Automated Manual Transmissions

Shift buttons on the steering wheel of a FIAT Bravo (Source: www.fiat.it)

The automated manual transmission (AMT) is an intermediate technological solution between the manual transmission used in Europe and Latin America and the automated transmission popular in North America, Australia, and parts of Asia. The driver, instead of using a gear stick and clutch pedal to shift gears, presses an upshift or downshift button and the system automatically disengages the clutch pedal, shifts the gear, and engages the clutch again while modulating the throttle; the driver can also choose a fully automated mode. AMT is an add-on solution on classical manual transmission systems, with control technology helping to guarantee performance and ease of use.

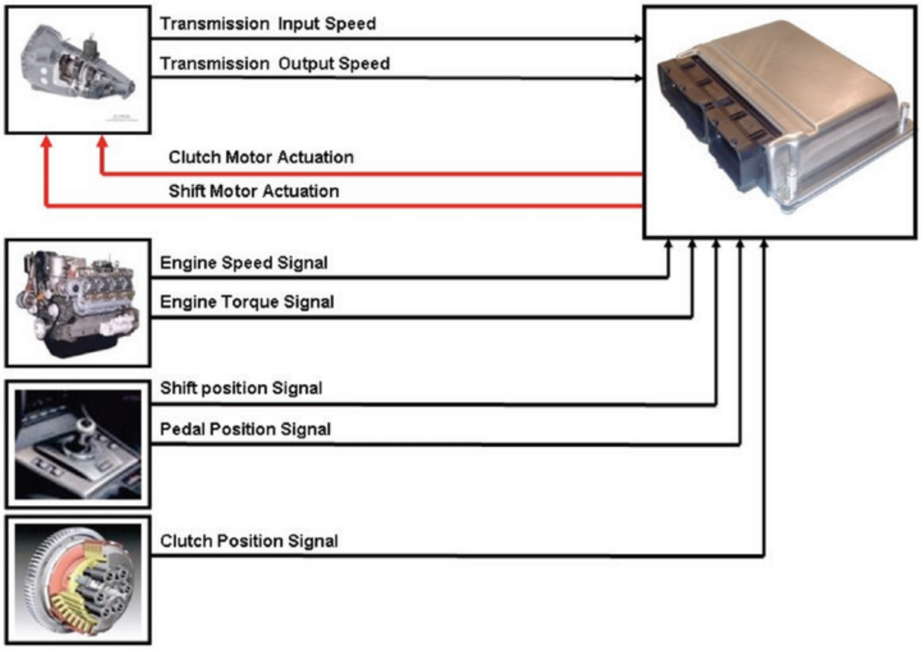
AMT Overview

An AMT is composed of a dry clutch, a gearbox, and an embedded dedicated control system that uses electronic sensors, processors, and actuators to actuate gear shifts on the driver's command. This eliminates the need for a clutch pedal while still allowing the driver to decide when to change gears. The clutch itself is actuated by electronic equipment that can synchronize the timing and the torque required to make gear shifts quick and smooth. The system is designed to provide a better driving experience, especially in cities where congestion frequently causes stop-and-go traffic patterns.

AMTs have been used in racing cars for many years, but only recently have they become feasible for use in everyday vehicles with their more stringent requirements for reliability, cost, and ease of use.

Benefits of AMT

- Changing gears without using a foot to operate the clutch
- No engine or gear modifications
- Less physical or psychological stress
- More comfortable than manual transmissions
- More "fun" factor compared to fully automatic transmissions



Inputs and outputs for a typical AMT system (Source: www.itri.org.tw)

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AMT systems are currently installed by several automakers under different commercial names, such as SeleSpeed by FIAT, Sequential Manual Gearbox by BMW, 2Tronic by Peugeot, SensoDrive by Citroen, and EasyTronic by Opel.

Commercial dual-clutch transmission (DCT) systems include the Direct-Shift Gearbox by Volkswagen Group and the Dual Dry Clutch Transmission by FIAT Group.

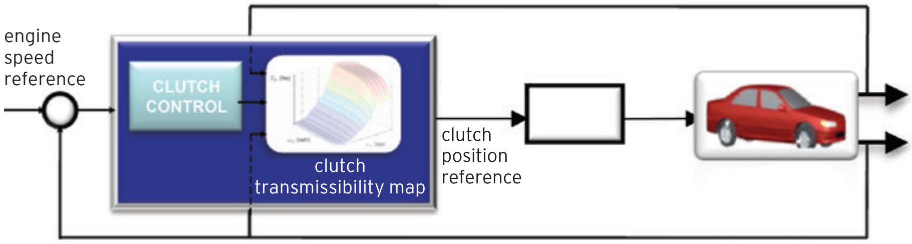
Inventions and Innovations

AMT is an interesting example showing the importance and potential of automatic control. The control of the clutch engagement on AMT systems must satisfy different and conflicting objectives:

- It should result in the same or better shifting times as with manual transmissions.
- It should improve performance in terms of emissions and facing wear.

In a typical AMT control scheme, a constant engine speed is requested during the engagement so as to equalize engine and clutch torques as well as possible. In this case, the clutch control provides a clutch torque reference, and through a suitable model (or map), the torque reference is converted into a position reference for the clutch actuator position control (see figure below).

Commercial implementations of AMT today rely on enhancements of PID controllers with feedforward actions and controller gain scheduling.



Future View: Toward Model-Based Control of AMTs

Model-based approaches are attracting increasing interest as evidenced by several control strategies that have recently been proposed in the literature. These strategies are based on optimal control, predictive control, decoupling control, and robust control.

Innovative AMT technology uses a dual-clutch transmission consisting of one clutch for odd gears and another for even gears. The goal is to improve the speed and comfort of the gear shift. But effective AMT controllers, particularly for dual-clutch systems, are difficult to design without an accurate model of the clutch torque transmissibility characteristic, or the relationship between the clutch actuator position (or the pressure applied by the clutch actuator) and the torque transmitted through the clutch during the engagement phase.

The clutch transmissibility model, key to advanced control of AMTs, is difficult to attain: it depends on various parameters and phenomena, such as friction pad geometries, cushion spring compression and load, and slip-speed-and-temperature-dependent friction. Accurate clutch transmissibility models will allow the use of advanced model-based control strategies aimed at improving the overall behavior of the system with respect to current commercial solutions.