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Road vehicles — Alternators with regulators — Test methods and general requirements

Véhicules routiers — Alternateurs avec régulateurs — Méthodes d'essai et conditions générales

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Foreword

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ISO 8854 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 3, *Electrical and electronic equipment*.

This second edition cancels and replaces the first edition (ISO 8854:1988), which has been technically revised.

Road vehicles — Alternators with regulators — Test methods and general requirements

1 Scope

This International Standard specifies test methods and general requirements for the determination of the electrical characteristic data of alternators for road vehicles.

It applies to alternators, cooled according to the supplier's instructions, mounted on internal combustion engines.

2 Terms and definitions

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

2.1
alternator frequency
n_G
alternator rotational frequency in reciprocal minutes (min^{-1})

2.2
cut-in speed
n_A
alternator rotational frequency, in reciprocal minutes (min^{-1}), at which the alternator begins to supply current when speed is increased for the first time, depending on pre-exciting power (input), speed changing velocity, battery voltage, residual flux density of the rotor, and regulator characteristics

2.3
efficiency
η
alternator efficiency calculated from the measured values of voltage, current, speed and torque

2.4
minimum application speed
n_L
alternator rotational frequency, in reciprocal minutes (min^{-1}), which corresponds approximately to the idling speed of the engine

2.5
minimum application current
I_L
current, in amperes, which is delivered by a warmed-up alternator at test voltage U_t and minimum application speed n_L

2.6
rated current
I_R
minimum current, in amperes, which the warmed-up alternator shall supply at a speed n_R = 6 000 min^{-1} and at test voltage U_t

NOTE The mean value minus twice the standard deviation should be stated unless the customer has requested otherwise.

2.7
rated speed
n_R
alternator rotational frequency, in reciprocal mintues (min^{-1}), at which the alternator supplies its rated current, I_R, specifying the rated speed as n_R = 6 000 min^{-1}

2.8
test voltage
U_t
specified value, in volts, at which the current measurements shall be carried out

2.9
weighted efficiency
η_W
speed-evaluated mean value of efficiency at different alternator speeds

2.10
zero-amp. speed
n_0
alternator rotational frequency, in reciprocal minutes (min^{-1}), at which the alternator reaches the specified test voltage, U_t, without any current output

NOTE When plotted on a graph, this is the point at which the current/speed characteristic $I = f(n)$ intersects the abscissa.

3 Test conditions

3.1 Ambient temperature

Tests shall be carried out at an ambient temperature of $T_{amb} = (23 \pm 5)$ °C and may optionally also be performed at higher temperatures.

3.2 Air pressure

Tests shall be carried out at the standard atmospheric pressure.

Deviating conditions (e.g. measuring location, altitude, weather) shall be recorded.

3.3 Sense of rotation

Sense of alternator rotation shall be in accordance with the supplier's specification.

3.4 Drive control

The drive control shall meet the set alternator frequency values with a limit deviation of ($n_{G\ set} \pm 5$) min^{-1}.

3.5 Load current control

The load current control shall meet the requested set current values with a limit deviation of ($I_{Set} \pm 1{,}0$) A.

3.6 Measuring accuracy

The test equipment shall allow measurements of all parameters to be carried out within the limit deviations specified in Table 1.

Table 1 — Accuracy of test equipment

Parameters	Limit deviation
Voltage	±0,1 % of measured value
Current	±0,2 % of measured value
Torque	±0,5 % of rated value of torque sensors
Rotational frequency	±2 min^{-1}
Ambient temperature	±1 K
Air pressure	±5 hPa
Test period	±1 s

3.7 Measured values

All measured values shall be obtained at the end of each holding time of an operating point.

Each data record shall comprise at least the following measured values:

$n_{\text{G actual}}$ alternator rotational frequency (actual value = measured value);

$I_{\text{G actual}}$ alternator current (actual value = measured value);

U_{G} alternator voltage;

M alternator torque, if needed;

T_{amb} ambient temperature;

t_{M} time of acquisition of measured values from start of testing.

4 Test equipment

4.1 Ambient air

4.1.1 Flow rate

The input air flow within the alternator area shall be constant and reproducible. The maximum permissible flow rate shall be limited to 1 m/s.

4.1.2 Direction of flow

The direction of the air flow within the alternator area shall be constant and reproducible. If possible, the air should flow from bottom to top.

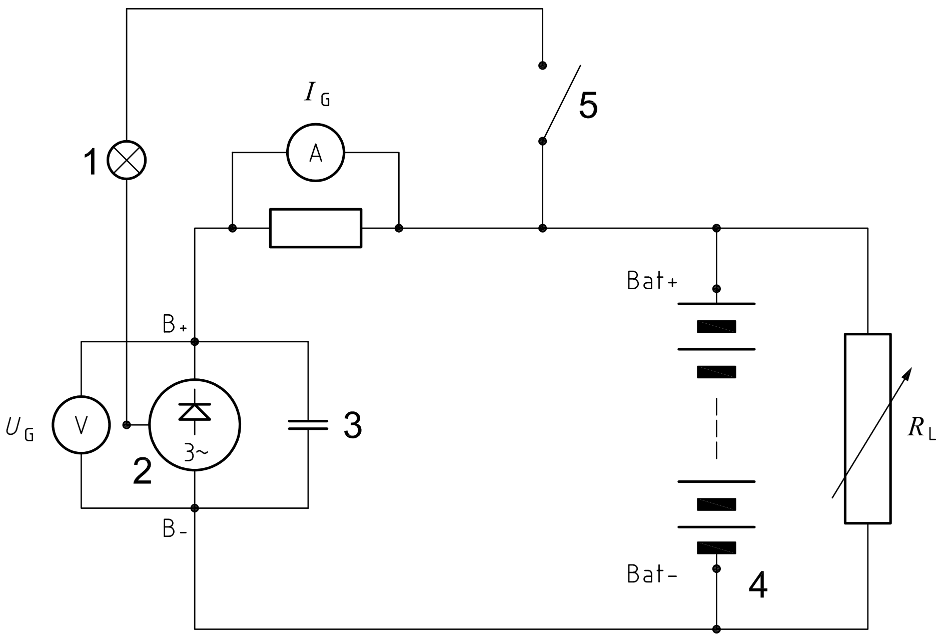
4.1.3 Measurement of ambient temperature

The measuring point is located on the B side of the alternator (slip ring end, shield side) in line with the shaft and at a distance of (10 ± 1) cm from the protective cap.

The spatial extent of the sensitive part of the temperature probe shall be limited to a cube with edges of 20 mm in length.

4.2 Terminal connecting plan

For the tests, connections shall be established according to Figure 1. During the tests, the ignition switch is “on”.



Key

1 load control lamp

2 D+ or L– lamp connection alternator

3 optional filter capacitor or test stand

4 battery/storage device

5 ignition lock, terminal 15

I_G alternator current

R_L load resistor

U_G alternator voltage

Figure 1 — Test circuit schematic

4.2.1 Voltage measurement

A voltmeter shall be connected directly to the output terminal(s) and/or alternator housing.

4.2.2 Filter capacitor C (optional)

A capacitor should be connected to the output terminals of the alternator. The connecting cable shall be as short as possible.

— Capacitor type: polarized electrolytic capacitor

— Capacity: 68 000 µF

— Connecting cable: cross-section of at least 4 mm^2, maximum cable length (2 × 1) m, copper

4.3 Measuring system

The measuring system shall record the parameters to be measured. Voltage, current, speed and torque shall be measured simultaneously. If parameters are recorded subsequently, there shall be no more than 1 s between the measurements of the first and last parameter.

5 Measurement procedure

5.1 Current/rotational frequency characteristic

This measurement shall be performed at full load. The alternator works at full load when the regulator duty cycle is 100 %, i.e. when the full excitation current is available.

In the measuring circuit, a battery and an adjustable resistor, R_L, shunted to the battery shall be used (see Figure 1).

The tests shall be conducted using a power-storing device (e.g. lead-acid battery, Li-ion battery or large capacitors).

The measurements shall be carried out using an integral or separate regulator.

To prevent the regulator from working, measurements shall be made at the following test voltages (for lead-acid batteries):

— (13,5 ± 0,1) V for 12 V systems;

— (27 ± 0,2) V for 24 V systems.

NOTE Measurements at other voltages are optional.

5.1.1 Warm tests — Rotational frequencies and measuring points

Current measurements shall be taken at the following rotational frequencies (in min^{-1}). At each operating point, the alternator shall reach equilibrium steady-state temperature before current values are recorded.

In order to simplify the measuring set-up, this should be ensured by specifying a set holding time for each operating point:

1 500 – 1 800 – 2 000 – 2 500 – 3 000 – 3 500 – 4 000 – 5 000 – 6 000 – 8 000 – 10 000 – 12 000 – n_{max}

The power adsorbed by the alternator shall be calculated at these measuring points.

The current/rotational frequency characteristic shall be indicated by the following four points:

a) Cut-in speed, n_A

Increase the alternator rotational frequency slowly (50 min^{-1}/s to 100 min^{-1}/s) until the charge indicator system indicates the commencement of battery charging, and record this speed.

This applies only if the regulator does not affect the timing.

b) Zero-amp. speed, n_0 (indirect measurement)

Reduce the alternator rotational frequency until an alternator output current between 5 % of I_R and 2 A, but not less than 2 A, is reached. Record the speed and current. To determine the zero-amp. speed, record a second speed/current point in the linear part of the characteristic, i.e. the zero-amp. speed shall be determined by extrapolation of the current/rotational frequency characteristic until the abscissa is intersected.

c) Minimum application current, I_L

Adjust the alternator rotational frequency to the idling speed of the engine (typically n_L = 1 800 min^{-1}) and record the alternator output current, I_L.

d) Rated current, I_R

Adjust the alternator rotational frequency to n_R = 6 000 min^{-1} and record the alternator output current, I_R.

5.1.2 Short-form tests

5.1.2.1 Short-form warm test

The alternator shall be warmed up until it reaches thermal equilibrium at fixed speed time and ambient temperature, T_{amb}.

The voltage shall be constant and equal to the test voltage, U_t, during the warm-up and the measuring period.

The warm-up current measurements shall then be taken at least at the following rotational frequency values in reciprocal minutes (min^{-1}):

1 500 – 1 800 – 2 000 – 3 000 – 4 000 – 6 000 – 8 000 –10 000 – 12 000 – n_{max}

If desired, further intermediate values may be recorded and the zero-amp. speed may be determined.

The test time after warm-up shall not exceed 30 s, with constant variation of speed.

Warm-up time and speed shall be in accordance with the vehicle manufacturer's specification (typical values are 20 min to 45 min at 3 000 min^{-1}, 5 000 min^{-1} and 6 000 min^{-1}).

5.1.2.2 Short-form cold test

The whole alternator shall have an ambient temperature of (23 ± 5) °C.

Current measurements shall be taken at ambient temperature T_{amb} = (23 ± 5) °C at least at the following rotational frequency values in reciprocal minutes (min^{-1}):

1 500 – 1 800 – 2 000 –3 000 – 4 000 – 6 000 – 8 000 – 10 000 –12 000 – n_{max}

If desired, further intermediate values may be recorded and the zero-amp. speed may be determined.

The test time shall not exceed 30 s with constant variation of speed.

5.2 Partial load measurement

During partial load tests, the current shall be kept constant by regulating the load R_L. The voltage shall be controlled by the regulator. The regulator duty cycle shall be less than 100 %.

5.3 Testing functional ability of regulator

The alternator shall be run at rated rotational frequency and rated current until the temperature of the regulator becomes stable. The load shall then be reduced slowly to 5 A and a check shall be made to ensure that the stabilized voltage does not rise above the alternator voltage specified by the supplier.

NOTE The regulator setting is specific to the vehicle manufacturer.

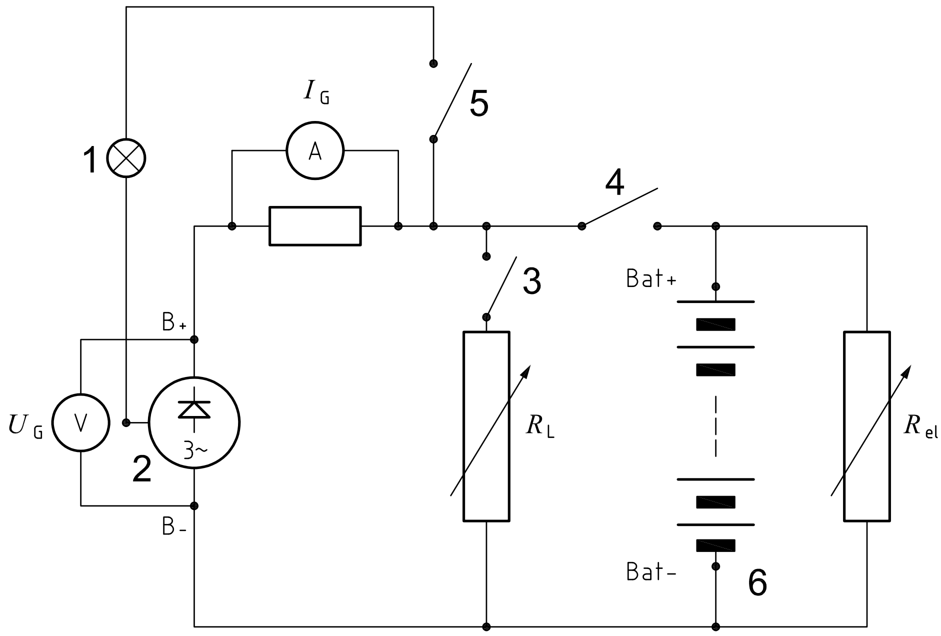
5.4 Load dump

A "load dump" is a voltage peak caused by the magnetic energy stored in the alternator and the dump of a load or an interruption of a cable. A critical load dump for the alternator and the system is a dump of a large load at high speed. The load dump time shall be measured as the time from the dump of a load until the regulator returns to the previous condition (see Figure 3). See also ISO 7637-2.

5.4.1 Measuring conditions

5.4.1.1 General

The measurement should be carried out with an oscilloscope or similar equipment. Terminals shall be connected directly to the alternator so that the wiring resistance is less than 10 mΩ. The regulator terminals shall be connected as specified in each case so that the alternator is working at full load. See Figure 2.



Key

1 load control lamp
2 D+ or L– lamp connection alternator
3 switch B
4 switch A
5 ignition lock, terminal 15
6 battery storage device
I_G alternator current
R_{el} electronically controlled load of test stand
R_L resistance load
U_G alternator voltage

Figure 2 — Example measuring harness — Load dump

5.4.1.2 Full load dump (to 0 A, interruption of cable)

Measuring conditions in the case of a full load dump (to 0 A, interruption of cable) shall be as follows:

— Alternator speed: n_G = speed, where the thermally stabilized current (see 5.1.1) reaches maximum

— Electric load: full load, thermally stabilized

— Ambient temperature: T_{amb} = (23 ± 5) °C

— Operating voltage: U_G = (13,5 ± 0,1) V (for other voltage systems, see 5.1)

— Load dump: to I_G = 0 A

5.4.1.3 Partial load dump (to a defined load)

Measuring conditions in the case of a partial load dump (to a defined load) shall be as follows:

— Alternator speed: n_G = speed, where the thermally stabilized current (see 5.1.1) reaches maximum

— Electric load: full load, thermally stabilized

— Ambient temperature: T_{amb} = (23 ± 5) °C

— Operating voltage: U_G = (13,5 ± 0,1) V (for other voltage systems, see 5.1)

NOTE The operating voltage is the voltage before the load dump.

— Load dump: from full load to $R_L = U_G$ / (e.g. 20 % of I_R)

In order to compare different alternators in the same output class, one common absolute value nearing 20 % of rated current (I_R) should be used.

After the measurement, the alternator shall be fully operative.

5.4.2 Measuring sequence

5.4.2.1 Full load dump to 0 A

The measuring sequence in the case of a full load dump to 0 A shall be as follows:

— Switch B open.

— Switch A (opening time $<$ 20 ms):

closed	open	closed	open	closed	open
until alternator is thermally stabilized	2 s to 3 s	> 10 s	2 s to 3 s	> 10 s	> 2 s

The cycles shall be in sequence.

5.4.2.2 Partial load dump to a defined load

The measuring sequence in the case of a partial load dump to a defined load shall be as follows:

— Switch B closed, R_L adjusted to the corresponding value.

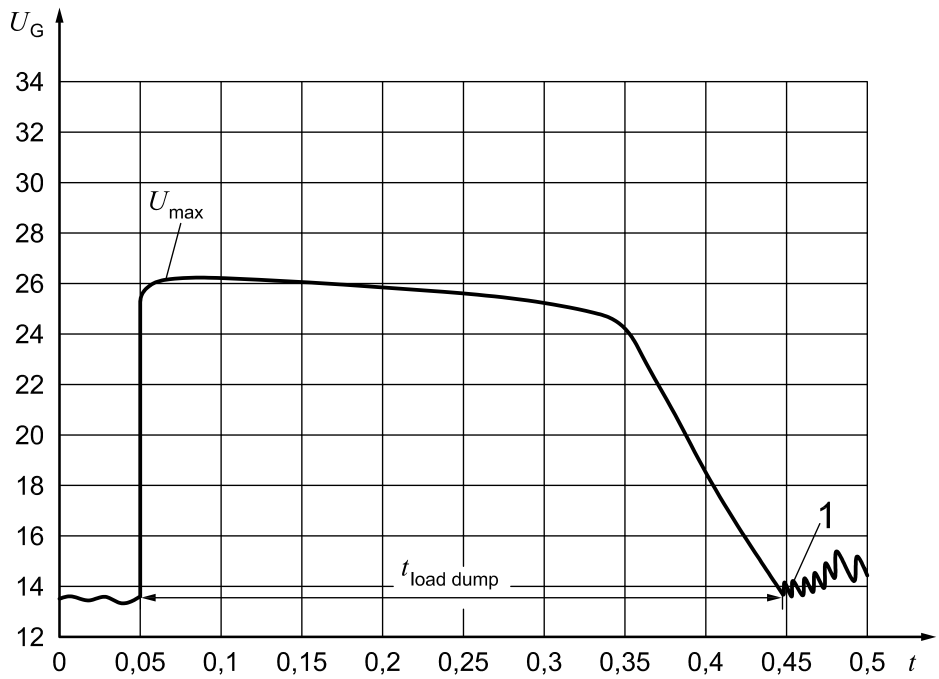
— Switch A (opening time $<$ 20 ms):

closed	open	closed	open	closed	open
until alternator is thermally stabilized	2 s to 3 s	> 10 s	2 s to 3 s	> 10 s	> 2 s

The cycles shall be in sequence.

5.4.3 Results

The load dump voltage, U_{max}, shall be taken as the maximum voltage measured in the three cycles shown in the tables above. The load dump time, $t_{load\ dump}$, shall be taken as the duration from the dump of a load until the regulator returns to the previous condition (see Figure 3). Both values shall be recorded. See also ISO 7637-2.



Key

1	regulator conditions without battery and load
t	time, in seconds
$t_{load\ dump}$	load dump time, in seconds
U_G	alternator voltage, in volts
U_{max}	load dump voltage, in volts

Figure 3 — Example load dump voltage curve

5.5 Voltage ripple

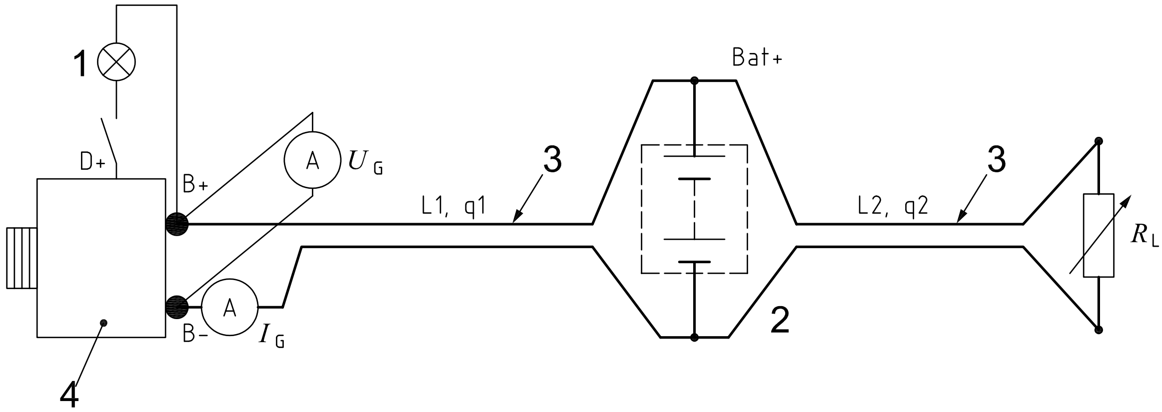
Voltage ripple is the alternating part (AC) of the voltage generated by the alternator.

The relevant data that shall be measured are the time of the basic ripple and the peaks caused by the commutation of the diodes.

During the measurement, the regulator shall be fully excited and shall not affect the result.

5.5.1 Measuring conditions

The regulator terminals shall be connected as specified in each case, so that the alternator is working at full load (see Figure 4).



Key

1 load control lamp

2 battery

3 wires

4 alternator

I_G alternator current

R_L resistance load

U_G alternator voltage

For L1, L2, q1 and q2, see Table 2.

Figure 4 — Measuring harness — Voltage ripple

Table 2 — Values for system harnesses

Harness	**Inductivity of harness** µH	**Length** L1 m	**Cross-section** q1 mm^2	**Length** L2 m	**Cross-section** q2 mm^2
12 V system					
short	2,2 ± 0,2	2,0	25	1,5	50
long	4,0 ± 0,2	4,0	50	1,5	50
24 V system					
short	4,0 ± 0,2	4,0	50	1,5	50
long	10,0 ± 0,2	13,5	50	1,5	50

The battery shall be new or as good as new and fully charged (state of charge: 100 %), as follows:

— 12 V system: 12 V, standard battery (e.g. 40 Ah);

— 24 V system: 24 V, standard battery (e.g. 150 Ah).

Other systems are optional.

Battery size should be recorded.

The B+ and B– cable shall be parallel and close together so that, with the battery and alternator disconnected and the load terminals connected, the inductivity of the harness is as shown in Table 2. The distance of the cables shall be adjusted until the required inductivity is reached.

The measurement of the current shall be carried out without changing the inductivity of the harness (e.g. with a current probe). The measurement device shall be connected to B–.

Measurement of the current shall be carried out under the following conditions:

— Resistance load: load with resistive and linear behaviour

— Temperature: T_{amb} = (23 ± 5) °C

— Operating voltage: U_G = (13,5 ± 0,1) V (for other voltage systems, see 5.1)

5.5.2 Measuring sequence

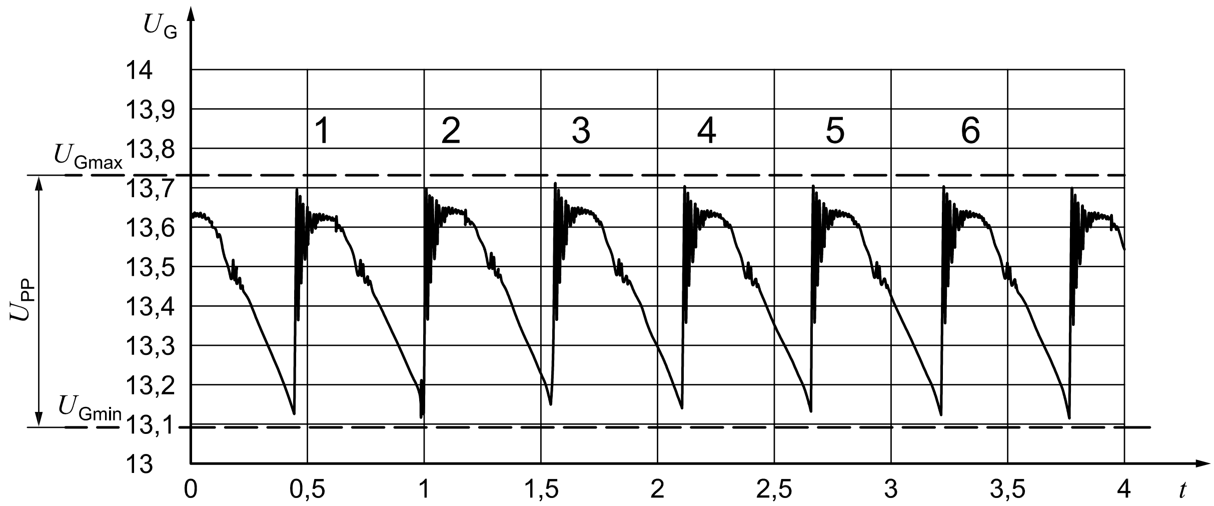
Measurement shall be carried out as follows:

— Alternator rotational frequency: 1 800 min^{-1}; 3 000 min^{-1}; 6 000 min^{-1}; 9 000 min^{-1}; 12,000 min^{-1}; 15 000 min^{-1} or n_{max}.

— The resistance load, $R_{L,}$ shall be adjusted for each speed in order to keep the alternator at full load, i.e. U_G as defined in 5.1. The measuring shall be carried out after the alternator is thermally stabilized.

— The number of measured voltage ripples shall be as high as the number of pole pairs, p (p = 6; 8 …).

— The measuring frequency shall be correlated to the speed in order to properly record the peak voltage.



Key

t time, in milliseconds

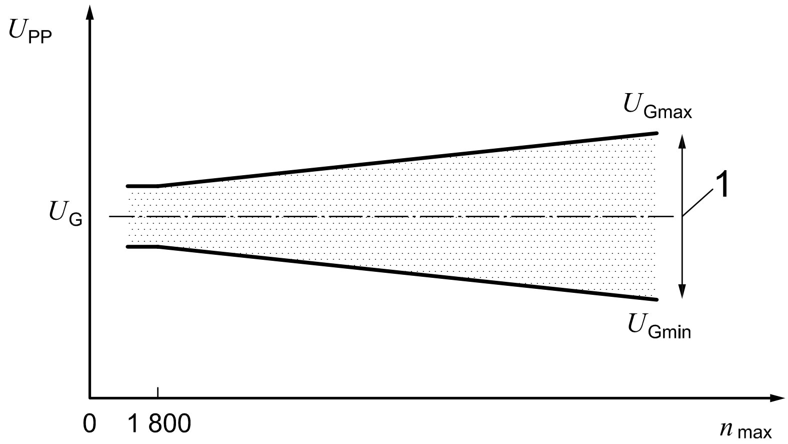
U_G alternator voltage, in volts

U_{PP} peak to peak voltage

Figure 5 — Schematic display of voltage ripple (p = 6)

5.5.3 Results

A sensible display of the results is an envelope curve; see Figure 6.



Key

1 voltage ripple

n_{max} rotational frequency, in reciprocal minutes

U_G alternator voltage, in volts

U_{PP} peak to peak voltage

Figure 6 — Example of schematic display of measuring results

5.6 Efficiency determination

Testing comprises the measurement of parameters in Clause 3 at defined operating points as per Table 3. Operating points shall be set in the specified order and in immediate succession and shall be kept constant throughout their respective holding times.

Table 3 — Specifications for operating points

Operating point Step No.	Holding time t_D s	Rotational frequency n_G min^{-1}	Alternator current I_G A
1	1 200	1 800	I_R / 2
2	1 200	3 000	I_R / 2
3	600	6 000	I_R / 2
4	300	10 000	I_R / 2

At each operating point, the alternator shall reach steady-state temperature. In order to simplify the measuring set-up, this should be ensured by specifying a set holding time for each operating point.

The alternator current is the same for all four operating points and shall be kept constant throughout the duration of the test.

Current intensity shall be defined as half the rated current, I_R.

The alternator should be driven without radial stress via a directly coupled torque measuring shaft.

If the alternator cannot deliver half the rated current (I_R / 2 A) at 1 800 min^{-1}, the efficiency value at 1 800 min^{-1} should be measured at full load with a specified voltage, as specified in 5.1.

6 Method of calculation of efficiency

6.1 Determination of efficiency

For each operating point, i, the efficiency shall be calculated in accordance with Formula (1).

$$\eta_i = \frac{60 \times U_i \times I_i}{2\pi \times M_i \times n_i} \times 100 \quad (1)$$

where

η_i is the efficiency at operating point i, as a percentage;

U_i is the voltage at operating point i, in volts;

I_i is the current at operating point i, in amperes;

M_i is the torque at operating point i, in Newton-metres:

n_i is the rotational frequency at operating point i, in reciprocal minutes.

6.2 Determination of weighted efficiency

Weighted efficiency shall be calculated in accordance with Formula (2).

$$\eta_{\mathrm{w}} = \sum_{i=1}^{4} \eta_i \times h_i \quad (2)$$

where:

η_{w} is the weighted efficiency, as a percentage;

η_i is the efficiency at operating point i, as a percentage;

h_i is the frequency of operating points i, as per Table 4.

Table 4 — Operating points

Operating point i	Rotational frequency min^{-1}	Frequency h_{i}
1	1 800	h_1
2	3 000	h_2
3	6 000	h_3
4	10 000	h_4

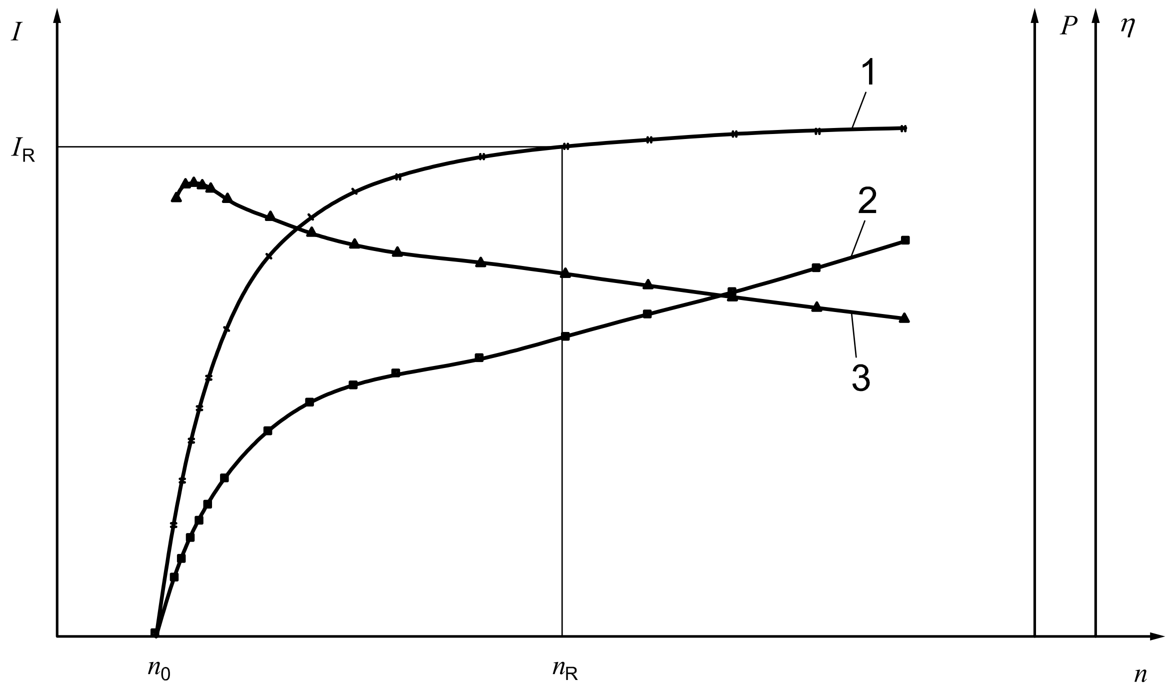
The frequency, h_i, shall be adjusted to the manufacturer’s needs and regions.

Typically used frequencies for the European region are: $h_1 = 0{,}25$; $h_2 = 0{,}40$; $h_3 = 0{,}25$; $h_4 = 0{,}10$.

7 Presentation of results

Measurements of current/rotational frequency and power absorption characteristics shall be presented in accordance with Figure 7.

The tests described in 5.1.1 and 5.1.2 will produce different characteristic curves and therefore different current values. The manufacturer shall indicate which test method shall be used.



Key

1 current

2 output power

3 efficiency

n alternator rotational frequency, in reciprocal minutes

n_0 zero-amp. speed, in reciprocal minutes

n_R rated speed = 6 000 min^{-1}

I current, in amperes

I_R rated current, in amperes

P output power, in kilowatts

η efficiency, as a percentage

Figure 7 — Presentation of results

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