ICS 27.180
F 11

GB/T 20320—2013/IEC 61400-21:2008
GB/T 20320—2006

风

Measurement and assessment of power quality characteristics of wind turbines generator systems

(IEC 61400-21:2008, Wind turbines—
Part 21: Measurement and assessment of power quality characteristics of grid connected wind turbines, IDT)

2013-12-31 2014-10-01

GB/T 1.1—2009

GB/T 20320—2006 GB/T 20320—2006 , :

— “ ” “ ” (3.8.3.2.1);

— “ ”“ ” “ ”;

— “ ” “ ” ;

— “ ” “ ” ;

— “ 10 min ” (7.1.2);

— ;

— (6.4.7.4);

— “ ” (6.5.7.5);

— (6

1

:

— ;

— ;

— , ,

a IEC 61000-4-15 (EMC) 4 : 15 :

(Electromagnetic compatibility (EMC)—Part 4 :Testing and measurement techniques—Section 15 : Flickermeter—Funct

3.5

( ) **maximum measured power (for wind turbines)**

,

3.6

network impedance phase angle

:

$$\psi_k = \arctan(X_k / R_k) \qquad \cdots\cdots (3)$$

:

X_k ——;

R_k ——

3.7

( ) **normal operation (for wind turbines)**

3.8

( ) **operational mode (for wind turbines)**

,

3.9

( ) **output power (for wind turbines)**

3.10

point of common coupling; PCC

3.11

( ) **power collection system (for wind turbines)**

3.12

( ) **rated apparent power (for wind turbines)**

:

$$S_n = \sqrt{3} U_n I_n \qquad \cdots\cdots (4)$$

:

U_n ——;

I_n ——

3.13

( ) **rated current (for wind turbines)**

3.14

( ) **rated power (for wind turbines)**

3.15

( ) **rated wind speed (for wind turbines)**

,

3.16

( ) **standstill (for wind turbines)**

3.17

( ) **start-up (for wind turbines)**

3.18

( ) **switching operation (for wind turbines)**

3.19

turbulence intensity

,

3.20

( ) **voltage change factor (for wind turbines)**

:

$$k_u(\psi_k) = \sqrt{3} \times \frac{U_{fic,max} - U_{fic,min}}{U_n} \times \frac{S_{k,fic}}{S_n} \quad \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots \quad (5)$$

:

$U_{fic,min}$ —— , ;

$U_{fic,max}$ —— , ;

U_n —— ;

S_n —— ;

$S_{k,fic}$ ——

: k_u k_i , k_u k_u k_i

3.21

wind turbine; WT

3.22

wind turbine terminals

,

4

:

$\frac{\Delta U_{dyn}}{U_n}$ (%)

ψ_k (°)

$\alpha_m(t)$ (°)

β

$c(\psi_k)$

$E_{\mathrm{Pst}i}$

f_{g} (50 Hz 60 Hz)

$f_{\mathrm{m},i}$ i

f_{over}

f_{under}

$f_{\mathrm{y},i}$ i

h

$I_{h,i}$ i h

$i_{\mathrm{m}}(t)$ (A)

I_{n} (A)

$k_{\mathrm{f}}(\psi_{\mathrm{k}})$

k_i

$k_{\mathrm{u}}(\psi_{\mathrm{k}})$

L_{fic} (H)

N_{10m} 10 min

N_{120m} 120 min

N_{bin} $v_{\text{cut-in}}$ 15 m/s

n_i i

N_{m}

$N_{\mathrm{m},i}$ i

$N_{\mathrm{m},i,c<x}$ i x

N_{wt}

P (W)

$P_{0.2}$ (0.2 s) (W)

P_{60} (60 s) (W)

P_{600} (600 s) (W)

P_{lt}

P_{n}

$P_{\mathrm{r}}(c<x)$ c

P_{st}

$P_{\mathrm{st,fic}}$

Q (var)

R_{fic} (Ω)

S_{k} (VA)

$S_{\mathrm{k,fic}}$ (VA)

S_{n} (VA)

THC (% I_{n})

T_{p} (s)

U (V)

$u_0(t)$ (V)

$u_{\mathrm{fic}}(t)$ (V)

$U_{\mathrm{fic,max}}$ (V)

$U_{\mathrm{fic,min}}$ (V)

U_n (V)
U_{under}
U_{over}
v_a (m/s)
v_{cut-in} (m/s)
v_i i
w_i i
X_{fic} (Ω)
Z_1 (Ω)
Z_2 (Ω)

5

:

A/D converter
DFT
HV
LV
MV
PCC
RMS
SCADA
THC
WT

6

6.1

, (6.2) (6.3~6.4) (6.5) (6.6~6.7) (6.8~6.9) A

,

,

6.2

( ) , P_n S_n U_n I_n

:

6.3

6.3.1

( ) 6.3.2 6.3.3

6.3.2

, v_a 6 m/s 7.5 m/s 8.5 m/s 10 m/s 4

, ψ_k 30° 50° 70° 85°

$c(\psi_k, v_a)$, 99% 10 min

( )

, , ,

$Q = 0$,

:

(6) :

$$F(v) = 1 - \exp - \frac{\pi}{}$$

,

$Q = 0$,

: ,

6 5

a) 0 1 P_n ~ 0 3 P_n b) 0 9 P_n [redacted]

1

(VD1 ~ VD6) ,

,

( ) ,

,

( )

1 (

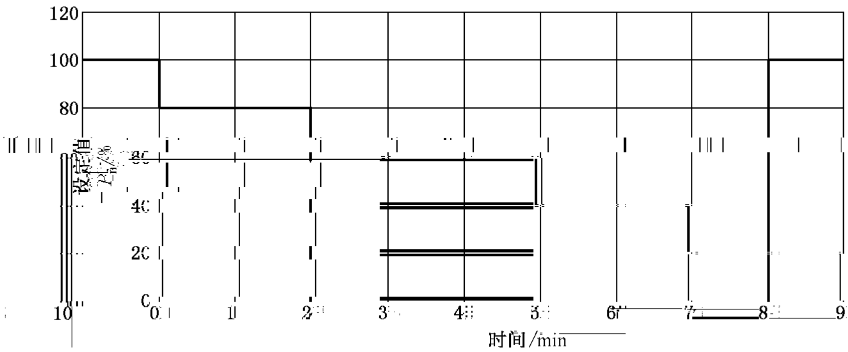
100% ，20% 2min

20% ， ， 1

0.2 s

： ，

SCADA



1

6.7

6.7.1

1 min 0% 10% … 90% 100% ，

， 1min

6.7.2

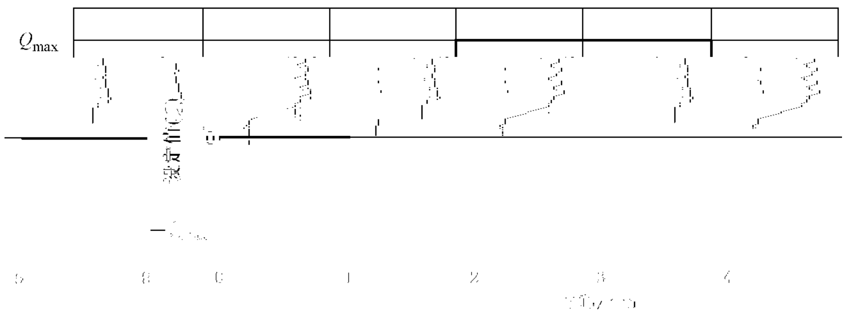
：

， 0% 10% 20% … 100%

1 min

2

50% ， 1 min 0.2 s



2

： ，

SCADA

6.8

，

*

,

/ /

6 9

,

10 s 1 min 10 min

7

7 1

7 1 7 2 ~ 7 9

, (7 2) (7 3 ~ 7 4) (7 5)

(7 6 ~ 7 7) (7 8 ~ 7 9)

15 m/s (1),

, ,

(2)

1 : 15 m/s 15 m/s ,

2 : 15 m/s , (0 2 s)

, 15 m/s

15 m/s , , 8 2 (7 3 3 5)

7 1 1

,

, † Ơ - ǂ - ņ ľ ł -

10 min 5%

0 2 s ± 1% , 0 2 s

0 2% ,

, ,

10 min ± 10%

10 min 2%

IEC 61800-3 :2004 B 3 ,

,

, (2)

, (

) / -

1 : , ,

2 : ,

7 6 1 ,

, Z

2

	1 0	IEC 60044-2
	1 0	IEC 60044-1
	± 0 5 m/s	IEC 61400-12-1 ( )
+ A/D +	1%	IEC 62008

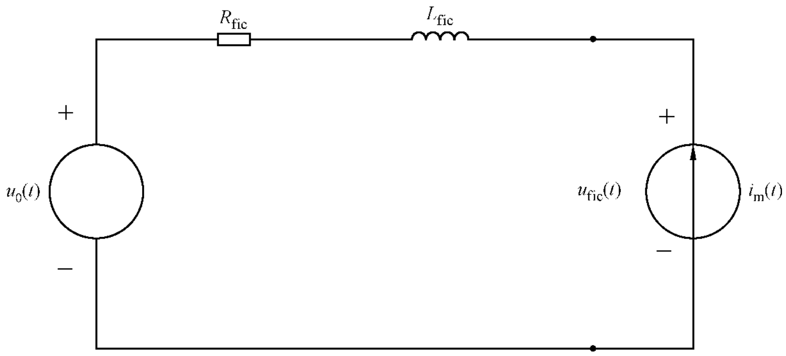
, C ⅹ Ψ Ʒ ɜ Ņ

2 kHz ( ) , 20 kHz

1 Hz

,

, 2 5



4

$u_0(t)$ R_{fic} L_{fic}

$i_m(t)$ ，$i_m(t)$ (7)，

$u_{fic}(t)$：

$$u_{fic}(t)=u_0(t)+R_{fic}\times i_m(t)+L_{fic}\times\frac{\mathrm{d}i_m(t)}{\mathrm{d}t} \quad\cdots\cdots(7)$$

$u_0(t)$ ：

a) ， ；

b) $u_0(t)$ $\alpha_m(t)$ $|u_{fic}(t)-u_0(t)|$ $|u_0(t)|$ ，

$u_{fic}(t)$ $i_m(t)$

，$u_0(t)$ ：

$$u_0(t)=\sqrt{\frac{2}{3}}\times U_n\times\sin(\alpha_m(t)) \quad\cdots\cdots(8)$$

：

U_n——

：

$$\alpha_m(t)=2\pi\times\int_0^t f(t)\,\mathrm{d}t+\alpha_0 \quad\cdots\cdots(9)$$

：

$f(t)$—— ( )；

t —— ；

α_0 ——$t=0$

(10) R_{fic} L_{fic} ψ_k：

$$\tan(\psi_k)=\frac{2\pi\times f_g\times L_{fic}}{R_{fic}}=\frac{X_{fic}}{R_{fic}} \quad\cdots\cdots(10)$$

：

f_g—— (50 Hz 60 Hz)

(11) ：

$$S_{k,fic}=\frac{U_n^2}{\sqrt{R_{fic}^2+X_{fic}^2}} \quad\cdots\cdots(11)$$

P_{st} IEC 61000-4-15 ，

$S_{k,fic}/S_n$ IEC 61000-4-15 ，

， $u_{fic}(t)$

$u_0(t)$, ,

:

$N_{m,i}$ —— i ;

N_m ——

6) $v_{cut\text{-}in}$ 15 m/s 1 m/s , $f_{y,i}$ $f_{m,i}$ (15):

$$w_i = \frac{f_{y,i}}{f_{m,i}} \qquad \cdots\cdots (15)$$

, , $c(\psi_k, v_a)$ 99%

(4 5) :

7) (16):

$$P_r(c < x) = \frac{\sum_{i=1}^{N_{bin}} w_i \times N_{m,i,c<x}}{\sum_{i=1}^{N_{bin}} w_i \times N_{m,i}} \qquad \cdots\cdots (16)$$

:

$N_{m,i,c<x}$ —— i x ;

N_{bin} ——

8) 99% $P_r(c < x)$,

4)~8) B.3

IEC 61000-3-7, 12

, 2 h 12

,

1: , ,

:

$$u_1 = \frac{u_{12} - u_{31}}{3} \qquad \cdots\cdots (17)$$

$$u_2 = \frac{u_{23} - u_{12}}{3} \qquad \cdots\cdots (18)$$

$$u_3 = \frac{u_{31} - u_{23}}{3} \qquad \cdots\cdots (19)$$

:

u_1, u_2, u_3 —— ;

u_{12}, u_{31}, u_{23} ——

2: IEC 61000-4-15 $u_{fic}(t)$, 35 Hz

400 Hz, 800 Hz

$\alpha_m(t)$

3: B.4.1

4: 99%

5: 6.3.2 , v_a 6 m/s 7.5 m/s 8.5 m/s 10 m/s $c(\psi_k, v_a)$

, 15 m/s , v_a = 6 m/s

,15 m/s 99% , v_a = 7.5 m/s 8.5 m/s

10 m/s , 96% 91% 83% , $c(\psi_k, v_a)$

99% , v_a = 7.5 m/s 8.5 m/s 10 m/s ,

B.3 , v_a = 7.5 m/s 8.5 m/s

(4)

5) 15

1 : “ ” ,

1 500 Hz (7 3 3 2)

2 : IEC 61000-3-3 , B 4 2

3 : $P_{st,fic}$ T_p

4 : B 4 3

7 4

, 6 4

, 10 min

: GB/T 17626 7—2008 5 6

7 5

1 , 6 5

,

10 min

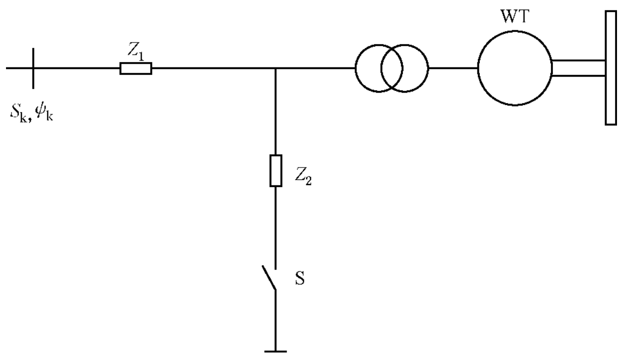
(50 Hz 60 Hz)

(C)

a) 0 1P_n ~ 0 3P_n b) 0 9P_n

5 ,

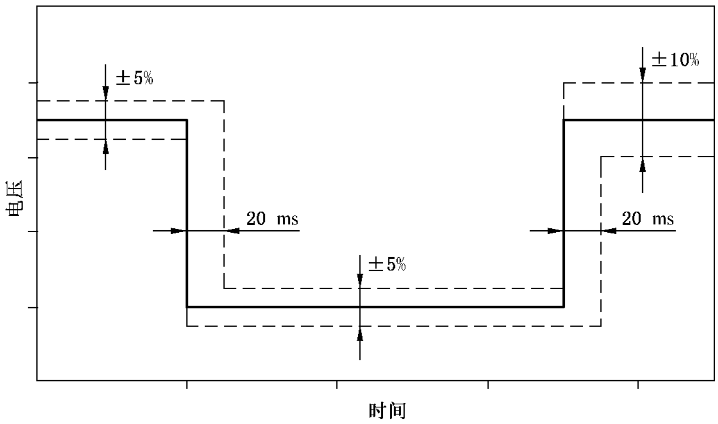
,



5 ( )

Z_1 ,

, - ņ ∩



6

: a)0 1 P_n ~ 0 3 P_n , ( )
; b) 0 9 P_n ,

7 6

7 6 1

6 6 1 , 10 min P_{600} 1 min P_{60} 0 2 s $P_{0 2}$,
:

—— ;

—— ;

—— 15 m/s , 1 m/s 5 10 min ;

——

7.6.3

6.6.3 ,
:
—— 10 min;
—— , ;
—— 1 , 100% 20% ,
2 min;
—— , 90%;
—— ;
—— 0.2 s
3 , 2
1 Hz
,
,

7.7

7.7.1

6.7.1
—— ,

—— ,

:
—— ;
—— ;
—— 10% , 30 1 min
;
—— 1 min , 1 min
—— 1 min , 0% 10% …
90% 100% 0% 10% … 90% 100%

3 , 2

7.7.2

6.7.2 ,
, :
—— ;
—— ;
—— 10% , 30 1 min
;
—— 1 min , 1 min ;

—— 1 min , 0% 10% ···
90% 100% ,0% 10% ··· 90% 100%

( ) ,

± 1 s

×

$$P_{st} = P_{lt} = c(\psi_k, v_a) \times \frac{S_n}{S_k} \quad \cdots\cdots (26)$$

:

$c(\psi_k, v_a)$ —— ψ_k v_a

, ;

S_n —— ;

S_k ——

ψ_k v_a , 7 3 3

, (27) :

$$P_{st\Sigma} = P_{lt\Sigma} = \frac{1}{S_k} \times \sqrt{\sum_{i=1}^{N_{wt}} \left(c_i(\psi_k, v_a) \times S_{n,i} \right)^2} \quad \cdots\cdots (27)$$

:

$c_i(\psi_k, v_a)$ —— i ;

$S_{n,i}$ —— i ;

N_{wt} ——

8 2 3

(28) (29) :

$$P_{st} = 18 \times N_{10\,m}^{0\,31} \times k_f(\psi_k) \times \frac{S_n}{S_k} \quad \cdots\cdots (28)$$

$$P_{lt} = 8 \times N_{120\,m}^{0\,31} \times k_f(\psi_k) \times \frac{S_n}{S_k} \quad \cdots\cdots (29)$$

:

$k_f(\psi_k)$ —— ψ_k (1)

ψ_k , 7 3 4

, (30)

(31) :

$$P_{st\Sigma} = \frac{18}{S_k} \times \left(\sum_{i=1}^{N_{wt}} N_{10m,i} \times \left(k_{f,i}(\psi_k) \times S_{n,i} \right)^{3\,2} \right)^{0\,31} \quad \cdots\cdots (30)$$

$$P_{lt\Sigma} = \frac{8}{S_k} \times \left(\sum_{i=1}^{N_{wt}} N_{120m,i} \times \left(k_{f,i}(\psi_k) \times S_{n,i} \right)^{3.2} \right)^{0.31} \quad \cdots\cdots (31)$$

:

$N_{10m,i}$ —— i 10 min ;

$N_{120m,i}$ —— i 2 h ;

$k_{f,i}(\psi_k)$ —— i ;

$S_{n,i}$ —— i (2)

- ņ ñ Ŏ K ľ † ÿ /

$k_u(\psi_k)$ —— ψ_k

ψ_k , 7 3 4

,

,

1： B 4 2 , 10 min 2 h (28) (29)

2： (30) (31) (28) (29) ,

, , ,

8 3

,

IEC 61000-3-6

IEC 61000-3-6 ,

(33) :

$$I_{h\Sigma} = \sqrt[\beta]{\sum_{i=1}^{N_{wt}} \left(\frac{I_{h,i}}{n_i}\right)^{\beta}} \quad \cdots\cdots (33)$$

:

N_{wt} —— ;

$I_{h\Sigma}$ —— h ;

n_i —— i ;

$I_{h,i}$ —— i h ;

β —— , 3

3 (IEC 61000-3-6)

	β
$h < 5$	1 0
$5 \leq h \leq 10$	1 4
$h > 10$	2 0

, , ,

$\beta = 1$

(33) ,

(33) ,

$\beta = 2$

A

( )

,

,

,

GB/T 20320 :

(/)	
/m	
/m	
(/)	
(/ /)	
/kW	
/kVA	
/kvar	
/kVA	

,	
GB/T 20320	

N_{10m}				
N_{120m}				
ψ_k / (°)	30	50	70	85
$k_f(\psi_k)$				
$k_u(\psi_k)$				

N_{10m}				
N_{120m}				
ψ_k / (°)	30	50	70	85
$k_f(\psi_k)$				
$k_u(\psi_k)$				

A.3

10 20 … 100% P_n ,

I_n

:

$Q = 0$
:

A.3.1

P_{bin} / %	0	10	20	30	40	50	60	70	80	90	100
h	I_h / %	I_h / %	I_h / %	I_h / %	I_h / %	I_h / %	I_h / %	I_h / %	I_h / %	I_h / %	I_h / %
2											
3											
4											
5											
6											
7											
8											
9											
10											
11											
12											

P_{bin} / %	0	10	20	30	40	50	60	70	80	90	100
h	I_h / %	I_h / %	I_h / %	I_h / %	I_h / %	I_h / %	I_h / %	I_h / %	I_h / %	I_h / %	I_h / %
13											
14											
15											
16											
17											
18											
19											
20											
21											
22											
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25											
26											
27											
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32											
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34											
35											
36											
37											
38											
39											
40											
41											
42											
43											
44											
45											
46											
47											
48											
49											
50											
THC/ %											

A.3.2

P_{bin}/%	0	10	20	30	40	50	60	70	80	90	100
f/Hz	I_h/%	I_h/%	I_h/%	I_h/%	I_h/%	I_h/%	I_h/%	I_h/%	I_h/%	I_h/%	I_h/%
75/90											
125/150											
175/210											
225/270											
275/330											
325/390											
375/450											
425/510											
475/570											
525/630											
575/690											
625/750											
675/810											
725/870											
775/930											
825/990											
875/1 050											
925/1 110											
975/1 170											
1 025/1 230											
1 075/1 290											
1 125/1 350											
1 175/1 410											
1 225/1 470											
1 275/1 530											
1 325/1 590											
1 375/1 650											
1 425/1 710											
1 475/1 770											
1 525/1 830											
1 575/1 890											
1 625/1 950											
1 675											
1 725											
1 775											
1 825											
1 875											
1 925											
1 975											

A 3 3

P_{bin} / %	0	10	20	30	40	50	60	70	80	90	100
f / kHz											

P

I_h

z z

A 4

:

:

A 1 (VD1 ~ VD6)

0 1P_n ~ 0 3P_n :

A 2a) (VD1 ~ VD6) ;

A 2b) (VD1 ~ VD6)

A 3a) (VD1 ~ VD6) ;

A 3b) (VD1 ~ VD6)

A 4 (VD1 ~ VD6)

0 9P_n :

A 5a) (VD1 ~ VD6) ;

A 5b) (VD1 ~ VD6)

A 6a) (VD1 ~ VD6) ;

A 6b) (VD1 ~ VD6)

A 7) ć

A.5.3

:

A.9a)

A.9b)

A.6

A.6.1

:

(/%)											
/kvar											
/kvar											

A.6.2

:

= 0 kvar:

(% P_n)											
/kvar											

:

A.10

A.11 (50%)

A.7

			/s	

A 8

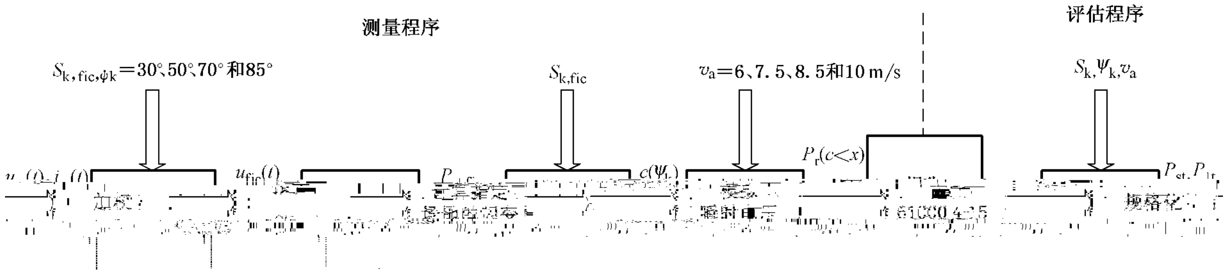
	10 s	1 min	10 min
/s			
/s			

B

( )

B.1

B 1 B 1 ,



B.1

B 1 :

1) 15 m/s $u_m(t)$ $i_m(t)$;

2) , $S_{k,fic}$ 4 ψ_k $u_{fic}(t)$;

3) $u_{fic}(t)$, IEC 61000-4-15 , $P_{st,fic}$;

4) $P_{st,fic}$ $c(\psi_k)$, $S_{k,fic}$;

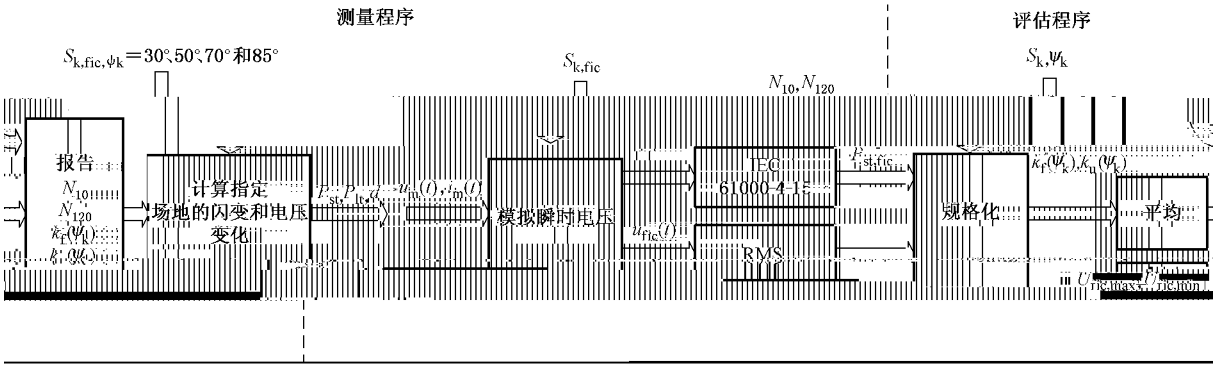
5) 4 , ψ_k , $P_r(c<x)$, $P_r(c<x)$ v_a ;

6) , $c(\psi_k, v_a)$ 99%

B.2

B 2

,



B.2

:

1) , $u_m(t)$ $i_m(t)$;

2) , $S_{k,fic}$ 4 ψ_k $u_{fic}(t)$;

3) $u_{fic}(t)$, IEC 61000-4-15 , $P_{st,fic}$; RMS , $U_{fic,max}$ $U_{fic,min}$;

4) $P_{st,fic}$ $k_f(\psi_k)$, $U_{fic,max}-U_{fic,min}$, $k_u(\psi_k)$;

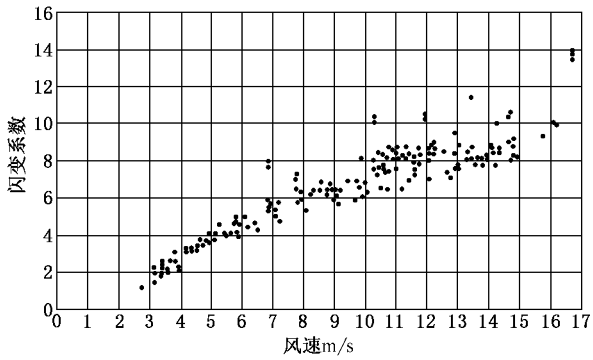
5) ψ_k , ;

6) , , 10 min N_{10m} 120 min N_{120m}

B.3

4 $c(\psi_k, v_a)$ $\psi_k = 50°$ 30° 70° 85°

B.3 $\psi_k = 50°$, $c(\psi_k)$



B.3

$c(\psi_k, v_a)$, :

—— 1 m/s $c(\psi_k)$;

—— ;

—— w_i ;

—— $P_r(c < x)$;

—— 99% , $c(\psi_k, v_a)$

, $v_{\text{cut-in}} = 3$ m/s 15 m/s

, 15 m/s

$c(\psi_k, v_a)$

B 1

$f_{m,i}$ v_a = 6 m/s 7 5 m/s 8 5 m/s 10 m/s $f_{y,i}$

B 1 15 m/s $N_{m,i}$ $f_{m,i}$ $f_{y,i}$

/ (m/s)	$N_{m,i}$	$f_{m,i}$ %	$f_{y,i}$ % (6 m/s)/%	$f_{y,i}$ (7 5 m/s)/%	$f_{y,i}$ (8 5 m/s)/%	$f_{y,i}$ (10 m/s)/%
3 ~ < 4	30	5 38	11 64	8 21	6 64	4 98
4 ~ < 5	36	6 45	12 57	9 44	7 83	6 02
5 ~ < 6	45	8 06	12 37	10 04	8 59	6 80
6 ~ < 7	33	5 91	11 26	10 04	8 91	7 32
7 ~ < 8	42	7 53	9 58	9 53	8 83	7 56
8 ~ < 9	33	5 91	7 67	8 65	8 41	7 56
9 ~ < 10	33	5 91	5 80	7 52	7 74	7 34
10 ~ < 11	69	12 37	4 15	6 29	6 88	6 93
11 ~ < 12	87	15 59	2 82	5 07	5 94	6 39
12 ~ < 13	60	10 75	1 82	3 95	4 97	5 75
13 ~ < 14	45	8 06	1 11	2 97	4 05	5 07
14 ~ < 15	45	8 06	0 65	2 16	3 21	4 37
N_m	558					

w_i $f_{y,i}$ $f_{m,i}$ B 2

w_i

B 2 w_i

/ (m/s)	w_i 6 m/s	w_i 7 5 m/s	w_i 8 5 m/s	w_i 10 m/s
3 ~ < 4	2 165	1 527	1 236	0 927
4 ~ < 5	1 949	1 464	1 214	0 933
5 ~ < 6	1 533	1 245	1 065	0 843
6 ~ < 7	1 904	1 698	1 507	1 237
7 ~ < 8	1 273	1 267	1 173	1 005

B 2 ( )

/ (m/s)	w_i 6 m/s	w_i 7 5 m/s	w_i 8 5 m/s	w_i 10 m/s
8 ~ < 9	1 297	1 462	1 423	1 278
9 ~ < 10	0 980	1 272	1 308	1 241
10 ~ < 11	0 335	0 509	0 557	0 561
11 ~ < 12	0 181	0 325	0 381	0 410
12 ~ < 13	0 169	0 367	0 463	0 535
13 ~ < 14	0 138	0 368	0 502	0 628
14 ~ < 15	0 081	0 267	0 398	0 542

, B 3

B 3

v_a / (m/s)	6 0	7 5	8 5	10
$\sum_{i=1}^{N_{bin}} w_i \times N_{m,i}$	454 40	467 99	457 64	424 60

, $c(\psi_k)$ B 4 , 3 m/s ~ 15 m/s
$c(\psi_k)$ $c(\psi_k)$ 100 ,
$P_r(c < 11\ 495) = 1\ 0$ B 4 ,
(B 2) (B 3)

B 4 $P_r(c < x)$

	m/s	$P_r(c < x)$ 6 m/s	$P_r(c < x)$ 7 5 m/s	$P_r(c < x)$ 8 5 m/s	$P_r(c < x)$ 10 m/s
11 495	13 4	1 000 0	1 000 0	1 000 0	1 000 0
11 379	13 4	0 999 7	0 999 2	0 998 9	0 998 5
11 298	13 4	0 999 4	0 998 4	0 997 8	0 997 0
10 584	14 6	0 999 1	0 997 6	0 996 7	0 995 6
10 472	11 9	0 998 9	0 997 1	0 995 8	0 994 3
10 444	14 6	0 998 5	0 996 4	0 995 0	0 993 3
10 418	11 9	0 998 3	0 995 8	0 994 1	0 992 0
10 418	10 3	0 997 9	0 995 1	0 993 3	0 991 1
10 364	14 6	0 997 2	0 994 0	0 992 1	0 989 8
10 308	14 6	0 997 0	0 993 5	0 991 2	0 988 5
10 286	10 3	0 996 8	0 992 9	0 990 3	0 987 2
10 280	11 9	0 996 1	0 991 8	0 989 1	0 985 9
10 104	10 3	0 995 7	0 991 1	0 988 3	0 984 9

B 4 ( )

	m/s	$P_r(c<x)$ 6 m/s	$P_r(c<x)$ 7 5 m/s	$P_r(c<x)$ 8 5 m/s	$P_r(c<x)$ 10 m/s
10 059	14 2	0 995 0	0 990 0	0 987 1	0 983 6
9 931	14 2	0 994 8	0 989 4	0 986 2	0 982 3
8 882	12 9	0 990 6	0 978 8	0 971 3	0 962 0
8 858	12 9	0 990 2	0 978 0	0 970 3	0 960 8
8 846	12 1	0 989 8	0 977 2	0 969 3	0 959 5
8 836	11 3	0 989 5	0 976 5	0 968 3	0 958 2
8 831	12 1	0 989 1	0 975 8	0 967 4	0 957 3

B 4 99% B 5 50° , 99% $c(\psi_k, v_a)$

B 5

ψ_k/(°)	30	50	70	85
v_a/(m/s)				
6 0		8 9		
7 5		10 1		
8 5		10 3		
10 0		10 4		

15 m/s , 99% ,

B 6

3 m/s~15 m/s

99% , B 6

15 m/s

99% , B 6

, ,

15 m/s , ,

B 6

v_a/(m/s)	6 0	7 5	8 5	10 0
$P_r(v<3$ m/s$)$/%	17 8	11 8	9 3	6 8
$P_r(3$ m/s$<v<15$ m/s$)$/%	81 4	83 9	82 0	76 1
$P_r(v>15$ m/s$)$/%	0 7	4 3	8 7	17 1
/%	99 2	99 2	99 2	99 2
/%	98 4	94 8	90 5	82 2
: 3 m/s~15 m/s ,				

B.4

B.4.1

$P_{st,fic}$ $S_{k,fic}$ ψ_k $P_{st,fic}$ $S_{k,fic}$,
$P_{st,fic}$ ψ_k , $c(\psi_k)$:

$$P_{st,fic} = c(\psi_k) \times \frac{S_n}{S_{k,fic}} \quad \text{…………………………… (B.1)}$$

:

S_n——

, $c(\psi_k)$:

$$c(\psi_k) = P_{st,fic} \times \frac{S_{k,fic}}{S_n} \quad \text{…………………………… (B.2)}$$

B.4.2

IEC 61000-3-3 $F = 1$
$k_f(\psi_k)$
, :

$$d_{max} = k_f(\psi_k) \times \frac{S_n}{S_{k,fic}} \times 100 \quad \text{…………………………… (B.3)}$$

:

d_{max}——

IEC 61000-3-3 , d_{max} t_f :

$$t_f = 2.3 \times d_{max}^{3.2} \quad \text{…………………………… (B.4)}$$

$P_{st,fic}$:

$$P_{st,fic} = \left(\frac{\sum t_f}{T_p}\right)^{1/3.2} \quad \text{…………………………… (B.5)}$$

T_p , t_f , :

$$P_{st,fic} = 100 \times k_f(\psi_k) \times \frac{S_n}{S_{k,fic}} \times \left(\frac{2.3}{T_p}\right)^{1/3.2} \quad \text{…………………………… (B.6)}$$

$k_f(\psi_k)$:

$$k_f(\psi_k) = \frac{S_{k,fic}}{100 \times S_n} \times \left(\frac{T_p}{2.3}\right)^{1/3.2} \times P_{st,fic} \quad \text{…………………………… (B.7)}$$

(B.7) T_p

B.4.3

Δu , $S_{k,fic}$ ψ_k Δu
$S_{k,fic}$, Δu ψ_k , $k_u(\psi_k)$
:

$$\Delta u = k_u(\psi_k) \times \frac{S_n}{S_{k,fic}} \quad \text{…………………………… (B.8)}$$

$S_{k,fic}$, :

$$k_u(\psi_k)=\sqrt{3}\times\frac{U_{fic,max}-U_{fic,min}}{U_n}\times\frac{S_{k,fic}}{S_n} \quad \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots \text{(B9)}$$

:

$U_{fic,max}$—— $u_{fic}(t)$;

$U_{fic,min}$—— $u_{fic}(t)$

C

( )

,

:

1)

2) ,

,

3) ,

$$U_{1+} = \sqrt{\frac{3}{2}(u_{1+,\sin}^2 + u_{1+,\cos}^2)} \qquad \cdots\cdots (C10)$$

:

$$I_{P1+} = \frac{P_{1+}}{\sqrt{3}U_{1+}} \qquad \cdots\cdots (C11)$$

$$I_{Q1+} = \frac{Q_{1+}}{\sqrt{3}U_{1+}} \qquad \cdots\cdots (C12)$$

:

$$\cos\varphi_{1+} = \frac{P_{1+}}{\sqrt{P_{1+}^2 + Q_{1+}^2}} \qquad \cdots\cdots (C13)$$

,

[1] IEC 61000-3-3 Electromagnetic compatibility (EMC)—Part 3-3: Limits—Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current ≤16 A per phase and not subject to conditional connection

[2] IEC/TR 61000-3-6 Electromagnetic compatibility (EMC)—Part 3-6: Limits—Assessment of emission limits for the connection of distorting installations to MV, HV and EHV power systems

[3] IEC/TR 61000-3-7 Electromagnetic compatibility (EMC)—Part 3-7: Limits—Assessment of emission limits for the connection of fluctuating installations to MV, HV and EHV power systems—Basic EMC publication

[4] IEC 61000-4-30 Electromagnetic compatibility (EMC)—Part 4-30: Testing and measurement techniques—Power quality measurement methods

[5] IEC 61400-1 Wind turbines—Part 1: Design requirements

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