



SURFACE VEHICLE RECOMMENDED PRACTICE

J1843™

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Superseding J1843 MAY2018

Accelerator Pedal Position Sensor for Use with Electric Controls
in Medium- and Heavy-Duty Vehicle Applications - Truck and Bus

RATIONALE

The following changes have been made to the document:

Foreword: Changed the intent of the document from minimizing the number of accelerator position sensors to guidance on the currently accepted signal types.

3.2, 3.3: Added definition of APS1 and APS2 for redundancy in the sensor signals.

3.13: Changed "Modulated" to "Modulation" for clarification.

Figure 1: Updated the graphic to make easier to read.

Figure 2: Updated the graphic to make it easier to read.

Figure 3: Updated the graphic to make it easier to read.

Section 6 and 6.1: Added "Dual" signals for redundant and independent electrical signals.

6.4: Updated the output range to account for dual signals.

6.5: Updated the diagnostic range per 6.4.

Figure 7: Updated the graphic for dual signals.

Figure 8: Updated the graphic to make easier to read.

6.12: Added "each" and "A short between redundant APS signals will result in a violation of correlation" to account for the dual signals.

Section 7 and 7.1: Added "dual" signals for redundant and independent signals.

7.2: Removed battery voltage supplies. It is recommended to operate the throttle signals off of a regulated supply.

7.3: 20 mA should be sufficient current to power the sensors.

7.4: Updated the output range to account for the dual signals.

7.5: Updated the fault range to account for dual signals.

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7.8: Added clarification to tighter tolerance within a range of acceptable frequencies.

7.9: Added signal transition time. This value is dependent on the system setup and should be discussed and validated with the ECU supplier.

7.13: Added clarification for dual signals.

Figure 10: updated the graphic to make it easier to read.

Figure 11: updated the graphic to make it easier to read.

9.1: Added clarification that EMC should be considered in the design.

SAE J1843 has been reaffirmed to comply with the SAE Five-Year Review policy.

FOREWORD

Many electronic controls used in medium- and heavy-duty vehicles require an electrical indication of accelerator pedal position. A common accelerator pedal position sensor function and performance criterion is desired to optimize performance for this safety critical component. A single universal electrical interface has not been defined. Two electrical interface types are defined in this SAE Recommended Practice. The intent of providing a choice of two signal types is to provide guidance for the industry accepted signal types.

While a common mechanical definition of the size, shape, etc., of the accelerator pedal and accelerator position sensor is desirable, it is realized that vehicles are not designed around the accelerator pedal. The present variations in vehicle configurations and ergonomic design requirements cannot be satisfied by a single mechanical interface specification for the accelerator pedal. The intent of this specification is to provide best practices for designing the electrical interface of the pedal assembly.

The specification outlines portions of the physical interface between an accelerator pedal and the accelerator pedal position sensor as a recommendation for those that want a common interface for floor, suspended and remote applications. However, it is understood that industry has allowed for effective design solutions with custom sensors that may not meet these mechanical physical interfaces (e.g., contactless sensors with the sensing element separated from the sensed element). For the remainder of this document, the term "pedal" can be construed to mean any physical means of converting operator motion into an acceleration or deceleration command.

1. SCOPE

The purpose of this SAE Recommended Practice 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 vehicle applications.

2. REFERENCES

2.1 Applicable Documents

The following publication forms a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

SAE J1455 Recommended Environmental Practices for Electronic Equipment Design in Heavy-Duty Vehicle Applications

2.1.2 The APS assembly shall comply with all appropriate Federal Motor Vehicle Safety Standards.

3. DEFINITIONS

3.1 ACCELERATOR POSITION SENSOR (APS)

The sensor portion of the physical device used to convert the accelerator position into an electrical signal.

3.2 ACCELERATOR POSITION SENSOR 1 (APS1)

APS1 is the accelerator position sensor number 1 of a sensor assembly with multiple independent position sensors integrated into a single physical package.

3.3 ACCELERATOR POSITION SENSOR 2 (APS2)

APS2 is the accelerator position sensor number 2 of a sensor assembly with multiple independent position sensors that are integrated into a single physical package.

3.4 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.

3.5 DUTY CYCLE

The ratio of signal time high to signal period (see Figure 1).

3.6 ELECTRICAL INTERFACE

The electrical signals to be passed from the APS to other electronic/electrical devices.

3.7 FAULT RANGES

The ranges of the APS output values beyond the diagnostic range(s) that indicate an absolute fault condition in the accelerator pedal assembly.

3.8 FULL SCALE

The difference between the theoretical maximum and minimum signal outputs (i.e., 100% of analog supply voltage or 100% duty cycle).

3.9 MECHANICAL INTERFACE

The physical boundaries of the APS.

3.10 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.

3.11 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 values (see Figure 2).

3.12 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 (see Figure 3).

3.13 PULSE WIDTH MODULATION (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.

3.14 SENSING ELEMENT

The portion of, or discrete device contained within, the APS that converts physical motion into a usable electrical signal.

3.15 SUPPLY VOLTAGE

The voltage measured between the +V supply and -V supply leads with the APS device connected.

3.16 TREADLE

The lever operated by the foot.

3.17 IDLE VALIDATION SIGNAL (IVS)

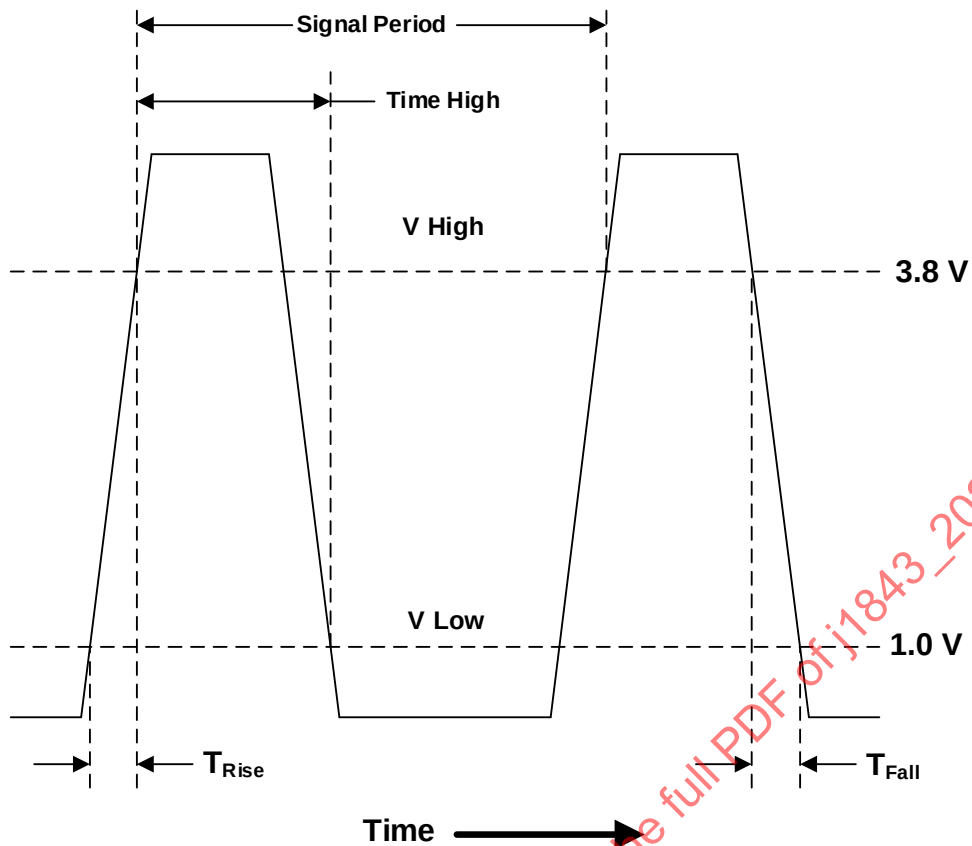
A signal generated by the accelerator pedal assembly to indicate that the assembly is in the idle position.

3.18 TRANSMISSION SHIFT POINT TRANSITION SIGNAL

The electrical signal used by an automatic transmission to provide early shift points at low throttle and higher shift points at increased throttle positions.

3.19 KICK DOWN SIGNAL

The electrical signal used by an automatic transmission to raise the shift points to provide maximum performance at full throttle.



$$\text{Duty Cycle (\%)} = \frac{\text{Time High}}{\text{Signal Period}} \times 100$$

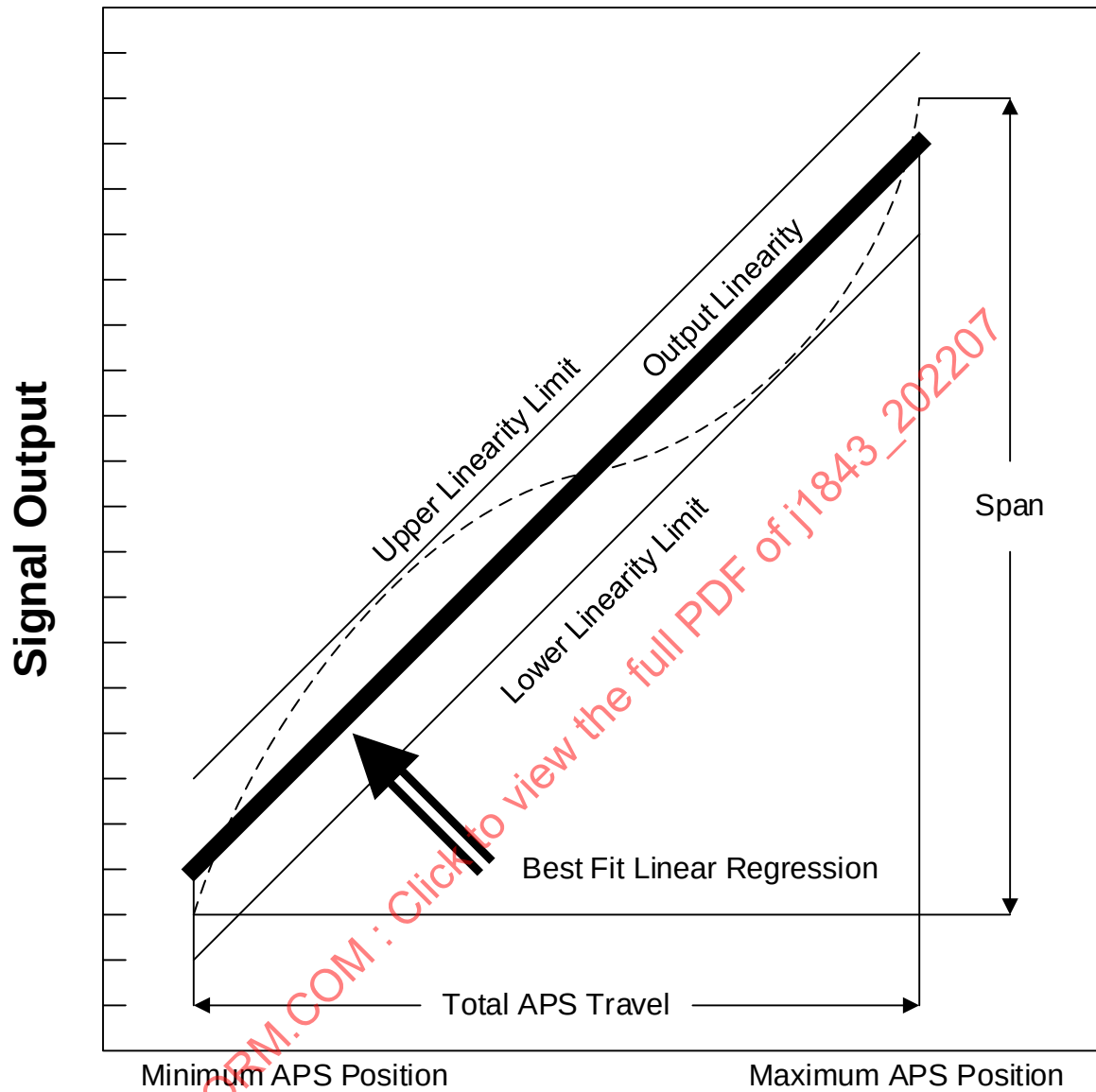
$$\text{Output Frequency} = 1/\text{Signal Period}$$

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

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

Figure 1 - Pulse width modulation signal waveform

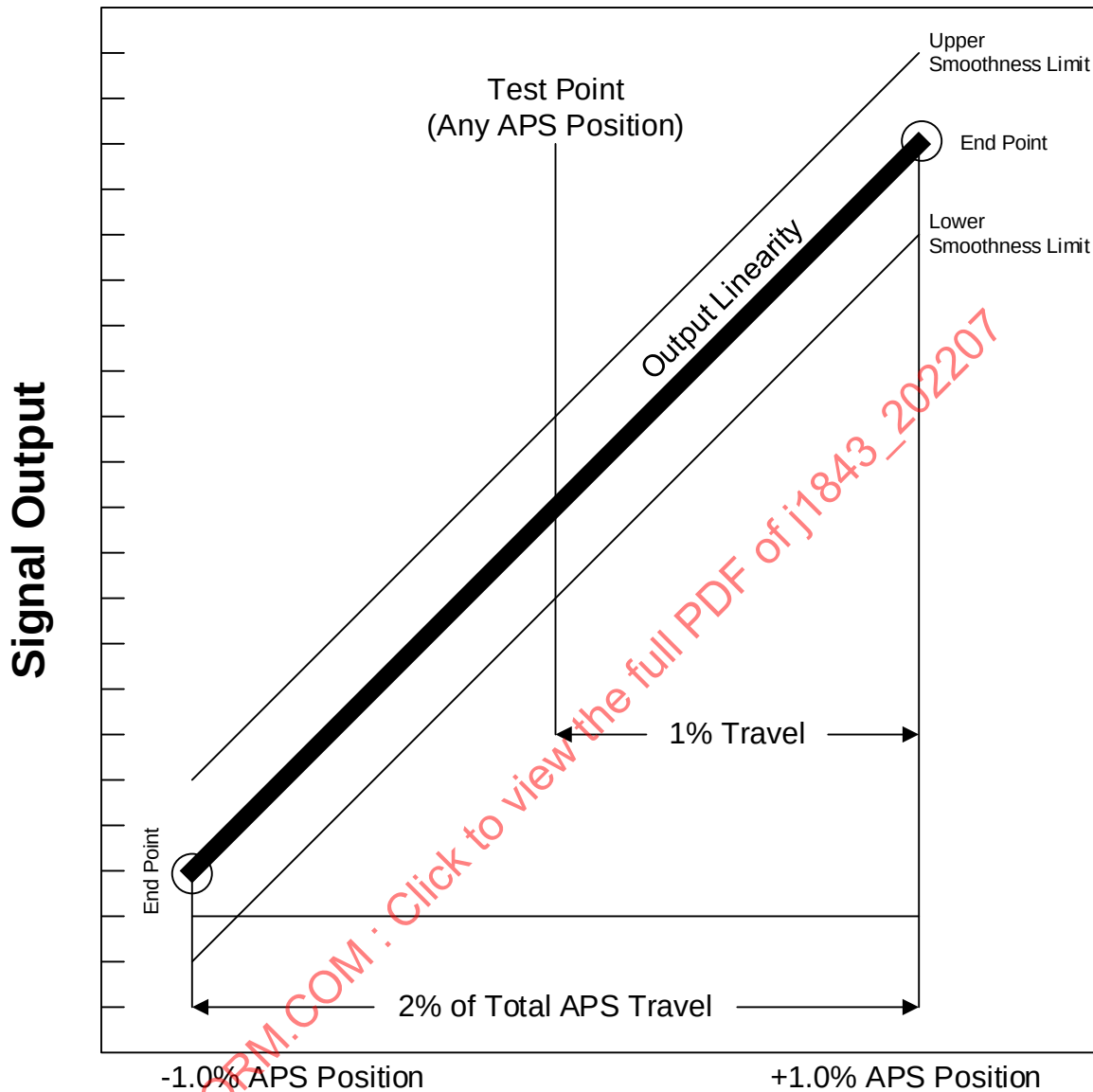
Output Linearity



Accelerator Pedal Position

Figure 2 - Output linearity definition

Output Smoothness



Accelerator Pedal Position

Figure 3 - Output smoothness definition

4. MECHANICAL INTERFACE

The following specifications are for an accelerator pedal to accelerator position sensor interface. It is intended to allow the design of sensors that are interchangeable for different electronic applications. The driveshaft configuration and APS mounting pattern are the critical areas for commonality.

Figure 4 outlines the mounting pattern and driveshaft orientation.

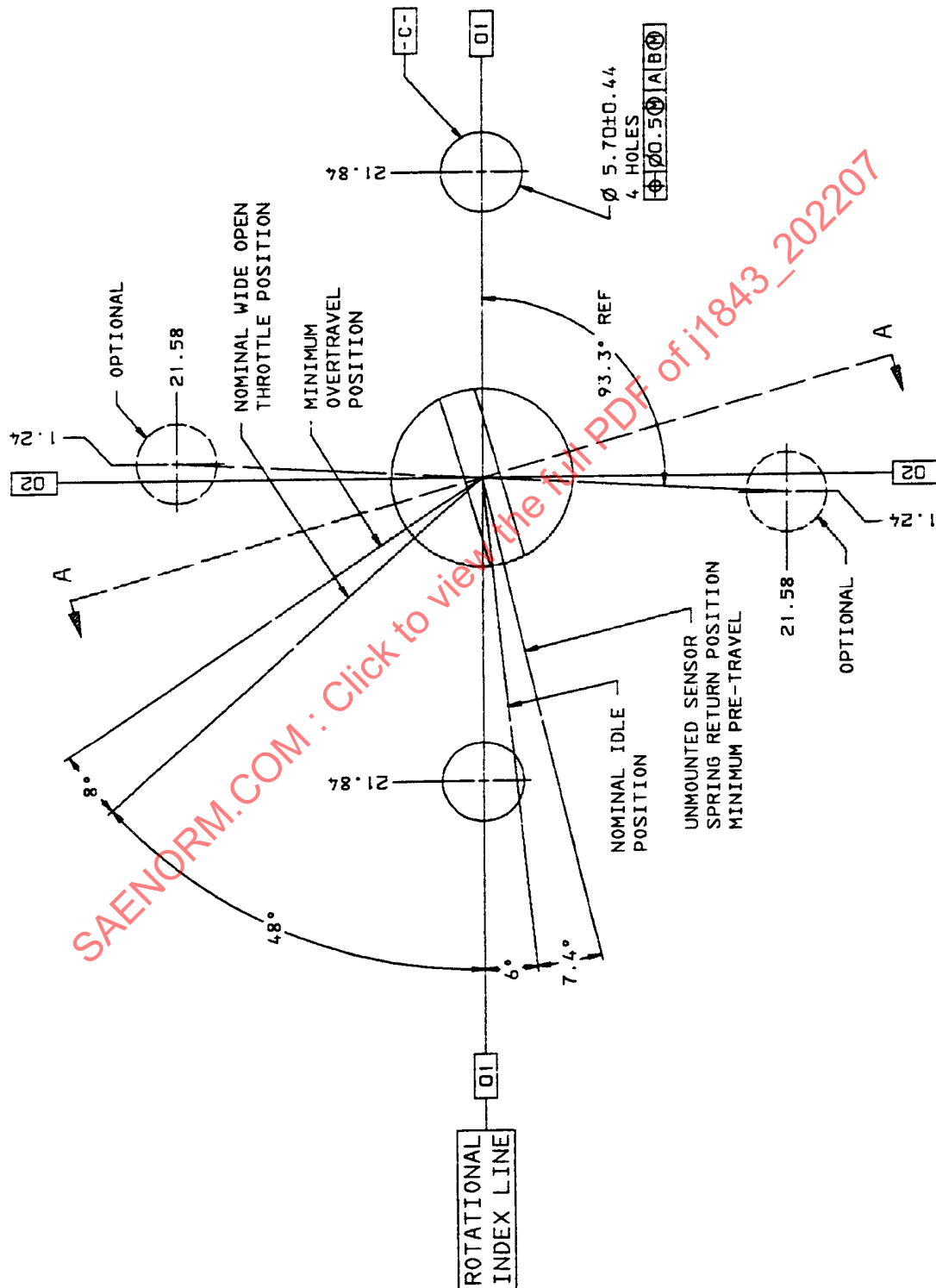


Figure 4 - APS mounting specifications sensor mounting hole pattern and angular rotation requirements

Figure 5 outlines the APS mechanical interface in the area around the APS driveshaft. Figure 5 is a view from section A-A of Figure 4.

Overall drift of the minimum accelerator pedal position driveshaft to be ± 3 degrees over the operating life of the accelerator pedal.

Overall drift of the maximum accelerator pedal position driveshaft to be ± 3 degrees over the operating life of the accelerator pedal.

Due to variations in actual pedal designs and applications, sources of auxiliary signals, as defined in Section 8, may utilize, but are not required to utilize, this APS-to-pedal mechanical interface.

If the APS has an optional cutaway driveshaft receptacle as illustrated in Figure 6, then the APS must not contain an integral IVS. In this case, if the IVS is required, it must be located and operated independently of the APS.

The APS shall contain an internal source of energy capable of returning the internal portions of the APS to the end of travel nearest the idle state. It is not intended that the APS be capable of returning the entire accelerator pedal assembly to an idle condition. The accelerator pedal assembly is expected to accomplish return of the treadle through other sources of energy. When the APS is an integrated part of the pedal unit, this internal source of energy may not be required.

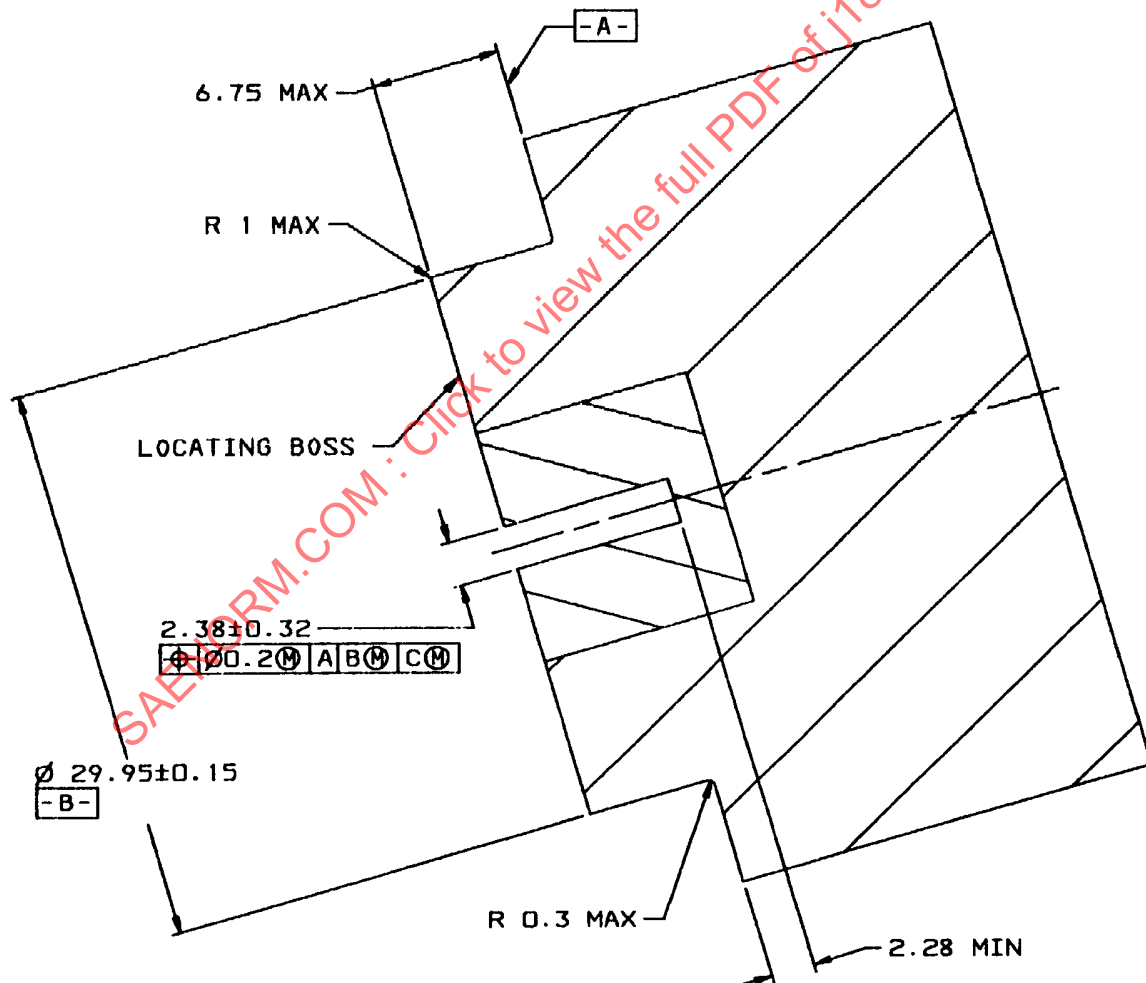


Figure 5 - APS mounting specifications section A-A

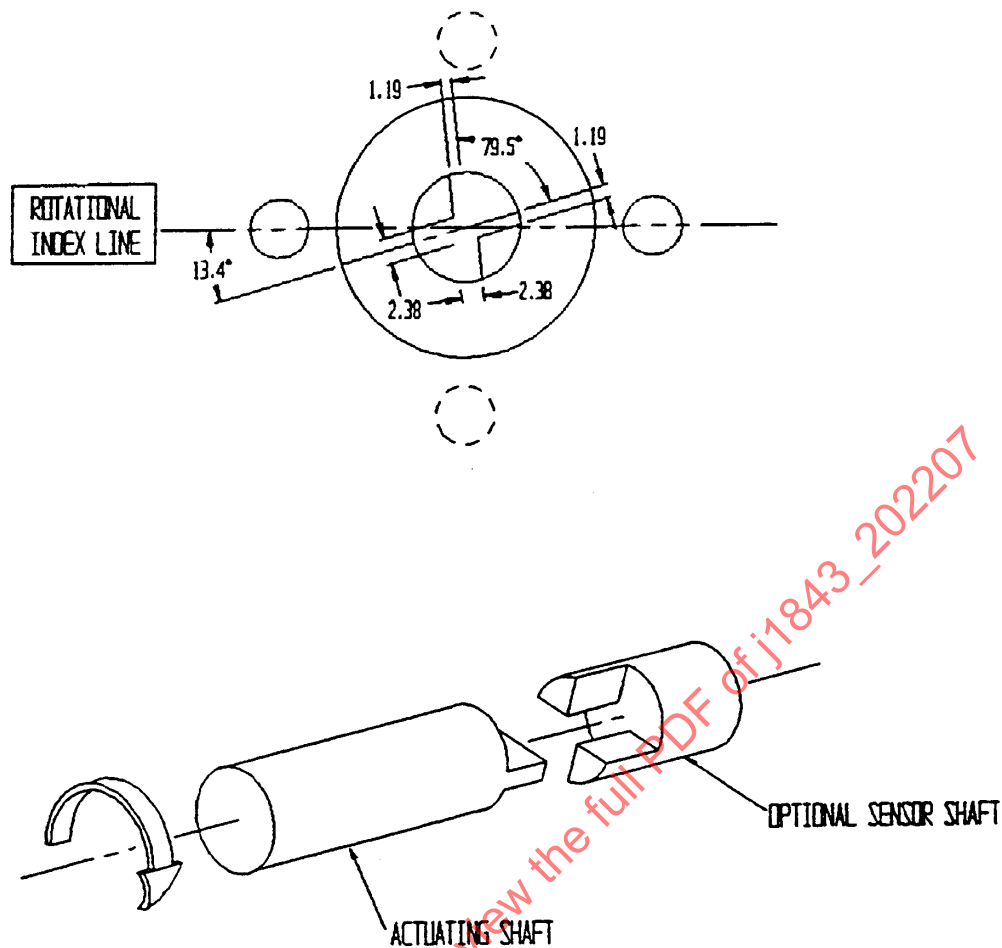


Figure 6 - Optional sensor cutout

5. ELECTRICAL INTERFACE

Any one electrical output signal of the accelerator pedal assembly 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 some manner of isolation and buffering of the APS signal should be provided to each device, 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.

6. DUAL ANALOG RATIOMETRIC ELECTRONIC INTERFACE (OPTION A)

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

6.1 Dual Signals for Redundancy

The sensor shall provide two electrically independent output signals, with separate supply and return circuits.

6.2 Supply Voltage

5.0 V DC $\pm$ 0.50 V DC.

6.3 Supply Current

20 mA maximum.

Output Range

See Figure 7.

- a. The minimum accelerator signal output as a percentage of the supply voltage shall not be less than 18% for APS1 and 8% for APS2.
- b. The maximum accelerator signal output as a percentage of the supply voltage shall not be greater than 86% for APS1 and 44% for APS2.
- c. APS1 and APS2 signals should correlate to $APS2 = (APS1 / 2) \pm 2\%$ of the supply voltage.

6.4 Diagnostic Range

See Figure 7.

- a. Lower Range = Less than 8% of supply voltage.
- b. Upper Range = Greater than 86% of supply voltage.

6.5 Fault Range

See Figure 7.

- a. Lower Range = Less than 5% of supply voltage.
- b. Upper Range = Greater than 90% of supply voltage.

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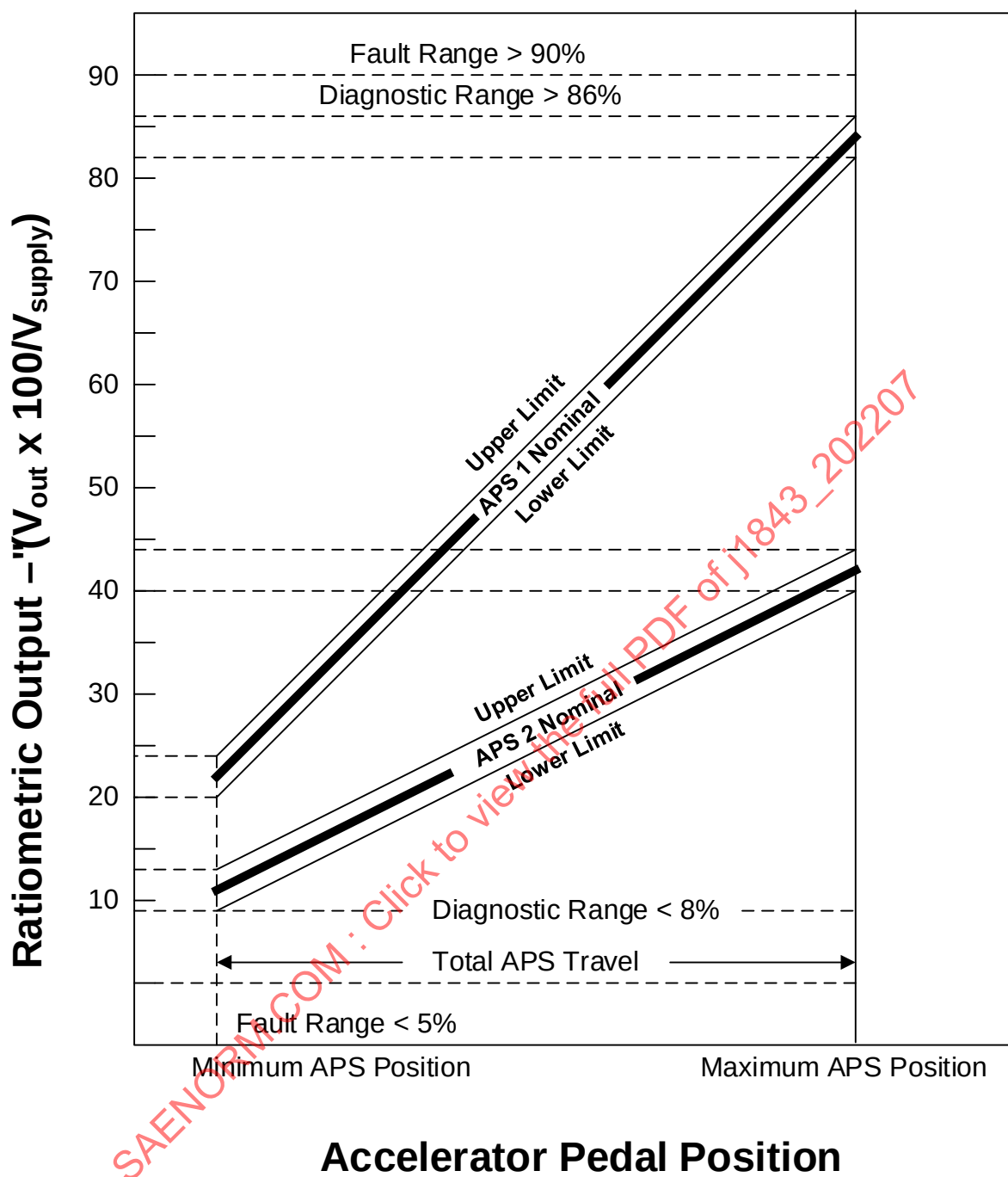


Figure 7 - Analog ratiometric output transfer function

6.6 Output Smoothness

0.5% of full scale output for any 2% interval of total travel over the output range (see Figure 3).

6.7 Output Linearity

±5% of full scale output over the output range.

6.8 Output Current

The output transfer function defined in Figure 7 is to be valid under an electrical test load of $47\text{ k}\Omega \pm 5\%$. (See Figure 8.)

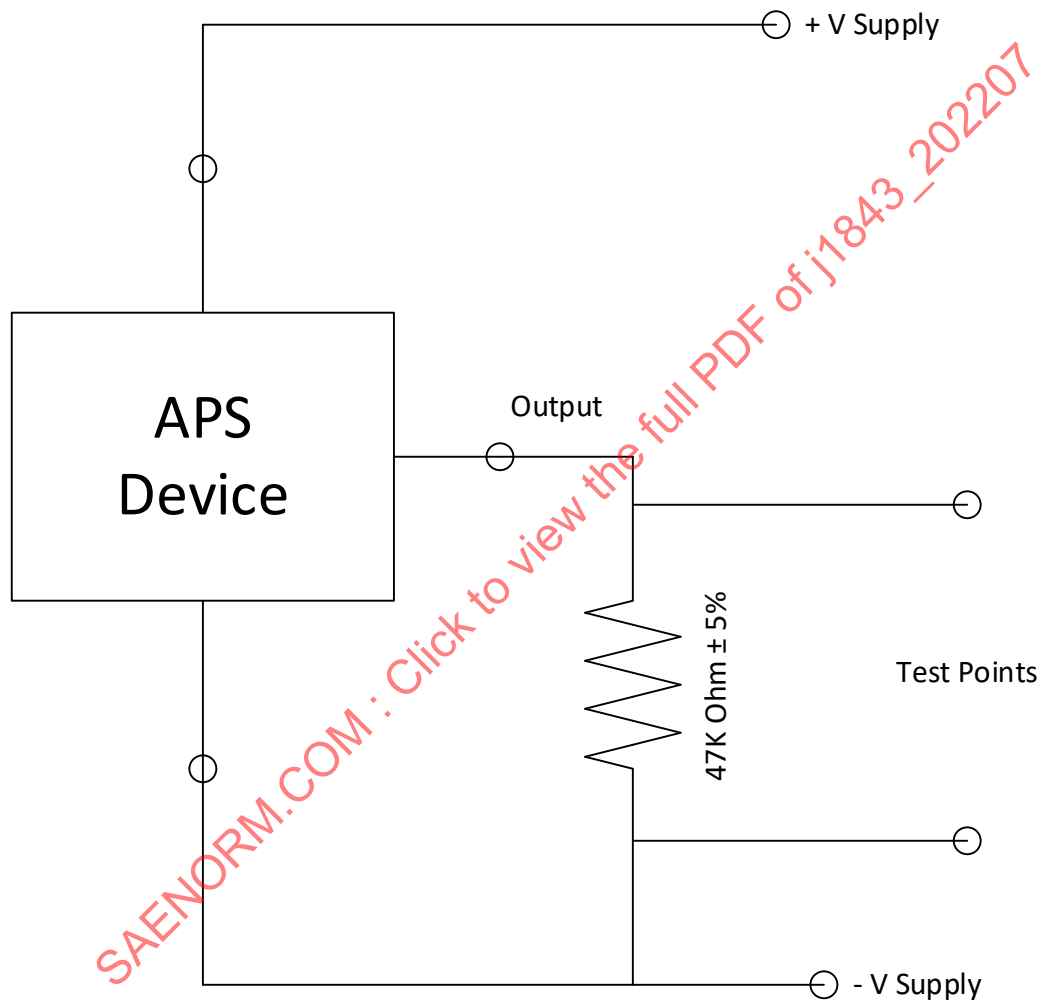


Figure 8 - Ratiometric APS output test circuit

6.9 Output Hysteresis

The sensing device must not exhibit output hysteresis greater than 2% of full scale output when measured over the entire span. 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 is not included.

6.10 Open Circuit Response

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

6.11 Short Circuit Response

A short circuit between any two leads of each APS at any position shall result in a signal as measured across the test points ($47\text{ k}\Omega \pm 5\%$ load as per Figure 8) within a specified fault range as shown in Figure 7 and within a maximum time of 1.0 second. A short between redundant APS signals will result in a violation of correlation (6.4). The signal shall transit from a specified fault range signal to the correct reading at any APS position in less than 0.1 second (signal slew rate only) upon return to a normal operation.

7. DUAL PULSE WIDTH MODULATION (PWM) ELECTRONIC INTERFACE (OPTION B)

The following specifications shall apply when for a dual pulse width modulation electronic interface. Figure 1 illustrates the PWM waveform used in this interface.

7.1 Dual Signals for Redundancy

The sensor shall provide two electrically independent output signals, with separate supply and return circuits.

7.2 Supply Voltage

Regulated $5\text{ V DC} \pm 0.5\text{ V DC}$.

7.3 Supply Current

20 mA DC maximum per channel.

7.4 Output Range

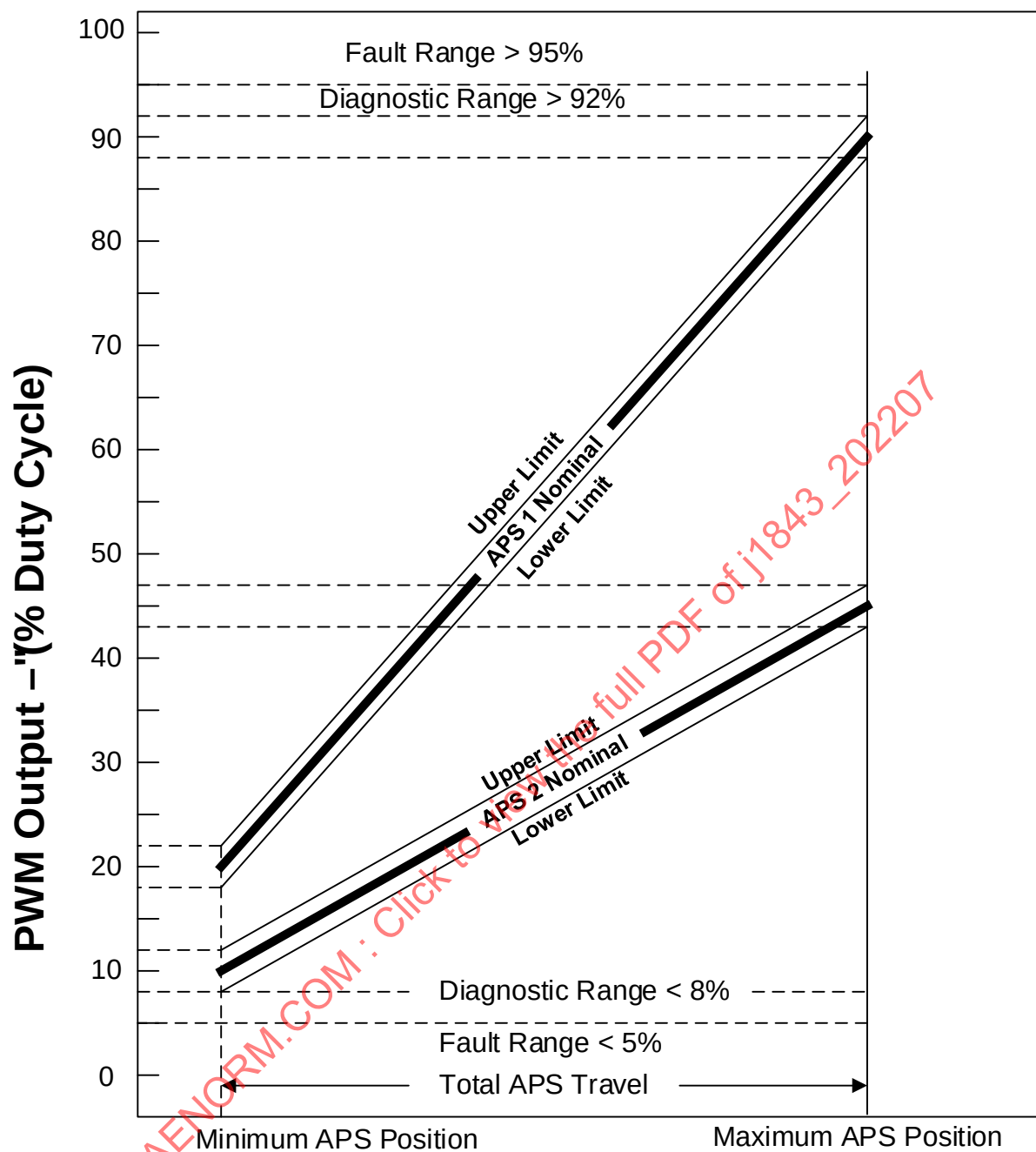
See Figure 9.

- a. The minimum accelerator signal duty cycle shall not be less than 20% for APS1 and 9% for APS2.
- b. The maximum accelerator signal duty cycle shall not be greater than 90% for APS1 and 46% for APS2.
- c. APS1 and APS2 signals shall correlate to $\text{APS2} = (\text{APS1}/2) \pm 2\%$ duty cycle.

7.5 Fault Range

See Figure 9.

- a. Lower Range = Less than 10% duty cycle for APS1 and less than 5% duty cycle for APS2.
- b. Upper Range = Greater than 96% duty cycle for APS1 and greater than 48% duty cycle for APS2.



Accelerator Pedal Position

Figure 9 - Pulse width modulated output transfer function

7.6 Output Smoothness

0.5% of full scale output for any 2% interval of total travel over the output range (see Figure 3).

7.7 Output Linearity

±5% of full scale output over the output range (see Figure 2).

7.8 Output Frequency

- a. Working range fixed between 200 and 1100 Hz.
- b. $\pm 10\%$ tolerance on working range.

7.9 Signal Transition Time

The pulse width modulated signals shall have the wave shape shown in Figure 1 while connected to the electrical test load impedance as shown in Figure 10.

It should be recognized that ECU circuit characteristics which the sensor signal is connected to has a direct effect on the signal rise and fall time. Evaluation of this impact should be evaluated at time of sensor and ECU integration.

7.10 Output Current

The output transfer function as defined in Figure 9 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 Figure 10 for test schematic.

7.10 Output Waveform

The pulse width modulation signal shall have the wave shape shown in Figure 1 while connected to the electrical test load impedance as shown in Figure 10.

7.11 Output Hysteresis

The sensing device must not exhibit output hysteresis greater than 2% of full scale output when measured over the entire span. 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.

7.12 Open Circuit Response

An open circuit of any lead to the APS at any position 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 Figure 10) within a specified fault range as shown in Figure 9 and within a maximum time of 1.0 second. The signal shall transit from a specified fault range signal to the correct reading at any APS position in less than 0.1 second (signal slew rate only) upon return to a normal operation.

7.13 Short Circuit Response

A short circuit between any two leads of each APS at any position 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 Figure 10) within a specified fault range as shown in Figure 9 and within a maximum time of 1.0 second. A short between redundant APS signals shall result in a violation of correlation. The signal shall transit from a specified fault range signal to the correct reading at any APS position in less than 0.1 second (signal slew rate only) upon return to a normal operation.