

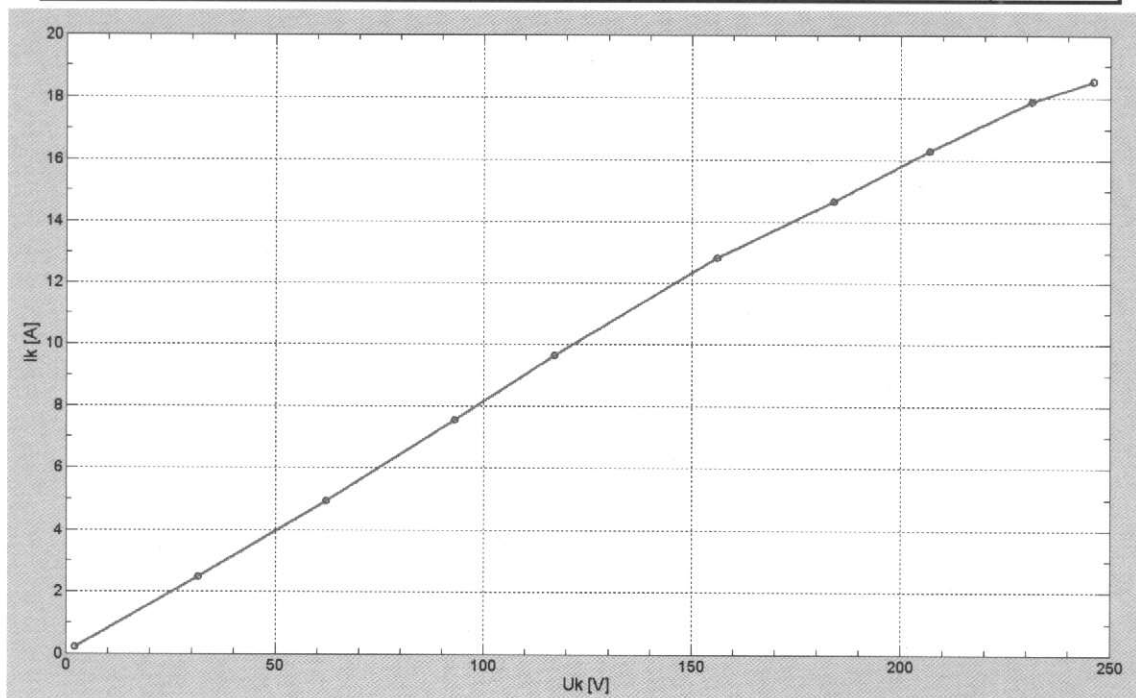
P1: Tabulka naměřených hodnot - měření naprázdno a nakrátko.

NAPRÁZDNO

No.	U_{10} [V]	U_{20} [V]	U_{30} [V]	I_{10} [A]	I_{20} [A]	I_{30} [A]	P_0 [W]	M_0 [Nm]	$\cos \varphi_0$ [-]
1	448,29	450,13	450,35	2,877	3,006	2,764	219	0,015	0,1690
2	434,52	436,27	436,21	2,361	2,484	2,284	180	0,005	0,1739
3	419,68	421,03	421,26	1,952	2,041	1,885	151	0,005	0,1832
4	401,46	402,94	402,55	1,558	1,653	1,532	125	0,006	0,1965
5	377,40	378,8	378,72	1,221	1,286	1,185	95	-0,009	0,2041
6	359,13	360,74	360,59	1,036	1,104	1,008	82	0,001	0,2170
7	339,86	341,02	341,14	0,900	0,945	0,872	72	-0,004	0,2333
8	320,25	321,14	321,1	0,795	0,833	0,783	62	-0,066	0,2405
9	301,01	302,04	302,31	0,738	0,776	0,712	57	-0,027	0,2545
10	279,62	280,35	280,87	0,682	0,707	0,653	52	-0,010	0,2726
11	259,91	260,51	261,01	0,637	0,662	0,613	46	0,001	0,2771
12	240,25	240,73	240,84	0,580	0,602	0,574	41	0,000	0,2911
13	230,84	231,82	231,78	0,561	0,602	0,558	40	-0,002	0,3012
14	198,84	199,75	199,65	0,494	0,541	0,499	32	0,009	0,3138
15	179,94	180,35	180,77	0,483	0,512	0,468	29	0,004	0,3297
16	160,29	160,24	160,99	0,487	0,500	0,463	27	-0,001	0,3480
17	140,32	140,87	141,86	0,491	0,527	0,464	25	0,009	0,3589
18	109,84	109,47	110,59	0,531	0,540	0,493	22	-0,001	0,3837
19	89,82	90,03	91,38	0,641	0,684	0,609	23	-0,001	0,3946
20	68,93	69,77	70,26	0,867	0,924	0,869	25	0,001	0,4048

NAKRÁTKO

No.	U_{1k} [V]	U_{2k} [V]	U_{3k} [V]	I_{1k} [A]	I_{2k} [A]	I_{3k} [A]	P_k [W]	M_k [Nm]	$\cos \varphi_k$ [-]
1	3,10	5,87	2,84	0,142	0,229	0,231	1	0,192	0,728
2	53,12	56,41	54,30	2,346	2,549	2,476	175	0,313	0,752
3	106,91	108,82	107,34	4,811	4,988	4,947	702	0,647	0,765
4	160,15	162,00	160,89	7,395	7,607	7,563	1649	1,646	0,786
5	201,64	203,83	202,80	9,450	9,711	9,649	2705	2,328	0,802
6	269,24	271,66	270,73	12,617	12,942	12,875	4956	4,744	0,826
7	317,41	319,17	318,82	14,447	14,778	14,723	6814	6,631	0,843
8	357,20	359,48	258,69	16,073	16,421	16,354	8617	7,840	0,852
9	403,39	394,17	403,87	17,949	17,841	17,787	10674	9,961	0,862
10	425,26	426,52	426,93	18,339	18,642	18,584	11874	11,065	0,868



P2: Tabulka naměřených hodnot - měření při zatížení.

No.	U ₁ [V]	U ₂ [V]	U ₃ [V]	I ₁ [A]	I ₂ [A]	I ₃ [A]	P [W]	n [min ⁻¹]	M [Nm]	cos φ [-]
1	414,63	414,65	416,63	5,896	5,900	5,826	-2 555,9	3300,1	-12,309	-0,6049
2	414,79	414,95	416,69	4,841	4,864	4,785	-1 868,9	3250,3	-9,429	-0,5377
3	414,98	415,34	416,84	4,655	4,684	4,593	-1 759,2	3240,0	-8,954	-0,5261
4	413,54	413,99	415,53	4,403	4,430	4,341	-1 666,2	3229,2	-8,445	-0,5287
5	415,15	415,44	416,96	4,232	4,259	4,175	-1 582,2	3219,7	-8,030	-0,5203
6	414,34	414,51	416,17	4,010	4,030	3,955	-1 505,4	3209,9	-7,388	-0,5238
7	415,42	415,57	417,32	3,885	3,896	3,825	-1 439,5	3200,3	-7,048	-0,5163
8	414,93	415,00	416,50	3,604	3,619	3,552	-1 353,6	3189,4	-6,546	-0,5237
9	414,92	414,92	416,59	3,463	3,470	3,409	-1 287,3	3179,9	-6,067	-0,5189
10	415,06	415,14	416,69	3,306	3,313	3,251	-1 214,8	3169,9	-5,708	-0,5129
11	414,03	414,04	416,13	3,150	3,125	3,084	-1 182,6	3159,7	-5,458	-0,5277
12	414,53	414,70	416,17	3,002	3,005	2,944	-1 066,7	3150,2	-4,985	-0,4972
13	414,86	414,75	416,43	2,859	2,851	2,805	-1 021,4	3139,7	-4,748	-0,5002
14	415,62	415,29	417,37	2,741	2,717	2,686	-949,85	3129,6	-4,328	-0,4855
15	415,62	415,48	417,35	2,620	2,597	2,559	-884,82	3119,5	-4,129	-0,4736
16	415,96	415,56	417,52	2,499	2,474	2,446	-813,93	3109,6	-3,834	-0,4564
17	416,38	415,80	417,90	2,387	2,354	2,332	-744,11	3099,9	-3,425	-0,4373
18	416,07	415,63	417,62	2,270	2,241	2,211	-665,71	3089,7	-3,206	-0,4119
19	416,46	415,91	417,92	2,162	2,132	2,104	-584,23	3079,8	-2,850	-0,3795
20	415,76	415,45	417,34	2,061	2,030	1,995	-509,78	3070,1	-2,456	-0,3486
21	416,45	416,15	418,02	1,978	1,946	1,910	-431,07	3059,9	-2,198	-0,3070
22	415,89	415,50	417,22	1,859	1,837	1,800	-331,49	3049,9	-1,860	-0,2510
23	415,66	415,33	417,03	1,786	1,760	1,717	-279,23	3039,8	-1,667	-0,2209
24	414,21	413,93	415,72	1,706	1,676	1,629	-190,01	3030,0	-1,279	-0,1584
25	413,57	413,34	415,17	1,636	1,610	1,555	-95,60	3019,8	-1,100	-0,0833
26	413,72	413,55	415,27	1,592	1,575	1,514	-14,33	3010,0	-0,827	-0,0128
27	415,45	415,28	417,20	1,588	1,570	1,496	109,76	2999,9	-0,342	0,0982
28	414,72	414,55	416,20	1,554	1,541	1,472	145,80	2994,9	-0,218	0,1332
29	415,35	415,06	416,51	1,559	1,551	1,489	199,80	2990,6	-0,023	0,1810
30	414,70	414,80	416,33	1,538	1,548	1,457	283,50	2980,0	0,255	0,2603
31	415,03	415,14	416,68	1,564	1,585	1,491	385,20	2970,1	0,563	0,3460
32	414,82	414,99	416,56	1,626	1,653	1,548	487,80	2959,7	0,998	0,4213
33	414,67	414,78	416,49	1,682	1,711	1,598	577,80	2949,9	1,330	0,4828
34	415,26	415,22	417,01	1,760	1,791	1,678	677,70	2939,8	1,571	0,5398
35	414,15	414,47	416,36	1,805	1,851	1,721	752,40	2930,2	1,834	0,5840
36	414,64	414,69	416,52	1,897	1,938	1,820	843,30	2919,8	2,161	0,6220
37	414,96	415,05	416,97	1,996	2,046	1,917	927,90	2909,7	2,373	0,6489
38	414,34	414,59	416,19	2,078	2,137	2,014	1 014,3	2899,6	2,680	0,6795
39	415,06	415,54	417,04	2,173	2,242	2,114	1 097,1	2889,6	3,005	0,6998
40	415,01	415,11	416,74	2,293	2,356	2,232	1 190,7	2879,7	3,300	0,7211
41	415,09	415,22	416,91	2,398	2,466	2,337	1 274,4	2870,3	3,505	0,7373
42	414,92	414,80	416,59	2,499	2,553	2,428	1 349,1	2859,9	3,678	0,7520
43	414,78	414,88	416,53	2,589	2,655	2,524	1 421,1	2850,1	3,875	0,7628
44	414,75	414,81	416,51	2,685	2,753	2,621	1 491,3	2840,2	4,159	0,7717
45	415,04	414,95	416,82	2,791	2,856	2,721	1 565,1	2829,9	4,324	0,7795
46	412,64	412,75	414,49	2,859	2,934	2,796	1 616,4	2820,0	4,498	0,7887
47	414,57	414,47	416,38	2,977	3,046	2,907	1 699,2	2810,1	4,702	0,7939
48	415,12	414,48	416,61	3,086	3,136	3,006	1 767,6	2799,9	4,833	0,7987
49	414,43	414,14	416,15	3,133	3,196	3,057	1 807,2	2790,0	4,844	0,8038
50	414,35	414,17	416,09	3,213	3,278	3,140	1 864,8	2780,0	4,985	0,8084
51	414,36	414,37	416,22	3,278	3,356	3,213	1 912,5	2770,0	5,187	0,8106
52	414,63	414,62	416,50	3,362	3,438	3,292	1 971,9	2759,9	5,279	0,8150
53	414,26	414,04	415,91	3,448	3,519	3,380	2 027,7	2749,7	5,456	0,8184
54	414,35	414,09	416,10	3,494	3,560	3,419	2 056,5	2739,9	5,564	0,8198
55	413,79	413,36	415,58	3,576	3,644	3,495	2 107,8	2730,0	5,630	0,8225
56	413,88	413,34	415,53	3,656	3,717	3,574	2 160,9	2719,7	5,724	0,8253
57	415,17	414,61	416,83	3,740	3,804	3,660	2 220,3	2710,0	5,912	0,8260
58	414,37	413,95	416,06	3,799	3,865	3,720	2 259,0	2700,0	5,869	0,8286
59	414,06	413,57	415,77	3,811	3,875	3,732	2 268,0	2689,9	5,836	0,8301
60	413,80	413,55	415,50	3,865	3,940	3,796	2 307,6	2680,1	6,002	0,8316
61	414,27	414,00	415,91	3,940	4,013	3,871	2 358,9	2670,2	6,027	0,8332
62	413,59	413,23	415,31	3,998	4,070	3,922	2 392,2	2660,0	6,080	0,8346
63	414,16	414,08	415,94	3,951	4,032	3,891	2 375,1	2649,8	6,096	0,8354
64	414,57	414,22	416,07	4,321	4,395	4,252	2 610,0	2599,7	6,543	0,8401

P3a: Uživatelský manuál měřícího přístroje YOKOGAWA WT1600.

Model 760101-S15
Digital Power Meter
WT1600S

IM 760101-S15E
2nd Edition

■ Overview

The WT1600S's specifications are different from standard WT1600 as follows.

Therefore some functions written in IM760101-01E are not available, and performance is limited.

Please understand the differences, and please use WT1600S correctly.

	Standard	WT1600S (-S15)	
No. of Elements	1, 2, 3, 4, 5, 6	1, 2, 3, 4	
Optional	/B5 (Built-In Printer)	/B5 (Built-In Printer)	
	/C7 (SCSI Interface)	N/A	
	/C10 (Ethernet, HDD, SCSI)	/C10 (Ethernet, HDD, SCSI)	
	/DA (30-channel DA output)	N/A	
	/MTR (Motor evaluation function)	/MTR (Motor evaluation function)	
	/EC (Test Certificate)	/EC (Test Certificate)	
Current Range	1/2/5/10/20/50A	1/2/5/10/20A	
Continuous Max. allowed input	Peak Current of 150A or RMS of 50A (whichever less)	Peak Current of 100A or RMS of 30A (whichever less)	
Accuracy			
	50/60Hz at other Freq.	0.1%rdg+0.05%rng See Bulletin	0.1%rdg+0.1%rng See Bulletin
Frequency bandwidth			
	5A input element	DC, 0.5Hz - 1MHz	DC, 0.5Hz - 300kHz (V,A) DC, 0.5Hz - 200kHz (W)
	20A input element	---	DC, 0.5Hz - 100kHz
	50A input element	DC, 0.5Hz - 100kHz	---
	External input (Standard for each current input)	DC, 0.5Hz - 500kHz	DC, 0.5Hz - 300kHz (V, A) DC, 0.5Hz - 200kHz (W)
Effective input range	max. 110% of range 50A at 50A input element.	max. 110% of range	
Up Date Rate	50m/100m/200m/500m/1/2/5s	200m/500m/1/2/5s	
Weight	Approximately 15kg	Approximately 14kg	

■ MODEL and SUFFIX Codes

Model	Suffix codes	Description			
760101-S15		WT1600S Digital Power Meter Main Unit			
Element Type and Quantities The numbers in the "Description" column have the following meanings. 20: 20A input element 5: 5A input element Blank: no element Elements are inserted in the order shown starting on the left side on the back.		Element Number			
		1	2	3	4
	-01	20			
	-02	20	20		
	-03	20	20	20	
	-04	20	20	20	20
	-10	5			
	-11	5	20		
	-12	5	20	20	
	-13	5	20	20	20
	-20	5	5		
	-21	5	5	20	
	-22	5	5	20	20
	-30	5	5	5	
	-31	5	5	5	20
-40	5	5	5	5	
Communication Functions	-C1	GP-IB			
	-C2	Serial (RS-232)			
Power Cord	-D	UL/CSA Standard			
	-F	VDE Standard			
	-R	SAA Standard			
	-Q	BS Standard			
	-H	GB Standard			
Option Specifications	/B5	Internal Printer			
	/C10	Ethernet, HDD, SCSI			
	/MTR	Motor evaluation function			
	/EC	QIC			

Example of specifications and suffix code: 760101-21-C1-F/B5/C10/Z
 5-A input terminals in elements 1 through 2, 20-A input terminals in elements 3, GP-IB interface, VDE standard power code, built-in printer, and Ethernet I/F.

■ Input

Parameter	Voltage	Current (5A input element)	Current (20A input element)
Input type	Floating input		
	Resistive potential division method	Shunt input method	
Rated value (range-value)	Crest factor 3 1 5/3/6/10/15/30/60/100/150/300/600/1000V	Direct input: 10m/20m/50m/100m/200m/500m/1/2/5A External input: 50m/100m/250m/500m/1/2.5/5/10V	Direct input: 1/2/5/10/20A External input: 50m/100m/250m/500m/1/2.5/5/10V
	Crest factor 6 750m/1.5/3/5/7.5/15/30/50/75/150/300/500V	Direct input: 5m/10m/25m/50m/100m/250m/500m/1/2.5A External input: 25m/50m/125m/250m/500m/1.25/2.5/5V	Direct input: 0.5/1/2.5/5/10A External input: 25m/50m/125m/250m/500m/1.25/2.5/5V
Instrument loss (input resistance)	Approximately 2MΩ	Direct input: Approximately 100mΩ + Approximately 0.07 μH External input: Approximately 100kΩ	Direct input: Approximately 2mΩ + Approximately 0.07 μH External input: Approximately 100kΩ
Instantaneous maximum allowed input (1 cycle, for 20 ms)	Peak voltage of 4 kV or rms of 1.5 kV (whichever is lower)	Peak current of 30 A or rms of 15 A (whichever is lower) External input: Peak not to exceed 10 times range-value	Peak current of 450 A or rms of 300 A (whichever is lower) External input: Peak not to exceed 10 times range-value
Continuous maximum allowed input	Peak voltage of 1.5 kV or rms of 1 kV (whichever is lower)	Peak current of 10 A or rms of 7 A (whichever is lower) External input: Peak not to exceed 5 times range-value	Peak current of 100 A or rms of 30 A (whichever is lower) External input: Peak not to exceed 5 times range-value
Continuous maximum common mode voltage (50/60 Hz)	600 Vrms CATII		
Influence from common mode voltage	(with voltage input terminals shorted and current input terminals open) 50/60 Hz: ±0.01% of rng or less (±(0.01 × 15/(rated value of rng))% of rng or less for 10-V rng or less). Up to 100 kHz: Reference value ±(0.1 × 1% of rng) or less, ±(0.1 × 15/(rated value of rng))% of rng or less for 10-V rng or less. ±(0.1 × f × 40/(rated value of rng (unit mA))) % of rng or less for 20mA rng or less, but no less than 0.01%. Two times these values for crest factor 6. ; frequency unit: kHz		
Input terminal type	Plug-in terminal (safety terminal)	Direct input: Large binding post External input: BNC connector (insulation type)	
A/D converter	Voltage/current input simultaneous conversion, 16-bit resolution, conversion speed (sampling interval) of approximately 5 μsec		
Switching range-value	Range-value can be set independently for each element, through manual setting, automatic setting, or online setting		
Auto-range function	Increasing range-value: Range-value is increased when rms exceeds 110% of rated value or peak value exceeds approximately 330% (or 660% for crest factor 6) of rated value. Decreasing range-value: Range-value is decreased when peak is 300% (or 600% or less for crest factor 6) or less of lower range-value while rms is 30% or less of rated value.		

Measurement Function

Method	Digital multiplication method					
Crest factor	Crest factor 3: Up to 300 (in the effective input range). 3 (when inputting rated values of the measuring range). However, 2 for the 1000 V range.					
	Crest factor 6: Up to 600 (in the effective input range). 6 (when inputting rated values of the measuring range). However, 4 for the 500V range.					
Accuracy	Frequency	Accuracy = (reading error + measurement range error)	Power Accuracy = (reading error + measurement range error)			
	DC	0.2% of rdg + 0.2% of rng	0.3% of rdg + 0.2% of rng			
	0.5Hz ≤ f < 45Hz	0.1% of rdg + 0.2% of rng	0.3% of rdg + 0.2% of rng			
	45Hz ≤ f ≤ 66Hz	0.1% of rdg + 0.1% of rng	0.1% of rdg + 0.1% of rng			
	66Hz < f ≤ 1kHz	0.1% of rdg + 0.2% of rng (*1) 0.2% of rdg + 0.1% of rng (*2)	0.2% of rdg + 0.2% of rng			
	1kHz < f ≤ 10kHz	(0.07×f)% of rdg + 0.3% of rng (*1) (0.1×f+0.2)% of rdg + 0.1% of rng (*2)	0.1% of rdg + 0.3% of rng + 0.067×(f-1)% of rdg (*1) (0.1×f+0.2)% of rdg + 0.2% of rng (*2)			
	10kHz < f ≤ 50kHz	0.5% of rdg + 0.5% of rng + 0.04×(f-10)% of rdg (*1) (0.1×f+0.2)% of rdg + 0.1% of rng (*2)	0.5% of rdg + 0.5% of rng + 0.09×(f-10)% of rdg (*1) (0.1×f+0.2)% of rdg + 0.2% of rng (*2)			
	50kHz < f ≤ 100kHz	0.5% of rdg + 0.5% of rng + 0.04×(f-10)% of rdg (*1) (0.1×f+0.2)% of rdg + 0.2% of rng (*2)	0.5% of rdg + 0.5% of rng + 0.09×(f-10)% of rdg (*1) (0.3×f-9.5)% of rdg + 0.3% of rng (*2)			
	100kHz < f (design value)	100kHz < f ≤ 300kHz 0.12×(f-100)% of rdg + 6% of rng (*1)	100kHz < f ≤ 200kHz 0.21×(f-100)% of rdg + 9% of rng (*1)			
	Power factor effect ϕ is phase angle between Voltage and current.	When cos ϕ = 0.45 Hz to 66 Hz: 0.15% of apparent power reading is added to the above power accuracy. For other frequencies: Reference value. For 5 A input element current direct input, add (0.15 + 0.05 × f)% of apparent power reading to the above accuracy. For 20 A input element current direct input, add (0.15 + 0.3 × f)% of apparent power reading to the above accuracy. For external input, add (0.15 + 0.1 × f)% of apparent power reading to the above accuracy. When 0 < cos ϕ < 1, add (tan ϕ × (influence of power factor = 0))% of power reading.				
Effective input range	Voltage, current: Rms and AC: 1% to 110% of rated range-value, DC: 0% to ±110% of rated range-value. Mean: 10% to 110% of rated range-value. Power: DC measurement: 0% to ±110% of rated range-value, AC measurement: Up to ±110% of power range-value, with voltage and current within 1% to 110% of rated range-value (Sync source signal level must be 10% or more (20% or more for crest factor 6) of rated range value) Effective input is in the range up to 1000V at Voltage, 5A at 5A input element and 10V at External input.					
Accuracy of crest factor 6	Add the accuracy of measurement range error (accuracy of crest factor 3 after calibration) × 1 to the accuracy after calibration.					
Line filter function	Measurement can be made with a line filter inserted in the input circuit. Cutoff frequency (fc): 500 Hz or 5.5 kHz					
Line filter on accuracy	Cut-off frequency of 500 Hz: Voltage, current: Add 0.2% of rdg in range of 45 to 66 Hz. Under 45 Hz, add 0.5% of rdg. Power: Add 0.3% of rdg in range of 45 to 66 Hz. Under 45 Hz, add 1% of rdg. Cut-off frequency of 5.5 kHz: Voltage, current: Add 0.2% of rdg under 66 Hz. At 66 Hz to 500 Hz, add 0.5% of rdg. Power: Add 0.3% of rdg under 66 Hz. At 66 Hz to 500 Hz, add 1% of rdg.					
Temperature coefficient	±0.03% of rdg/°C at 5 to 20°C and 26 to 40°C					
Conditions for detecting lead and lag	Lead and lag are detected correctly when the voltage and current signals are both sine waves, the lead and lag amplitude is greater than or equal to 50% (or 100% for crest factor 6) of the measurement range, the frequency is between 20 Hz to 10 kHz, and the phase angle is between ±(5 to 175°).					
Measurement lower limit	Data update rate	200 msec	500 msec	1 sec	2 sec	5 sec
frequency	Measurement lower limit frequency	15 Hz	5 Hz	2.5 Hz	1.5 Hz	0.5 Hz

(*1) for 5A input element current direct input and external input
(*2) for 20A input element current direct input

- Current and power DC accuracy (5 A input element) ----Add 20uA to current and 20uA x (voltage reading) to power (20 A input element) ----Add 1 mA to current and 1 mA x (voltage reading) to power (External input) ----Add (0.05/scaling value) A to current and (0.05/scaling value) A x (voltage reading) to power
 - Zero level correction or as a zero level correction in current and power DC accuracy relating to temperature changes following range-value changes.
5 A input element: add 10uA /°C to current and add (10uA x voltage reading) /°C to power.
20 A input element: add 1 mA /°C to current and add (1 mA x voltage reading) /°C to power.
external input: add (0.05/scaling value) A/°C to current and add ((0.05/scaling value) A x (voltage reading)) /°C to power.
 - Add (0.006 x I²)% at 5 A input element. Add (0.00006 x I²)% at 20 A input element.
 - Current rms, mean, AC ----Accuracy figures are specified with line filter turned ON for 2 mA or less on a 5 A input element, for 200 mA or less on a 20 A input element, for 10/(scaling value) A or less on an external input.
 - All accuracy of 0.5 Hz to 10 Hz: Reference values
Voltage ---- Reference values in cases where f(Hz) x voltage(V) > 2.2 x 10⁷ at 100 kHz or higher.
 - For currents less than 5 mA with frequencies above 1 kHz, the current accuracy and the power accuracy figures are the reference values.
 - Add 20% of rng to the accuracy above for the accuracy of the waveform display data, voltage peak (Upk), and current peak (Ipk) in the range up to 1 MHz. (Reference Value)
- Effective input range of Upk and Ipk is within 300% (within ±600% for crest factor 6) in the range. However, within ±200% for the 1000 V range of crest factor 3 (within ±400% in the 500 V range of crest factor 6).

rdg: reading, rng: range Maximum measurement value must be within maximum allowed input.

■ Calculation Functions

		Single-phase, three-wire	Three-phase, three-wire (2V2A)	Three-phase, three-wire (3V3A)	Three-phase, four-wire
Voltage U, ΣU		U_i	$(U1+U2)/2$	$(U1+U2+U3)/3$	
Current I, ΣI		I_i	$(I1+I2)/2$	$(I1+I2+I3)/3$	
Active power P, ΣP		P_i	$P1+P2$		$P1+P2+P3$
Reactive Power Q, ΣQ	Normal measurement	$Q_i = \sqrt{S_i^2 - P_i^2}$	$Q1+Q2$		$Q1+Q2+Q3$
	Harmonic measurement	Q_i			
Apparent Power S, ΣS	Normal measurement	$S_i = U_i \times I_i$	$S1+S2$	$\sqrt{3}(S1+S2)/2$	$\sqrt{3}(S1+S2+S3)/3$
	Harmonic measurement	$S_i = \sqrt{P_i^2 + Q_i^2}$	$\sqrt{\Sigma P^2 + \Sigma Q^2}$		
Power factor λ , $\Sigma \lambda$		$\lambda_i = P_i/S_i$	$\Sigma P / \Sigma S$		
Phase angle Φ , $\Sigma \Phi$		$\Phi_i = \cos^{-1}(P_i/S_i)$	$\cos^{-1}(\Sigma P / \Sigma S)$		
Calculation precision (of calculated values relative to measured values)		Apparent power (S) and reactive power (Q): $\pm 0.001\%$ of power range-value Power factor (λ): ± 0.0001 Phase angle (Φ): $\pm 0.005^\circ$ relative to calculation from power factor			

- Note 1: Apparent power (S), reactive power (Q), power factor (λ), and phase angle (Φ) for this equipment are calculated from active power. (However, reactive power during harmonic measurement is the sum of every order.) Therefore, in the case of distorted-wave input, these values may be different from those of other instruments based on different measurement principles.
- Note 2: Since the phase is determined using the equation $\Phi = W/VA$, there is no rule for accuracy.
- Note 3: The value of var in the Σ var calculation is calculated with a preceding minus sign (-) when the current input leads the voltage input, and a plus sign when it lags the voltage input, so the value of Σ var may be negative.
- Note 4: Other parameters (during normal measurement) Upk, Ipk (peak value), CF (crest factor), FF (form factor), |Z| (impedance), Rs and Rp (resistance), Xs and Xp (reactance), γ and $1/\gamma$ (efficiency), Pc (Corrected Power), F1 to F4 (user-defined functions), delta calculations (three-phase three-wire_3V3A conversion, Y- Δ conversion, Δ -Y conversion)
- Note 5: Wiring settings: Settings can be divided into three groups (ΣA , ΣB , and ΣC). Each group is selected from the following: 1P2W (single-phase two-wire, one element used), 1P3W (single phase three-wire, two elements used), 3P3W (three-phase three-wire, two elements used), 3V3A (three phase three-wire, three elements used), 3P4W (three-phase four-wire, three elements used).

■ Display Functions

- Display: 6.4-inch color TFT LCD
- Pixels in full screen: 640 x 480 (The LCD unit may contain defects of approximately 0.02% in the pixels of the full screen)
- Display type
- Numerical values: Normal measurement: 4/8/16/42/78/ALL
Harmonic measurement: 4/8/16/Single List/Dual List/ Σ List
- Waveforms: Single/Dual/Triad/Quad
- Vector: Phase diagram for first-order components in harmonic measurement
- Bar: Bar graph up to upper limit of analyzed orders in harmonic measurement
- Trend display: Trend display of measured/calculated values
- Data updating rate: Selected from 200msec/500msec/1sec/2sec/5sec. (waveform OFF)
However, Maximum data update is approximately 770ms when waveform data acquisition is ON.
- Display update rate: Same as the data update rate. However, when waveform data acquisition is OFF
Note: Data can be stored in the internal memory every data update late
- Max. Display: 140% of the voltage and current range rating
- Min. Display: Urms, Uac, Irms, and Iac are up to 0.3% relative to the measuring range (or up to 0.6% for a crest factor of 6). Umn and Imn are up to 1% (or 2% for a crest factor of 6). Below that, zero suppress. Current integration value q also depends on the current value.
- Response time: Up to data updating rate x 2 (Waveform OFF)
- Display scaling function: PT ratio, CT ratio, and power scaling factor can be scaled.
- Averaging functions
- Normal measurement Methods: Exponential average or simple moving average
- Exponential average: Attenuation constant of 2, 4, 8, 16, 32, or 64
- Moving average: Number of averages (N) set to 8, 16, 32, 64, 128 or 256
- Harmonic measurement
- When using an exponential average, the attenuation constant is 5.625 if the frequency of the PLL synchronization source is 55 Hz or greater but less than 75 Hz; otherwise, the attenuation constant is 4.6875. (When data length = 8192)
- Display resolution
- U, I, P: During rated range-value input, the decimal place and the counting unit are set so that the display does not exceed a count value of 60000
- ΣU , ΣI , ΣP : The decimal place and the counting unit are the same as for the maximum range-value of the calculated element.
- Key lock function is available (version 3.21 and later)

■ Frequency Measurement Functions

Measurement input: Select three of the following: U1, I1, U2, I2, U3, I3, U4, I4

Measurement method: Reciprocal method

Frequency range:	Data updating rate	Frequency range
	200 msec	$15 \text{ Hz} \leq f \leq 100 \text{ kHz}$
	500 msec	$5 \text{ Hz} \leq f \leq 100 \text{ kHz}$
	1 sec	$2.5 \text{ Hz} \leq f \leq 100 \text{ kHz}$
	2 sec	$1.5 \text{ Hz} \leq f \leq 50 \text{ kHz}$
	5 sec	$0.5 \text{ Hz} \leq f \leq 20 \text{ kHz}$
	Accuracy	$\pm(0.06\% \text{ of reading})$

Note: Input signal level is greater than or equal to 0.6 V (voltage input), 25 mV (external input), 5 mA (5-A input element), or 150 mA (20-A input element) and the signal is greater than or equal to 30% (from 0.5 Hz to less than 440 Hz, with zero crossing filter ON) or 10% (from 440 Hz to 100 kHz) of the measurement range. However, input signal level is 2 times for crest factor 6.

Zero Crossing Filter: OFF/500Hz

■ Integration Functions

The integrating functions do not work during waveform acquisition or in harmonic analysis mode ON.

Measured parameters: Power (Wp), positive-only power (+Wp), negative-only power (-Wp), current (q), positive-only current (+q), negative-only current (-q) (For current integration, select only one of the following for each element: rms, mean, DC, AC.), time (Time)

Mode :
Standard integration mode (timer mode)
Continuous integration mode (repeat mode)
Manual integration mode

Individual element integration: Integration can be started/stopped element by element using GP-IB or serial (RS-232) communications.

Timer: Integration can be stopped automatically according to a timer setting.

Setting Range: 0000h00min00sec to 10000h00min00sec

Count overflow: If the integration value exceeds ± 999999 MWh (MAh), the elapsed time is saved and the operation is stopped.

Accuracy: $\pm(\text{unit accuracy} + 0.05\% \text{ of rdg})$

Timer accuracy: $\pm 0.02\%$

■ Harmonic Measurement Functions

Measurements: Select one of the following: ΣA , ΣB , ΣC

Method: PLL synchronization or external sampling clock

Measurement frequency PLL synchronization: Synchronization source fundamental frequency of 10 Hz to 1 kHz

Range: External sampling clock: Fundamental wave of 0.5Hz to 100 Hz (Input 2048 times the fundamental frequency. The waveform is a square wave with a duty cycle of 50% at the TTL level.)

Analyzed parameters: For each order: U, I, P, S, Q, λ , $\Phi(U-I)$, ΦU , ΦI (phase difference of harmonic component relative to fundamental wave), $|Z|$, R_s , R_p , X_s , X_p

Total: U, I, P, S, Q, λ , Φ , Σ calculation of fundamental wave and total: U, I, P, S, Q, λ and Φ

For each order: Harmonic content of U, I, and P THD of U, I and P

UTHF (voltage telephone harmonic factor), ITHF (current telephone harmonic factor), UTIF (voltage telephone influence factor), ITIF (current telephone influence factor), HVF (harmonic voltage factor), HIF (harmonic current factor)

FFT data length: 8192, 4096 or 2048

FFT processed word length: 32 bits

Window function: Rectangular

Anti-aliasing filter: Set by line filter ($f_c = 5.5 \text{ kHz}$)

PLL synchronization

Fundamental frequency (Hz)	Sampling frequency	Window width relative to FFT data length (number of fundamental wave cycles)			Maximum analyzed orders
		8192	4096	2048	
$10 \leq f < 20$	$f \times 2048$	4	2	1	100
$20 \leq f < 40$	$f \times 1024$	8	4	2	100
$40 \leq f < 75$	$f \times 512$	16	8	4	100
$75 \leq f < 150$	$f \times 256$	32	16	8	100
$150 \leq f < 440$	$f \times 128$	64	32	16	50
$440 \leq f \leq 1000$	$f \times 64$	128	64	32	25

External sampling clock

Fundamental frequency (Hz)	Sampling frequency	Window width relative to FFT data length (number of fundamental wave cycles)			Maximum analyzed orders
		8192	4096	2048	
$0.5 \leq f \leq 100$	$f \times 2048$	4	2	1	100

However, it is $1 \leq f \leq 100$ when the FFT data length is 8192

Accuracy: \pm (reading error + measurement range error) (Line filter 5.5 kHz ON)

	Voltage/Current	Power
$0.5 \leq f < 10$	0.4% of rdg+0.2% of rng	0.7% of rdg+0.3% of rng
$10 \leq f < 45$	0.4% of rdg+0.1% of rng	0.6% of rdg+0.2% of rng
$45 \leq f \leq 66$	0.3% of rdg+0.05% of rng	0.4% of rdg+0.05% of rng
$66 < f \leq 1\text{kHz}$	1% of rdg+0.1% of rng	1.5% of rdg+0.1% of rng
$1\text{kHz} < f \leq 2.5\text{kHz}$	2% of rdg+0.1% of rng	-----

However, the amplitude level of the PLL source is 30% of range or more (or 60% for a crest factor of 6).

Two times these values for crest factor 6.

During nth-order component input, add $\{(n/(m+1))/50\}$ % of the nth-order reading to (n-m)th order and (n+m)th order.

(Line filter OFF) For normal measurement accuracy, during nth-order component input, add $\{(n/(m+1))/50\}$ % of the nth-order reading to (n-m)th order and (n+m)th order. Add (n/500)% of the nth-order reading to the nth-order component.

■ **Waveform Display Function**

- Data memory size: 1 kW (Peak to peak compression data)
- Vertical zoom: 0.1 to 100 times
- Waveforms: Single/Dual/Triad/Quad
- Interpolation: dot or linear
- Cursor Measurement: Measure the value at the point where the cursor is placed on the waveform
- Triggers
 - Mode: Auto/Normal
 - Type: Edge
 - Source: U1, I1, U2, I2, U3, I3, U4, I4, external
 - Slope: Rising/falling/both
 - Position: 0% (fixed)
 - Sample rate: Approximately 200 kHz
 - Time/Div: 0.5msec to 500msec (not to exceed 1/10 of display updating period)
(No ZOOM functions for Time Axis.)
The frequency that allows displaying of waveforms is up to approximately 10 kHz.

■ **Trend Display**

- No. Items: max. 16
- Time Axis:
 - Normal mode (waveform OFF) 3/6/10/30sec/1/3/6/10/30min/1/3/6/12/24 hour/div
 - Normal mode (waveform ON) 1 to 500 points/div (P/div is the number of data points per grid section)
 - Harmonic mode 1 to 500 points/div (P/div is the number of data points per grid section)
- Scale: Auto/Manual

■ **Internal Memory Functions**

- Internal Memory: Approximately 11MB
- Store Interval: Maximum 200msec to 99 hour 59 minutes 59 seconds. (Waveform OFF)
* The fastest store interval is approximately 770ms (Waveform ON)

Guideline for Storage Time (Waveform Display OFF, Integration Function OFF)

No. of Channels	No. of Measurement Items (each channel)	Store interval	Measurable time
1ch	3	200ms	Approximately 34 hours
1ch	10	1 second	Approximately 66 hours
4ch	10	200ms	Approximately 2 hours 20 minutes
4ch	20	1 second	Approximately 6 hours

Note: Depending on the user-defined math, integration, and other settings, the actual measurement time may be shorter than stated above.

■ Motor Evaluation Functions (/MTR) (optional)

The motor evaluation functions do not work in harmonic measurement mode.

Calculated parameters Torque, rpms, mechanical power, synchronization, speed, slip, motor efficiency, total efficiency

Measured parameters

Analog input for calculating torque and rpms

Input resistance:	Approximately 1M.
Accuracy:	$\pm(0.1\% \text{ of rdg} + 0.2\% \text{ of rng})$
Input range-values:	1/2/5/10/20 V
Effective input range:	Up to $\pm 110\%$ of range-value
Temperature coefficient:	$\pm 0.03\%$ of rng/ $^{\circ}\text{C}$

Pulse input for rpm calculation

Input resistance:	Approximately 1M.
Accuracy:	$\pm 0.05\%$ of rdg + 1 mHz + 1 digit
Input range:	$\pm 5 \text{ Vpk}$
Effective amplitude:	1 Vp-p or higher
Input waveform:	50% duty ratio rectangular wave
Frequency measurement range:	2 Hz to 200 kHz

■ Built-in Printer (/B5) (optional)

Printing method: Thermal line-dot

Dot density: 8 dots/mm

Paper width: 80 mm

Effective recording width: 72 mm

Recorded information: Screenshots, list of measured values, harmonic bar graph printouts, settings

■ Ethernet (/C10) (optional)

Transmission method: Ethernet (10BASE-T)

Supported services: FTP server, FTP client, LPR (network printing),
SMTP (automatic mail transfer), DHCP, DNS

Electrical and mechanical specifications:

As per IEEE802.3

Connector: RJ-45 connector

Built-in Hard Drive

Capacity: 10 GB (2GB x 5) IBM format

SCSI ID: 4 (fixed)

Other: Cannot be used for DIAdem and other protocols

■ External I/O

EXT CLK: (Sync source during normal measurement, PLL source or external sampling clock during harmonic analysis)

Connector: BNC

Input voltage: TTL level

EXT MEAS.START: (external measurement start I/O)

EXT MEAS.STOP: (external measurement stop I/O)

Connector: BNC

Synchronized measurement:

Connect the EXT MEAS.START terminal of the master unit with the EXT MEAS.START terminal of the slave unit, and connect the EXT MEAS.STOP terminal of the master unit with the EXT MEAS.STOP terminal of the slave unit.

Internal floppy drive

Size: 3.5-inch

Format: 1.44 MB

Communication functions

GP-IB or serial (RS-232) provided as a standard function.

GP-IB interface:

Electrical and mechanical specifications

As per IEEE St'd 488-1978

Functional specifications

SH1, AH1, T6, L4, SR1, RL1, PR0, DC1, DT0, C0

Protocol: As per IEEE St'd 488.2 1992

Serial (RS-232) interface

Connector: D-Sub 9-pin
Specification: EIA-574 (specifications for 9-pin interface in EIA-232 (RS-232) standard)
Transfer rate: 1200, 2400, 4800, 9600, 19200 bps

VGA video output

Connector type: D-Sub 15-pin (VGA VIDEO OUT)
Output format: VGA-compatible

SCSI interface (optional)

Specification: SCSI (Small Computer System Interface)
ANSI X3.131-1986
Connector: D-sub half-pitch 50-pin (pin type)
Connector pin assignments:
Unbalanced (single-end), internal terminator

■ General Specification

Safety standard (*1): Complying standard EN61010-1
Overvoltage category (Installation category) II (*2)
Pollution degree 2 (*3)

Emission (*1): Complying standard EN61326 Class A
EN61000-3-2
EN61000-3-3
AS/NZS 2064 Class A

Immunity (*1): Complying standard EN61326 Annex A (*4)

Warmup time: Approximately 1 hour

Operating temperature and humidity ranges:
5 to 40°C, 20 to 80%RH when not using the printer,
5 to 40°C 35 to 80%RH when using the printer.(no condensation)

Storage temperature: -25 to 60°C (no condensation)

Operating elevation: 2000 meters or less

Insulating resistance: 50 Ω or higher at 500 VDC
Between casing and power plug
Between voltage input terminals (ganged) and casing
Between current input terminals (ganged) and casing
Between voltage input terminals (ganged) and current input terminals (ganged)
Between input terminals of each element.
Between torque/speed input terminals (ganged) and casing
Between input terminals of each element.
Withstand voltage 1500 VAC for one minute at 50/60 Hz
Between casing and power plug
3700 VAC for one minute at 50/60 Hz
Between voltage input terminals (ganged) and casing
Between current input terminals (ganged) and casing
Between voltage input terminals (ganged) and current input terminals (ganged)
Between input terminals of each element.

Rated supply voltage: 100 to 120 VAC, 200 to 240 VAC (switches automatically)

Allowed supply voltage fluctuation range:
90 to 132VAC, 180 to 264 VAC

Rated supply frequency: 50/60 Hz

Allowed supply frequency fluctuation range:
48 to 63 Hz

Consumed power: Maximum 150 VA (when using internal printer)

External dimensions: Approximately 426 mm (W) · 177 mm (H) · 400 mm (D) (excluding protrusions)

Weight: Approximately 14kg (main unit with 4 input elements and options installed)

(*1) Emission, immunity and safety standards apply to products having the CE Mark. For all other products, please contact your nearest YOKOGAWA representative as listed on the back cover of this manual.

(*2) Overvoltage Categories define transient overvoltage levels, including impulse withstand voltage levels Overvoltage Category II. Applies to equipment supplied with electricity from fixed installations like a distribution board.

(*3) Pollution Degree: Applies to closed atmospheres (with no, or only dry, non-conductive pollution). Pollution Degree 2: Applies to normal indoor atmospheres (with only non-conductive pollution).

(*4) Annex A (normative). Immunity test requirements for equipment intended for use in industrial locations.

Appendix 1 Symbols and Determination of Measurement Functions

Measurement Functions during Normal Measurement

(Table 1/3)

Measurement Functions during Normal Measurement		Method of Determination, Equation					
Voltage U [V]	Urms	Urms	Umn	Udc	Uac	U+pk	U-pk
	Umn Udc Uac U+pk U-pk	$\sqrt{\frac{1}{T} \int u(t) dt}$	$\frac{\pi}{2\sqrt{2}} \frac{1}{T} \int u(t) dt$	$\frac{1}{T} \int u(t) dt$	$\sqrt{U_{rms} - U_{dc}}$	Maximum	Minimum
Current I [A]	Irms	Irms	Imn	Idc	Iac	I+pk	I-pk
	Imn Idc Iac I+pk I-pk	$\sqrt{\frac{1}{T} \int i(t) dt}$	$\frac{\pi}{2\sqrt{2}} \frac{1}{T} \int i(t) dt$	$\frac{1}{T} \int i(t) dt$	$\sqrt{I_{rms} - I_{dc}}$	Maximum	Minimum
fU (FreqU) [Hz] fI (FreqI) [Hz]	The voltage frequency (fU) and current frequency (fI) are measured using zero crossing detection.						
Voltage form factor Ffu Current form factor Ffi	Voltage form factor $FfU = \frac{U_{rms}}{\frac{2\sqrt{2}}{\pi} U_{mn}}$			Current form factor $FfI = \frac{I_{rms}}{\frac{2\sqrt{2}}{\pi} I_{mn}}$			
Voltage crest factor CfU Current crest factor Cfi	Voltage crest factor $CfU = \frac{U_{pk}}{U_{rms}}$ U _{pk} = IU+pkI or IU-pkI whichever is larger			Current crest factor $CfI = \frac{I_{pk}}{I_{rms}}$ I _{pk} = II+pkI or II-pkI whichever is larger			
Active power P [W]	$\frac{1}{T} \int u(t) i(t) dt$						
Apparent power S [VA]	$\begin{matrix} U_{rms} & I_{rms} \\ (U_{mn} & I_{mn}) \\ (U_{dc} & I_{dc}) \\ (U_{mn} & I_{rms}) \end{matrix}$ Combinations of rms, mn, and dc are selectable. See section 6.6.						
Reactive power Q [var]	$\sqrt{S - P}$						
Power factor λ	$\frac{P}{S}$						
Phase difference φ [°]	$\cos \left(\frac{P}{S} \right)$ The phase format can be displayed using Lead (D)/Lag (G) format or 360° format. See section 6.7.						
Z [Ω]	$\frac{U_{rms}}{I_{rms}}$						
Rs [Ω]	$\frac{P}{I_{rms}}$						
Xs [Ω]	$\frac{Q}{I_{rms}}$						
Rp [Ω] (=1/G)	$\frac{U_{rms}}{P}$						
Xp [Ω] (=1/B)	$\frac{U_{rms}}{Q}$						
Corrected power Pc [W]	IEC76-1(1976), IEEE C57.12.90-1993			IEC76-1(1993)			
	$\frac{P}{P1 + P2 \left(\frac{U_{rms}}{U_{mn}} \right)}$ P1, P2: Coefficients as defined in the applicable standard			$P \left(1 + \frac{U_{mn} - U_{rms}}{U_{mn}} \right)$			

(Continues to the next page)

Appendix 1 Symbols and Determination of Measurement Functions

(Table 2/3)

Measurement Functions during Normal Measurement		Method of Determination, Equation					
Integration	Integration time [h:m:s]	Elapsed time from the start of integration to stop					
	Watt hour [Wh] Wp Wp+ Wp-	$\int u(t) i(t) dt$ <p>Wp is the sum of positive and negative watt hours. Wp+ is the sum of positive P (power consumed). Wp- is the sum of negative P (returned to the power supply, regenerated energy)</p>					
	Ampere hour [Ah] q q+ q-	$\sum I$ <p>q is the sum of positive and negative current hours. q+ is the sum of positive I (current hour). q- is the sum of negative I (current hour). The selected item from Irms, Imn, Idc, and Iac is applied to I. For the selection procedure, see section 6.10.</p>					
Σ Function	Wiring system	Single-phase, three-wire (1P3W)	Three-phase, three-wire (3P3W)	Three-voltage, three-current (3V3A)	Three-phase, four-wire (3P4W)		
	UΣ [V]	UrmsΣ	(Urms1 + Urms2) / 2		(Urms1 + Urms2 + Urms3) / 3		
		UmnΣ	(Umn1 + Umn2) / 2		(Umn1 + Umn2 + Umn3) / 3		
		UdcΣ	(Udc1 + Udc2) / 2		(Udc1 + Udc2 + Udc3) / 3		
		UacΣ	(Uac1 + Uac2) / 2		(Uac1 + Uac2 + Uac3) / 3		
	IΣ [A]	IrmsΣ	(Irms1 + Irms2) / 2		(Irms1 + Irms2 + Irms3) / 3		
		ImnΣ	(Imn1 + Imn2) / 2		(Imn1 + Imn2 + Imn3) / 3		
		IdcΣ	(Idc1 + Idc2) / 2		(Idc1 + Idc2 + Idc3) / 3		
		IacΣ	(Iac1 + Iac2) / 2		(Iac1 + Iac2 + Iac3) / 3		
	PΣ [W]	P1 + P2			P1 + P2 + P3		
	SΣ [VA]	S1 + S2	$\frac{\sqrt{3}}{2} (S1 + S2)$	$\frac{\sqrt{3}}{3} (S1 + S2 + S3)$	S1 + S2 + S3		
	QΣ [var]	Q1 + Q2			Q1 + Q2 + Q3		
	PcΣ [W]	Pc1 + Pc2			Pc1 + Pc2 + Pc3		
	WpΣ [Wh]	WpΣ	W + W			W + W + W	
		Wp+Σ	W + W			W + W + W	
Wp-Σ		W + W			W + W + W		
qΣ [Ah]	qΣ	q + q			q + q + q		
	q+Σ	q + q			q + q + q		
	q-Σ	q + q			q + q + q		
$\lambda_{\Sigma} = \frac{P_{\Sigma}}{S_{\Sigma}}$ $X_{s\Sigma} [\Omega] = \frac{Q_{\Sigma}}{I_{rms\Sigma}}$ η (efficiency 1) [%] = $\frac{P_{\Sigma B}}{P_{\Sigma A}} 100$		$\phi_{\Sigma} [^{\circ}] = \cos \left(\frac{P_{\Sigma}}{S_{\Sigma}} \right)$ $R_{p\Sigma} [\Omega] = \frac{U_{rms\Sigma}}{P_{\Sigma}}$ (= 1/G)		$Z_{\Sigma} [\Omega] = \frac{S_{\Sigma}}{I_{rms\Sigma}}$ $X_{p\Sigma} [\Omega] = \frac{U_{rms\Sigma}}{Q_{\Sigma}}$ (= 1/B)			
$R_{s\Sigma} [\Omega] = \frac{P_{\Sigma}}{I_{rms\Sigma}}$		η (efficiency 2) [%] = $\frac{P_{\Sigma A}}{P_{\Sigma B}} 100$					

(Continues to the next page)

Note

- Period T is the measurement period. For details on the measurement period, see section 1.2.
- u(t) and i(t) denote the sampled data of the voltage signal and the current signal, respectively.
- PΣA and PΣB denote the active power of the wiring units ΣA and ΣB, respectively. The assignment of input elements to wiring units ΣA and ΣB is determined by the number of input elements that are installed in the WT1600 and the selected wiring system pattern. For details, see section 1.3.
- The numbers 1, 2, and 3 in the equations UΣ, IΣ, PΣ, SΣ, QΣ, PcΣ, WpΣ, and qΣ indicate the case when input elements 1, 2, and 3 are set to the wiring system shown in the table. If elements 2, 3, and 4 are set to the wiring system shown in the table, replace the numbers 1, 2, and 3 with 2, 3, and 4, respectively. The same also holds true when using elements 5 and 6.
- For single phase models (one input element) and those with a 1P2W wiring system, the Σ functions' numerical data are the same as that of the elements that were assigned to wiring units ΣA, ΣB, and ΣC.
- With QΣ[var] calculation, the current at a given voltage is calculated as a negative value for a leading phase, and a positive value for lagging phase.

(Table 3/3)

Measurement Functions during Normal Measurement	Method of Determination, Equation
Motor Evaluation	<p>When the type of input signal from the revolution sensor is DC voltage (analog signal) Input voltage from the revolution sensor Scaling factor Scaling factor: Number of rotations per volt of input voltage</p> <p>When the type of input signal from the revolution sensor is pulse count $\frac{\text{Number of input pulses from the revolution sensor per minute}}{\text{Number of pulses per rotation}} \text{ Scaling factor}$ Scaling factor: When the signal of the gear ratio or revolution sensor is a converted signal, you can specify the gear ratio for the scaling factor to determine the rotating speed before the gear change.</p>
	<p>Torque Input voltage from the torque meter Scaling factor Scaling factor: torque per volt of input voltage</p>
	<p>Synchronized speed (Sync) $120 \frac{\text{Frequency of the frequency measurement source (Hz)}}{\text{Motor's number of poles}}$</p> <ul style="list-style-type: none"> • The unit of synchronized speed is fixed to "min (or rpm)." • Normally, the frequency measurement source is set to the voltage or current that is supplied to the motor. The synchronized speed may not be determined correctly if a different signal is specified.
	<p>Slip [%] $\frac{\text{Sync} - \text{Speed}}{\text{Sync}} \times 100$</p>
	<p>Motor output P_m $\frac{2\pi \text{ Speed Torque}}{60} \text{ Scaling factor}$</p> <p>When the unit of Speed is "min (or rpm)," the unit of Torque is "N·m," and the scaling factor is 1, the unit of motor output P_m is "W." For products with ROM version 1.05 or earlier, the equation for P_m is as follows: P_m = Speed + Torque × Scaling factor</p>
	<p>Motor efficiency [%] or total efficiency [%]</p> $\eta_{mA} = \frac{P_m}{P_{\Sigma A}} \times 100$ $\eta_{mB} = \frac{P_m}{P_{\Sigma B}} \times 100$ <ul style="list-style-type: none"> • Motor efficiency is the ratio of the motor output with respect to the power consumed by the motor. • Total efficiency is the ratio of the motor output versus the power consumed by the motor as well as the converter through which power is fed to the motor. • If P_{ΣA} is the power to the converter and the motor and P_{ΣB} is the power to the motor, η_{mA} and η_{mB} are the total efficiency and motor efficiency, respectively. Conversely, if P_{ΣB} is the power to the converter and the motor and P_{ΣA} is the power to the motor, η_{mB} and η_{mA} are the total efficiency and motor efficiency, respectively.

P4: Průběh magnetické indukce ve vzduchové mezeře

```
/POST1
APLOT
!*
PATH,AG,2,120,120,
CSWPLA,23
!*
WPOFF,0,0
CSWPLA,24,1
CSCIR,24,1
PPATH,1,0,0.32126E-01,0.1E-05,0
PPATH,2,0,0.32124E-01,-0.1E-05,0
PMAP,'UNI '
/PBC,PATH,1
/REPLOT
WPCSYS,1,23
CSWPLA,23
!*
!*
PDEF,BAG,B,SUM,AVG
/PBC,PATH, ,0
```

P5: Průběh magnetické indukce hlavami rotorových zubů (střed)

```
/POST1
APLOT
!*
PATH,RH,2,120,120,
CSWPLA,23
!*
WPOFF,0,0
CSWPLA,24,1
CSCIR,24,1
PPATH,1,0,0.314585E-01,0.1E-05,0
PPATH,2,0,0.314584E-01,-0.1E-05,0
PMAP,'UNI'
/PBC,PATH,1
/REPLOT
WPCSYS,1,23
CSWPLA,23
!*
!*
PDEF,BRH,B,SUM,AVG
/PBC,PATH, ,0
```

P6: Průběh magnetické indukce rotorovými zuby (střed)

```
/POST1
APLOT
!*
PATH,RT,2,120,120,
CSWPLA,23
!*
WPOFF,0,0
CSWPLA,24,1
CSCIR,24,1
PPATH,1,0,0.2587E-01,0.1E-05,0
PPATH,2,0,0.2585E-01,-0.1E-05,0
PMAP,'UNI '
/PBC,PATH,1
/REPLOT
WPCSYS,1,23
CSWPLA,23
!*
!*
PDEF,BRT,B,SUM,AVG
/PBC,PATH, ,0
```

P7: Průběh magnetické indukce hlavami statorových zubů (střed)

```
/POST1
APLOT
!*
PATH,SH,2,120,120,
CSWPLA,23
!*
WPOFF,0,0
CSWPLA,24,1
CSCIR,24,1
PPATH,1,0,0.32662607E-01,0.1E-05,0
PPATH,2,0,0.32662605E-01,-0.1E-05,0
PMAP,'UNI '
/PBC,PATH,1
/REPLOT
WPCSYS,1,23
CSWPLA,23
!*
!*
PDEF,BSH,B,SUM,AVG
/PBC,PATH, ,0
```

P8: Průběh magnetické indukce statorovými zuby (střed)

```
/POST1
APLOT
!*
PATH,ST,2,120,120,
CSWPLA,23
!*
WPOFF,0,0
CSWPLA,24,1
CSCIR,24,1
PPATH,1,0,0.3915E-01,0.1E-05,0
PPATH,2,0,0.3905E-01,-0.1E-05,0
PMAP,'UNI '
/PBC,PATH,1
/RELOT
WPCSYS,1,23
CSWPLA,23
!*
!*
PDEF,BST,B,SUM,AVG
/PBC,PATH, ,0
```

P9: Rozložení magnetické indukce v magnetickém obvodu

```
RESUME
ALLS
APLOT
ESEL,R,TYPE,,1
ESEL,U,MAT,,8
ESEL,U,MAT,,2
ESEL,U,MAT,,3
/REPLOT
EPLOT
/EFACET,1
/POST1
PLNSOL, B,SUM, 0
/PLOPTS,INFO,1
/PLOPTS,LEG1,1
/PLOPTS,LEG2,0
/PLOPTS,LEG3,1
/PLOPTS,FRAME,0
/PLOPTS,TITLE,0
/PLOPTS,MINM,1
/PLOPTS,FILE,0
/PLOPTS,LOGO,0
/PLOPTS,WINS,0
/PLOPTS,WP,0
/PLOPTS,DATE,0
/TRIAD,OFF
/REPLOT
!*
/CONT,1,15,0,0.2,3.0
/REPLOT
WPSTYLE,,,,,,,,,0
/VIEW,1,,1
/ANG,1
/REP,FAST
```


P11: Zobrazení magnetických siločar v magnetickém obvodu

```
/POST1
!*
/PLOPTS,INFO,0
/PLOPTS,LEG1,0
/PLOPTS,LEG2,0
/PLOPTS,LEG3,0
/PLOPTS,FRAME,0
/PLOPTS,TITLE,0
/PLOPTS,MINM,0
/PLOPTS,FILE,0
/PLOPTS,LOGO,0
/PLOPTS,WINS,0
/PLOPTS,WP,0
/PLOPTS,DATE,0
/TRIAD,ORIG
/REPLOT
!*
ALLS
APLOT
ESEL,U,MAT,,8
/AUTO,1
/REP,FAST
/DIST,1,0.729,1
/REP,FAST
/DIST,1,0.729,1
/REP,FAST

PLF2D,100,0,10,1
!*

```


P13: Výpočet elektromagnetického momentu

RESUME

/POST1

TORQC2D,0.032125,300,0, ,

P14: Discrete Fourier Transform (DFT)

```
CLC;
CLEAR;
%
% DFT IN A COMPACT IMPLEMENTATION
%
% ENTER DATA IN Y
Y=[ {PLACE FOR DISCRETE DATA FROM MEASUREMENT} ];
N=LENGTH(Y);
% COMPUTE THE MATRICES OF TRIGONOMETRIC FUNCTIONS
P=1:N/2+1;
N=1:N;
C=COS(2*PI*N*(P-1)/N);
S=SIN(2*PI*N*(P-1)/N);
% COMPUTE FOURIER COEFFICIENTS
A=2/N*Y*C;
B=2/N*Y*S;
A(N/2+1)=A(N/2+1)/2;
% RECONSTRUCT SIGNAL
PMAX={NUMBER OF FREQUENCIES USED IN INCREASING ORDER};
YNEW=A(1)/2+C(:,2:PMAX)*A(2:PMAX)+S(:,2:PMAX)*B(2:PMAX);
% PLOT DATA
SUBPLOT(1,2,1)
NN=1:1:N;
PLOT(NN,Y);
SUBPLOT(1,2,2)
PLOT(Y,'O')
% PLOT RECONSTRUCTION OVER DATA
HOLD ON
PLOT(YNEW,'R')
HOLD OFF
AABS=ABS(A);
BABS=ABS(B);
```

P15: Vstupní parametry pro výpočetní model (ANSYS)

```

/NOPR
*SET,FRM , -88.28649368916
*SET,FRMR , -1.540890000000
*SET,FSM , 57.95181618539
*SET,FSMR , 1.011450000000
*SET,IR01 , -159.2697696757
*SET,IR02 , -152.0781424027
*SET,IR03 , -133.6075750188
*SET,IR04 , -105.2279450098
*SET,IR05 , -69.04403970527
*SET,IR06 , -27.73945383124
*SET,IR07 , 15.62244043390
*SET,IR08 , 57.82568975997
*SET,IR09 , 95.74027221146
*SET,IR10 , 126.5542366556
*SET,IR11 , 147.9822523142
*SET,IR12 , 158.4351012923
*SET,IR13 , 157.1375436000
*SET,IR14 , 144.1858131553
*SET,IR15 , 120.5404805550
*SET,IR16 , 87.95521194802
*SET,IR17 , 48.84670763915
*SET,IR18 , 6.115466483508
*SET,IR19 , -37.06933084482
*SET,IR20 , -77.50486548529
*SET,IR21 , -112.1922188139
*SET,IR22 , -138.5587885183
*SET,IR23 , -154.6490867426
*SET,IRM , 159.3410207442
*SET,IS01 , 2.194724223389
*SET,IS02 , 0.9254260134687E-01
*SET,IS03 , -2.287266824736
*SET,ISM , 2.589333000000
*SET,JSR01 , -6125760.372142
*SET,JSR02 , -5849159.323179
*SET,JSR03 , -5138752.885339
*SET,JSR04 , -4047228.654224
*SET,JSR05 , -2655539.988664
*SET,JSR06 , -1066902.070432
*SET,JSR07 , 600863.0936116
*SET,JSR08 , 2224064.990768
*SET,JSR09 , 3682318.161979
*SET,JSR10 , 4867470.640601
*SET,JSR11 , 5691625.089007
*SET,JSR12 , 6093657.742012
*SET,JSR13 , 6043751.676922
*SET,JSR14 , 5545608.198279
*SET,JSR15 , 4636172.329039
*SET,JSR16 , 3382892.767231
*SET,JSR17 , 1878719.524583
*SET,JSR18 , 235210.2493657
*SET,JSR19 , -1425743.494031
*SET,JSR20 , -2980956.364819
*SET,JSR21 , -4315085.338996
*SET,JSR22 , -5329184.173781
*SET,JSR23 , -5948041.797792
*SET,JSS01 , 1897521.984805
*SET,JSS02 , 1897521.984805
*SET,JSS03 , 1977532.775553
*SET,JSS04 , 1977532.775553
*SET,JSS05 , 1977532.775553
*SET,JSS06 , 80010.79074782
*SET,JSS07 , 80010.79074782
*SET,JSS08 , 80010.79074782
*SET,JSS09 , -1897521.984805
*SET,JSS10 , -1897521.984805
*SET,JSS11 , -1897521.984805
*SET,JSS12 , -1977532.775553
*SET,JSS13 , -1977532.775553
*SET,JSS14 , -1977532.775553
*SET,JSS15 , -80010.79074782
*SET,JSS16 , -80010.79074782
*SET,JSS17 , -80010.79074782
*SET,JSS18 , 1897521.984805
*SET,NR , 1.000000000000
*SET,NS , 83.000000000000
*SET,R01 , 202.0000000000
*SET,R02 , 203.0000000000
*SET,R03 , 204.0000000000
*SET,R04 , 205.0000000000
*SET,R05 , 206.0000000000
*SET,R06 , 207.0000000000
*SET,R07 , 208.0000000000
*SET,R08 , 209.0000000000
*SET,R09 , 210.0000000000
*SET,R10 , 211.0000000000

```

```
*SET,R11 , 212.0000000000
*SET,R12 , 213.0000000000
*SET,R13 , 214.0000000000
*SET,R14 , 215.0000000000
*SET,R15 , 216.0000000000
*SET,R16 , 217.0000000000
*SET,R17 , 218.0000000000
*SET,R18 , 219.0000000000
*SET,R19 , 220.0000000000
*SET,R20 , 221.0000000000
*SET,R21 , 222.0000000000
*SET,R22 , 223.0000000000
*SET,R23 , 224.0000000000
*SET,RD , 23.0000000000
*SET,S01 , 169.0000000000
*SET,S02 , 170.0000000000
*SET,S03 , 171.0000000000
*SET,S04 , 172.0000000000
*SET,S05 , 173.0000000000
*SET,S06 , 174.0000000000
*SET,S07 , 175.0000000000
*SET,S08 , 176.0000000000
*SET,S09 , 177.0000000000
*SET,S10 , 178.0000000000
*SET,S11 , 179.0000000000
*SET,S12 , 180.0000000000
*SET,S13 , 181.0000000000
*SET,S14 , 182.0000000000
*SET,S15 , 183.0000000000
*SET,S16 , 166.0000000000
*SET,S17 , 167.0000000000
*SET,S18 , 168.0000000000
*SET,SD , 18.0000000000
*SET,SRD , 38461.53846154
*SET,SRDR , 26.0000000000
*SET,SSD , 864583.3333333
*SET,SSDR , 96.0000000000
*SET,UNR , 0.000000000000
*SET,_AYZ , 0.000000000000
*SET,_BUTTON , 0.000000000000
*SET,_CHKMSH , 0.000000000000
*SET,_CONTYP , 172.0000000000
```

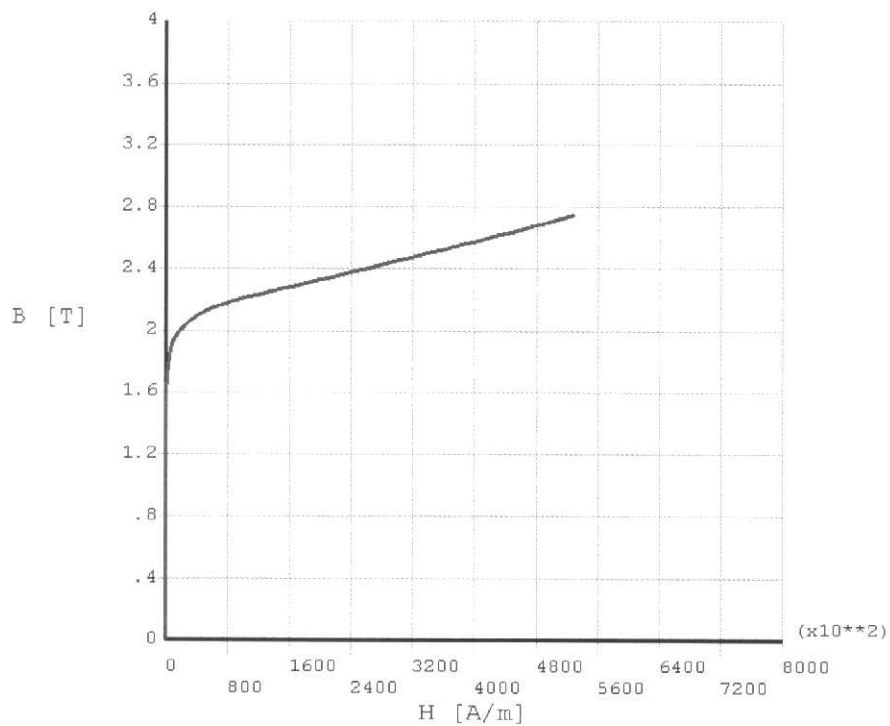
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*SET,_CS0 , 21.00000000000
*SET,_DEFAMP , -1.000000000000
*SET,_DEFCSG , -1.000000000000
*SET,_DEFLIS , -1.000000000000
*SET,_ET_NEXT , 4.000000000000
*SET,_ET_TYPE , 7.000000000000
*SET,_GUI_CLR_BG,' SYSTEMBUTTONFACE
'
*SET,_GUI_CLR_FG,' SYSTEMBUTTONTEXT
'
*SET,_GUI_CLR_INFOBG,'
SYSTEMINFOBACKGROUND '
*SET,_GUI_CLR_SEL,' SYSTEMHIGHLIGHT
'
*SET,_GUI_CLR_SELBG,'
SYSTEMHIGHLIGHT '
*SET,_GUI_CLR_SELFG,'
SYSTEMHIGHLIGHTTEXT '
*SET,_GUI_CLR_WIN,' SYSTEMWINDOW
'
*SET,_GUI_FNT_FMLY,'ARIAL
'
*SET,_GUI_FNT_PXLS, 16.00000000000
*SET,_GUI_FNT_SLNT,'R
'
*SET,_GUI_FNT_WEGT,'MEDIUM
'
*SET,_IMAT , 8.000000000000
*SET,_KDIST , 0.3225000000000E-01
*SET,_RC_SET , 3.000000000000
*SET,_RETURN , 0.000000000000
*SET,_STATUS , 1.000000000000
*SET,_UIQR , 1.000000000000
*SET,_ZX , '
'
/GO
```

P16: BH křivka materiálu M800-65A.

BH Table Preview

ANSYS OCT 21 2010
10:21:29
Table Data

T1=0.00



P17: Electrical Steel Strip

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Electrical Steel Strip

Final-Annealed Electrical Steel Strip in accordance with EN10106

Steel Grade	Rated thickness [mm]	Density [kg/dm ³]	Rated Magnetization Reversal P max.		Magnetic Polarisation J min.		
			P1.0 T [W/kg]	P1.5 T [W/kg]	J25 [T]	J50 [T]	J100 [T]
M 300-35 A	0.35	7.65	1.20	3.00	1.49	1.60	1.70
M 300-35 A	0.35	7.65	1.30	3.30	1.49	1.60	1.70
M 310-50 A	0.50	7.65	1.25	3.10	1.50	1.60	1.70
M 330-50 A	0.50	7.65	1.35	3.30	1.50	1.60	1.70
M 350-50 A	0.50	7.65	1.50	3.50	1.50	1.60	1.70
M 400-50 A	0.50	7.70	1.70	4.00	1.53	1.63	1.73
M 470-50 A	0.50	7.70	2.00	4.70	1.54	1.64	1.74
M 530-50 A	0.50	7.70	2.30	5.30	1.56	1.65	1.75
M 600-50 A	0.50	7.75	2.60	6.00	1.57	1.66	1.76
M 700-50 A	0.50	7.80	3.00	7.00	1.60	1.69	1.77
M 800-50 A	0.50	7.80	3.60	8.00	1.60	1.70	1.78
M 940-50 A	0.50	7.85	4.20	9.40	1.62	1.72	1.81
M 350-65 A	0.65	7.60	1.50	3.50	1.53	1.63	1.73
M 400-65 A	0.65	7.65	1.70	4.00	1.53	1.63	1.73
M 470-65 A	0.65	7.65	2.00	4.70	1.53	1.63	1.73
M 530-65 A	0.65	7.70	2.30	5.30	1.54	1.64	1.74
M 600-65 A	0.65	7.75	2.60	6.00	1.56	1.66	1.76
M 700-65 A	0.65	7.75	3.00	7.00	1.57	1.67	1.76
M 800-65 A	0.65	7.80	3.60	8.00	1.60	1.70	1.78
M 940-65 A	0.65	7.80	4.20	9.40	1.61	1.71	1.80
M 1000-65 A	0.65	7.80	4.40	10.00	1.61	1.71	1.80
M 1300-100 A	1.00	7.80	5.80	13.00	1.60	1.70	1.78

We can also offer two insulating coatings.

C3 type

- organic varnish - this offers good interlaminar resistance and also acts as a lubricant, which will improve the periods between grinding and also extending tool life.

C5 type

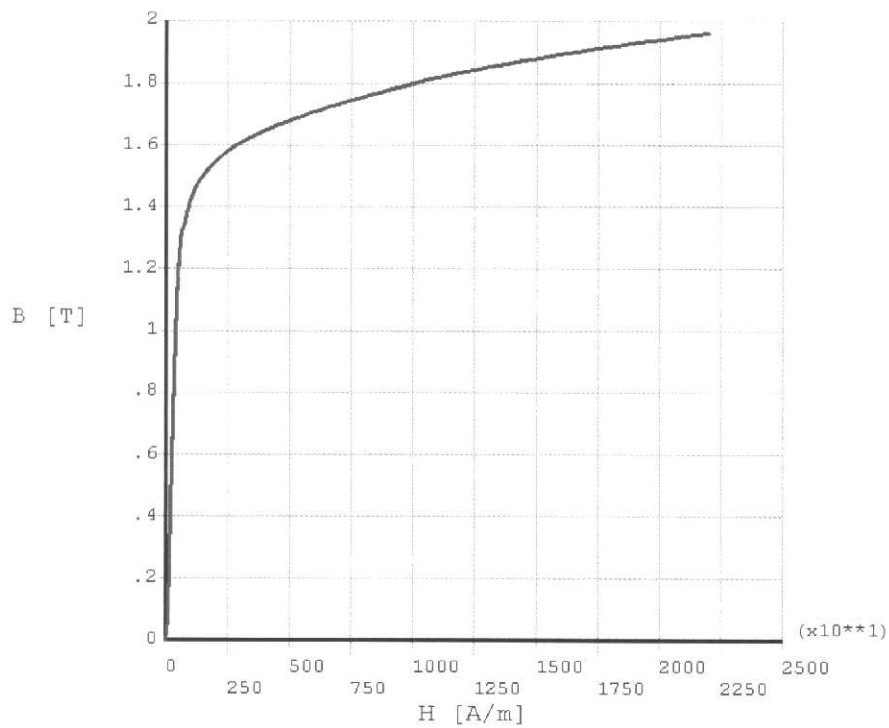
- inorganic insulation - which is more suitable for applications requiring the laminations to be welded together as it has a heat resistance quality.

P18: BH křivka materiálu ČSN 10 004.

BH Table Preview

ANSYS OCT 21 2010
10:24:01
Table Data

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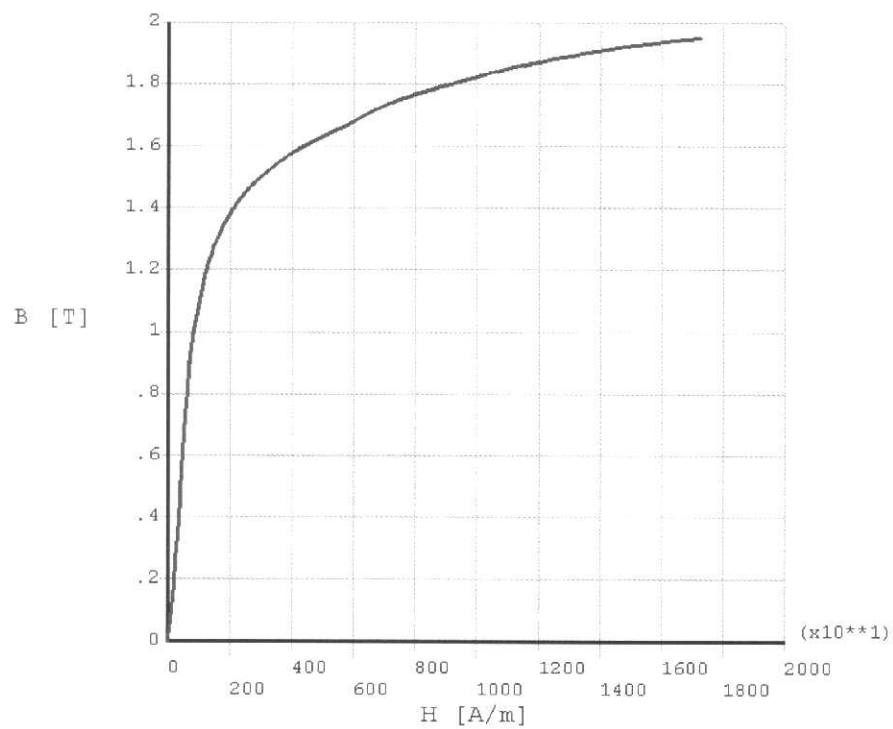


P19: BH křivka materiálu STEEL 1018.

BH Table Preview

ANSYS 12.1
OCT 21 2010
10:26:15
Table Data

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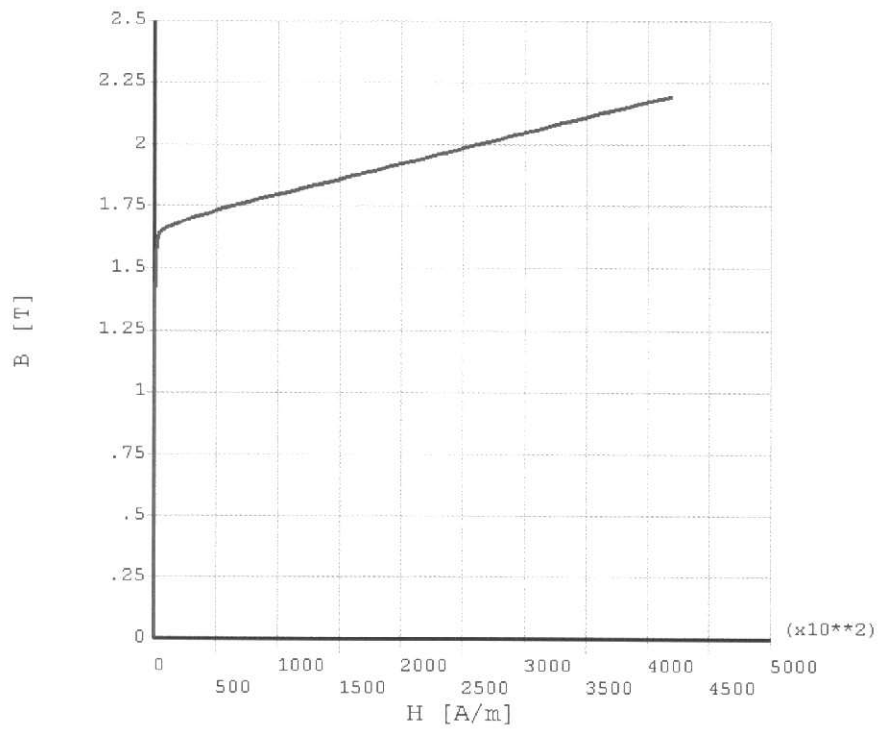


P20: BH křivka materiálu SILICON CORE IRON.

BH Table Preview

ANSYS 12.1
OCT 21 2010
10:31:23
Table Data

T1=0.00



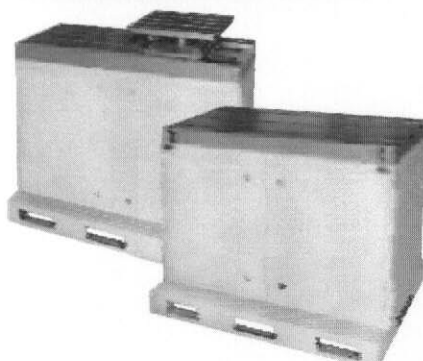
P21: Parametry dynamometru ASD 10K-2.

TYP DYNAMOMETRU			ASD 5K-4V		ASD 5K-4		ASD 6000		ASD 6,3K-4		ASD 10K-2	
HODNOTY DYNAMOMETRU			Brzda	Motor	Brzda	Motor	Brzda	Motor	Brzda	Motor	Brzda	Motor
Jmenovitý výkon	P_n	kW	5,0	4,4	5,0	4,4	7,0	6,0	6,3	5,7	11	10
Výkon v n_{max}	P_{nmax}	kW	1,3	1,0	4,0	3,4	7,0	5,0	3,0	1,9	11	10
Jmenovitý moment	M_{n1}	Nm	31,9	28,0	31,8	28,0	23,0	19,7	40,0	36,3	14,0	12,7
Moment v n_2	M_{n2}	Nm	11,9	10,5	12,0	11,4	6,7	12,9	20,0	19,4	6,6	6,0
Moment v n_{max}	M_{nmax}	Nm	1,0	0,8	7,6	6,5	6,7	4,8	4,1	2,6	6,6	6,0
Maximální moment	M_{max}	Nm	45		45		30		70		15	
Kalibrační moment	M_{kal}	Nm	35		30		25		50		15	
Jmenovité otáčky	n_1	min^{-1}	1 500	1 500	1 500	1 500	2 915	2 915	1 500	1 500	7 500	7 500
Otáčky	n_2	min^{-1}	4 000	4 000	4 000	3 690	10 000	4 447	3 000	2 800	16 000	16 000
Maximální otáčky	n_{max}	min^{-1}	12 000		5 000		10 000		7 000		16 000	
Minimální provozní otáčky	n_{min}	min^{-1}	100		100		100		50		100	
Proud naprázdno	I_0	A	5,5		4,4		8,8		6,5		8,6	
Jmenovitý proud	I_{n1}	A	11,9		9,6		19,7		12,8		20,6	
Jmenovité napětí	U_{n1}	V	275	290	350	368	226	240	350	367	350	360
Napětí v n_2	U_{n2}	V	380	380	460	460	360	360	380	380	360	360
Jmenovitá frekvence	f_{n1}	Hz	49	51	49	51	47	50	49	51	123	127
Frekvence v n_2	f_{n2}	Hz	131	136	131	125	165	75	98	96	263	271
Frekvence v n_{max}	f_{nmax}	Hz	399	402	165	169	165	168	231	235	263	271
cos ϕ	-	-	0,77		0,75		0,80		0,73		0,83	
TECHNICKÁ DATA												
Kalibrační rameno	L_C	m	1,0194		0,5098		0,5098		0,5098		0,2549	
Kalibrační hmotnost	m_{KAL}	kg	3,5		6		5		10		6	
Snímače teploty - vinutí			KTY84		KTY84		PTC		KTY84		PTC	
- AS ložisko			Pt100		Pt100		-		Pt100		Pt100	
- BS ložisko			Pt100		Pt100		-		Pt100		Pt100	
Moment setrvačnosti	J	kgm^2	0,0314		0,0314		0,008		0,036		0,0075	
Barva dynamometru			RAL5014		RAL5014		RAL5014		RAL5414		RAL5014	
Hmotnost	m	kg	270		138		160		161		102	
Snímač otáček - typ			ROD426		ROD426		ROD426		ROD426		ERO1421	
- počet pulzů			1024		1024		1024		1024		512	
Snímač síly - typ			SM50		SM100		SM100		SM100		SM25	
- jmenovitá síla	F_N	N	222		445		445		445		111	
Spojka - typ			Rotex		Rotex, Modulflex		Rotex, Modulflex		Rotex, Modulflex		Rotex, Modulflex	
MECHANICKÉ ROZMĚRY - mm												
A			INFO VERTIKÁLNÍ PŘÍKRYTÍ				370				370	
B					220				300			
C					424				410			
D		530			530		588		458			
E					274				340			
F					200				200			
G					305				305			
H					28				32			
I					60				28			

Změna technických údajů vyhrazena.

Příslušenství pohonu s dynamometrem ASD

Zatěžovací sestavy, zvedací stoly



Spojky Rotex, Modulflex

Přípravky, konzoly, příruby, ...

