AUTOMOTIVE ELECTRONICS HANDBOOK

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CHAPTER 14
CRUISE CONTROL

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14.1 CRUISE CONTROL SYSTEM

A vehicle speed control system can range from a simple throttle latching device to a sophisticated digital controller that constantly maintains a set speed under varying driving conditions. The next generation of electronic speed control systems will probably still use a separate module (black box), the same as present-day systems, but will share data from the engine, ABS, and transmission control systems. Futuristic cruise control systems that include radar sensors to measure the rate of closure to other vehicles and adjust the speed to maintain a constant distance are possible but need significant cost reductions for widespread private vehicle usage.

The objective of an automatic vehicle cruise control is to sustain a steady speed under varying road conditions, thus allowing the vehicle operator to relax from constant foot throttle manipulation. In some cases, the cruise control system may actually improve the vehicle's fuel efficiency value by limiting throttle excursions to small steps. By using the power and speed of a microcontroller device and fuzzy logic software design, an excellent cruise control system can be designed.

14.1.1 Functional Elements

The cruise control system is a closed-loop speed control as shown in Fig. 14.1. The key input signals are the driver's speed setpoint and the vehicle's actual speed. Other important inputs are the faster-accel/slower-coast driver adjustments, resume, on/off, brake switch, and engine control messages. The key output signals are the throttle control servo actuator values. Additional output signals include cruise ON and service indicators, plus messages to the engine and/or transmission control system and possibly data for diagnostics.

14.1.2 Performance Expectations

The ideal cruise system features would include the following specifications:

- *Speed performance:* ±0.5 m/h control at less than 5 percent grade, and ±1 m/h control or vehicle limit over 5 percent grade.
- *Reliability:* Circuit designed to withstand overvoltage transients, reverse voltages, and power dissipation of components kept to minimum.

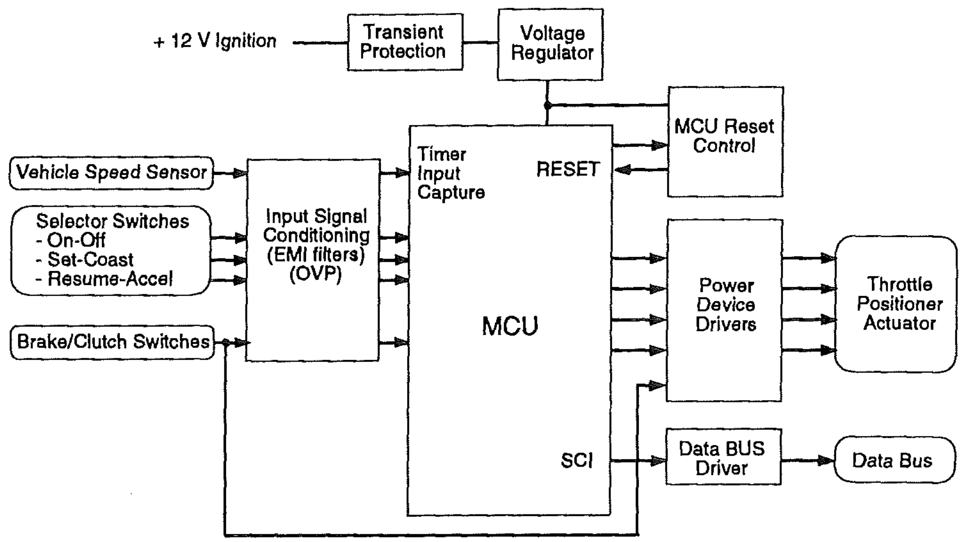

FIGURE 14.1 Cruise control system.

- *Application options:* By changing EEPROM via a simple serial data interface or over the MUX network, the cruise software can be upgraded and optimized for specific vehicle types. These provisions allow for various sensors, servos, and speed ranges.
- *Driver adaptability:* The response time of the cruise control can be adjusted to match the driver's preferences within the constraints of the vehicle's performance.
- *Favorable price-to-performance ratio:* The use of integrated actuator drivers and a high-functionality MCU reduce component counts, increase reliability, and decrease the cruise control module's footprint.

14.1.3 Safety Considerations (Failsafe)

Several safety factors need to be considered for a vehicle speed control design. The most basic is a method designed into the throttle control circuit to insure a failsafe mode of operation in the event that the microcontroller or actuator drivers should fail. This electronic failsafe circuit shuts off the control servos so that the throttle linkage will be released when the brake switch or cruise off switch is activated, no matter the condition of the MCU or servo actuator control transistors. (This assumes the actuators are mechanically in good shape and will release.)

Other safety-related items include program code to detect abnormal operating conditions and preserving into memory the data points associated with the abnormal condition for later diagnostics. Abnormal conditions, for example, could be an intermittent vehicle speed sensor, or erratic driver switch signals. A test could also be made during the initial ignition "key on time" plus any time the cruise is activated to verify the integrity of the cruise system, with any faults resulting in a warning indicator to the driver. Obviously, the most serious fault to avoid is runaway acceleration. Continuous monitoring of the MCU and key control elements will help minimize the potential for this type of fault.

14.2 MICROCONTROLLER REQUIREMENTS FOR CRUISE CONTROL

The MCU for cruise control applications requires high functionality. The MCU would include the following:

- a precise internal timebase for the speed measurement calculations
- A/D inputs
- PWM outputs
- timer input capture
- timer output compares
- serial data port (MUX port)
- internal watchdog
- EEPROM
- low-power CMOS technology

14.2.1 Input Signals

The speed sensor is one of the most critical parts in the system, because the microcontroller calculates the vehicle speed from the speed sensor's signal to within $1/32$ m/h. Any speedometer cable whip or oscillation can cause errors to be introduced into the speed calculation. An averaging routine in the speed calculations can minimize this effect. The speedometer sensor drives the microcontroller's timer input capture line or the external interrupt line. The MCU then calculates the vehicle's speed from the frequency of the sensor signals and the MCU internal timebase. The vehicle's speed value is continually updated and stored into RAM for use by the basic speed control program. Speed sensors traditionally have been a simple ac generator located in the transmission or speedometer cable. The ac generator produces an ac voltage waveform with its frequency proportional to the sensor's rpm and vehicle speed. Optical sensors in the speedometer head can also be incorporated. Usually the speed sensor produces a number of pulses or cycles per km or mile. With the increasing ABS system usage, a backup speed sensor value could be obtained from the ABS wheel speed sensors. The ABS speed data could be obtained by way of a MUX network.

The user command switch signals could either be single MCU input lines to each switch contact or a more complex analog resistor divider type to an A/D input line. Other input signals of interest to the cruise system program would be throttle position, transmission or clutch status, A/C status, actuator diagnostics, engine status, etc., which could be obtained over the MUX data network.

14.2.2 Program Flow

The microcontroller is programmed to measure the rate of vehicle speed and note how much, and in which direction, the vehicle speed is drifting. The standard PI (proportional-integral) method produces one output signal p that is proportional to the difference between the set-speed and actual vehicle speed (the error value) by a proportional gain block Kp. Another signal i is generated that ramps up or down at a rate set by the error signal magnitude. The gains of both Ki and Kp are chosen to provide a quick response, but with little instability. In effect, the PI system adds up the error rate over time, and, therefore, if an underspeed condition occurs as in a long uphill grade, the error signal will begin to greatly increase to try to compensate. Under level driving conditions, the integral control block Ki will tend toward zero

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