectable one-way clutch can hold torque or freewheel in one or both directions depending on the desired operating mode. In this project, it is used as the reaction element to hold torque selectively in 1st gear and reverse. This paper describes hardware design, vehicle implementation, and control of the selectable one-way clutch. In additions, lower parasitic losses due to low/reverse clutch removal is measured and compared with production 6-speed RWD automatic transmissions. Other issues such as durability, cost, packaging, and mass are also addressed. This idea is demonstrated in a 6-speed RWD SUV. Vehicle results show very good static and rolling garage shifts as well as 1-2 upshifts, and 2-1 powered and coast downshifts. The main challenge of this work is to perform 1st gear engine braking with the selectable one-way clutch. This is done using the electronic throttle control and precise control of the selectable one-way clutch speed.

INTRODUCTION

One-way clutches are used in numerous applications to selectively transmit power from one shaft to another. Both shafts may rotate but one is typically fixed to a stationary (reaction) member or housing. One-way clutches transmit torque when the rotation of one shaft relative to the other results in a type of wedging action to occur inside of the one way clutch. The wedging action is different for every type of one way clutch. When the

relative rotation direction of the shafts reverses the wedging action is released and the clutch can freewheel or "over run".

One-way clutches exist in a wide variety of design types [2, 3]. All types have an inner and an outer race. In some designs these races are concentrically located with the locking members placed in between. This can be seen in the roller and sprag types shown in Figure 1. The Mechanical Diode (MD) style shown in Figure 1 uses two plates placed facing each other. The locking member is placed axially between the two plates. All styles shown use rings which are concentrically located with respect to each other about a common axis of rotation. Torque is transmitted from one race to the other through various styles and configurations of elements. Although the design types may differ, the functions are the same.

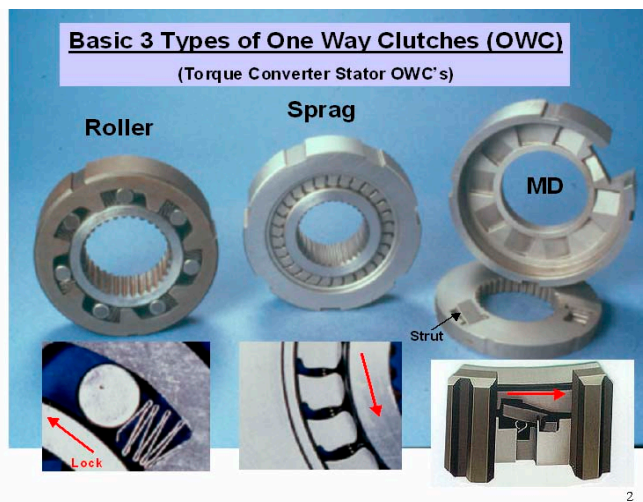


Figure 1: Three basic types of one way clutches

Disengaged multi-plate disc clutches, depending on various conditions, produce drag when there is relative motion between the input and the output members. One characteristic of a disengaged multi-plate clutch is that, as the relative speed between the input and output members increase, typically, so does the drag or spin loss. This spin loss contributes to decreased fuel economy. For example, the low and reverse clutch in GM's 6-speed automatic transmissions [1] is disengaged in all of the forward gears. Therefore, there is a measurable amount of overall spin loss in the transmission that can be attributed to the drag in the disengaged low/reverse (CB1R) clutch.

GM has evaluated various type of selectable one-way clutch such as roller type [2], and MD type [3] in 4/5-speed automatic transmission in which the low/reverse clutch and production roller or sprag were replaced with a selectable one-way clutch. In this research project, the focus is on 6-speed automatic transmissions and the respective CB1R and traditional one-way clutches which were totally eliminated and replaced by a selectable one-way clutch, SOWC. Controls were developed to handle all functions of the SOWC in all possible driving maneuvers especially 2-1 engine braking. Other benefits of a SOWC such as fuel economy improvement, mass savings, and cost are also discussed in this report.

SELECTABLE ONE-WAY CLUTCH: HOW IT WORKS

Selectable clutches are a departure from traditional one way clutch designs. Selectable OWC's add a second set of locking members (struts) in combination with a slide plate. The additional set of struts plus the slide plate adds multiple functions to the OWC. Depending on the needs of the design, SOWC's are capable of producing a mechanical connection between rotating or stationary shafts in one or both directions. Also, depending on the design, SOWC's are capable of overrunning in one or both directions. A SOWC contains an externally controlled selection mechanism. Movement of this selection mechanism can be between two or possibly even three positions. Typically only a two position (on-off) selection is used. "On" controls an operating mode of the device while "off" is yet another mode.

A SOWC (Figure 2) is similar to a one-way clutch in basic operation. A SOWC contains the traditional "forward" locking elements of the one way clutch designed into the two races. In addition to this, a second "reverse" set of struts is placed into the design in such a manner that they can lock the two races in a direction opposite that of the traditional "forward" OWC. Without any features to control the second "reverse" set of struts the clutch would lock in both directions at all times. A selector plate is also added to the clutch allowing the second "reverse" set of struts to be selectively turned on and off. The selector plate turns

the "reverse" set of struts on and off by being moved rotationally a few degrees about the central axis. A hydraulic valve as shown in Figure 4, connected to the shift fork, is used to shuttle the selector plate back and forth. Figure 2 shows some of the major components of the 6-speed RWD SOWC such as pocket plate (reaction or stationary race), notch plate ("driving" or rotating race), and selector plate.

Figure 3 shows the forward struts, reverse struts, selector plate and compression springs. The selector plate is shown in a position where it will allow the reverse struts to engage into the notch plate.

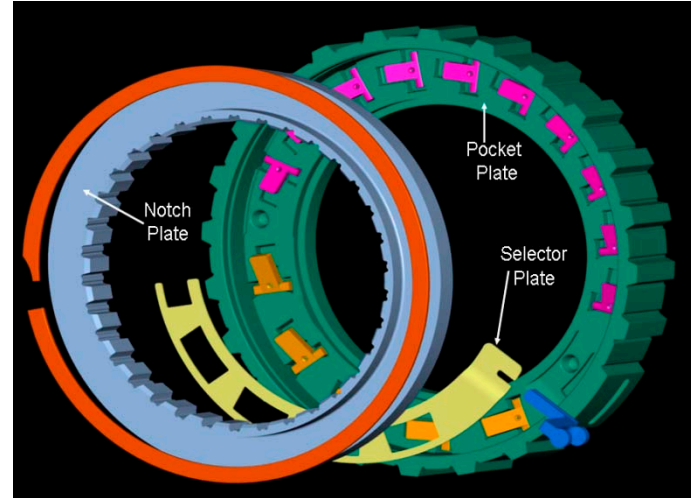


Figure 2: Selectable one-way clutch components

Figure 2 shows the forward and reverse struts as segregated into respective groups. This allows a simplification and reduction in size of the selector plate and a reduction in the overall radial cross section of the design. The smaller selector plate reduces the amount of over running drag forces created by the viscous shear of the adjacent rotating notch plate. Reduced overrun plate drag reduces the size of the return spring as well as hydraulic valve size.

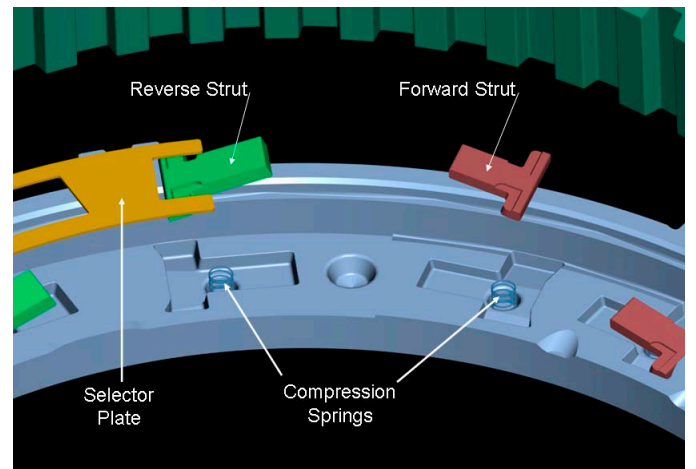


Figure 3: Internal SOWC components

The ability of the driving member of a SOWC to transmit torque to the reaction or possibly the driven member depends on whether or not the engaging torque transmitting elements of the SOWC, typically rollers, sprags, rockers, or struts, etc., are able to freely engage one or more cams, notches, recesses, or similar features in the adjacent race. Also, the ability of the driving member to freewheel in one or both directions with respect to the driven member also depends on whether or not the engaging elements are free to interact with the adjacent member.

Shown in Figure 4 is a traditional “forward” strut engaged into the notch plate. Shown in Figure 5 is a “reverse” strut engaged into the notch plate. The reverse strut was designed especially for the selectable clutches so that it could be disengaged by the slide plate with no movement of the notch plate. Also note that the selector plate cannot move while the reverse struts carry torque.

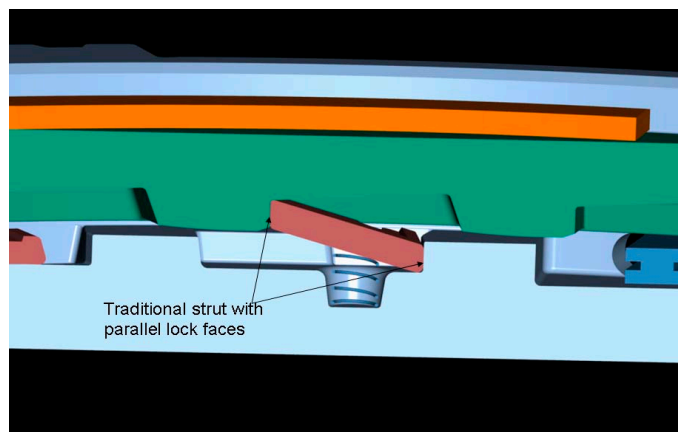


Figure 4: Traditional strut design

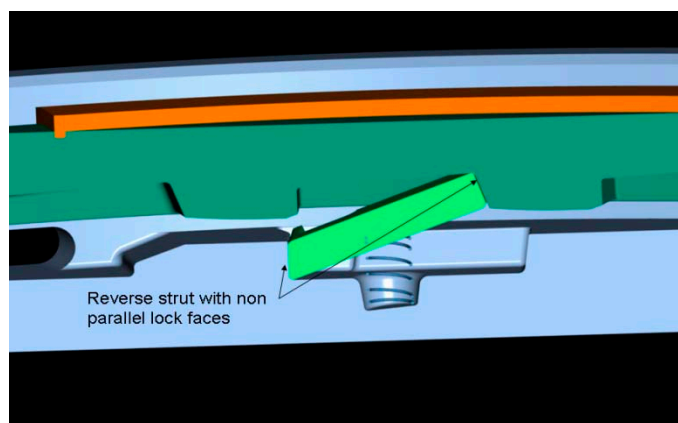


Figure 5: “Reverse” strut for selectable clutches

For this 6-speed transmission project application the operation of a SOWC is shown schematically in Figure 6. As seen there, for the “off” mode in a two mode (on-off) SOWC, torque can be transmitted between the inner race and the outer race by the forward strut. The notch plate would try to rotate to the left while the pocket plate remains stationary. When the notch plate tries to move

to the right it can because the selector plate is to the left covering the reverse struts. This is called the forward or traditional mode of the SOWC. For the “on” mode pressure is supplied to the hydraulic valve the piston inside is moved to the right. This adds additional compression to the return spring. This also allows the reverse struts to engage into the notch plate. Because both the forward and reverse struts are engaged the notch plate is unable to rotate in either direction. Therefore, the “off” position provides the one way clutch function and the “on” position provides the clutch pack function.

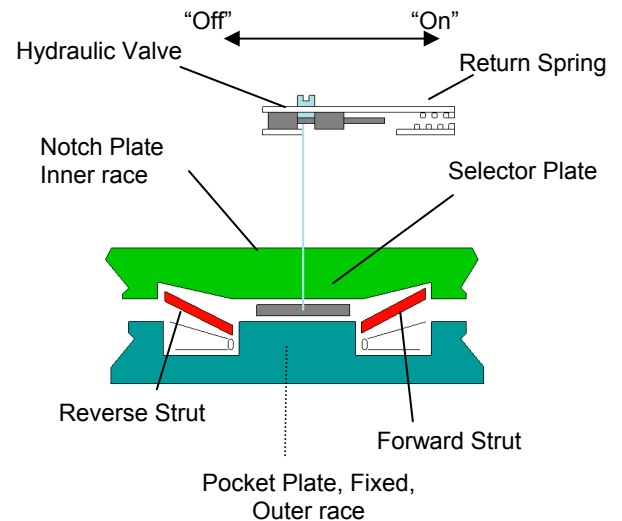


Figure 6: SOWC operation

IMPLEMENTATION OF SOWC IN GM’S 6-SPEED RWD TRANSMISSIONS

As described earlier, the objective of this research project is to implement the SOWC in GM RWD 6-speed automatic transmissions. These transmissions embody five clutching elements and an OWC. In first gear, C1234 is applied and OWC is the reaction element. In reverse mode, C35R applied and CB1R is the reaction element. As a result, a SOWC can be utilized as the reaction element in both forward first gear and reverse.

Table 1 shows the clutching sequence for GM RWD 6-speed transmission when a SOWC is used. It will be described in full detail later the selection mechanism for which CB1R apply feed is used to shift the SOWC from forward to reverse mode by moving the slider plate. Therefore, it was decided to have the forward first gear as the default mode and use a spring to hold the slide plate in forward mode.