INVOICE FOR ISSUE OF

TOYOTA ENGINEERING STANDARD

NO. : TSC7021G

TITLE : GENERAL RULE FOR BENCH TEST METHOD FOR PERFORMANCE OF AUTOMOTIVE ELECTRONIC EQUIPMENT UNDER FLUCTUATING POWER SUPPLY VOLTAGE

CLASS : C2

PUBLICATION RECORD

This standard has been revised in consequence of the following changes:
(1) Test conditions for cranking 1 have been changed.
(2) Test item "IG 1 to/from 2 switching" has been additionally specified.
(3) The recommended random waveform generator has been changed.
(4) Misdescriptions have been corrected.

Engineering Information
Management Dept.
Engineering Administration Div.
TOYOTA MOTOR CORPORATION

GENERAL RULE FOR BENCH TEST METHOD FOR PERFORMANCE OF AUTOMOTIVE ELECTRONIC EQUIPMENT UNDER FLUCTUATING POWER SUPPLY VOLTAGE

1. Scope

This standard covers the method for testing on bench the operation performance of automotive electronic equipment and systems under fluctuating power supply voltage.

2. Terms and Definitions

Excepting the following, definitions of the terms used in this standard shall conform to Section 2 of TSC7000G.

(1) +B
The term "+B" refers to the power sources or signals that are input continuously from a battery to the equipment, among those input to the equipment.

(2) ACC
The term "ACC" refers to the power sources or signals that are input to the equipment through the ACC terminal of ignition switch, among those input to the equipment.

(3) IG
The term "IG" refers to the power sources or signals that are input to the equipment through the IG contacts of ignition switch, among those input to the equipment.

(4) Universal waveform generator
The term "universal waveform generator" refers to a device that can change arbitrarily the output voltage waveform of a constant-voltage power supply for a desired period of time.

3. Test Items

The test items specified in this standard and equipment applicable to the test are as shown in Table 1.

Prepared and Written by:
Electronics Laboratory
Electronics Engineering Div. 1

Engineering Administration Div.

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Table 1 Test Items and Applicable Equipment

Test item	Equipment
(1) Battery connection/disconnection (2) Battery terminal chattering (3) IG switch repetitive ON/OFF (4) IG instantaneous interruption 1 (5) IG instantaneous interruption 2 (6) Instantaneous interruption by IG switching	All equipment
(7) IG ON before/after main relay OFF	Equipment with main relay
(8) IG OFF and ON from READY state (9) Battery instantaneous interruption due to DC-DC converter failure in READY state	HV system
(10) Cranking 1 (11) Cranking 2 (12) Cranking 3 (13) Battery flat + battery instantaneous interruption (14) Engine starting with jumper lead after battery undervoltage (15) IG switching with undervoltage battery (16) IG 1 to/from 2 switching (17) When program heavily loaded (18) When load operated (19) When communication system heavily loaded	All equipment

4. Preparation for Test

4.1 Test Specimen

Use electronic equipment and systems the normal functions of which have been already confirmed on bench (debugged on bench).

4.2 Test Apparatus

(1) Constant-voltage power supply

The constant-voltage power supply to be used for the test shall have the performance specified in Table 2.

Table 2 Required Performance of Constant-Voltage Power Supply

Response	10 kHz
Output voltage range	0 to 20 V min. [0 to 30 V min.]
Output current capacity	Depends on the specifications of each unit of equipment

Remark 1:
Numerical values given in [ ] are for parts driven at 24 V.
Remark 2:
Recommendation: Bipolar power supply unit PBX20-20 (made by KIKUSUI ELECTRONICS CO.)

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(2) Universal waveform generator
A device that can vary arbitrarily the output voltage waveform of a constant-voltage power supply for a desired period of time
Performance: Output frequency of 10 kHz min.
Recommendation: simulator (dSPACE, etc.). Or, a function generator 33120A (made by Agilent Technology) or a programmable power source meeting (1) and (2) of Section 4.2 may be sued.

(3) Load
The input and output loads used in operating the ECUs shall be actual loads, as a rule. When using dummy loads, carry out the test after taking into account the rating, inductance, impedance, and other factors that may affect the performance of the test specimen. If the test specimen is provided with a communication unit, connect a device that has to be coupled with this unit or a communication evaluation device (see Fig. 1.).

Remark:
The communication evaluation device shall be provided with the following functions:
(a) Function capable of confirming the communication data transmitted from the test specimen
(b) Function capable of transmitting communication data to the test specimen

(4) Ammeter
This ammeter is used for measuring dark current after the test. Its dissolution shall be 0.1 mA min.

4.3 Test Circuit
After electrically connecting the test specimen and test apparatuses specified in Sections 4.1 and 4.2 as shown in Fig. 1, adjust each apparatus so that the necessary fluctuating waveforms of power supply voltage specified in (1) through (16) of Table 3 can be obtained. The tolerance of the output voltage waveform shall conform to Fig. 2.
To check the waveforms, connect an oscilloscope to the power input terminals of the test specimen.

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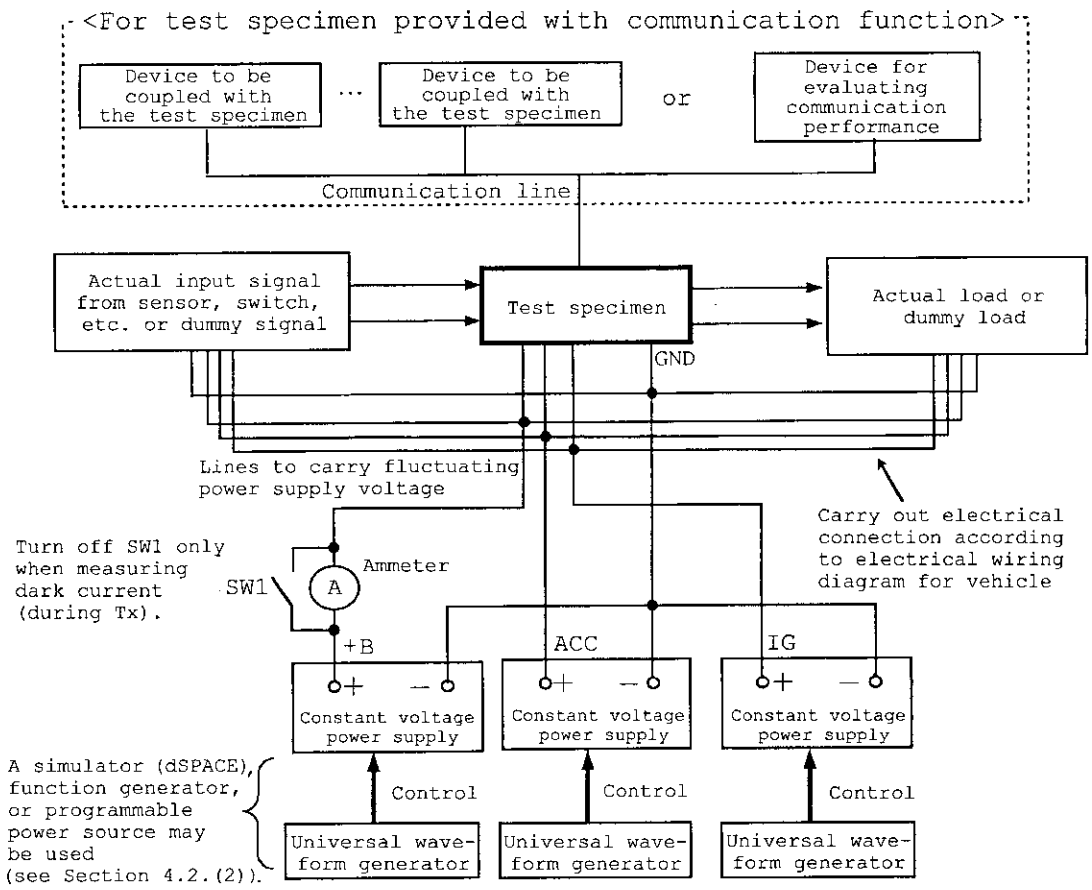

Fig. 1 Test Circuit Diagram

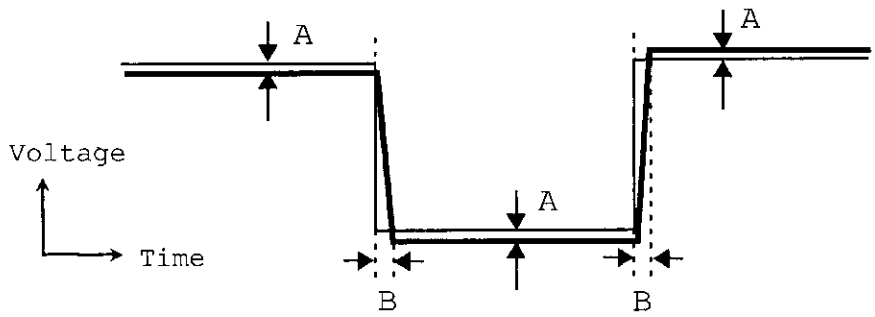

Fig. 2 Tolerance of Output Voltage Waveform

Remark:

——: Desired voltage waveform
——: Actual output voltage waveform

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A: ±0.05 V max.
B: ±50 μs max.

5. Description of Test

5.1 Test Condition

(1) Temperature and humidity
Shall be maintained at the standard values.

(2) Operating condition of electrical load
The operating condition of the test specimen during the test will be specified in respective equipment standards.

5.2 Test Method

(1) Apply the test specimen with each waveform of fluctuating power supply voltage specified in the test items (1) through (16) of Table 3.
During and after the test, check the test specimen for malfunction(1).
When the test specimen contains a dark current, measure it after the test.
When selecting the waveform in which dark current is to be measured, conform to respective equipment standards.

Note: (1)
This term refers to operations not designed for the equipment (unexpected operation), and is defined in respective equipment standards. Check the diagnosis system at least once every application of the fluctuating power supply voltage waveform.

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Table 3 Fluctuating Waveform of Power Supply Voltage

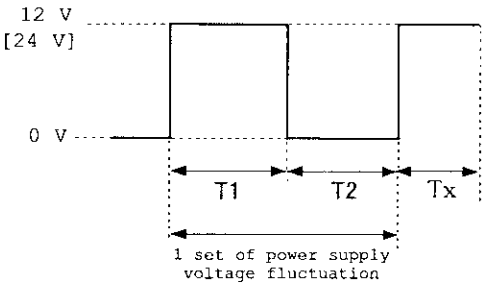
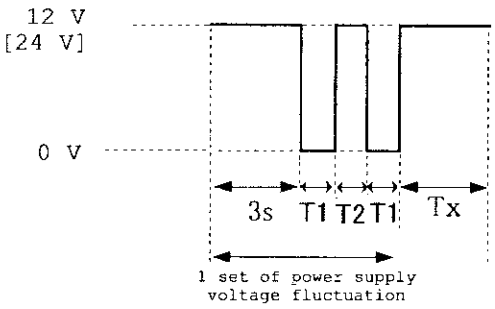
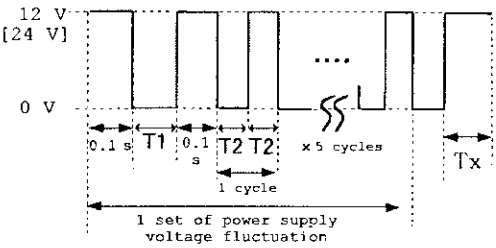
<table>
<tr><th>Test item</th><th>Test condition</th></tr>
<tr><td>(1) Battery connection and disconnection</td><td> 
</td><td><T1, T2>
Combine the following times. (228 sets in total)
Test pattern 1:
T1: 1.0 to 15.0 s (in increments of 1.0 s)
T2: 1.0 to 15.0 s (in increments of 1.0 s)
Test pattern 2:
T1: 100 ms
T2: 10, 30, 50 ms
<Power supply>
Supply power according to (i) to (iii) shown below.
Combination of power supply terminals
<table><tr><th></th><th>(i)</th><th>(ii)</th><th>(iii)</th></tr><tr><td>+B</td><td>○</td><td>○</td><td>○</td></tr><tr><td>ACC</td><td>OPEN</td><td>○</td><td>○</td></tr><tr><td>IG</td><td>OPEN</td><td>OPEN</td><td>○</td></tr></table>Remark:
○ : Fluctuate power supply voltage.</td></tr>
<tr><td>(2) Battery terminal chattering</td><td> 
</td><td><T1, T2>
Combine the following durations. (90 sets in total)
T1: 10, 30, 50 ms
T2: 0.01 s to 0.3 s (increase by 0.01 s)
<Power supply>
Supply power according to (i) to (iii) shown below.
Combination of power supply terminals
<table><tr><th></th><th>(i)</th><th>(ii)</th><th>(iii)</th></tr><tr><td>+B</td><td>○</td><td>○</td><td>○</td></tr><tr><td>ACC</td><td>OPEN</td><td>○</td><td>○</td></tr><tr><td>IG</td><td>OPEN</td><td>OPEN</td><td>○</td></tr></table>Remark:
○ : Fluctuate power supply voltage.</td></tr>
<tr><td>(3) IG switch repetitive ON/OFF</td><td> 
</td><td><T1, T2>
Combine the following durations. (3006 sets in total)
Test pattern 1:
T1: 0.5 s to 30 s (increase by 0.5 s)
T2: 0.1 s to 5.0 s (increase by 0.1 s)
Test pattern 2:
T1: 1 s
T2: 1, 2, 5, 10, 20, 50 ms
<Power supply>
Supply power according to (i) and (ii) shown below.
Combination of power supply terminals
<table><tr><th></th><th>(i)</th><th>(ii)</th></tr><tr><td>+B</td><td>12 [24] V</td><td>12 [24] V</td></tr><tr><td>ACC</td><td>○</td><td>12 [24] V</td></tr><tr><td>IG</td><td>○</td><td>○</td></tr></table>Remark:
○ : Fluctuate power supply voltage.</td></tr>
</table>

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Table 3 (Continued)

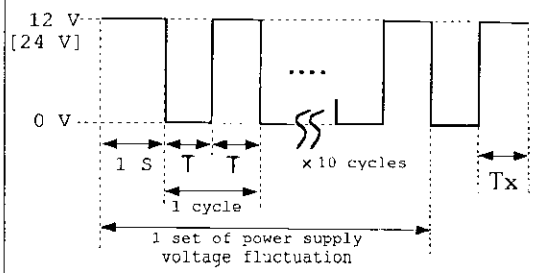
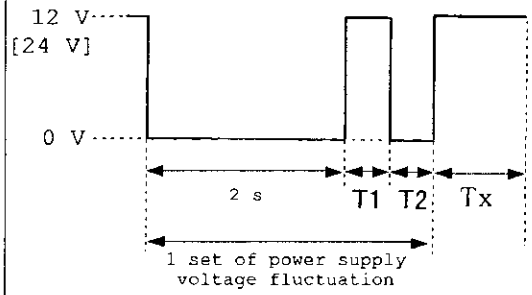
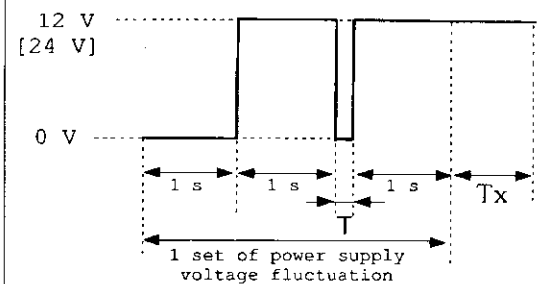
Test item	Test condition	
(4) IG instantaneous interruption 1		<T> Change the duration as follows. (9 sets in total) T: 1, 5, 10, 15, 20, 50, 100, 200, 1000 ms <Power supply> Supply power according to (i) through (iv) shown below. Combination of power supply terminals | | (i) | (ii) | (iii) | (iv) | |---|---|---|---|---| | +B | ○ | 12 [24] V | 12 [24] V | 12 [24] V | | ACC | ○ | 12 [24] V | 12 [24] V | 12 [24] V | | IG1 | ○ | ○ | ○ | 12 [24] V | | IG2 | ○ | ○ | 12 [24] V | ○ | Remark: ○: Fluctuate power supply voltage.
(5) IG instantaneous interruption 2		<T1, T2> Combine the following durations. (110 sets in total) T1: 1 ms to 20 ms (increase by 1 ms), 50 ms, 0.1 s T2: 1 ms to 5 ms (increase by 1 ms) <Power supply> Supply power according to (i) to (iv) shown below. Combination of power supply terminals | | (i) | (ii) | (iii) | (iv) | |---|---|---|---|---| | +B | 12 [24] V | 12 [24] V | 12 [24] V | 12 [24] V | | ACC | ○ | ○ | 12 [24] V | ○ | | IG | OPEN | 12 [24] V | ○ | ○ | Remark: ○: Fluctuate power supply voltage.
(6) Instantaneous interruption by IG switching		<T> Change the duration as follows. (100 sets in total) T: 30 to 3000 ms (increase by 30 ms) <Power supply> Supply power according to (i) and (ii) shown below. Combination of power supply terminals | | (i) | (ii) | |---|---|---| | +B | 12 [24] V | 12 [24] V | | ACC | ○ | 12 [24] V | | IG | ○ | ○ | Remark: ○: Fluctuate power supply voltage.

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Table 3 (Continued)

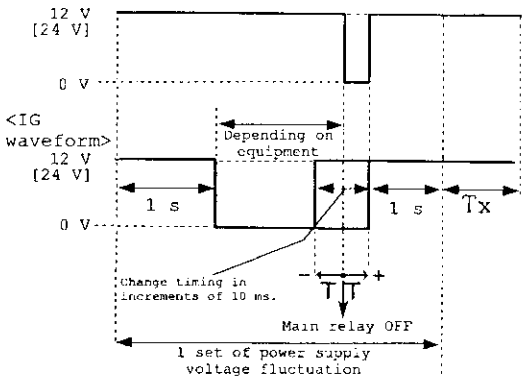
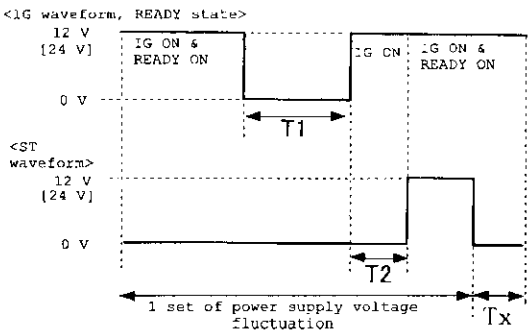
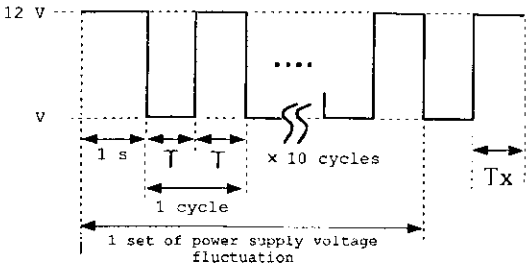
<table>
<tr><th>Test item</th><th>Test condition</th><th></th></tr>
<tr><td>(7) IG ON before/after main relay OFF</td><td>Only for systems provided with main relay
<Main relay waveform>
 
</td><td><T>
Change the duration as follows.
(21 sets in total)
T: Within the range of 100 ms before and after the main relay turning OFF, change IG in increments of 10 ms.</td></tr>
<tr><td>(8) IG OFF and ON from READY state</td><td>For HV systems only
 
</td><td><T1, T2>
Combine the following durations.
(78 sets in total)
T1: 500 ms to 3000 ms (increase by 100 ms)
T2: 0, 500, 1000 ms</td></tr>
<tr><td>(9) Battery instantaneous interruption due to DC-DC converter failure in READY state</td><td>Only for HV systems with DC-DC converter
 
</td><td><T, V>
Combine the following durations and voltages. (42 sets in total)
T: 5, 10, 20, 50, 90, 150, 200 ms
V: 2, 4, 5, 7, 8, 9 V
<Power supply>
Supply power according to (i) to (iii) shown below.
Combination of power supply terminals
<table>
<tr><th></th><th>(i)</th><th>(ii)</th><th>(iii)</th></tr>
<tr><td>+B</td><td>○</td><td>○</td><td>○</td></tr>
<tr><td>ACC</td><td>OPEN</td><td>○</td><td>○</td></tr>
<tr><td>IG</td><td>OPEN</td><td>OPEN</td><td>○</td></tr>
</table>
Remark:
○: Fluctuate power supply voltage.</td></tr>
</table>

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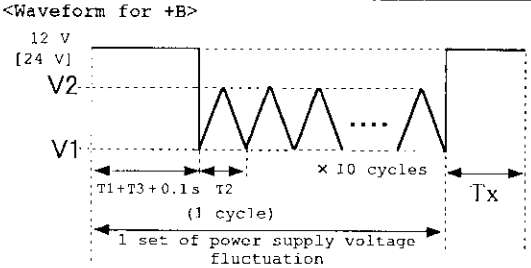
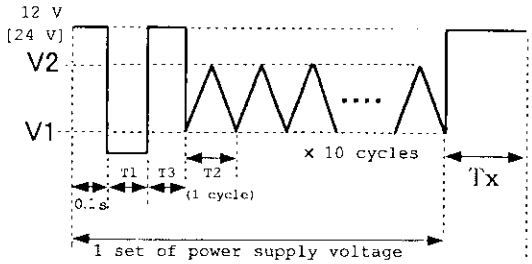
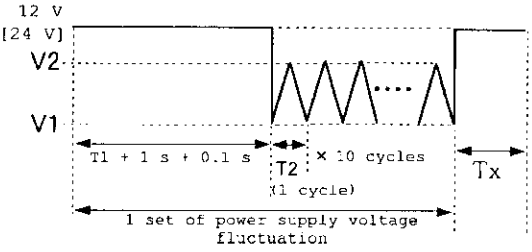
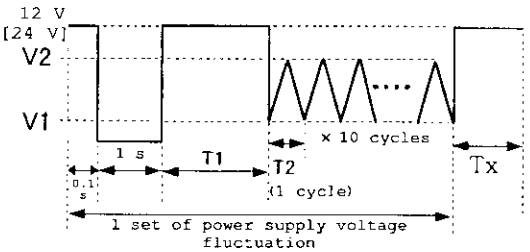
Table 3 (Continued)

<table>
<tr><th>Test item</th><th>Test condition</th></tr>
<tr><td>(10) Cranking 1</td><td>
<Waveform for +B>


<Waveform for ACC and IG>


</td><td>
<T1, T2, T3, V1, V2>
Combine the following times and voltages. (4743 patterns in total)
T1: 0.5 to 30.5 s (in increments of 1.0 s)
Combine T2 and T3 according to the patterns 1 through 3.
Combination of T2 and T3
<table>
<tr><td>Pattern</td><td>1</td><td>2</td><td>3</td></tr>
<tr><td>T2</td><td>0.1 s</td><td>0.5 s</td><td>1.0 s</td></tr>
<tr><td>T3</td><td>35 ms</td><td>65 ms</td><td>0.1 s</td></tr>
</table>
V1: 3 to 8 V (in increments of 0.1 V)
[3 to 16 V (in increments of 0.1 V)]
V2: V1 + 1 V
<Power supply>
Supply power according to (i) and (ii) shown below.
Combination of power supply terminals
<table>
<tr><td></td><td>(i)</td><td>(ii)</td></tr>
<tr><td>+B</td><td>○</td><td>○</td></tr>
<tr><td>ACC</td><td>OPEN</td><td>○</td></tr>
<tr><td>IG</td><td>○</td><td>○</td></tr>
</table>
Remark:
○ : Fluctuate power supply voltage.
</td></tr>
<tr><td>(11) Cranking 2</td><td>
<Waveform for +B>


<Waveform for ACC and IG>


</td><td>
<T1, T2, V1, V2>
Combine the following times and voltages. (900 patterns in total)
T1: 0.1 to 15.0 s (in increments of 0.1 s)
T2: 0.6 s
V1: 3 to 8 V (in increments of 1 V)
[3 to 16 V (in increments of 1 V)]
V2: V1 + 1 V
<Power supply>
Supply power according to (i) and (ii) shown below.
Combination of power supply terminals
<table>
<tr><td></td><td>(i)</td><td>(ii)</td></tr>
<tr><td>+B</td><td>○</td><td>○</td></tr>
<tr><td>ACC</td><td>OPEN</td><td>○</td></tr>
<tr><td>IG</td><td>○</td><td>○</td></tr>
</table>
Remark:
○ : Fluctuate power supply voltage.
</td></tr>
</table>

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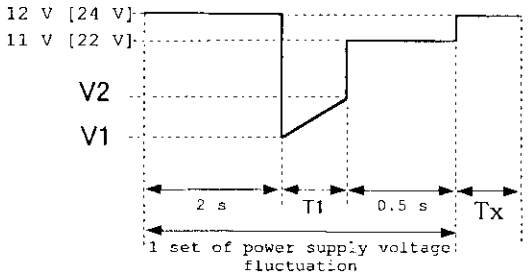
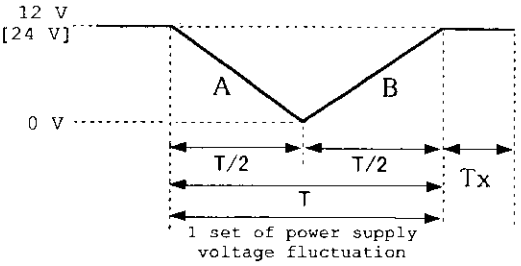
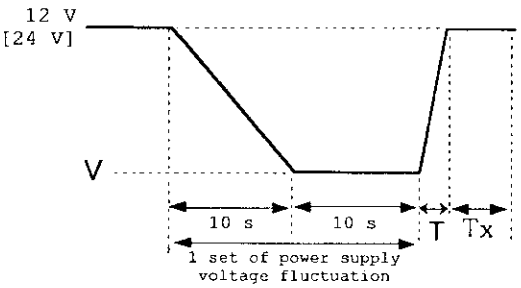
Table 3 (Continued)

<table>
<tr><th>Test item</th><th>Test condition</th></tr>
<tr><td>(12) Cranking 3</td><td> 

<T1, V1, V2>
Combine the following times and voltages. (189 patterns in total)
T1: 10 to 30 ms (in increments of 1 ms)
V1: 4.0 to 8.0 V (in increments of 0.5 V) [4.0 to 16.0 V (in increments of 0.5 V)]
V2: V1 + 1 V
<Power supply>
Supply power according to (i) and (ii) shown below.
Combination of power supply terminals
<table>
<tr><th></th><th>(i)</th><th>(ii)</th></tr>
<tr><td>+B</td><td>○</td><td>○</td></tr>
<tr><td>ACC</td><td>OPEN</td><td>○</td></tr>
<tr><td>IG</td><td>○</td><td>○</td></tr>
</table>
Remark:
○: Fluctuate power supply voltage.</td></tr>
<tr><td>(13) Battery flat + battery instantaneous interruption</td><td> 

<T>
Vary the waveform according to the following times. (6 patterns in total)
T: 0.1, 0.5, 1, 10, 20, and 60 s
<Power supply>
Supply power according to (i) through (iii) shown below.
Combination of power supply terminals
<table>
<tr><th></th><th>(i)</th><th>(ii)</th><th>(iii)</th></tr>
<tr><td>+B</td><td>○</td><td>○</td><td>○</td></tr>
<tr><td>ACC</td><td>OPEN</td><td>○</td><td>○</td></tr>
<tr><td>IG</td><td>OPEN</td><td>OPEN</td><td>○</td></tr>
</table>
Remark:
○: Fluctuate power supply voltage.</td></tr>
<tr><td>(14) Starting engine with jumper lead after battery undervoltage</td><td> 

<T, V>
Combine the following durations and voltages. (32 sets in total)
T: 0, 50, 100, 1000 ms
V: 2, 4, 5, 6, 8, 9, 9.5, 10 [3 V to 16 V]
<Power supply>
Supply power according to (i) shown below.
Combination of power supply terminals
<table>
<tr><th></th><th>(i)</th></tr>
<tr><td>+B</td><td>○</td></tr>
<tr><td>ACC</td><td>○</td></tr>
<tr><td>IG</td><td>○</td></tr>
</table>
Remark:
○: Fluctuate power supply voltage.</td></tr>
</table>

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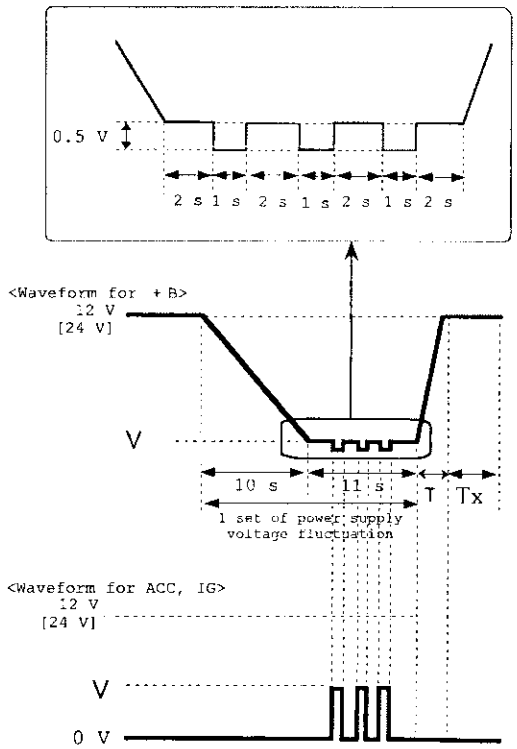
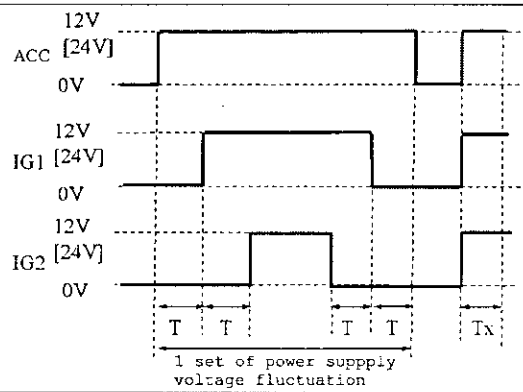
Table 3 (Continued)

<table>
<tr><th>Test item</th><th>Test condition</th></tr>
<tr><td>(15) IG switching with undervolt-age battery</td><td> 

[T, V]
Combine the following durations and voltages. (84 sets in total)
T: 0, 50, 100, 1000 ms
V: Change by 0.1 V between the range of (microcomputer reset voltage + 1 V) to (microcomputer reset voltage - 1 V)
[Power supply]
Supply power according to (i) shown below

Combination of power supply terminals
<table>
<tr><th></th><th>(i)</th></tr>
<tr><td>+B</td><td>○</td></tr>
<tr><td>ACC</td><td>○</td></tr>
<tr><td>IG</td><td>○</td></tr>
</table>
○: Fluctuate power supply voltage.</td></tr>
<tr><td>(16) IG 1 to/from 2 switching</td><td> 

[T]
Vary the waveform according to the following times. (3 waveforms in total)
T: 5, 11, 31 s
+B: 12 V [24 V]

For a vehicle with an ECU, carry out the test at the following times.

At 1 ms intervals from (MIN - 10 ms) to (MAX + 10 ms) of power ON time specified for power supply ECU</td></tr>
</table>

Remark:
Numerical values given in [ ] are for parts supplied with 24 V current.

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(2) For Table 4, the times and voltages specified for the test items (1) through (16) of Table 3 shall be modified or added as follows so that they conform to the software (or control algorithm) installed in each test specimen. Three main factors to be considered in determining the time and voltage conditions are: (17) when program is heavily loaded; (18) when load is operated; and (19) when communication system is heavily loaded.

Table 4 Fluctuating Waveform of Power Supply Voltage

Test item	Test condition
(17) When program is heavily loaded	[Objective] The objective is to check whether the equipment malfunctions when the power supply voltage fluctuates under a condition where the program is fully loaded. Example: For equipment designed to start primary checking after 10 seconds from IG ON <Additional test> (a) For the waveform (1) (iii), perform the test in increments of 0.1 s in the time zone near T1 = 10 s. (b) For the waveform (3), change the upper limit of time, T2, from 5 s to approx. 12 s. (c) For the wave form (6), perform the test from the first 1 s ON to about 10 s (in increments of 0.1 s). (d) For the waveform (10), perform additional tests in the time zone near T1 = 10 s (in increments of 0.1 s). (e) For the waveform (12), perform the test at around 10 s (in increments of 0.1 s) in addition to the already specified 2 s. Remark: The condition that will maximize the load onto the program shall be determined theoretically.
(18) When load is operated	[Objective] The objective is to check whether the equipment or its output system malfunctions when the power supply voltage fluctuates under a condition where the load is driven. Example: When the tape eject switch and power window are operated <Additional test> (a) For the waveform (1), perform additional tests by operating the tape eject switch and power windows at T1. (b) For the waveform (5), perform additional tests by operating the tape eject switch and power windows at or around T2. (c) For the waveforms (10) and (11), perform additional tests by operating the tape eject switch and power windows immediately before and in the middle of T2. (d) For the waveform (12), perform an additional test by operating the tape eject switch and power windows immediately before T1. (e) For the waveform (13), perform additional tests by operating the tape eject switch and power windows at or around T2.
(19) When communication system is heavily loaded	[Objective] The objective is to check whether the equipment malfunctions when the power supply voltage fluctuates under a condition where the communication system is fully loaded. Example: When the load to the communication system increases sharply at the same time when IG is switched from OFF to ON <Additional test> (a) For each waveform in (1) (iii), apply the load equivalent to IG ON to the communication system when the waveform rises after T2. (b) For each waveform in (5) (iii) and (iv), apply the load equivalent to IG ON to the communication system when the waveform rises. (c) For each of the waveforms in (10) and (11), apply the load equivalent to IG ON to the communication system when the waveform rises after completion of the cranking. (d) For each waveform in (12), apply the load equivalent to IG ON to the communication system when the waveform rises after completion of T1. Vary the point of time to apply the communication load in increments of 1 ms within the range of "target time ± 5 ms."

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Remark:
The symbol "Tx" refers to the time required for checking the diagnosis system and other systems after a fluctuating power voltage waveform is applied.

Applicable Standard

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