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(JARI/JSA)

**Rolling stock — Combined testing of
power convertor with ac motors —
Part 1: Inverter system**

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Foreword

This translation has been made based on the original Japanese Industrial Standard established by the Minister of Land, Infrastructure, Transport and Tourism through deliberations at the Japanese Industrial Standards Committee according to the proposal for establishment of Japanese Industrial Standard by Japan Association of Rolling Stock Industries (JARI) /Japanese Standards Association (JSA) with the draft being attached, based on the provision of Article 12 Clause 1 of the Industrial Standardization Law.

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JIS E 5011 consists of the following 2 parts under the general title “*Rolling sotck — Combined testing of power convertor with ac motors*”:

Part 1: Inverter system

Part 2: Convertor-inverter system with intermediate dc link

Rolling stock — Combined testing of power convertor with ac motors — Part 1 : Inverter system

Introduction

This Japanese Industrial Standard has been prepared based on the first edition of IEC 61377-1 published in 2006 by modifying some of the technical contents so as to add specification items and contents that are not given in the corresponding International Standard (e.g. examples of involved manufacturer and supplier, contents of load profile that should be considered and electric cable).

The portions with continuous sidelines and dotted underlines are the matters in which the contents of the corresponding International Standard have been modified. A list of modifications with explanations is given in Annex JA.

1 Scope

This Standard applies to the combinations of ac motor(s), inverter and their control system, and its object is to specify :

- the performance characteristics of electric drives consisting of an inverter, alternating current motors, and the related control system ;
- methods of verifying these performance characteristics by tests.

Two categories of combined systems can be considered :

- a) alternating current motor(s) fed from an inverter without any control between the mechanical output (torque, speed) and the inverter itself (mostly auxiliary motors, for example cooling fan motors). The motor works exactly as if it were fed from a busbar (at variable frequency and voltage or not) ;
- b) alternating current motor(s) (paralleled or not) with a control between the mechanical output and the inverter.

The systems of category **a)** is tested according to **JIS E 5008** and **JIS E 6102**.

This Standard applies to the category **b)**, mainly traction drives (see figure 1).

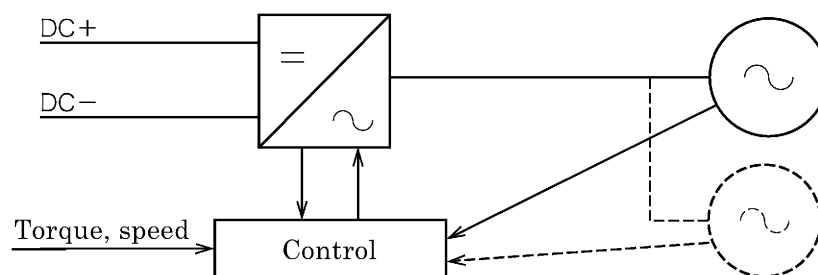


Figure 1 Traction drive

JIS E 6102 applies to convertor-fed alternating current motors, **JIS E 5008** to power electronic convertors, **JIS E 5006** to electronic equipments, and this Standard applies to the combination of ac motor(s), inverter, and their control system. As a consequence, **JIS E 6102** describes the tests to demonstrate the compliance of the motor to its specification, **JIS E 5008** does the same for the inverter. It is self-evident that some of the tests mentioned in this Standard generally may replace the corresponding ones described in the above-mentioned standards. An agreement should be reached between the user and the manufacturer (hereafter referred to as "the interested parties") to avoid the duplication of tests (see, for example, the "possible duplication of test" column in table 1).

A complete combined test is heavy, and often requires high power, which is not always available in a workshop. An agreement between the interested parties may be reached to allow testing either in the workshop or on the vehicle. Testing may be split off partially in a workshop and partially on track.

At the time of drafting this Standard, only the following combinations of motors and inverters were used for traction applications, but it may also apply to other combinations which may be used in the future :

- a) asynchronous motors fed by voltage stiff (voltage source) inverter ;
- b) synchronous motors fed by voltage stiff (voltage source) inverter ;
- c) asynchronous motors fed by current stiff (current source) inverter ;
- d) synchronous motors fed by current stiff (current source) inverter.

The input of these inverters can be a d.c. supply line, a rectifier, a chopper, an input convertor, a diesel generator with integrated rectifiers, etc.

NOTE 1 An inverter is "a device to convert dc input energy directly into ac output energy".

NOTE 2 The International Standard corresponding to this Standard and the symbol of degree of correspondence are as follows :

IEC 61377-1 : 2006 *Railway applications — Rolling stock — Part 1 : Combined testing of inverter-fed alternating current motors and their control system* (MOD)

The symbols which denote the degree of correspondence in the contents between **JIS** and the corresponding International Standard are IDT (identical), MOD (modified) and NEQ (not equivalent) according to ISO/IEC Guide 21.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this Standard. For standards with the year indication, only the editions of the indicated year shall be applied and any revisions (including amendments) made thereafter shall not be applied. For those without the indication of the year, the most recent edition (including amendments) shall be applied.

JIS E 4001 *Railway rolling stock — Vocabulary*

NOTE: Corresponding International Standard : IEC 60050-811 *International Electrotechnical Vocabulary (IEV) — Chapter 811 : Electric traction* (MOD)

JIS E 5006 *Electronic equipment for rolling stock*

NOTE: Corresponding International Standard : IEC 60571 *Electronic equipment used on rail vehicles* (MOD)

JIS E 5008 : 2009 *Rolling stock — Power convertors installed on board rolling stock*

NOTE: Corresponding International Standard : IEC 61287-1 : 2005 *Railway applications — Power convertors installed on board rolling stock — Part 1 : Characteristics and test methods* (MOD)

JIS E 6102 : 2004 *AC traction motors for rolling stock*

NOTE: Corresponding International Standard : IEC 60349-2 : 2002 *Electric traction — Rotating electrical machines for rail and road vehicles — Part 2 : Electronic convertor-fed alternating current motors* (MOD)

IEC 60050-411 *International Electrotechnical Vocabulary (IEV) — Chapter 411 : Rotating machinery*

IEC 60050-551 *International Electrotechnical Vocabulary (IEV) — Chapter 551 : Power electronics*

IEC 60850 *Railway applications — Supply voltages of traction systems*

3 Terms and definitions

For the purposes of this Standard, the terms and definitions given in JIS E 4001, JIS E 5008, JIS E 6102, IEC 60050-411 and IEC 60050-551, and the following apply :

3.1 combined system

unit consisting of the inverter, the motor(s), their related control system, equivalent power cables connecting them, and an equivalent cooling system

3.2 user

organization which orders the combined system

The user is normally an organization which uses the vehicle or the equipment, unless the responsibility is delegated to a main contractor or consultant (see figure 1A)

3.3 manufacturer or prime contractor

organization which has the technical responsibility for the supply of the combined system (see figure 1A)

NOTE : An inverter supplier may be a prime contractor.

3.4 supplier or subcontractor

organization which has the responsibility of one or more of the electric constituents such as inverter, control system and motor(s) (see figure 1A)

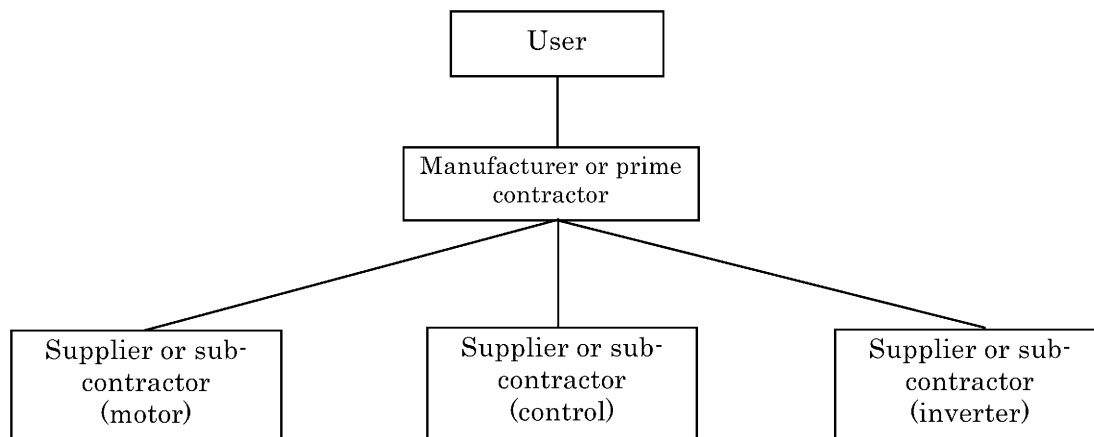


Figure 1A Combined system — involved manufacturer and supplier

3.5 manufacturer's works

location where tests are generally performed

3.6 duty

statement of the load to which the combined system is subjected, including, if applicable, electric braking, no load, rest and de-energized periods, including their durations and sequence in time

3.7 duty cycle of vehicle/load profile

duty cycle of vehicle is variation of load determined by the speed and mass of a train which runs on the track having gradients and curves at various spots

The load profile for inverter is calculated by the engineering from the duty cycle of vehicle.

Load profile (current/power versus time) is the repetitive cycle or the load current/power under specified conditions such as starting and braking. Also the voltage has to be considered

3.8 rating of a combined system

combination of simultaneous values of electrical and mechanical quantities, with their duration and sequence, assigned to the combined system by the manufacturer

3.9 rated value

numerical value of electrical and mechanical quantity included in a rating

3.10 continuous rating

mechanical output that the combined system can deliver on the test bed under specified conditions without exceeding the limits of temperature rise given in **JIS E 5008** and **JIS E 6102**

NOTE : Several continuous ratings may be specified (in the case of multi-power source system, for example).

3.11 short-time rating (for example, 1 h rating)

mechanical output that the combined system can deliver on the test bed under specified conditions for the stated time without exceeding the limits of temperature rise given in table 2 of **JIS E 6102** and in **JIS E 5008**, starting with the combined system cold, all other requirements of here mentioned standards being satisfied

NOTE : When the stated time is one hour, the rating is 1h rating.

3.12 short-time overload rating

mechanical output that the combined system can deliver on the test bed under specified conditions for the stated time

The test is carried out as specified in 8.1.6 of **JIS E 6102**, without exceeding the limits of temperature rise given in table 3 of **JIS E 6102** and in **JIS E 5008**

NOTE : Short-time overload ratings are of value in determining the suitability of combined systems for duties which involve relatively long periods of operation below the continuous rating followed by a period above it. These are most likely to occur in locomotive applications. They are not relevant to repeated short-load cycles of rapid transit and similar duties, and should not be specified for such applications.

3.13 intermittent duty rating

duty cycle on which the combined system may be operated without the temperature rise at any point exceeding the limits given in **JIS E 5008** and **JIS E 6102**

3.14 periodic duty rating

periodic duty on which the combined system may be operated without the temperature rise at any point exceeding the limits given in **JIS E 5008** and **JIS E 6102**

4 Environmental conditions

Environmental conditions relative to motor, inverter, and control system are detailed in **JIS E 6102**, **JIS E 5008** and **JIS E 5006**.

5 Combined system characteristics

5.1 Specified characteristics

Combined system specifications shall, as a general rule, include characteristic curves specified in this Standard. These curves are defined as the "specified characteristics". They shall be plotted to the designed operating limits of each variable. They shall generally be drawn for the d.c. supply voltage of the traction system at its specified nominal value. They may also be drawn for the lower and higher voltage of the supply of the traction system if agreed between the interested parties. These characteristics shall be drawn for a reference temperature of the windings of the motor as specified in 5.2 of JIS E 6102, and the temperature of the parts of the inverter expected by the supplier.

Figure 2 gives some examples of the points where d.c. voltage and current may be defined in order to have safe measurement conditions.

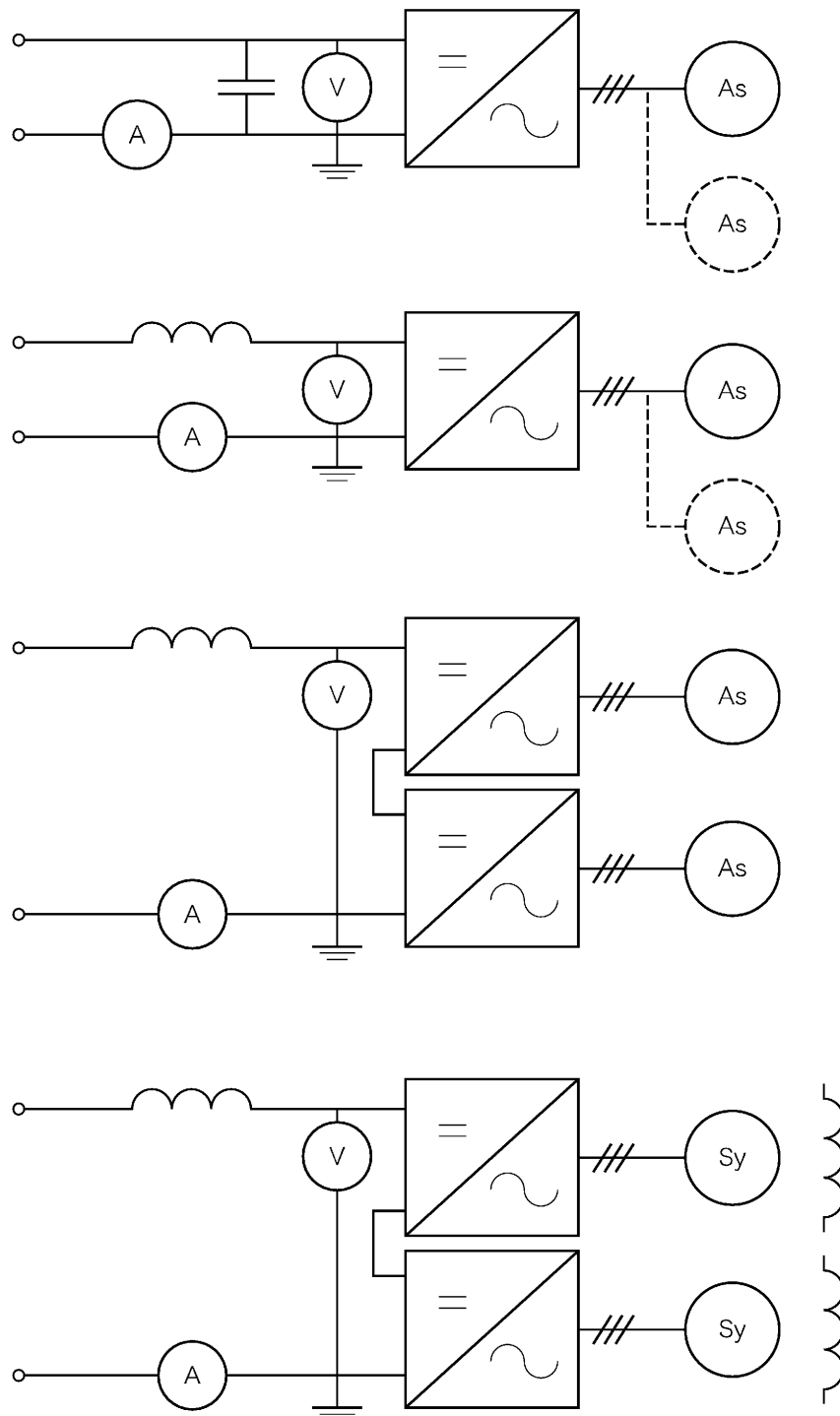


Figure 2 Example of measurement points of the d.c. input

As an alternative to the torque and speed, the characteristics may show tractive effort at the wheels and vehicle speed. In which case, the gear ratio, wheel diameter and transmission losses shall be stated. If conventional values are used for the latter, they shall be in accordance with figure B.1 of JIS E 6102.