Electronic Engine Control

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I. INTRODUCTION

Electronics in the automobile has a relatively long history beginning with the installation of AM radio receivers in automobiles. There has been essentially an orderly, continuous evolution from the earlier vacuum tube autoradios to the latest complex automotive entertainment systems employing microprocessors.

On the other hand the utilization of digital electronics for instrumentation or control application has been a major jump in automotive technology. This has resulted partly from the relatively low cost of the microprocessor and partly from its capability to implement multivariable adaptive control.

The control application of microprocessors in the automobile began in the middle 1970s, and this application is continuing to develop rapidly. By 1980 production automobiles had microprocessor-based control of the engine. In addition, there was widespread instrumentation application of microprocessors. It is clear that these applications will expand rapidly in the future, and it is likely that control of the entire power train will evolve. Moreover there is indication that electronic control of the vehicle dynamics in the form of "ride control" will be developed.

Probably the most significant control application of the microprocessor in the automobile is the electronic engine control system. This system provides much more precise control of air-fuel and spark advance than has been achievable with conventional pneumatic-mechanical control. In addition, it has the capability of optimizing engine fuel economy at any operating point subject to the exhaust emission constraints imposed by government regulation. Further, it operates the
evaporative emission control apparatus optimally with respect to vehicle performance and will likely control the transmission in the near future.

There is a great variety of powerplants available to the automotive designer at the present time. However, the most prevalent automotive engine at the time of this writing is the gasoline-fueled, spark-ignited internal combustion engine. This engine class is discussed exclusively in this chapter because it has been the greatest beneficiary of electronic controls to date. This engine class will be called the SI engine in this chapter.

A. Emission and Performance Constraints on the Automobile

Electronic control of the automotive engine has been motivated by the requirement to control exhaust emissions and by the requirement to meet government-mandated fuel economy standards. The latter requirement is known by the acronym CAFE (corporate average fuel economy).

Automotive exhaust emission control requirements have existed in the United States since 1966, when the earliest regulations became effective in California. Emission control limits were expanded to all states and became progressively more stringent through the late 1970s. The exhaust gases which are controlled are carbon monoxide (CO), various hydrocarbons (HC), and oxides of nitrogen (NO\textsubscript{x}). The emission requirements and CAFE for this period are presented in Table 1.

Attempts to meet the above standards using conventional mechanical or fluidic controls have failed. Moreover, mechanical controls do not have the capability to duplicate functions with sufficient accuracy across a range of production vehicles over all operating conditions and over the life of each vehicle.

Fortunately this problem can be alleviated through incorporation of self-compensating feedback control such as is available in an electronic control system. The technology of digital control systems has advanced to the point at which a multivariable automotive engine controller is feasible. Such a system has great flexibility in that it can be reconfigured through software changes.

<table>
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<tr>
<th>Year</th>
<th>HC/CO/NO\textsubscript{x}</th>
<th>CAFE</th>
<th>Fed</th>
<th>Calif</th>
<th>CAFE</th>
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<td>9.0</td>
<td>1.5</td>
<td>18</td>
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<tr>
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<td>0.41</td>
<td>9.0</td>
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