ภาคผนวก ข.

Method B and Method F (IEEE Std 112)

9.4 Form B–Method B

Type _____ Design _____ Frame _____ Rating _____ Phase _____
Frequency _____ Volts _____ Synchronous r/min _____ Serial No. _____
Degrees C Temperature Rise _____ Time Rating _____ Model No. _____

Cold Stator Winding Resistance Between Terminals _____ Ohms @ _____ °C						
Rated Load Temp. Test Stator Winding Resistance Between Terminals _____ Ohms @ ____ °C in ____ °C Ambient Rated Load Temperature Test Stator Temperature Rise _____ °C Total Stator Temperature, t_s _____ °C in a 25 °C Ambient						
Description (Motoring)(Generating)	1	2	3	4	5	6
Ambient Temperature, in °C						
Stator Winding Temperature, t_t, in °C						
Frequency, in Hz						
Synchronous Speed, in r/min						
Speed, in r/min						
Slip Speed, in r/min						
Slip in p.u.						
Line-to-Line Voltage, in V						
Line Current, in A						
Stator Power, in W						
Core Loss, in W						
Stator I^2R Loss, in W, at t_t						
Power Across Air Gap, in W						
Rotor I^2R Loss, in W						
Friction and Windage Loss, in W						
Total Conventional Loss, in W						
Torque, in N·m						
Dynamometer Correction, in N·m						
Corrected Torque, in N·m						
Shaft Power, in W						
Apparent Total Loss, in W						
Stray-Load Loss, in W						
Intercept _____ Slope _____ Correlation Factor _____ Point Deleted _____						
Stator I^2R Loss, in W, at t_s						
Corrected Power Across Air Gap, in W						
Corrected Slip, in p.u.						
Corrected Speed, in r/min						
Rotor I^2R Loss, in W, at t_s						
Corrected Stray-Load Loss, in W						
Corrected Total Loss, in W						
Corrected Shaft Power, in W						
Efficiency, in %						
Power Factor, in %						

The Summary of Characteristics shall be presented as with Form A in 9.2. For additional guidance, see 9.1.1.

9.5 Form B2–Method B calculations

Cold Stator Winding Resistance Between Terminals ___(1)____ Ohms @ ____(2)____°C From 6.4.1.1			
Hot Stator Winding Resistance Between Terminals __(3)__Ohms @ __(4)__°C in __(5)__°C Ambient From 6.4.1.2			
Rated Load Temp. Test Stator Temperature Rise __(6)__ °C, (6) = (4) – (5)		(4) ={[(3) / (1)] × [k_1 + (2)]} – k_1	
Total Stator Temperature, t_s, __(7)__ °C in a 25 °C Ambient, (7) = (6) + 25		If (6) & (7) are from duplicate, (3), (4) & (5) are N/A	
Item	Description (Motoring)(Generating)	Source or Calculation	
8	Ambient Temperature, in °C	From each test point, from 6.4.1.3	
9	Stator Winding Temperature, t_t, in °C	From each point, adjusted per 6.4.2.4	
10	Frequency, in Hz	From each test point, from 6.4.1.3	
11	Synchronous Speed, in r/min	=120 × (10) / number of poles	
12	Speed, in r/min	*= (11) – (13)	
13	Slip Speed, in r/min	*= (11) – (12)	
14	Slip in p.u.	= (13) / (11)	
15	Line-to-Line Voltage, in V	From each test point, from 6.4.1.3	
16	Line Current, in A	From each test point, from 6.4.1.3	
17	Stator Power, in W	From each test point, from 6.4.1.3	
18	Core Loss, in W	From 5.5.5 at voltage equal to (15)	
19	Stator I^2R Loss, in W,	= 1.5 × $(16)^2$ × R , Adjust R see 6.4.2.4	
20	Power Across Air Gap, in W	= (17) – (18) – (19) for motor = (17) + (18) + (19) for generator	
21	Rotor I^2R Loss, in W	= (20) × (14)	
22	Friction and Windage Loss, in W	From 5.5.4	
23	Total Conventional Loss, in W	= (18) + (19) + (21) + (22)	
24	Torque, in N·m	From each test point, from 6.4.1.3	
25	Dynamometer Correction, in N·m	From test per 5.6.1.2, if needed	
26	Corrected Torque, in N·m	= (24) + (25)	
27	Shaft Power, in W	= (26) × (12) / 9.549	
28	Apparent Total Loss, in W	= (17) – (27) for a motor = (27) – (17) for a generator	
29	Stray-Load Loss, in W	= (28) – (23)	
Intercept ____(30)_____ Slope ____(31)___ Correlation Factor ____(32)_____ Point Deleted ____(33)_____ (30), (31), (32) & (33) from the linear regression analysis of (29) & (26) entries as described in 6.4.2.8			
34	Stator I^2R Loss, in W, at t_s	= 1.5 × $(16)^2$ × (3) × {[k_1 + (7)] / [k_1 + (4)]}	
35	Corrected Power Across Air Gap, in W	= (17) – (18) – (34)	
36	Corrected Slip, in p.u.	= (14) × [k_1 + (7)] / [k_1 + (9)]	
37	Corrected Speed, in r/min	= (11) × [1.00 – (36)]	
38	Rotor I^2R Loss, in W, at t_s	= (36) × (35)	
39	Corrected Stray-Load Loss, in W	= (31) × $(26)^2$	
40	Corrected Total Loss, in W	= (18) + (22) + (34) +(38) + (39)	
41	Corrected Shaft Power, in W	= (17) – (40)	
42	Efficiency, in %	= 100(41)/(17) for a motor = 100(17)/(41) for a generator	
43	Power Factor, in %	= 100 × (17) / [1.732 × (15) × (16)]	

*Enter the measured speed or measured slip speed for each test point on the proper line and use the formula provided to calculate the other parameter. In (4), (19), (34), and (36), select k_1 based on conductor material. See 5.2.1 and 5.3.2. See 9.1.1 for Summary of Characteristics.

9.6 Form B1–Method B1

Type _____ Design _____ Frame _____ Rating _____ Phase _____

Frequency _____ Volts _____ Synchronous r/min _____ Serial No. _____

Degrees C Temperature Rise _____ Time Rating _____ Model No. _____

Cold Stator Winding Resistance Between Terminals _____ Ohms @ _____ °C						
Specified Stator Temperature, t_s _____ °C in a 25 °C Ambient						
Description (Motoring)(Generating)	1	2	3	4	5	6
Ambient Temperature, in °C						
Stator Winding Temp, (t_t), in °C						
Frequency, in Hz						
Synchronous Speed, in r/min						
Speed, in r/min						
Slip Speed, in r/min						
Slip in p.u.						
Line-to-Line Voltage, in V						
Line Current, in A						
Stator Power, in W						
Core Loss, in W						
Stator I^2R Loss, in W, at t_t						
Power Across Air Gap, in W						
Rotor I^2R Loss, in W						
Friction and Windage Loss, in W						
Total Conventional Loss, in W						
Torque, in N·m						
Dynamometer Correction, in N·m						
Corrected Torque, in N·m						
Shaft Power, in W						
Apparent Total Loss, in W						
Stray-Load Loss, in W						
Intercept _____ Slope _____ Correlation Factor _____ Point Deleted _____						
Stator I^2R Loss, in W, at t_s						
Corrected Power Across Air Gap, in W						
Corrected Slip, in p.u.						
Corrected Speed, in r/min						
Rotor I^2R Loss, in W, at t_s						
Corrected Stray-Load Loss, in W						
Corrected Total Loss, in W						
Corrected Shaft Power, in W						
Efficiency, in %						
Power Factor, in %						

The Summary of Characteristics shall be presented as with Form A in 9.2. For additional guidance, see 9.1.1.

9.7 Form B1-2–Method B1 calculations

Cold Stator Winding Resistance Between Terminals ____(1)_____ Ohms @ ____(2)____°C From 6.5.1.1			
Specified Stator Temperature, (t_s), __(3)___ °C in a 25 °C Ambient, From 3.3.2 c)			
Item	Description (Motoring)(Generating)	Source or Calculation	
4	Ambient Temperature, in °C	From each test point, from 6.5.1.4	
5	Stator Winding Temp, t_t, in °C	From each test point, from 6.5.1.4	
6	Frequency, in Hz	From each test point, from 6.5.1.4	
7	Synchronous Speed, in r/min	=120 × (6) / number of poles	
8	Speed, in r/min	*= (7) – (9)	
9	Slip Speed, in r/min	*= (7) – (8)	
10	Slip in p.u.	= (9) / (7)	
11	Line-to-Line Voltage, in V	From each test point, from 6.5.1.4	
12	Line Current, in A	From each test point, from 6.5.1.4	
13	Stator Power, in W	From each test point, from 6.5.1.4	
14	Core Loss, in W	From 5.3.5 at voltage equal to (11)	
15	Stator I^2R Loss, in W, at t_t	= 1.5 × $(12)^2$ × (1) × {[k_1 + (5)] / [k_1 + (2)]}	
16	Power Across Air Gap, in W	= (13) – (14) – (15) for a motor = (13) + (14) + (15) for a generator	
17	Rotor I^2R Loss, in W	= (16) × (10)	
18	Friction and Windage Loss, in W	From 5.5.4	
19	Total Conventional Loss, in W	= (14) + (15) + (17) + (18)	
20	Torque, in N·m	From each test point, from 6.5.1.4	
21	Dynamometer Correction, in N·m	From test per 5.6.1.2, if needed	
22	Corrected Torque, in N·m	= (20) + (21)	
23	Shaft Power, in W	= (22) × (8) / 9.549	
24	Apparent Total Loss, in W	= (13) – (23) for a motor = (23) – (13) for a generator	
25	Stray-Load Loss, in W	= (24) – (19)	
Intercept ____(26)_____Slope ____(27)_____Correlation Factor ____(28)_____Point Deleted ____(29)_____ (26), (27), (28) & (29) from the linear regression analysis of (25) & (22) entries as described in 6.4.2.7			
30	Stator I^2R Loss, in W, at t_s	= 1.5 × $(16)^2$ × (1) × {[k_1 + (3)] / [k_1 + (2)]}	
31	Corrected Power Across Air Gap, in W	= (13) – (14) – (30)	
32	Corrected Slip, in p.u.	= (10) × [k_1 + (3)] / [k_1 + (5)]	
33	Corrected Speed, in r/min	= (7) × [1.00 – (32)]	
34	Rotor I^2R Loss, in W, at t_s	= (31) × (32)	
35	Corrected Stray-Load Loss, in W	= (27) × $(22)^2$	
36	Corrected Total Loss, in W	= (14) + (18) + (30) +(34) + (35)	
37	Corrected Shaft Power, in W	= (13) – (36)	
38	Efficiency, in %	=100(37)/(13) for a motor = 100(13)/(37) for a generator	
39	Power Factor, in %	= 100 × (13) / [1.732 × (11) × (12)]	

*Enter the measured speed or measured slip speed for each test point on the proper line and use the formula provided to calculate the other parameter. In (15), (30), and (32), select k_1 based on conductor material. See 5.2.1 and 5.3.2. See 9.1.1 for Summary of Characteristics.

9.12 Form F–Methods F, F1, C/F, E/F, and E1/F1

Serial No. _____ Model No. _____

Type _____ Rating _____ Voltage _____ Synchronous Speed _____ Phase _____ Frequency _____

Description (Motoring)(Generating)		1	2	3	4	5	6
s	Slip in p.u.						
R_2/s	Effective rotor resistance						
X_2	Rotor reactance						
Z_2^2	Rotor impedance						
G_1	Rotor conductance						
G_{fe}	Core conductance						
G	Rotor & mag. circuit conductance						
$-B_2$	Rotor susceptance						
$-B_M$	Magnetizing susceptance						
$-B$	Rotor & magnetic circuit susceptance						
Y_2^2	Rotor & magnetizing circuit admittance						
R_g	Rotor & magnetic circuit resistance						
R_1	Stator resistance per phase						
R	Total resistance						
X_g	Rotor & magnetic circuit reactance						
X_1	Stator reactance						
X	Total reactance						
Z	Total impedance						
I_1	Stator current						
I_2	Rotor current						
	Stator power						
	Rotor power						
	Stator I^2R loss						
P_h	Core loss						
	Rotor I^2R loss						
P_f	Friction & Windage loss						
P_{SL}	Stray-Load loss						
	Total losses						
	Shaft power, in W						
	Efficiency in %						
	Power factor in %						
	Speed in r/min						
	Torque in N·m						

9.13 Form F2–Methods F, F1, C/F, E/F, and E1/F1 calculations

Serial No._____ Model No. _____

Type _____Rating _____Voltage _____ Synchronous Speed _____ Phase _____Frequency _____

Before starting calculation, fill in following items, obtained from previous tests: R_2 = ___(1)___V = phase volts___(2)___ P'_{SL}__(3)___at I'_2 __(4)___and n_S__(5)__also all the items below that are marked with an asterisk. (n_S = synchronous speed)			
Assume a value of slip, s, corresponding to expected full-load speed for full-load point and proportional values for other loads. For motor operation, s is positive. For generator operation, s is negative. Numbers in ( ) represent item numbers.			
Item	Description (Motoring)(Generating)		Source or Calculation
6	s	Slip in p.u.	Assume values for each load point
7	R_2/s	Effective rotor resistance	(7) = (1) / (6)
*8	X_2	Rotor reactance	From equivalent circuit, see 5.9
9	Z_2^2	Rotor impedance [Quantity squared]	(9) = $(7)^2 + (8)^2$
10	G_1	Rotor conductance	(10) = (7) / (9)
*11	G_{fe}	Core conductance	From equivalent circuit, see 5.9
12	G	Rotor & magnetic circuit conductance	(12) = (10) + (11)
13	$-B_2$	Rotor susceptance	(13) = (8) / (9)
*14	$-B_M$	Magnetizing susceptance	From equivalent circuit, see 5.9
15	$-B$	Rotor & magnetic circuit susceptance	(15) = (13) + (14)
16	Y_2^2	Rotor & magnetizing circuit admittance [Quantity squared]	(16) = $(12)^2 + (15)^2$
17	R_g	Rotor & magnetic circuit resistance	(17) = (12)/(16)
*18	R_1	Stator resistance per phase	From tests, see 5.9
19	R	Total resistance	(19) = (17) + (18)
20	X_g	Rotor & magnetic circuit reactance	(20) = (15) / (16)
*21	X_1	Stator reactance	From equivalent circuit, see 5.9
22	X	Total reactance	(22) = (20) + (21)
23	Z	Total impedance	(23) = square root of $[(19)^2 + (22)^2]$
24	I_1	Stator current	(24) = (2) / (23)
25	I_2	Rotor current	(25) = (24) / square root of [(9) × (16)]
26		Stator power	(26) = 3 × $(24)^2$ × (19)
27		Rotor power	(27) = 3 × $(25)^2$ × (7)
28		Stator I^2R loss	(28) = 3 × $(24)^2$ × (18)
29	P_h	Core loss	(29) = 3 × $(24)^2$ × (11) / (16)
30		Rotor I^2R loss	(30) = (6) × (27)
*31	P_f	Friction & Windage loss	From tests, see 9.14
32	P_{SL}	Stray-Load loss	(32) = (3) × $[(25) / (4)]^2$
33		Total losses	(33) = (28) + (29) + (30) + (31) + (32)
34		Shaft power, in W	(34) = (26) – (33)
35		Efficiency in %	For Motoring: (35) = 100 × (34) / (26) For Generating: (35) = 100 × (26) / (34)
36		Power factor in %	(36) = 100 × (19) / (23)
37		Speed in r/min	(37) =(5) × [1–(6)]
38		Torque in N·m	(38) = 9.549 × (34) / (37)

9.14 Test and equivalent circuit results

Machine _____ Serial No. _____ Model No. _____
Type _____ Rating _____ Voltage _____ Synchronous Speed _____ Frequency _____ Phases _____

Summary of Tests

No Load	
Line Current, I_o, in A	Stator Power, P_o, in W

Impedance Data by Method ____ of 5.9.1			
Frequency Hz	Line Volts V_L	Line Current, I, in A	Stator Power, P, in W

Constants and Summary of Equivalent Circuit Parameters

V_1 _____ volts per phase
R_1 _____ ohms
R_2 _____ ohms
R_{fe} _____ ohms
X_1 _____ ohms
X_2 _____ ohms
$(X_1 + X_2)$ _____ ohms
B_M _____ siemens
G_{fe} _____ siemens
P_f _____ # watts See 5.5.4.
P_h _____ #watts See 5.5.5.
P_{SL} _____ # * watts at I_2 = _____ amperes
N_S _____ r/min

*See 5.7.2, 5.7.3, or 5.7.4.

When used in Method F, F1, C/F, E/F, or E1/F1 tests, these quantities are for the total machine and all others are per phase.