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EEL 4914

Project Design Report:

Automated Rev Matcher

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Project Abstract

Our device will minimize the frequency differential between the engine and transmission of a manual automobile for increased longevity of the clutch plate. In human terms our device can be seen as an automated RPM matcher. Technical challenges may entail finding an appropriate sampling rate for the inputs of our microprocessor, and correctly calibrating the appropriate RPM value for each gear from a series of tests. We expect our product to be a valuable asset in the car performance industry.

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Features

Benefits:

- Maximized lifetime of clutch plate
- Minimized jerk from clutch engagement

Input Sensors and Switches:

- RPM sensor
- speed sensor
- up shift/downshift switch
- gear-number pad
- clutch pedal switch
- emergency disable switch

Output Devices and Actuation:

- throttle body controller and a shift-ready LED
- throttle body controller will likely use a servo to actuate the position of the throttle plate

Time permitting we may choose to incorporate additional features that would improve and upgrade our base design.

Components

PIC:

- perform the A/D conversion and send an interrupt to the Atmel processor

ATMEL:

- utilize a timer in measuring the time between interrupts to calculate the RPM value

OTHER:

- Tachometer Sensor
- Speedometer Sensor
- High Input Impedance Op Amp
- Servo Drive Hardware (throttle control)
- Schmidt Trigger Sensor

Objectives

To make a device that minimizes the frequency differential between the engine and transmission of a manual automobile for increased longevity of the clutch plate.

Design Stages:

1) Observe the waveforms of the tachometer sensor and speedometer sensor as a function of rpm and speed, respectively.

2) Using a high input impedance op amp, adjust the gain of each signal to the proper levels for A/D conversion without losing resolution.

3) Design hardware that will interface with the throttle body (servo driven)

4) Write software to capture the sensor data and, when the clutch is depressed, engage a servo that will control the throttle and rev match for the driver.

5) Consider additional features that will improve the marketability of the device.

INPUT HARDWARE:

1) Observe the relationship between the [engine RPM] and [voltage across the crankshaft position sensor], and note the effect of the RPM on the waveform of the sensor.

2) Observe the relationship between the RPM and voltage across the speedometer sensor.

3) Produce a chart for each gear (1 through 5) of the speed vs. rpm. At each gear, the relationship should be linear and intersect the origin.

4) Design a buffer amplifier with very high input impedance so that the additional hardware does not alter the waveforms of the sensors (and risk corrupting the inputs of the vehicles ECU). If the voltage ranges of each sensor are not between 0 and +5 volts, use the op-amp to also adjust the voltage to that range (0-5v).

5) Measure the voltage across the clutch pedal switch. This will likely be 0v or 12.5v (12.5 if engine is off, ~13.6 to 14.2 if the engine is running). Produce corrective hardware to clamp the voltage at 0 and 5 volts. The software and output hardware will only be activated while the pedal is depressed.

SOFTWARE (when the clutch is depressed):

6) The software will compute an error between the current RPM-Speed coordinate and, depending on if the driver is up shifting or downshifting, matches the RPM-Speed coordinate for the next gear. Additional hardware will be necessary to determine if the driver is up or downshifting.

Concept / Technology

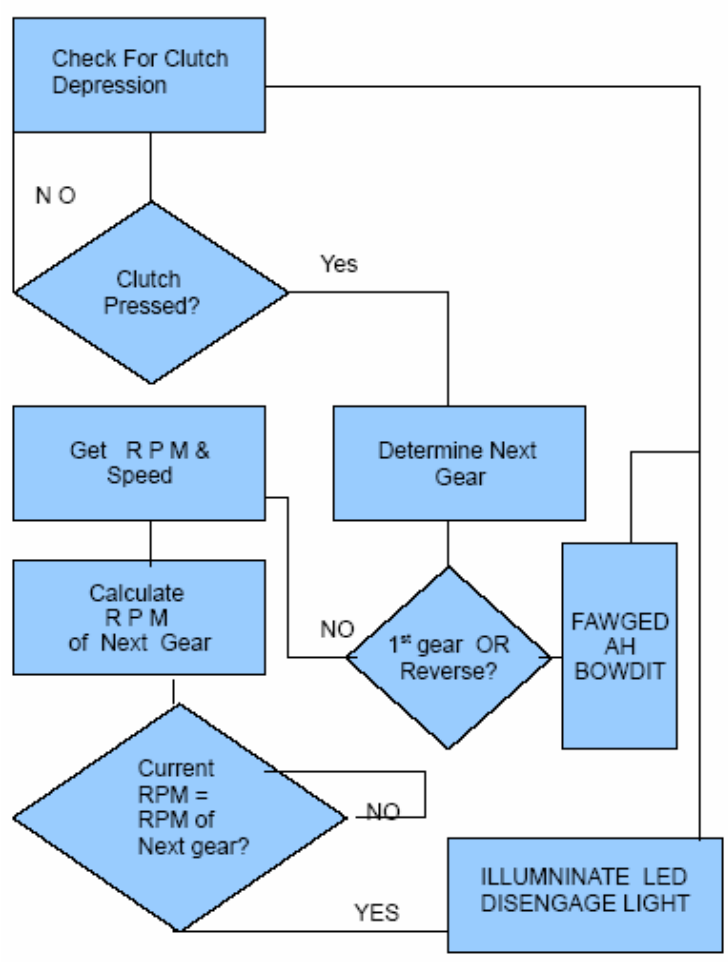
Many products and modifications have been made to improve transmission performance. However, these products are very limited in the automobile aftermarket industry. Most of the designs currently available are proprietary in nature, and are incapable of being retro-fitted into other transmission models. The Auto Rev Matcher is a unique product in that it can be installed in almost any vehicle with a manual transmission, and utilizes the same software package across all vehicles. The only compatibility restrictions depend on the types of tachometer and speedometer sensors used, and the shape of the throttle body. The potential sensor problems are expected to be minimal, since only two types are used (thanks to industry standards and DOT codes).

Why do many drivers prefer a manual transmission over an automatic? An automatic consistently becomes more complicated (and uncontrollable) as software becomes more complex, as opposed to a manual transmission where the driver is purely in control of the shift timing. An automatic may lag, shift late, or shift early. Some shifting software that monitors the throttle position in order to determine what gear it thinks you want may also cause strange and uncontrollable timing behaviors. The lag effect, if not due to software analyzing your accelerator pedal actions, is also caused by the slipping of torque converter, a device that uses a liquid to transfer power from the engine to the transmission. Manual transmissions are not faced with this lag issue, making them very favorable in performance-demanding environments. Instead of a torque converter, a manual uses a clutch plate to mechanically contact the rotating flywheel (attached to the crankshaft). When the clutch pedal is released, the pressure plate forces the clutch plate to contact the flywheel via friction. Thus, the slip/lag effect, caused by RPM differentials and clutch pedal position, is completely controllable by the driver. The Auto Rev Matcher, if activated, will eliminate the RPM differentials, and the inherent slipping effects they cause, making the performance nearly ideal.

What differentiates the Rev Matcher from other similar products is its ability to allow the driver to maintain control of the clutch pedal and shifter. This permits the driver to control the exact timing of when the vehicle is put into gear, taken out of gear, and the gear number. After all, this is the control desired by most manual transmission fanatics. Other available transmissions, such as BMW's Auto-Shifter, does allow pseudo-manual shifting, but does not use a clutch pedal or a shifting lever. In fact, it is simply an automatic transmission with modifications that control the shifting solenoids.

Flowcharts & Diagrams

Figure 1: System Flow Chart



The above figure is a flow chart for the overall system design.

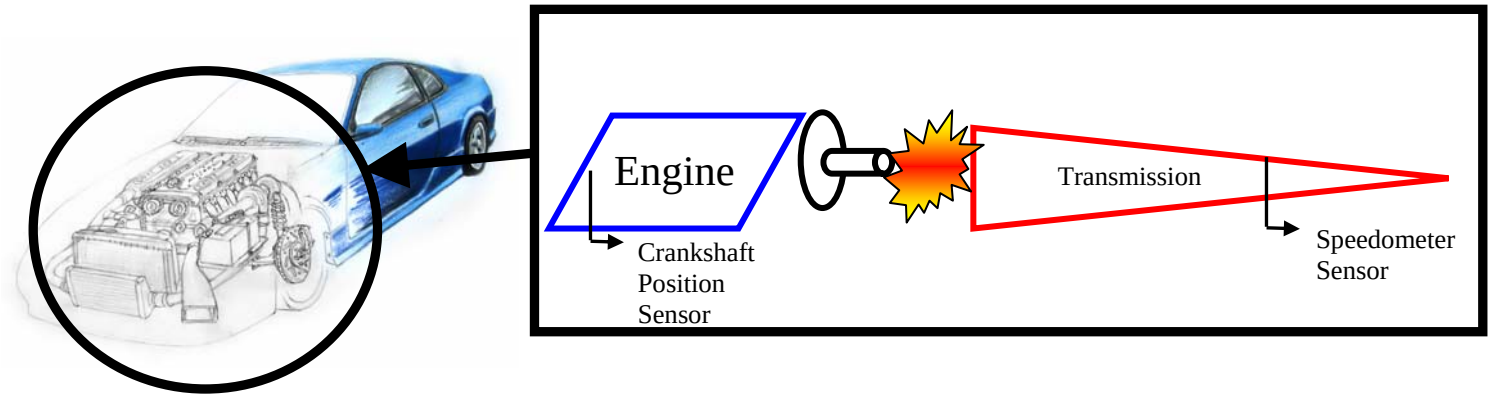
System Process:

Above all other code, an emergency bypass feature will have two modes: One is a simple subroutine entered by an external interrupt that simply bypasses the regular program. If the Emergency button is pressed again, another subroutine (inside of the external interrupt handler) will be entered that opens a power relay to the throttle control servo, thereby completely disabling the servo from interfering with the driver's control of the accelerator pedal.

The Main Program Will:
1) Watch for the clutch pedal being depressed.
2a) If not depressed, go back to 1.
2b) If depressed,
-check current RPM and speed
-determine the next gear (via input switch)
-determine the required RPM of the next gear at the current speed.

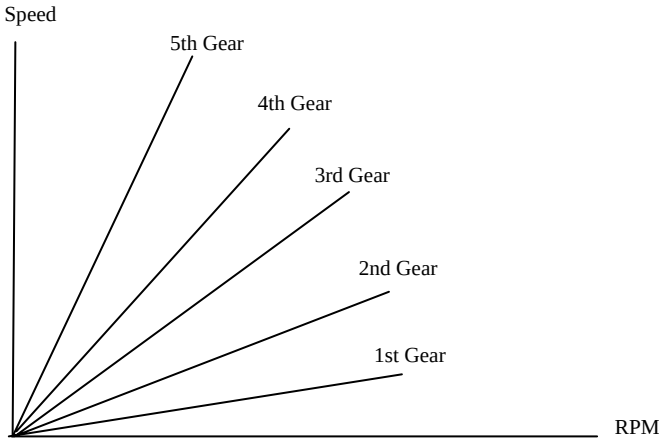
3) Now that speed is known and the required RPM has been determined, determine the servo position for the throttle control.
4) Probably by a subroutine that reads in an 8 bit number (or 16, depending on necessary resolution), the 8 bit number represents the position of the servo. The subroutine then outputs the correct waveform from the PWM to properly set the servo.
5) Recheck the current speed and RPM and determine the amount of error between desired RPM and current RPM.
6) If error < “x” %, enable Disengage LED, else go to 3.
7) Check clutch pedal for release. If released, go to step 1, otherwise, go back to 7.

Figure 2: System Diagram



In the above figure it is shown where the sensors are located that will be inputs to our microprocessor. Precise values are yet to be measured, but the “Auto Rev Matcher” must react to correct the throttle position quickly enough that the correct speed is found before the driver is ready to release the clutch pedal. The driver must not have to wait for the microprocessor. A range of this value of time will be sampled and possible adaptive software may be necessary.

Figure 3: Speed vs. RPM Graph



Each gear has a linear set of coordinates of the RPM-speed pair, which can be seen hypothetically in figure 3. The job of the microprocessor is to first read the inputs from the clutch pedal switch (which closes when the pedal is depressed), the crankshaft sensor, speedometer sensor, and a gear position array (which we will produce). With these inputs, the processor will determine the upcoming gear and the appropriate RPM-speed coordinate. The RPM value of the coordinate will determine the appropriate throttle position, which will be controlled by an actuator (probably servo driven) that connects to the throttle body of the engine.

Division of Labor

Brad	Monique
• System Level Design • Circuit Design & Purchasing • Schmidt Trigger • Input Conditioning • AVR Code	• PIC Code • Protel Design • Autocad Throttle Body Controller • PCB Parts Population

Timeline

Task Name & Assignment	Start Date	Planned	Extension	Downtime
Introduction / Project Proposal - B	7-Jan-08	7	0	0
Research / Abstract - B & M	9-Jan-08	10	0	0
Preliminary Design Report - B & M	12-Jan-08	16	0	0
Research & Data Gathering - B & M	28-Jan-08	14	0	0
System Level Design - B	11-Feb-08	10	0	0
Circuit Design & Purchase Parts - B	11-Feb-08	21	0	0
Software PIC - M	17-Feb-08	10	0	0
Breadboard Test / Troubleshoot - B & M	24-Feb-08	16	0	0
Software AVR - B	3-Mar-08	28	0	0
Protel - M	5-Mar-08	10	0	0
PCB & Populate - M	15-Mar-08	5	0	0
Physical Aparatus Construction - B & M	17-Mar-08	14	0	0
Test Validation - B & M	31-Mar-08	14	0	0
Report Write Up / Demo - B & M	14-Apr-08	10	0	0