Computer Science 773

Robotics and Real-time Control

OPEN-LOOP CONTROL

An ignition timing control system

Whether or not this is really open-loop control is to some degree a matter of definition. In a sense, there is some sort of feedback through the several input signals via the performance of the vehicle : a set of input signals will generate a set of output signals which will change the engine controls which will affect the performance which will lead to a new set of input signals …

But there is never a sense of reducing an error signal to zero. The essence of the closed-loop model is to compare some measurement with a required value, and to adjust things until the two values coincide.

(Thanks to the 473 group of 1989 for raising the question.)

Control unit input values

1. Battery voltage UB
   Battery voltage is measured as an additional value to the load and speed inputs.

2. Starting information UST
   The control unit identifies a starting attempt by way of terminal 50.

3. Engine speed n
   The flywheel gear ring has 116 teeth. A sensor above the gear ring responds to both flanks of each tooth and transmits 232 inductive impulses to the control unit for each revolution of the flywheel.

4. Reference mark signal BM
   A reference mark on the flywheel passes this sensor 100 degrees before crankshaft top dead center, and generates an inductive impulse for each rotation of the crankshaft.

5. Overheat protection switch UM
   A limit switch in parallel with NTC* sensor II short-circuits the NTC when a preset coolant temperature is reached, so that the overheat protection can take effect.

6. Throttle butterfly position UDK
   The control unit is informed of the throttle position at any given moment by the switches for idle speed (LL) or full load (VL).

7. Airflow volume Q
   The airflow meter measures the volume of air drawn into the engine. Depending on the angle to which the baffle unit is deflected, the potentiometer transmits a signal at an increasing voltage to the control unit. Together with the speed impulses, this is processed internally to determine the load on the engine.

8. Air temperature sensor NTC I
An NTC sensor is mounted in the air tract of the airflow meter, and measures the temperature of the incoming air. An equivalent signal is transmitted to the control unit.

9. Coolant temperature sensor NTC II
To indicate the engine's working condition, an NTC sensor measures coolant temperature and transmits a resistive value to the control unit.

* NTC sensors are sensors with a negative temperature coefficient, that is to say their electrical resistance becomes lower as they heat up, so that the rise in temperature can be transmitted to the control unit in the form of an increasing electrical voltage.

The fixed-value memory in the control unit of the digital motor electronics system contains 16 load and 16 speed parameters, and permits the programming of 256 fixed ignition timing settings based on the combinations of these stored values. In accordance with actual engine operation conditions, the control unit receives certain input data from the 9 sensors already referred to above. These data are evaluated by the micro-computer and compared with the programmed and stored ignition timing angles in the fixed-value memory.

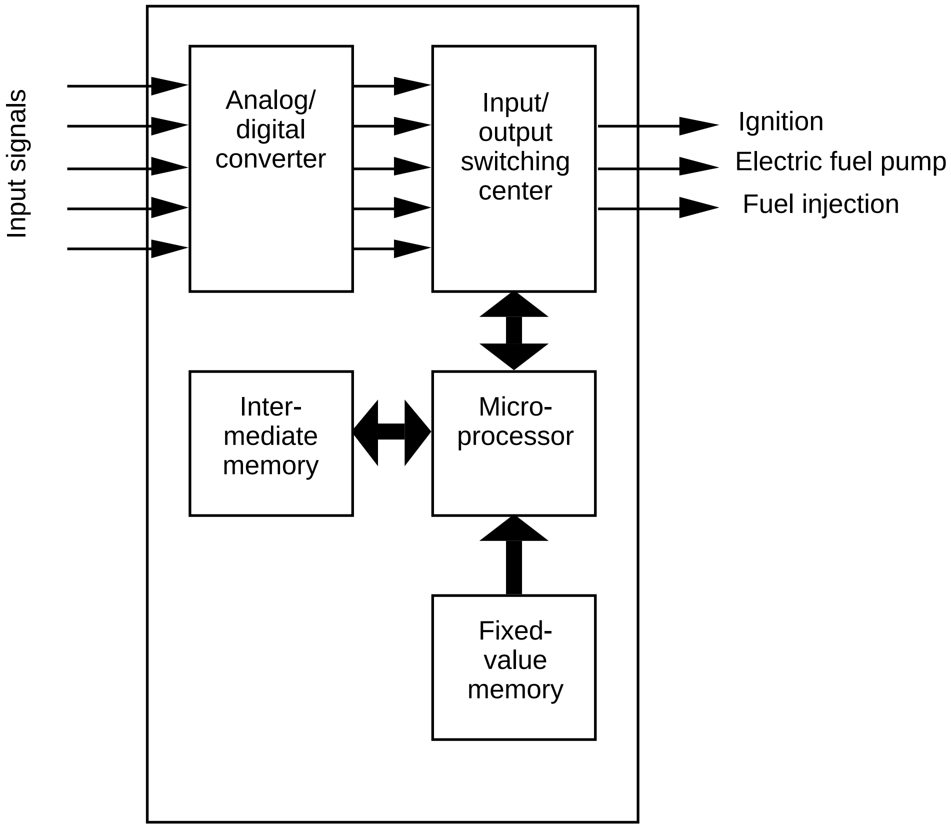
Arbitrary ignition advance
and retard control

If the evaluated information agrees with the fixed ignition timing values, the position of the crankshaft at which the micro-processor instructs the output switching center to produce the spark-inducing impulse at the power stage is already correctly programmed. (See block circuit diagram of computer.)

If the input values at the microprocessor prove to be in between the fixed settings, the intermediate memory is used to calculate an intermediate angle according to a programmed mathematical formula. The actual subdivisions are so small that a further three intermediate ignition timings are possible between any two fixed settings. This means that the transition from one fixed setting to the next is almost continuous in practice.

The smallest possible 'jump' in the ignition timing (increment) is (360° CS)/232 = 1.55° (CS = crankshaft).

The computing speed is so high that a fresh analysis of input data and ignition timing computation take place on every revolution of the engine at medium speed, so that the ignition timing is continuously advanced or retarded to suit operating conditions and avoid reaching the engine's knock limit.



REFERENCE.

Motronic digital motor electronics engine management system (BMW Australia Ltd.; I've lost my original copy, so can't give the date, but it was several years ago.)

Alan Creak,
March, 1998.