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**Accelerator Pedal
Position Sensor for
Use with Electronic
Controls in Medium-
and Heavy-Duty
Diesel On-Highway
Vehicle Applications**

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ACCELERATOR PEDAL POSITION SENSOR
FOR USE WITH ELECTRONIC CONTROLS IN
MEDIUM- AND HEAVY-DUTY DIESEL ON-HIGHWAY VEHICLE APPLICATIONS

1. INTRODUCTION:

Many electronic controls used in medium- and heavy-duty on-highway vehicles require an electrical indication of accelerator pedal position. A common accelerator pedal position sensor function and performance criteria is desired to minimize the number of different designs that would have to be stocked by those who service the many different types and brands of vehicles. A single universal electrical interface has not been defined. Two electrical interface types are defined in this document. The intent of providing a choice of two signal types is to allow the industry time to prove by actual application the best selection.

A common mechanical definition of the size, shape, etc. of the accelerator pedal position sensor is also desired. The present variations in vehicle configurations and design requirements cannot be satisfied by a single mechanical interface specification for the accelerator pedal position sensor. A mechanical interface for an integral floor-mounted accelerator pedal position sensor is proposed in this document with the intent that future vehicle designs will utilize the recommended configuration. A mechanical interface for a remote mount or suspended APS has not been defined at this time.

2. PURPOSE:

The purpose of this document is to provide a common electrical and mechanical interface specification that can be used to design electronic accelerator pedal position sensors and electronic control systems for use in medium- and heavy-duty on-highway diesel powered vehicles.

3. DEFINITIONS:

- 3.1 Accelerator Pedal Position Sensor (APS): The complete device used to convert the motion of the operator's foot representing an accelerator position in to an electrical signal.

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- 3.2 Diagnostic Ranges: The ranges of APS outputs between the maximum allowable output span during normal operation and the APS output values specified as an indication of an absolute fault condition. APS outputs in the diagnostic ranges may be used by the controller(s) as an out-of-range indication, but do not necessarily indicate an absolute fault.
- 3.3 Duty Cycle: The ratio of signal time high to signal period (Fig. 6).
- 3.4 Electrical Interface: The electrical signals to be passed from the APS to other electronic/electrical devices.
- 3.5 Fault Ranges: The ranges of the APS output values beyond the diagnostic range that indicate an absolute fault condition in the APS.
- 3.6 Full Scale: The difference between the theoretical maximum and minimum signal outputs (i.e., 100% of analog supply voltage or 100% duty cycle).
- 3.7 Mechanical Interface: The physical boundaries of the APS.
- 3.8 Output Hysteresis: The maximum output signal difference for a given input pedal position due to previous history of pedal motion in either the increasing or decreasing direction.
- 3.9 Output Linearity: The maximum deviation of the actual output transfer function from a straight line defined by the best fit linear regression straight line through the actual output values (Fig. 9).
- 3.10 Output Smoothness: Any spurious variation in the output not present in the input is measured as the difference between the actual output transfer function and the end points of a 2.0% of total pedal travel long line parallel to the output linearity function that passes through the actual output value for any APS position. The difference between the actual output values and the parallel line end points located $\pm 1.0\%$ of total travel from the APS position should be less than the output smoothness specification (Fig. 10).
- 3.11 Pulse Width Modulated (PWM): A system of modulation where the duty cycle of discrete pulses are varied by controlling the leading, trailing, or both edges to represent an output signal where the duty cycle of the pulse is proportional to the value represented.
- 3.12 Sensing Element: The portion of, or discrete device contained within, the APS that converts physical motion in to a usable electrical signal.
- 3.13 Supply Voltage: The voltage measured between the +V supply and -V supply leads with the APS device connected.
- 3.14 Treadle: The lever operated by the foot.
4. RELATED DOCUMENTS:
- 4.1 SAE J1455 JAN88, Joint SAE/TMC Recommended Environmental Practices for Electronic Equipment Design (Heavy-Duty Trucks)

- 4.2 The integral APS mechanism shall comply with all appropriate Federal Motor Vehicle Safety Standards.

5. MECHANICAL INTERFACE:

The following specifications are for an integral floor-mounted accelerator pedal position sensor. The geometry is intended to define the maximum package size and bolt mounting pattern for an integral sensor and treadle configuration.

The APS should be sized to fit within the envelope size defined in Fig. 1.

The APS mounting to the vehicle floor boards should comply with the dimensions shown in Fig. 2.

The accelerator pedal mechanism should provide a mechanical travel of 18 to 25 deg, as measured from the typical location of the rear of the operator's heel to a toe position, as shown in Fig. 3.

The accelerator pedal mechanism should minimize the amount of treadle motion that does not produce a change in the output signal.

6. ELECTRICAL INTERFACE:

The electrical output signal of the APS is intended to be used by only one recipient device (i.e., electronic engine control only, or electronic transmission control only). If multiple devices require a reliable signal from the APS, then isolated and buffered individual outputs from the APS to each device should be used to prevent the loss of the APS signal if a fault occurred in only one subsystem.

Two optional electrical interfaces are defined. Either Option A, an analog ratiometric signal or Option B, a pulse width modulated (PWM) electronic interface can be used. The two options are presented and both are presently used in the industry today. An APS is not expected to provide both Option A and Option B output signals, nor is the recipient device expected to be compatible with both.

7. ANALOG RATIOMETRIC ELECTRONIC INTERFACE (Option A):

The following specifications shall apply when an analog ratiometric electronic interface is used in the APS.

7.1 Supply Voltage: 5.0 V DC $\pm$ 0.50

7.2 Supply Current: 20 mA maximum

7.3 Output Range: (See Fig. 4).

Span = $67.5\% \pm 7.5\%$ of supply voltage.

Minimum APS Position = $15\% \pm 5\%$ of supply voltage.

Maximum APS Position = $77.5\% \pm 7.5\%$ of supply voltage.

7.4 Diagnostic Range: (See Fig. 4).

Lower Range = Less than 10% of supply voltage.

Upper Range = Greater than 85% of supply voltage.

7.5 Fault Range: (See Fig. 4).

Lower Range = Less than 5% of supply voltage.

Upper Range = Greater than 90% of supply voltage.

7.6 Output Smoothness: 0.5% of full scale output for any 2% interval of total travel over the output range (Fig. 10).

7.7 Output Linearity: $\pm 5\%$ of full scale output over the output range.

7.8 Output Current: The output transfer function defined in Fig. 4 is to be valid under an electrical test load of $47\text{ k}\Omega \pm 5\%$. (See Fig. 5).

7.9 Output Hysteresis: The sensing device must not exhibit output hysteresis greater than 2% of full scale output when measured at mid-travel. Output hysteresis is measured at the direct mechanical input to the accelerator pedal position sensing element. Hysteresis of the linkages between the treadle and the sensing element of the APS are not included.

7.10 Open Circuit Response: An open circuit of any lead to the APS shall result in a signal as measured across the test points ($47\text{ k}\Omega \pm 5\%$ test load as per Fig. 5) within a specified fault range as shown in Fig. 4 and within a maximum time of 1.0 s. The signal shall transit from a specified fault range signal to the correct reading at any APS position in less than 0.1 s (signal slew rate only) upon return to a normal operation.

7.11 Short Circuit Response: A short circuit between any two leads of the APS shall result in a signal as measured across the test points ($47\text{ k}\Omega \pm 5\%$ load as per Fig. 5) within a specified fault range as shown in Fig. 4 and within a maximum time of 1.0 s. The signal shall transit from a specified fault range signal to the correct reading at any APS position in less than 0.1 s (signal slew rate only) upon return to a normal operation.

8. PULSE WIDTH MODULATED (PWM) ELECTRONIC INTERFACE (OPTION B):

The following specifications shall apply when a pulse width modulated electronic interface, Fig. 6, is used in the APS.

8.1 Supply Voltage: Positive battery voltage, 12 or 24 V DC nominal.

8.2 Supply Current: 100 mA maximum.

8.3 Output Range: (See Fig. 7).

Minimum = 5% duty cycle.

Maximum = 95% duty cycle.

Minimum APS Position = $12.5\% \pm 7.5$ duty cycle.

Maximum APS Position = $87.5\% \pm 7.5$ duty cycle.

8.4 Fault Range: (See Fig. 7).

Lower Range = Less than 5% duty cycle.

Upper Range = Greater than 95% duty cycle.

8.5 Output Smoothness: 0.5% of full scale output for any 2% interval of total travel over the output range (Fig. 10).

8.6 Output Linearity: $\pm 5\%$ of full scale output over the output range.

8.7 Output Frequency:

Minimum = 200 Hz

Maximum = 1100 Hz

8.8 Output Current: The output transfer function as defined in Fig. 7 is to be valid under an electrical test load impedance of $47\text{ k}\Omega \pm 5\%$ and $0.001\text{ }\mu\text{F}$ capacitance. See Fig. 8 for test schematic. The output voltage across the test points high shall be greater than 3.8 V while sourcing a minimum 80 mA current. The output voltage low shall be less than 0.0 V while sinking a maximum 10 mA current.

8.9 Output Waveform: The pulse width modulated signal shall have the wave shape shown in Fig. 6 while connected to the electrical test load impedance as shown in Fig. 8.

8.10 Output Hysteresis: The sensing device must not exhibit output hysteresis greater than 2% of full scale output when measured at mid-travel. Output hysteresis is measured at the direct mechanical input to the accelerator pedal position sensing element. Hysteresis of the linkages between the treadle and the sensing element of the APS are not included.

8.11 Open Circuit Response: An open circuit of any lead to the APS shall result in a signal as measured across the test points ($47\text{ k}\Omega \pm 5\%$ and $0.001\text{ }\mu\text{F}$ test load per Fig. 8) within a specified fault range as shown in Fig. 7 and within a maximum time of 1.0 s. The signal shall transit from a specified fault range signal to the correct reading at any APS position in less than 0.1 s (signal slew rate only) upon return to a normal operation.

8.12 Short Circuit Response: A short circuit between any two leads to the APS shall result in a signal as measured across the test points ($47\text{ k}\Omega \pm 5\%$ and 0.001 microfarad test load per Fig. 8) within a specified fault range as shown in Fig. 7 and within a maximum time of 1.0 s. The signal shall transit from a specified fault range signal to the correct reading at any APS position in less than 0.1 s (signal slew rate only) upon return to a normal operation.

9. AUXILIARY APS SWITCH SIGNALS:

Some applications may require auxiliary "low idle" and "kick down" accelerator pedal position switch functions. If auxiliary switching functions are used, they shall comply to the following:

- 9.1 Switch Type: The switch signal shall be a "Form-C" switch, or an emulation of, and it shall be electrically independent of the APS output signal such that the switch signal is not derived from the APS output signal, see Fig. 11.
- 9.2 Voltage Drop: The conducting state voltage drop shall be less than 1.2 V when conducting between 1.0 and 25.0 mA.
- 9.3 Current Leakage: Nonconducting state current leakage shall be less than 100.0 mA with an applied potential of battery voltage.
- 9.4 State Change: The device shall establish a stable state in less than 50 ms after the indication of a state change.
- 9.5 Low Idle State: The APS low idle position signal shall be calibrated to change state at a point between 3 and 10% of the APS output span above the minimum APS position output and remain in the low idle state below the point at which the state change occurs.
- 9.6 Kick Down State: The APS kick down position signal shall be calibrated to change state at a point between 90 and 97% of the APS output span above the minimum APS position output and remain in the kickdown state above the point at which the state change occurs.
10. ENVIRONMENTAL REQUIREMENTS:
- The APS systems must meet these requirements over all applicable environmental specifications contained in SAE J1455 JAN88.
11. DURABILITY REQUIREMENTS:
- Performance degradation over the life of the APS shall not result in a failure of the sensor to meet these requirements.

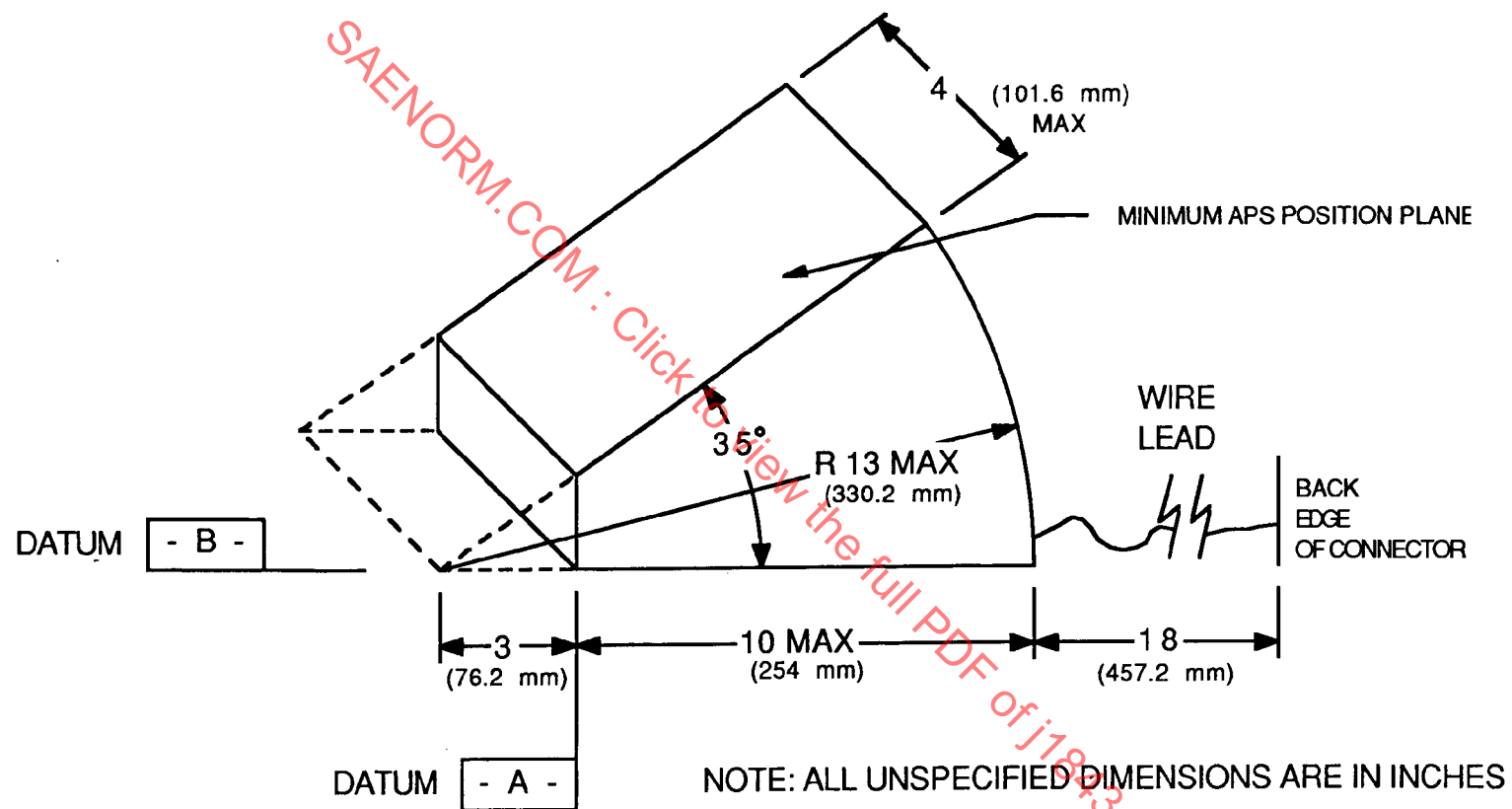


FIGURE 1 - Integral Floor Mount APS Envelope Definition

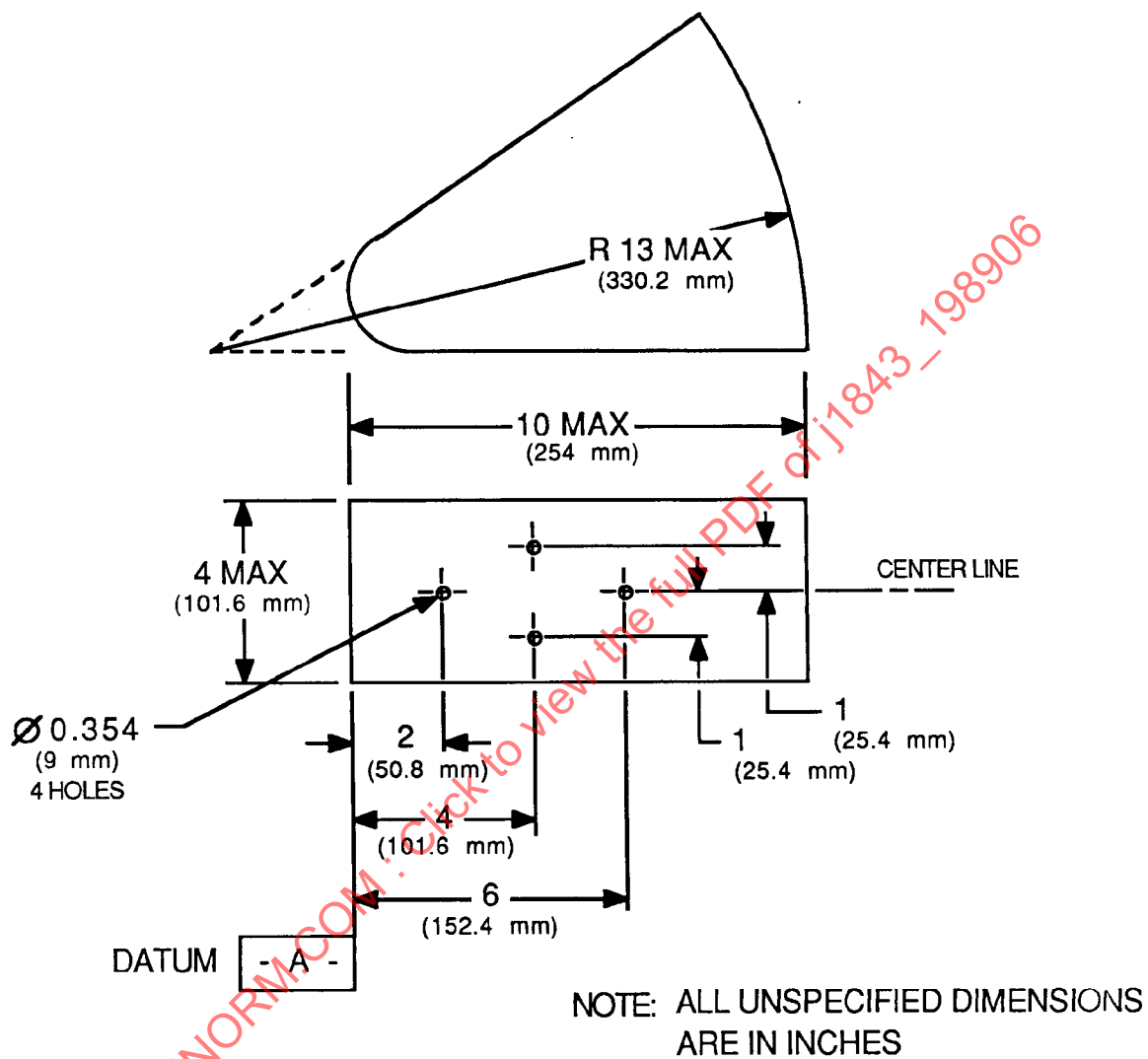


FIGURE 2 - Integral Floor Mount APS Mounting Bolt Pattern

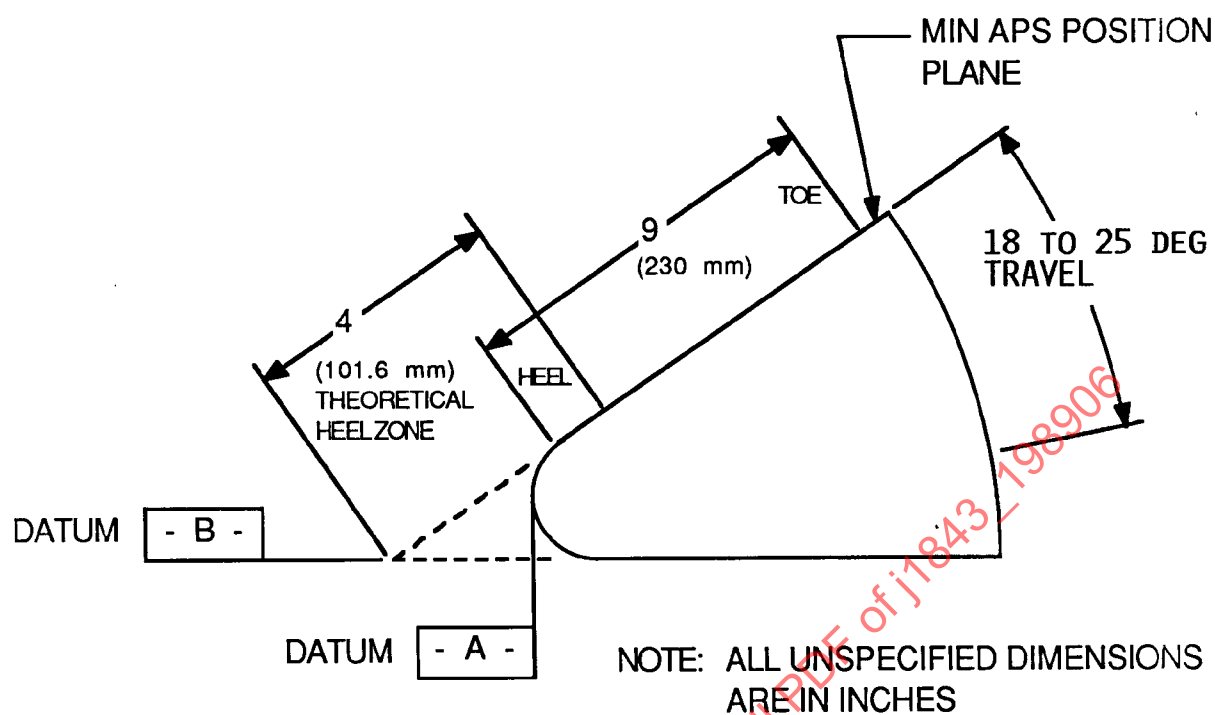


FIGURE 3 - APS Operating Travel Definition

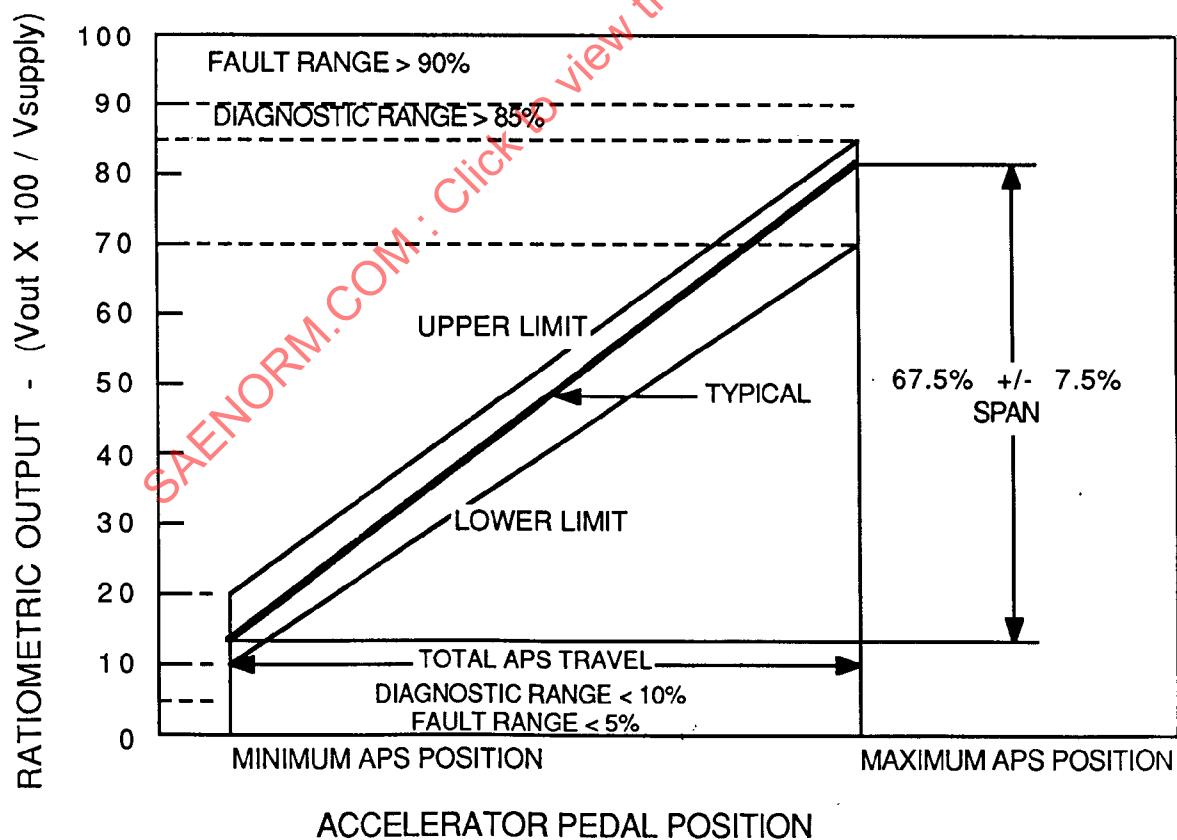


FIGURE 4 - Analog Ratiometric Output Transfer Function

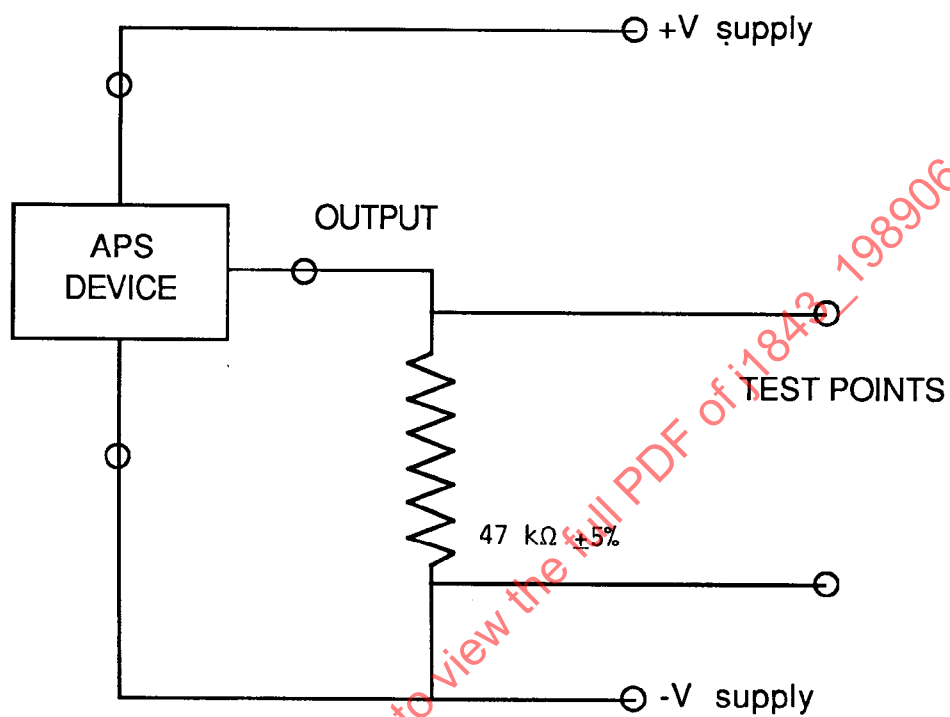
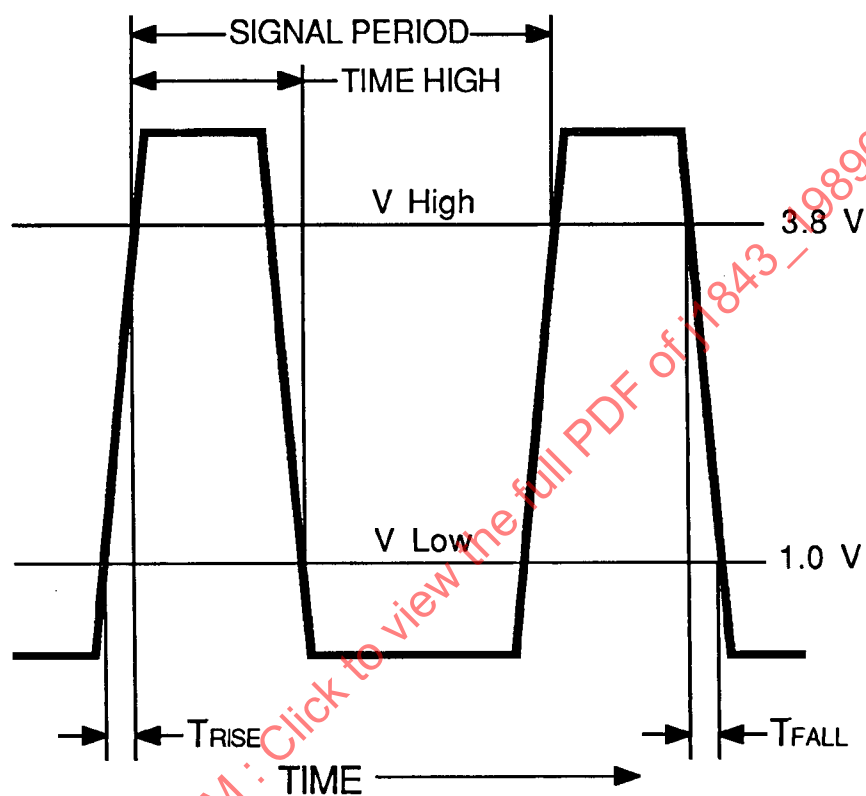


FIGURE 5 - Ratiometric APS Output Test Circuit



$$\text{DUTY CYCLE (\%)} = \frac{\text{TIME HIGH}}{\text{SIGNAL PERIOD}} \times 100$$

$$\text{OUTPUT FREQUENCY} = 1 / \text{SIGNAL PERIOD}$$

$$T_{\text{RISE}} \leq 5 \text{ microseconds}$$

$$T_{\text{FALL}} \leq 5 \text{ microseconds}$$

FIGURE 6 – Pulse Width Modulated Signal Waveform

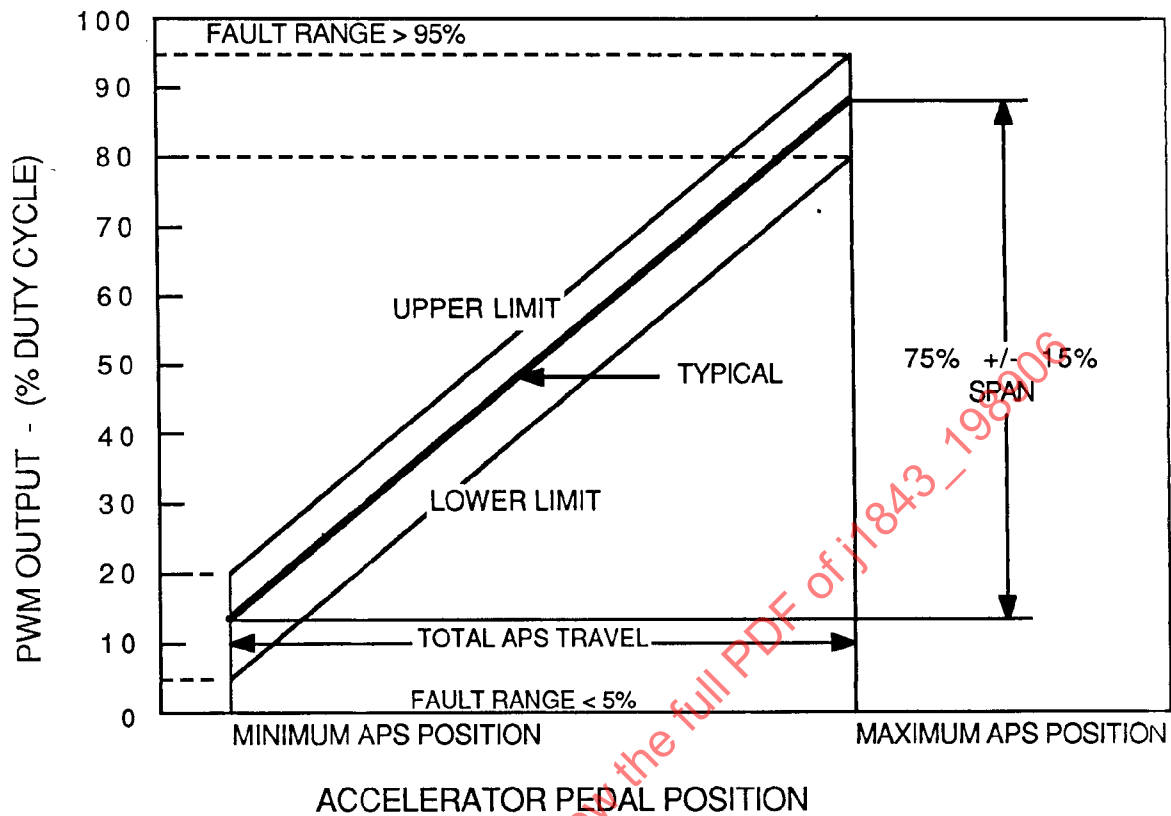


FIGURE 7 - Pulse Width Modulated Output Transfer Function

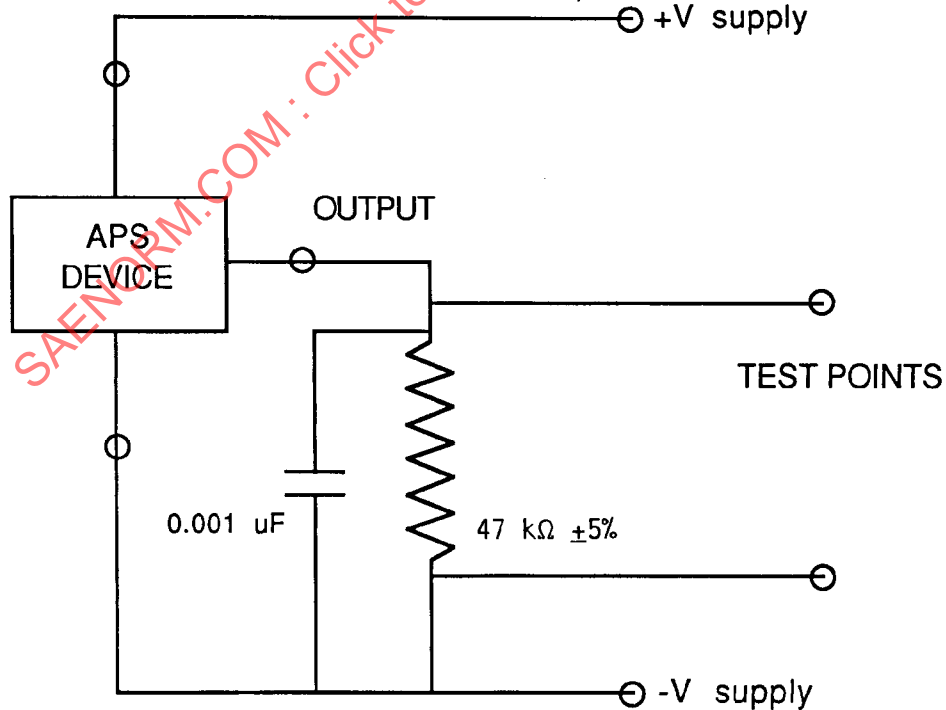


FIGURE 8 - PWM APS Output Test Circuit

OUTPUT LINEARITY

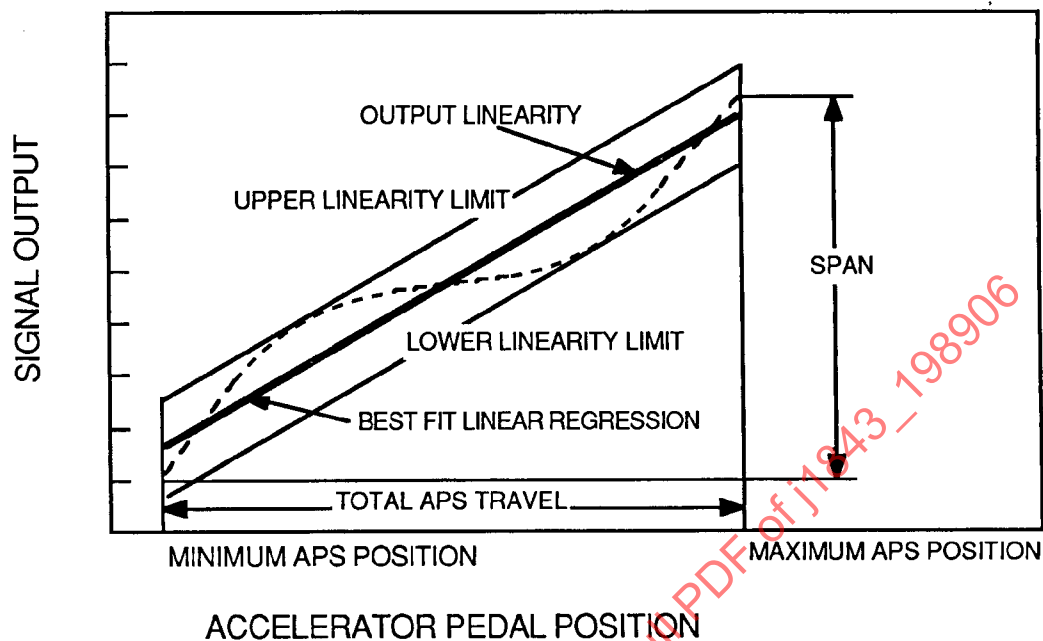


FIGURE 9 - Output Linearity Definition

OUTPUT SMOOTHNESS

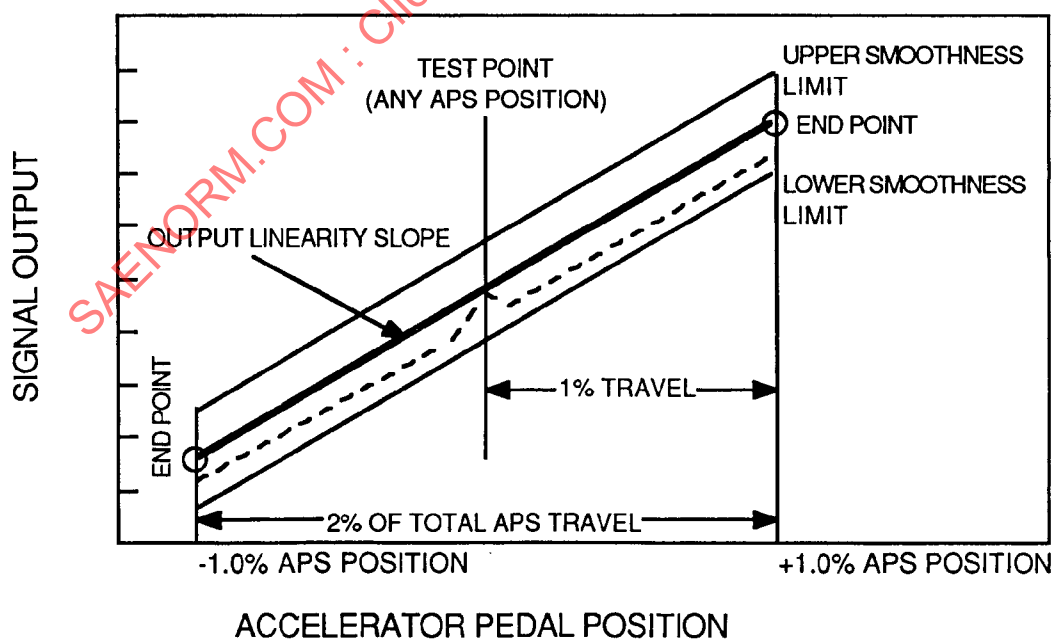


FIGURE 10 - Output Smoothness Definition