Michigan Tech
MEEM/EE 4295: Introduction to Propulsion Systems for Hybrid Electric Drive Vehicles

HW 9 and 10
Topics: Final Hybrid Vehicle Model
E-Motor, ICE and Torque Blending

In HW9 & 10 you will utilize the "real" IC engine provided earlier, a shifting finite ratio transmission and torque blending with the E-Motor and develop your final version this term of the Hybrid Vehicle Model utilizing Simulink. Using your knowledge of hybrids, Matlab, Simulink and your general engineering skills to do the following.

1) Utilizing the multispeed transmission from below, add the shift logic to "best" utilize the FRT over a drive cycle. You may assume all the drive cycles start at zero velocity and you start in 1st gear. You have the "real engine" from the performance map and the fuel flow for the engine and will be able to select the gear for lowest fuel usage at every point in the drive cycle. You may add an overdrive gear if you are not provided with a ratio. If you choose, you may add a second transmission to "split" the gears and have up to an eight speed transmission.

2) Using the E-Motor from previous HW's to provide the starting torque up to a set speed (list the speed), add the IC Engine at the appropriate speed and blend the torque until the IC Engine provides all of the torque. This can done using a variable gain, see figure below once you have a working HEV. The example below is for a embedded function, however you may use a method that best fits your Simulink model. You may start with a 50% torque blend.

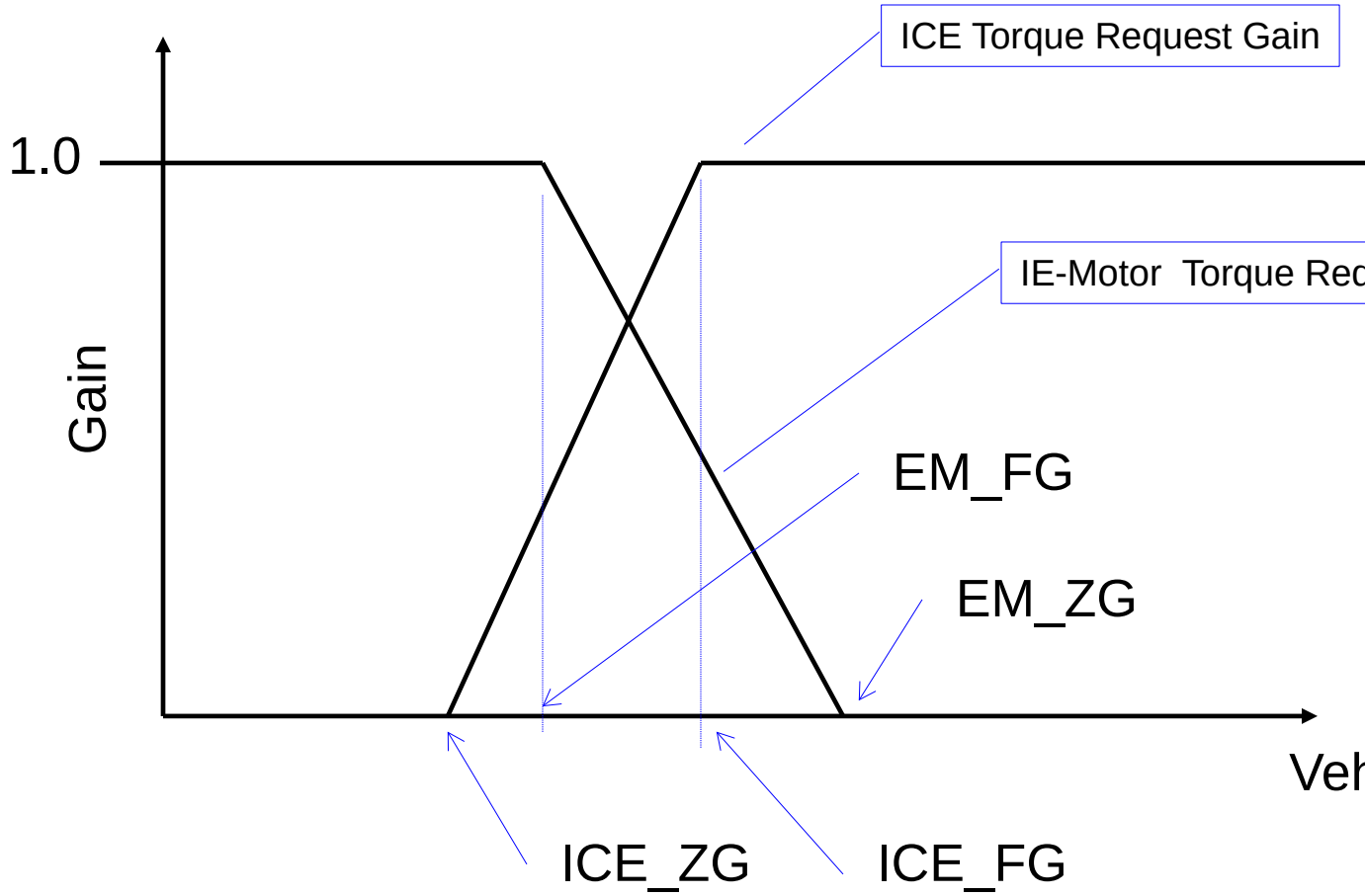

Figure 1: Variable gain method to blend torque.

Function	**Variable Name**
Sets the value of full gain based on Vehicle Speed for the E-motor, at zero for this example	X_Dot_EM_FG
Sets the value of zero gain based on Vehicle Speed for the E-motor	X_Dot_EM_ZG
Sets the value of full gain based on Vehicle Speed for the ICE	X_Dot_ICE_FG
Sets the value of zero gain based on Vehicle Speed for the ICE	X_Dot_ICE_ZG

Table 1: Variables for the variable gain example.

The Variable Gain is one method to blend the torque, in the write-up for the HW, explain the method utilized in your Simulink/Matlab model.

Your last name starts with	1st	2nd	3rd	4th	5th	Differential Ratio	Other information
AJ	2.2/1	1.64/1	1.28/1	1.0/1		3.73/1	Muncie "rock crusher" Transmission
KP	2.56/1	1.91/1	1.48/1	1.0/1		3.55/1	Muncie Transmission
QZ	3.42/1	2.14/1	1.45/1	1.03/1	0.77/1	3.82/1	Compact car

Table 2: Transmission and final drive (differential) ratios.

Your last name starts with	Weight, Newtons	Area, meters^2	Tire Radius, meters	Cd	Wheelbase, Meters L=variable	Front/Rear Weight Ratio	L/H Ratio H=height to cg.
AJ	18,680	2.40	0.318	0.44	2.89	52.0	3.71
KP	17,680	2.45	0.318	0.44	2.89	52.0	3.71
QZ	13,400	2.10	0.303	0.38	2.61	51.5	3.93

Table 3: Vehicle Parameters

For the actual fuel consumption output, use the conversion of 2,660 grams/gallon. To obtain the total fuel usage, use an integrator block.

General Output Requirements:

1) The fuel flow at each point in the drive cycle for each gear.
2) The gear you are in at each point in the drive cycle.
3) The total fuel usage in gallons for a complete drive cycle.
4) The "Engine Stop" flag. For HW-9 & 10 we want to know when we COULD stop the engine. We would only stop the engine at engine speeds below _____rpm. Give reasons for the values. Track the time engine could be off and possible fuel savings. This is highly drive cycle dependent.
5) Plots/scopes of the above in a format that **clearly** show the potential for fuel savings based on the shift criteria, frequency of shifting, engine off fuel savings, etc. This is your opportunity to demonstrate your understanding of hybrid powertrains, vehicle performance, Model Based Design, etc.

General Comments:

Since the actual shifting of the transmission is required, it should reflect a method to minimize the fuel usage, however you may have a tolerance for when it shifts to avoid "overshifting." The shift criteria for an actual vehicle, with acceptable drive quality, will be covered in MEEM5295.

In HW-9 & 10, The E-Motor is used for regeneration during braking and to provide the torque until the IC-Engine reaches the minimum speed shown in the engine fuel map and then reduces to zero torque as the IC Engine provides all the torque required/requested.

Select a minimum torque (or maximum speed) for the E-Motor and turn off the E-Motor at that point. Also in the write-up, list the torque (or speed) and reason for the choice.