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Road vehicles — Vocabulary and characteristics for engineering of starting devices

Véhicules routiers — Vocabulaire et caractéristiques pour l'ingénierie des équipements d'allumage

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Foreword

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This document was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 32, *Electrical and electronic components and general system aspects.*

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Introduction

This document harmonizes key terms and their definitions in the form of basic technical words and simple explanations, because third parties involved in starter motor testing and start/stop systems are spreading to various regions. The purpose is to guarantee an efficient and effective communication throughout development projects within and among engineering organizations and related institutions.

In practice, many inefficiencies have been observed due to unclear or ambiguous usage of engineering terms and missing knowledge about application to various starter motor development and testing. This document is meant to preserve the essential knowledge of best practices, which rely on undocumented usage of terms. With these terms and definitions, starter motor engineers as well as newcomers are able to refer to this vocabulary framework when working together on starter motor development and testing projects in an international environment.

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Road vehicles — Vocabulary and characteristics for engineering of starting devices

1 Scope

This document includes common definitions for terms and their interdependencies related to starting devices as well as describes their general and specific characteristics.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
armature
rotating assembly of the electric machine part of the starter motor

3.2
battery
electrical energy source connected to the starter motor

3.3
battery open circuit voltage
voltage at the *battery* (3.2) *terminals* (3.40) without electrical load

3.4
battery voltage
voltage between the *battery* (3.2) *terminals* (3.40)

3.5
cranking
condition in which the starter motor rotates the *internal combustion engine (ICE)* (3.17)

[SOURCE: ISO 20574:2019, 3.16, modified — "engine" has been replaced by internal combustion engine.]

3.6
cranking time
time period where the starter motor drives the *internal combustion engine (ICE)* (3.17) until a significant rotational frequency change, caused by the *first ignition* (3.13), can be observed

3.7
crankshaft
shaft of the *internal combustion engine (ICE)* (3.17), which is connected to the *ring gear* (3.31)

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3.8
direct starter motor
starter motor type in which the *pinion* (3.27) is driven at the same rotational frequency as the *armature* (3.1)

3.9
driveshaft
shaft of the starter motor, which supports and drives the *overrunning* (3.23) clutch and the *pinion* (3.27)

3.10
engagement lever
fork lever
lever to move the *pinion* (3.27)

3.11
engine speed
rotational frequency of the *crankshaft* (3.7)

3.12
excitation winding
field winding
winding that carries an exciting current to create an electromagnet

3.13
first ignition
initial ignition of the *internal combustion engine (ICE)* (3.17) while the starter motor is *cranking* (3.4) the ICE

3.14
helical spline
spline that transfers torque and axial load from the drive shaft to the *pinion* (3.27)

3.15
idle speed
rotational frequency of the *internal combustion engine (ICE)* (3.17) when the accelerator is not pushed

3.16
inrush current
maximum current when the starter motor is activated

3.17
internal combustion engine
ICE
engine, which generates motive power by the burning of a fuel-air mixture by means of a crank mechanism

3.18
lock current
stall current
current which is drawn by the starter motor when the *pinion* (3.27) is locked (no rotation)

3.19
lock torque
stall torque
torque of the starter motor at the *pinion* (3.27) with the *armature* (3.1) shaft locked (no rotation)

[SOURCE: ISO 8856:2014, 2.1, modified — The term "stall torque" has been added and Note 1 to entry has been removed.]

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3.20
meshing spring
spring that allows axial movement of the *pinion* (3.27)

3.21
minimum battery voltage
lowest *battery voltage* (3.4) which occurs when the starter motor is activated

Note 1 to entry: In practice the term voltage drop is used as a synonym.

3.22
nominal battery voltage
approximate value of the voltage used to identify a *battery* (3.2)

[SOURCE: Electropedia 482-03-31, modified — The word "battery" has been added to the term, the phrase "suitable approximate value" has been replaced by "approximate value", and the phrase "to designate or identify a cell, a battery or an electromechanical system" has been replaced by "to identify a battery".]

3.23
overrunning
condition in which the *internal combustion engine (ICE)* (3.17) rotates the starter motor *pinion* (3.27) before starter motor OFF

[SOURCE: ISO 20574:2019, 3.17, modified — The term "engine" has been replaced by "internal combustion engine".]

3.24
overrunning clutch
mechanism to transfer starter motor torque to the *pinion* (3.27) in only one direction of rotation

3.25
overrunning time
time period where engine drives the starter motor *pinion* (3.27) before starter motor OFF

3.26
permanent magnet type starter motor
starter motor type, which uses permanent magnets to create the magnetic field inside the motor

3.27
pinion
gear driving the *ring gear* (3.31)

3.28
plunger
relay armature
movable part of the *solenoid* (3.32), which moves the *engagement lever* (3.10)

3.29
reduction gear type starter motor
starter motor type for which the *pinion* (3.27) is driven with a lower rotational frequency than the *armature* (3.1) rotational frequency to increase the torque

3.30
return spring
spring exerting a force against the working direction of the *plunger* (3.28)

3.31
ring gear
gear to transfer torque from the starter motor to the *internal combustion engine (ICE)* (3.17)

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3.32
solenoid
engagement relay
magnetic switch
mechanism to move the *pinion* (3.27) and to close the contact bridge

3.33
solenoid cover
switch cover
cap of the *solenoid* (3.32) including the electrical *terminals* (3.40)

3.34
starter motor disengagement speed
rotational frequency of the *internal combustion engine (ICE)* (3.17) at starter motor OFF

3.35
starter motor current
I_{STR}
current drawn by the starter motor

[SOURCE: ISO 20574:2019, 3.27]

3.36
starter motor energy
E_{STR}
electrical energy consumed by the starter motor during one start event

3.37
starter motor ON time
time period where starter motor is activated

Note 1 to entry: It is typically the time period when *starter motor current* (3.35) is above a certain level.

3.38
starter motor voltage
U_{STR}
voltage at the *battery* (3.2) *terminal* (3.40) of the starter motor

[SOURCE: ISO 20574:2019, 3.26]

3.39
switch
device that supplies electricity to the *solenoid* (3.32) *terminal* (3.40)

3.40
terminal
electrical interface of the starter motor and the *battery* (3.2)

3.41
wound field type starter motor
starter motor type, which uses the *excitation windings* (3.12) to create the magnetic field inside the motor

3.42
yoke
pole housing
housing enclosing the *armature* (3.1) and containing the *excitation windings* (3.12) or magnets

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4 General characteristics of the starter motor

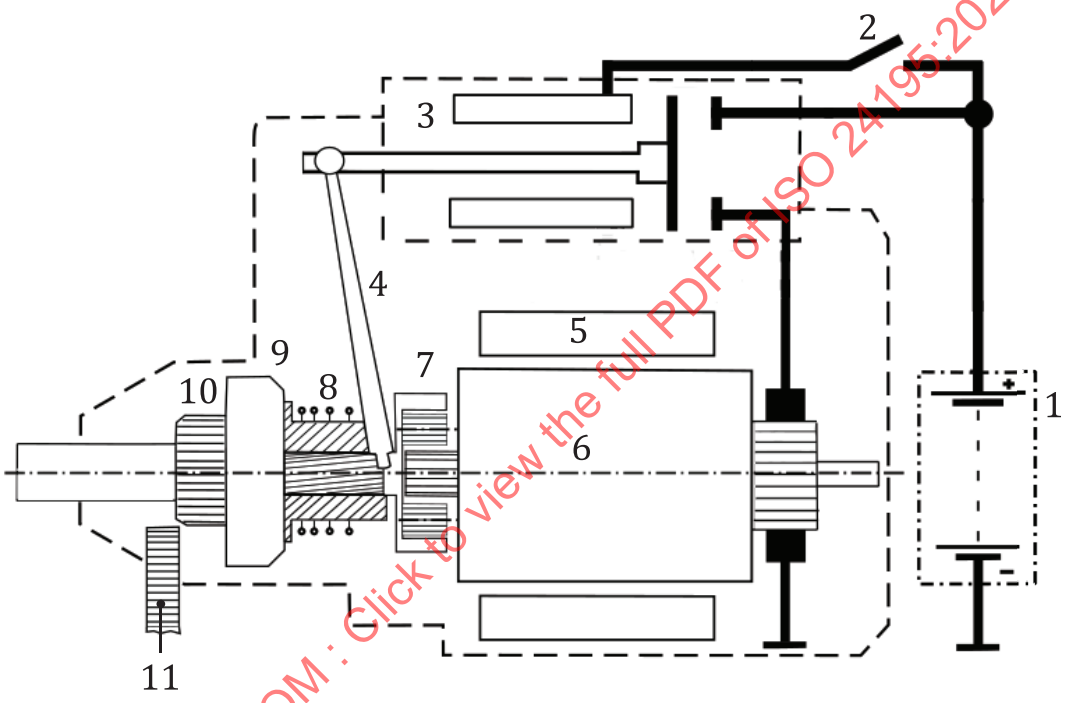
4.1 General

This clause describes the starter motor and its components.

Furthermore, this clause describes how certain terms related to each other and how they are used.

4.2 Starter motor components

The starter motor consists of the following components as shown in Figure 1.



Key

1 battery
2 ignition or driving switch
3 solenoid
4 engagement lever
5 permanent magnet
6 armature
7 planetary gear
8 meshing spring
9 overrunning clutch
10 pinion
11 ring gear

Figure 1 — Components of the permanent magnet type starter motor

The closed ignition switch connects the battery to the solenoid. An activated solenoid causes a forward movement of the engagement lever as well as closes the contact to the excitation/series winding which rotates the armature. The armature is connected to the planetary gear that transfers the rotational movement of the armature to the pinion shaft. The axial forward movement of the pinion gear is supported by the meshing spring. The overrunning clutch connects the armature shaft to the pinion which engages the ring gear.

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4.3 Starter motor functions

The starter motor can engage with the ring gear by using special forms of functions, such as the helical spline, the meshing spring and the overrunning clutch.

The helical spline allows a forward movement of the pinion gear initiated by a rotation of the armature. To furthermore allow an engagement of the pinion gear with the ring gear, the starter motor is equipped with a meshing spring that supports the engagement by applying an axial force towards the ring gear.

The solenoid operates the engagement lever by closing the contact inside the engagement relay. Hereby the connection inside the armature between the excitation winding and the battery gets closed, as well as the engagement lever pushes the pinion gear with the overrunning clutch outward in the direction of the ring gear.

After the ICE has reached its minimum rotational frequency, the ICE will continue to raise its rotational frequency. In order to not harm the starter motor by generating a voltage in the armature, the starter motor is equipped with an overrunning clutch which allows the ring gear to overrun the pinion gear of the starter motor.

4.4 Starting parameters

Important starting parameters are shown in Figure 2. In detail, Figure 2 shows typical wave forms of starter motor voltage, battery voltage, starter motor current and ICE rotational frequency versus time.

The start motor ON time defines the period where the starter motor is activated. The starter motor ON time is the sum of the cranking time and the overrunning time. Typically, the overrunning time begins with the 1st ignition of the ICE where the ICE drives the starter motor pinion before starter motor OFF.

Immediately after the starter motor is activated, the inrush current occurs and leads to the minimum battery voltage which is in practice often called the voltage drop.

The starter motor voltage differs from the battery voltage due to the line resistance.

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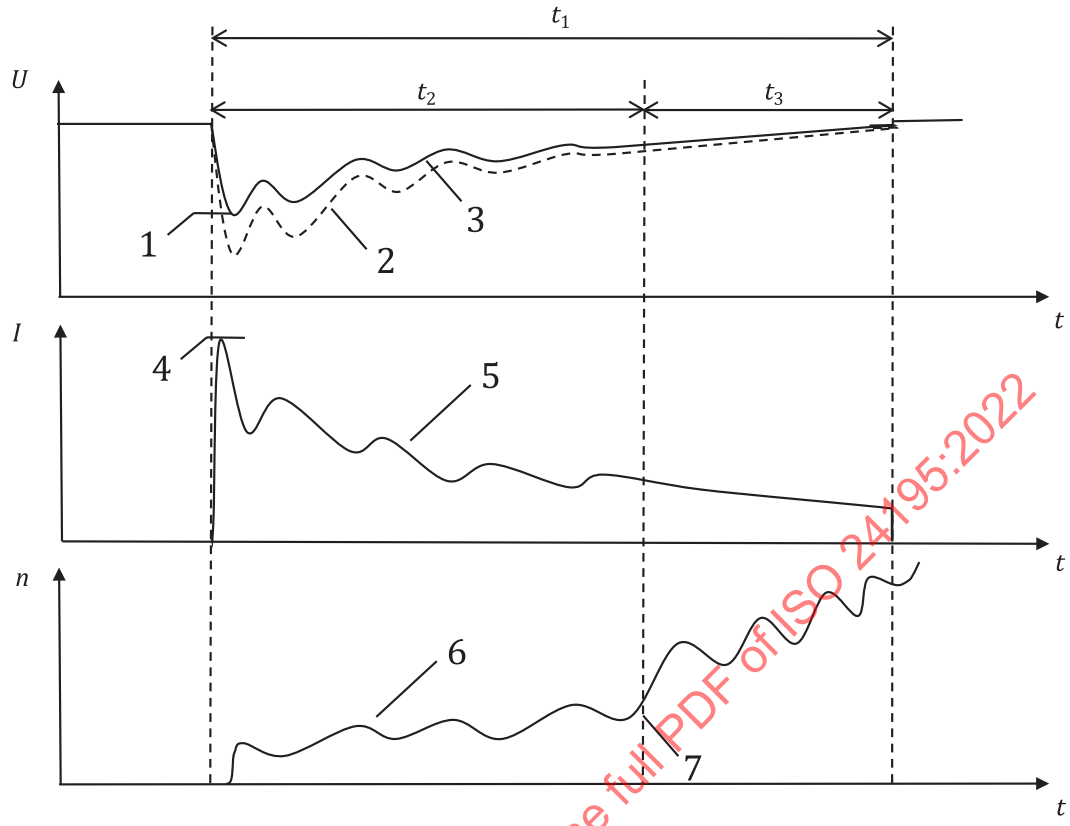

Key

U	voltage, expressed in V	1	minimum battery voltage
I	current, expressed in A	2	starter motor voltage
n	rotational frequency, expressed in rpm	3	battery voltage
t	time, expressed in s	4	inrush current
t_1	starter motor ON time	5	starter motor current
t_2	cranking time	6	ICE rotational frequency
t_3	overrunning time	7	first ignition

Figure 2 — Starting parameters: voltage, starter motor current, engine rotational frequency

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5 Special characteristics of the starter motor

5.1 General

This clause describes the special aspects of starter motor which support starter motor function and starter motor application design.

5.2 Magnetic field

Figure 3 shows the typical types of magnetic fields used in starter motor designs.

In the permanent magnet type starter motor, the magnetic field is constant because it is created by the permanent magnet. On the other hand, in the wound field type starter motor, the magnetic field changes depending on the starter motor current, so the magnetic field is low in the low current area and increases in the high current area. As a result, the features of the w ound field type starter motor are high no load speed and high torque. At present, the permanent magnet type starter motor is generally used below 2 kW and the wound field type starter motor is used above 2 kW.

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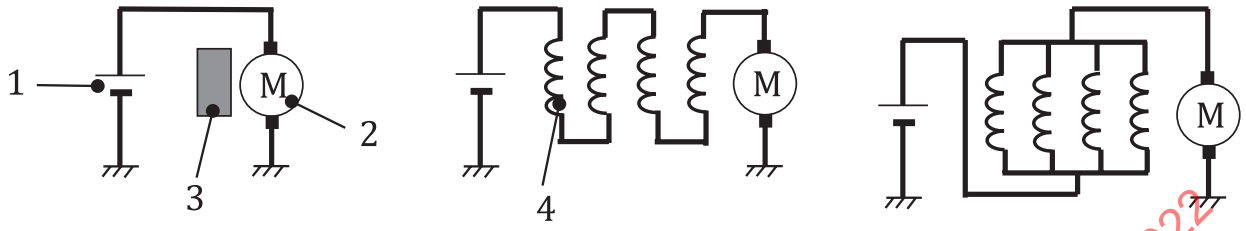
There are two types of connection methods, series and parallel.

A parallel type is often used at 12 V and a series type is often used at 24 V. This is because the resistance value is adjusted by wiring according to the voltage so that the amount of heat generated per body size will be the same.



a) permanent magnet b) series wound field type c) parallel wound field type

Key

1 battery
2 armature
3 permanent magnet
4 field coil

Figure 3 — Magnetic field types

5.3 Starting performance

The relationship between ICE friction torque and ICE rotational frequency, and the starter motor output converted to the ICE crankshaft axis, is shown by the torque-speed curve as shown in Figure 4. The intersection of ICE friction torque and the starter motor performance is estimated to be the ICE cranking point that will result from this specific starter motor.

Here, the starter motor performance is generally calculated under the following conditions:

— required temperature;

— input characteristic to starter (battery performance and line resistance);

— reduction ratio between the starter motor and the ICE (ratio of the pinion and the ring gear teeth).

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