SURFACE VEHICLE RECOMMENDED PRACTICE

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Superseding J1952 APR2018

(R) All-Wheel Drive Systems Classification

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RATIONALE

With the proliferation of hybrid and all-electric vehicles and their architectures, the all-wheel drive classifications currently in SAE J1952 do not accurately reflect the myriad of different ways all-wheel drive can be achieved with electrification. This revision proposes to update the standard to include relevant language and descriptions to cover all-electric, electrified (hybrid), and conventional internal combustion engine (ICE) architectures.

1. SCOPE

This document seeks to classify all-wheel drive (AWD) architectures primarily based on the installed hardware and does not consider the implementation of the controls and software. For example, a power transfer unit (PTU) may be equipped with a clutch that is capable of torque management, but the control implementation only uses it for disconnection functions without torque management.

In this SAE Recommended Practice, attention will be given to passenger cars and light trucks (through Class III). The definitions presented herein may also be applicable to heavy trucks (Class 4 through 8) and off-highway applications using more than two axles but are primarily focused on passenger cars and light trucks.

1.1 Purpose

The definitions are intended to outline basic nomenclature and to categorize AWD concepts. The goal is to give those working in the field a common base for discussion regarding the type of AWD systems independent of marketing terminology.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

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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 J1715 Hybrid Electric Vehicle (HEV) and Electric Vehicle (EV) Terminology

SAE J2059 All-Wheel-Drive-Drivetrain Schematic Symbol Standards

SAE J2817 Definition and Measurement of Torque Biasing Differentials

3. DEFINITIONS

3.1 ICE ONLY AWD SYSTEM DESCRIPTION

An ICE powered vehicle equipped with a conventional AWD system consists of a means to distribute torque to all wheels of a vehicle. Based on desired performance, traction, and handling characteristics, there are different types of systems to achieve these ends. These AWD systems include 4X4, 6X6, and other configurations. There are three basic types of systems defined below: Part-Time, Full-Time, and On-Demand. Combinations of these systems may also be used.

3.1.1 PART-TIME AWD SYSTEM DESCRIPTION

In a part-time AWD system, driver intervention is required to rigidly couple and decouple primary (always driven) and secondary (selectable) axles.

When a part-time system is engaged, the primary and secondary axles are rigidly connected through the torque distribution device (e.g., Power Transfer Unit (PTU), transfer case). The primary axle is normally connected unless in neutral mode. The secondary axle(s) is/are engaged in AWD and disengaged in two-wheel drive. The torque distribution device is commonly referred to as a transfer case in primary rear wheel drive based AWD vehicles. In a primarily front wheel drive vehicle, the torque distribution functions are typically managed in the PTU, transaxle, or secondary axle(s).

This basic type of system requires the driver to select between two-wheel drive and AWD commonly using either a switch or lever. Part-time systems may allow the driver to shift between two-wheel drive and AWD while the vehicle is in motion.

Part-time systems may have two speeds: one for normal driving (High-range) and one for improved ground speed control and increased gradeability (Low-range).

Although part-time AWD achieves maximum traction under certain conditions, it should be limited to off-pavement usage or on-pavement usage in low traction scenarios. Torque “wind up” is experienced during on-road dry pavement usage when making moderate to tight low-speed turns. This “wind up” (also referred to as crow hop or binding) is due to the fact the front and rear axles are rigidly connected (no center differential) and rotating at the same speed but traveling different distances.

3.1.2 FULL-TIME AWD SYSTEM DESCRIPTION

In a full-time AWD system, front and rear axles are driven at all times through a center differential.

Unlike a part-time system, the full-time system employs a center (inter-axle) differential that allows the front and rear axles to turn at different speeds on wet or dry surfaces. Depending upon the gear ratio in the differential, the input torque can be nominally split to the front and rear axles in a fixed ratio. For example, a 35:65 split means that 35% of the torque is directed to the front axle and 65% to the rear axle.

For maximum traction, torque through the center differential must be modulated to distribute power to the axles with the greatest traction. Torque modulation can be done passively, actively, with a torque biasing device, or with brake-based traction control systems.

This type of system can be used on any surface at any speed.

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3.1.3 ON-DEMAND AWD SYSTEM DESCRIPTION

In an on-demand AWD system, the secondary drive axle may be driven by an active or passive coupling device or by an independently powered drive system. A secondary drive axle, which is driven by an independently powered drive system, may also provide the primary vehicle propulsion.

In a typical on-demand AWD system, the vehicle operates in two-wheel drive (either front or rear depending upon the basic vehicle architecture) until AWD is required, such as during primary axle slip, yaw correction, or by other control strategies. In the case of secondary axles driven by an active or passive coupling device, torque transfer from the primary to the secondary axle(s) can be modulated, dependent on driving conditions. Most systems are typically relative speed control devices and activate when there is a speed difference between the primary and secondary axle(s) due to slippage; however, pre-emptive slip or other control strategies are common.

This type of system can be used on any surface at any speed.

3.1.4 AWD SYNCHRONIZATION

The act of mechanically bringing two or more torque carrying members to the same speed to engage AWD while the vehicle is in motion.

3.1.5 SPEED DIFFERENTIATION

A difference in speed between two or more driven members.

3.1.6 LONGITUDINAL TORQUE DISTRIBUTION

3.1.6.1 FIXED TORQUE DISTRIBUTION

Output torque distribution is fixed by the design of the device. Typical examples include open center differentials.

3.1.6.2 VARIABLE TORQUE DISTRIBUTION

Output torque distribution is variable by the design of the device. Typical examples include couplings and torque biasing devices.

3.1.6.3 INDETERMINATE TORQUE DISTRIBUTION

Output torque distribution is not determined by the device but by the input torque and tractive capability. Typical examples include part-time AWD systems.

3.1.7 COUPLING DEVICE

Primary functions are to connect input and output elements (analogous to series power flow) and vary torque (continuously or discretely).

3.1.8 ACTIVE CONTROL

Possesses variable tuning based on external control feedback. Actively controlled systems typically incorporate an electronic control unit. Active systems include electronically controlled electromagnetic, electromechanical, and electrohydraulic actuated wet clutches. Active systems can be integrated with other vehicle control systems to improve traction and/or stability.

3.1.9 PASSIVE CONTROL

Possesses preset tuning without external control feedback. Passively controlled systems do not incorporate an electronic control unit and thus do not sense non-driveline variables or interact with other vehicle control systems. Passive devices include viscous couplings and hydraulically activated clutch pack couplings without external controls.

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3.1.10 POWER TRANSFER UNIT (PTU)

In a transverse mounted drivetrain-based vehicle, this term refers to the drive mechanism that distributes power towards the secondary axle. Its primary function is to change the direction of power flow. The PTU may also contain torque management devices. Typically, PTUs are utilized in front wheel drive based applications.

NOTE: A Power Take Off Unit (PTO), not the same as a PTU, is a device whose primary function is to drive accessories (a PTO is not utilized to propel the vehicle).

3.1.11 TORQUE BIASING DEVICE

A coupling device in parallel with a differential.

3.1.12 TRANSFER CASE

In a longitudinal mounted drivetrain, ICE-based vehicle, this term refers to the drive mechanism that distributes power to the front and rear axles. Its primary function is to offset the power flow. The transfer case may also contain coupling and/or torque management devices.

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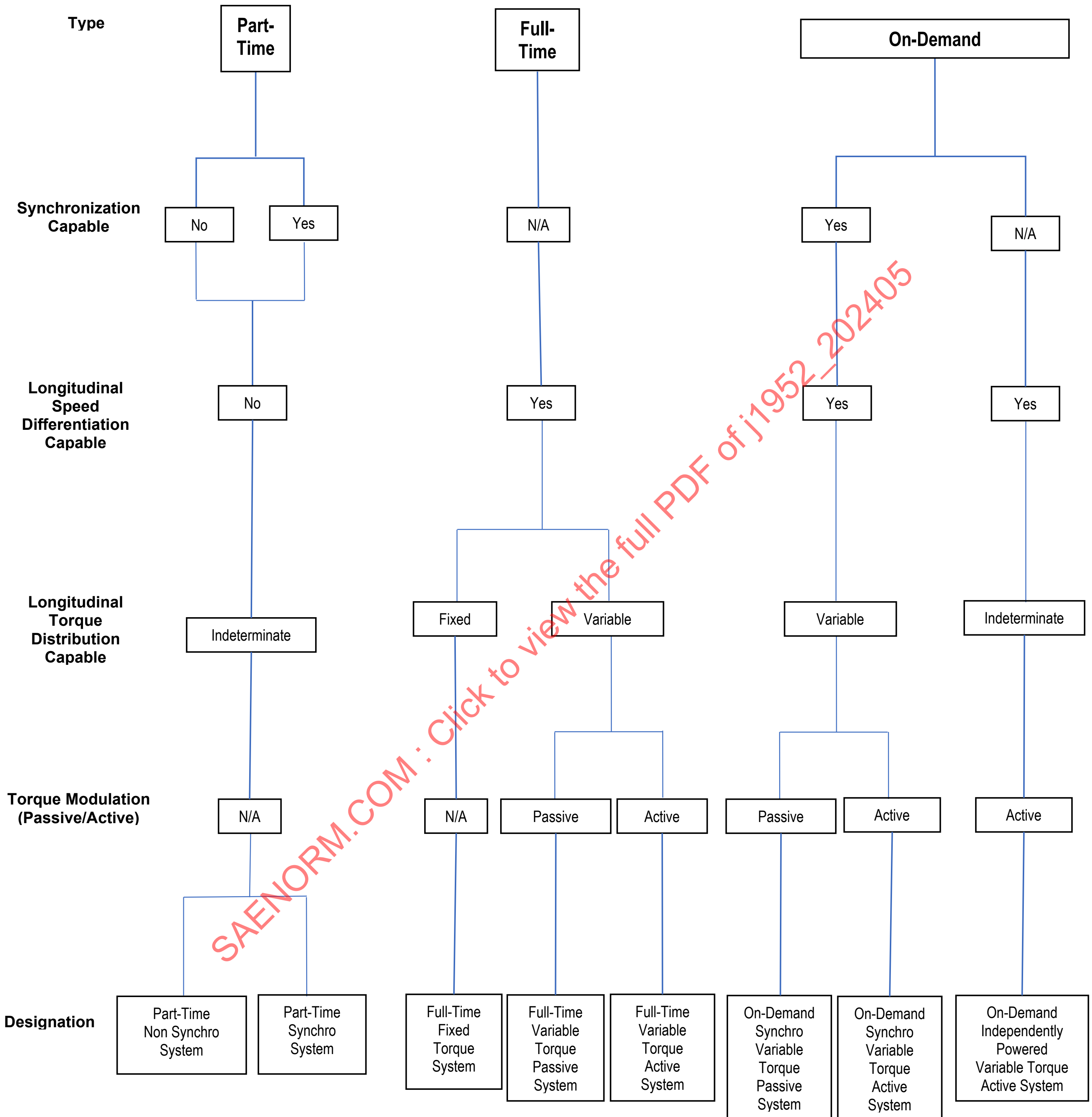
3.1.13 ICE ONLY AWD SYSTEMS CLASSIFICATION DIAGRAM



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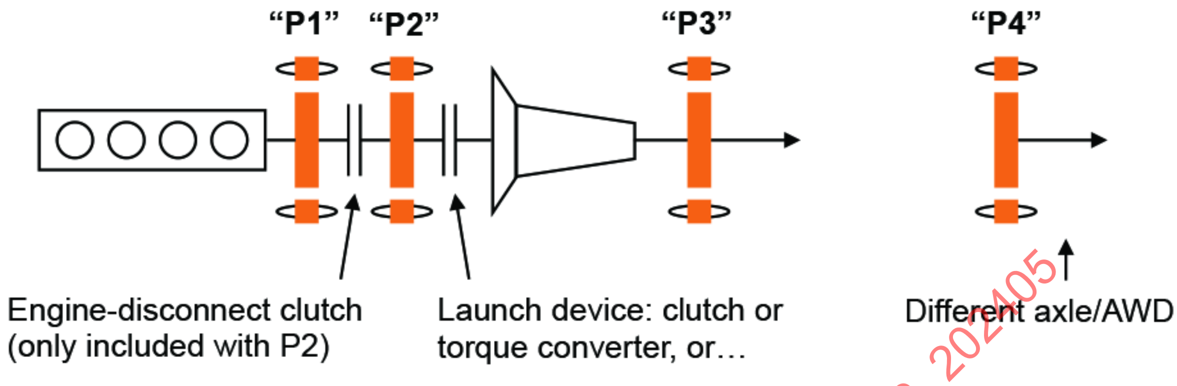
3.2 HYBRID (ICE + ELECTRIC) AWD SYSTEM DESCRIPTION

3.2.1 HYBRID POWER-SPLIT CLASSIFICATIONS

Hybrid vehicle architectures are classified by their ICE/electric power-split arrangement. The arrangement of the power-split will influence the classification of the AWD system. The image below is taken from J1715, §5.7.1 as a reference.



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A short summary of each power-split description is presented below.

P0 (not shown): Motor/generator electric machine on the ICE accessory drive;

P1: Motor/generator electric machine on ICE crankshaft output;

P2: Motor/generator electric machine on transmission input shaft;

P3: Motor/generator electric machine on transmission output shaft;

P4: Electrically driven axle, no mechanical connection to ICE drivetrain. This also applies to individually driven wheel positions, in-wheel motors, etc.

3.2.2 HYBRID (P0 THRU P3)

Hybrid arrangements from P0 through P3 all still share the base ICE powertrain. As the e-machine functions to augment the ICE power, or provides power in lieu of the ICE through the ICE driveline, please see 3.1 for all terminology related to AWD architectures.

3.2.3 STAND-ALONE E-AXLE HYBRID (P4)

The P4 hybrid arrangement uses an electrically driven axle (e-axle) in place of one of the axle positions. The e-axle may replace a driven axle in a conventional ICE AWD layout, or it may replace an unpowered axle position, thereby adding AWD functionality to a previously two-wheel-drive application.

Some e-axles may contain disconnect devices designed to mechanically decouple the electric machine from the rest of the e-axle when not being actively powered in order to protect the power electronics from high back-EMF. The conditions under which the disconnect are enabled are managed by the e-axle controls and are transparent to the user. For this document, the presence of a disconnect does not alter the classification of an AWD implementation using a P4 hybrid e-axle.

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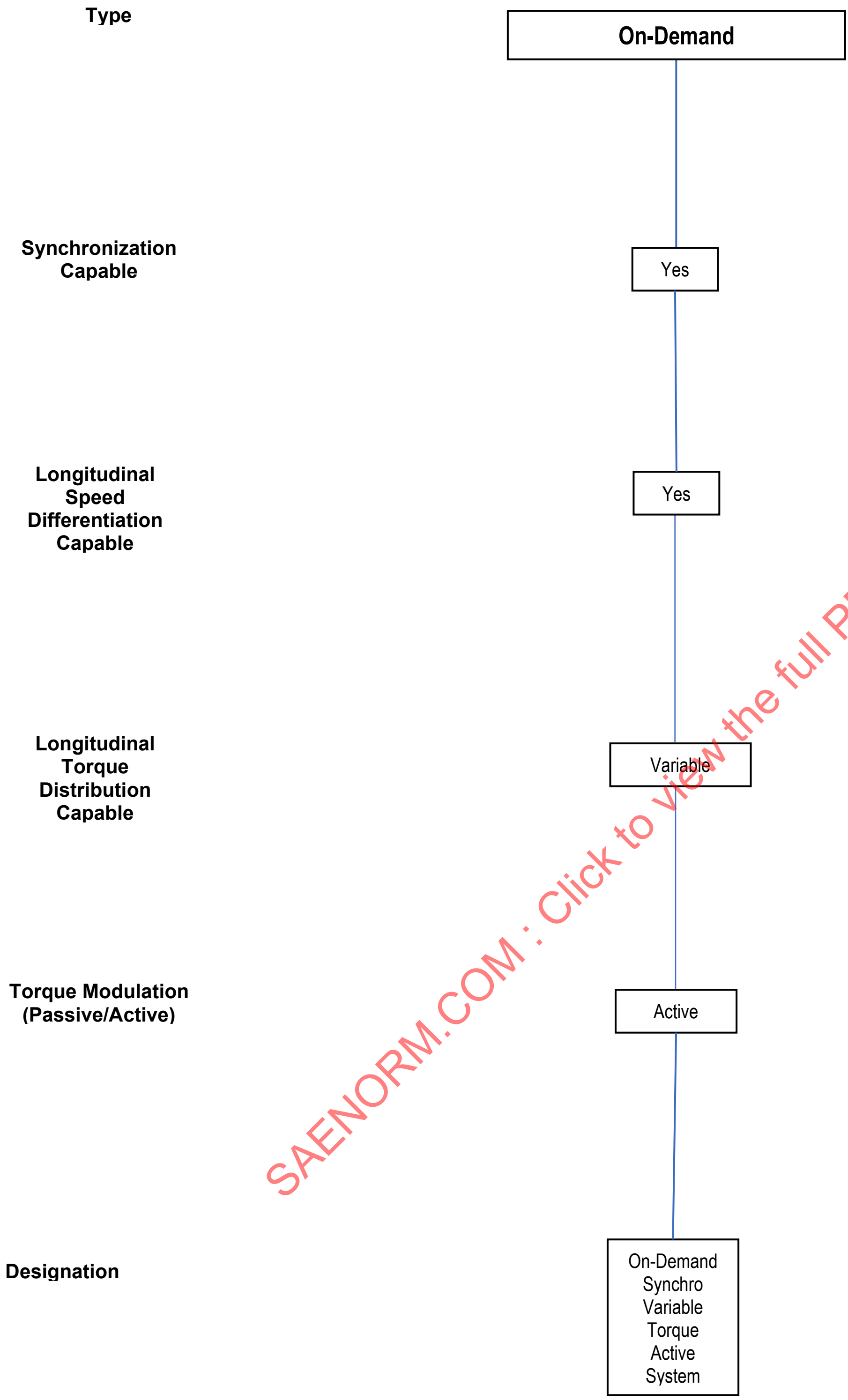
3.2.4 P4 HYBRID AWD CLASSIFICATION DIAGRAM



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3.3 ALL-ELECTRIC AWD SYSTEM DESCRIPTION

3.3.1 ELECTRICALLY DRIVEN TRANSFER CASE

This refers to an implementation in which the ICE (and possibly the transmission) has been replaced by one or more electric machines. These electric machines may be mechanically connected to the transfer case with a shaft, or they may be integrated directly into the casing of the transfer case. The transfer case is then mechanically coupled to the front and rear axles through conventional means.

Such AWD implementations are analogous to conventional ICE powered AWD implementations. As such, the definitions and classifications in 3.1 apply to all-electric AWD systems equipped with an electrically driven transfer case.

3.3.2 E-AXLES

Regardless of whether the physical implementation of the electric axle is achieved with a single motor with differential driving the left and right wheel positions, or independent motors driving each wheel position through half-shafts or in-wheel motors, this document treats the left/right pair of wheel stations as a single "e-axle" for classification purposes.

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