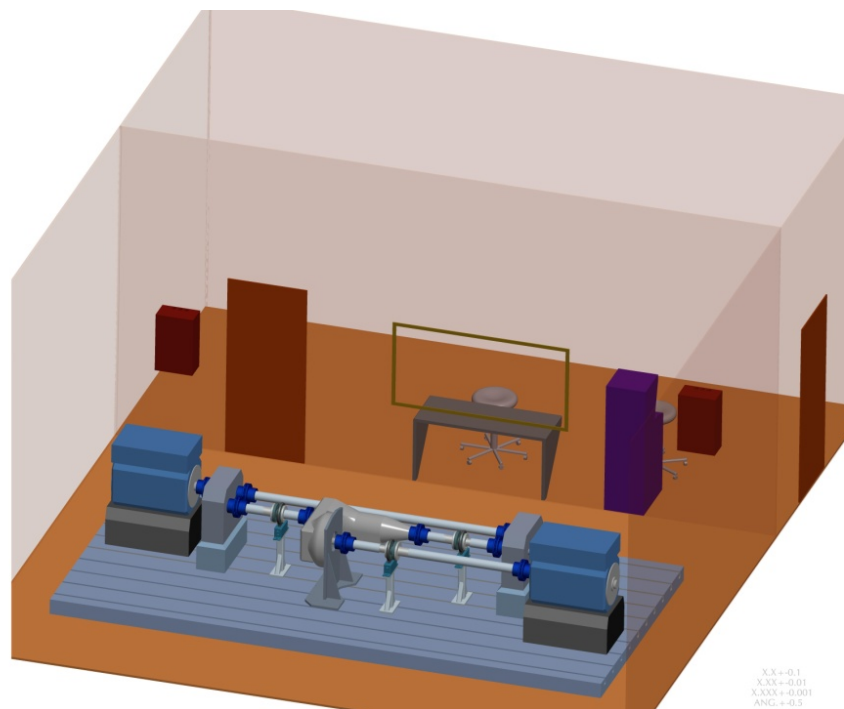


## Description of a Manual Transaxle Efficiency Test Stand

With the continual pressure to improve vehicle fuel consumption, it is important that powertrain components provide maximum efficiency across a wide range of operating conditions. To validate this, manufacturers must be able to conduct efficiency testing with very high levels of control and repeatability. Conducting such testing is particularly challenging for manual transaxles. This is because precise measurements must be made to quantify the relatively small energy losses that occur in relationship to the relatively higher power levels that are transmitted.

A representative manual transaxle efficiency test stand is shown in the figure below and consists of the following primary components:

- Input electric motor
- Input and output torque transducers
- Summing gearboxes
- Output electric dynamometer
- Fluid conditioning

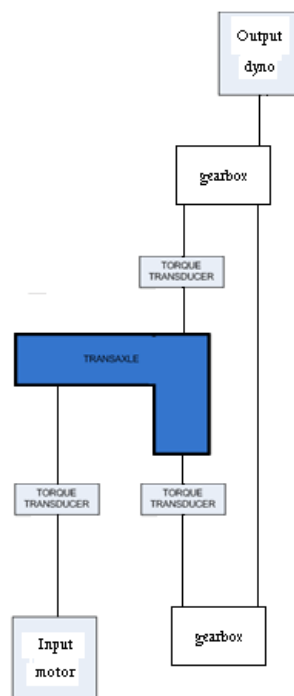


In order to conduct efficiency testing the input to the transaxle must be free of any torsional vibrations so an engine cannot be used. Instead an electric motor must be used and power must be transferred to the transaxle through horizontally mounted shafts and couplings in order to prevent any ‘one-per’ torque pulsations from occurring.

The transaxle will be mounted to a specially designed headstand containing a bearing supported shaft with a flange end configuration for mounting the flywheel.

The outputs from the two half shafts will be connected to two parallel offset gearboxes. The outputs of these two gearboxes will be lashed together with rigid shafting. This guarantees that there will be no speed differences across the differential, which would manifest itself as a power loss, and an artificially lowered transaxle efficiency.

Before and after the transaxle, speed and torque transducers would be mounted in order to monitor input and output torque values. These torque sensors are a non contacting, strain gauge type that transmits signals across an air gap to a stationary antenna at 2200 hz. The torque sensor has an accuracy  $\pm 0.1\%$  of its full scale rating. Integral to the torque transducer is a high resolution optical speed sensor. A block diagram showing the location of the torque transducers is shown in the figure below:



At the output of one of the gearboxes is an electric dynamometer that is used to load the transaxle. Each motor works in conjunction with a variable frequency drive to maintain set point conditions across a wide range of operating conditions.

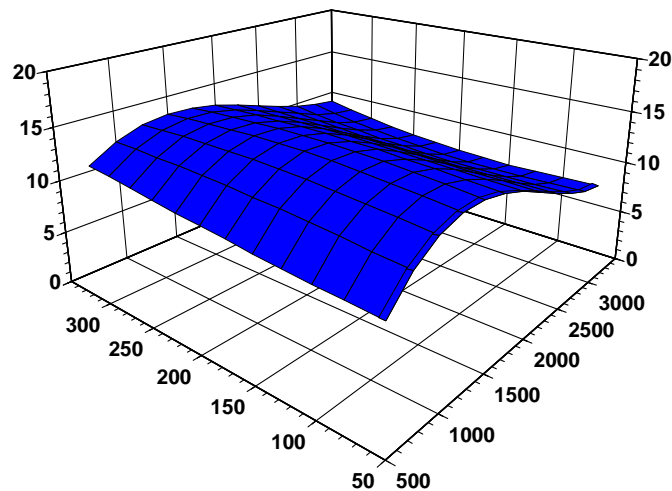
The variable frequency drives will have both motoring and absorbing capabilities. This will allow the motor and dynamometer to be operated and controlled in either speed or torque control. This allows the transaxle to be tested in both the engine driven mode and the front wheel driven, or ‘back driving’ mode as it is often referred to.

Efficiency testing is conducted at steady state conditions, so that the transaxle can be manually shifted between gears, thus eliminating the need for a robotic shifter.

The test stand is configured with flexible data acquisition hardware and software system. Specific features of the software include:

- an easy to use graphical user interface (GUI)
- calibration screens
- closed loop control
- data display
- data trending
- out of condition warning
- historical register
- self monitoring
- emergency shutdowns

Most importantly though is the automated presentation of transaxle efficiency values and the creation of three dimensional torque-speed- torque loss or efficiency surfaces that are regressed for R-square, RMSE and probability values. An example of such a surface is shown in the figure below:



These surfaces are transferred as a third order polynomial relationship, which in turn is reflected as math models of the transaxle. These models are used in vehicle simulations to project vehicle fuel economy, and to help the transaxle designers better understand the operating conditions where improved transaxle efficiencies would be most beneficial.

As regards additional information on the manual transaxle efficiency test stand, please contact Mike Kluger via e-mail at [mkluger@swri.org](mailto:mkluger@swri.org) or Dr. Gyanendra Sharma [gksharma@swri.org](mailto:gksharma@swri.org).