Responsible division:	Responsible unit:	Document type:	Confidentiality status:	
PPC	PPC ATVI	Technical Report	Public	BOMBARDIER
Prepared: 2013-02-11 E.Calis		Title: Data Sheet for Asynchronous Traction Motor 4 FBA 5750 C (Rev.52)	Document state: Approved	
Checked: 2013-02-15 L.Pfeil			3EJD000001-2542	
Approved: 2013-02-15 E.Moser		Calculated with: Imot 2.1.11	Revision: E (Mod,2013-10-28)	Language: en / Page: 1/ 4

Calc ID: bbtsvlsdc007-2013-6666

Project:	**Haramain Triebkopf**	Distrib.:	..... : .....
Variant:	Haramain Triebkopf		..... : .....
Project:	Haramain Triebkopf		..... : .....
Converter Type:	2-point IGBT , U_d = 2800 V		..... : .....
Connection:	star		..... : .....
Cooling:	air, forced ventilation, Q_a = 1.000 m^3/s, ΔP = 1650 Pa		..... : .....

Motor data driving		Starting Pt. 0	Saddle Pt. 1	Power Pt. 2	Type Pt. 3	Pull-Out Pt. 4	Max Pt. 5	Reference Pt. 6	Nominal Pt. 7
f_1	[Hz]	0.9	65.8	65.8	72.8	153.0	124.8	74.9	87.2
U_1 (ph.-ph.)	[V]	53	1988	1988	2183	2183	2183	2183	2183
I_1	[A]	382	383	383	348	376	354	98	343
cos φ	[1]	0.972	0.888	0.888	0.886	0.830	0.876	0.032	0.900
P_2	[kW]	0.	1122	1122	1122	1122	1122	0.	1122
T	[Nm]	5500	5500	5500	4965	2368	2898	0.	4143
T_K	[Nm]	5526	12112	12112	12025	2811	4205	11365	8492
n	[rpm]	0.	1948	1948	2158	4525	3697	2247	2587
f_2	[Hz]	0.90	0.90	0.90	0.81	2.16	1.55	0.00	0.99
s	[%]	100.00	1.37	1.37	1.12	1.41	1.24	0.00	1.13
I_μ	[A]	98	98	98	98	37	47	98	71
R_1	[Ω]	0.0428	0.0437	0.0437	0.0439	0.0475	0.0459	0.0439	0.0443
R'_r (s=0)	[Ω]	0.0440	0.0440	0.0440	0.0440	0.0435	0.0435	0.0440	0.0435
L'_σ	[mH]	1.798	1.798	1.798	1.798	1.785	1.785	1.798	1.786
L_μ	[mH]	27.468	27.468	27.468	27.468	31.653	31.652	27.468	31.288
U_d	[V]	2800	2800	2800	2800	2800	2800	2800	2800
$Z_{Vehicle}$	[kN]	200.3	200.3	200.3	180.8	86.2	105.6	0.0	150.9
$v_{Vehicle}$	[km/h]	0.0	158.1	158.1	175.1	367.2	300.0	182.3	210.0

$U_{d\,max}$ [V] = 2950	Motors / converter = 1	Motors / train = 8	D_{wheel} [mm] = 995.0	η_G [%] = 98.00
$\overline{f}_T$ [Hz] = 300	$Bogie_{comp.}$ = 1.00	$D_{wheel\ worn}$ [mm] = 950.0	ΔD_{wheel} [%] = 0.00	i_G = 1 : 2.311
f_p [Hz] = 791		$f_{1max\ worn}$ [Hz] = 130.7	$n_{o.speed\ min}$ [rpm] = 4646	p = 2
L_{kos} [mH] = 1.537		$n_{max\ worn}$ [min^{-1}] = 3872	$n_{protection}$ [rpm] =	k_w = 0.91

Speed sensor =

Number of sensors = ...per Motor

No. of teeth = ..., mounted on DE / nDE

Direction of motor rotation seen from DE = right / left

(with connection L1 L2 L3 to U1 V1 W1)

Pulse voltage = positiv / negativ (at connection A → B resp. C → D)

$T_E = L_{h1}/R'_2$ = 752 ms

Winding temperature protection

Max. allowed Temp.: ϑ_{max} [^oC] = ...– .....● $d\vartheta/dt$ [K/min]

Remarks

This document and its contents are the property of Bombardier Inc. or its subsidaries. This document contains confidential proprietary information. The reproduction, distribution, utilisation or communication of this document or any part thereof, without express authorisation is strictly prohibited. Offenders will be held liable for the payment of damages. ©2013, Bombardier Inc. or its subsidiaries. All rights reserved.

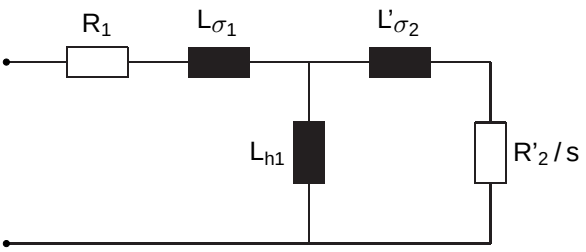
Saturation curve calculated at f_1 = 74.9 Hz (reference point)

$L_{h1} = f(\lvert\Psi\rvert)$ mit $(L_{h1} = 10^3 \cdot U_i/(2\pi f_1 \cdot I_\mu);\quad \Psi_{h1} = U_i / (2\pi f_1);\quad U_1 =$ motor voltage; $U_d =$ 2800 V$)$											
Ψ_{h1} [Vs]	0.2860	0.5721	0.8581	1.1441	1.4302	1.7162	2.0022	2.2882	**2.5743**	2.8603	3.1463
U_1 [V]	241.3	482.6	723.8	965.1	1206.4	1447.7	1689.2	1932.3	**2183.2**	2468.7	2885.3
U_i [V]	134.6	269.2	403.8	538.4	672.9	807.5	942.1	1076.7	**1211.3**	1345.9	1480.5
I_μ [A]	9.4	18.7	28.1	37.4	46.8	56.1	65.8	77.1	**97.5**	157.6	368.2
L_{h1} [mH]	30.585	30.585	30.585	30.585	30.583	30.567	30.438	29.670	**26.399**	18.144	8.546
L_μ [mH]	31.653	31.653	31.653	31.653	31.652	31.636	31.507	30.738	**27.468**	19.213	9.615
R'_r [Ω]	0.0435	0.0435	0.0435	0.0435	0.0435	0.0435	0.0435	0.0436	**0.0440**	0.0455	0.0514
L'_σ [mH]	1.785	1.785	1.785	1.785	1.785	1.785	1.785	1.788	**1.798**	1.842	2.005

Saturation curve calculated at f_1 = 87.2 Hz (nominial point)

$L_{h1} = f(\lvert\Psi\rvert)$ mit $(L_{h1} = 10^3 \cdot U_i/(2\pi f_1 \cdot I_\mu);\quad \Psi_{h1} = U_i / (2\pi f_1);\quad U_1 =$ motor voltage; $U_d =$ 2800 V$)$											
Ψ_{h1} [Vs]	0.2377	0.4754	0.7131	0.9508	1.1885	1.4262	1.6639	1.9016	**2.1393**	2.3769	2.6146
U_1 [V]	242.5	485.0	727.4	969.9	1212.4	1454.9	1697.4	1940.0	**2183.2**	2428.8	2684.0
U_i [V]	130.3	260.5	390.8	521.1	651.3	781.6	911.8	1042.1	**1172.4**	1302.6	1432.9
I_μ [A]	7.8	15.5	23.3	31.1	38.9	46.6	54.4	62.3	**70.8**	81.8	102.3
L_{h1} [mH]	30.585	30.585	30.585	30.585	30.585	30.583	30.573	30.513	**30.219**	29.064	25.555
L_μ [mH]	31.653	31.653	31.653	31.653	31.653	31.652	31.642	31.582	**31.288**	30.133	26.624
R'_r [Ω]	0.0435	0.0435	0.0435	0.0435	0.0435	0.0435	0.0435	0.0435	**0.0436**	0.0437	0.0441
L'_σ [mH]	1.785	1.785	1.785	1.785	1.785	1.785	1.785	1.785	**1.786**	1.789	1.801

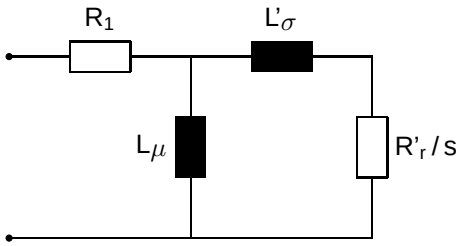
T - Equivalent circuit:



Parameter at nomial point

R_1 = 0.0443 Ω (150 °C)
R'_2 = 0.0406 Ω (150 °C)
L_{h1} = 30.219 mH
$L_{\sigma 1}$ = 1.069 mH
$L'_{\sigma 2}$ = 0.634 mH

L - Equivalent circuit:



Parameter at nomial point

R_1 = 0.0443 Ω (150 °C)
R'_r = 0.0435 Ω (150 °C)
L_μ = 31.288 mH
L'_σ = 1.786 mH

Transformation formulas

$R'_r = R'_2(1+\sigma_1)^2$	$L'_\sigma = L_\mu \frac{\sigma}{1-\sigma}$	$L_\mu = L_{\sigma 1} + L_{h1}$	$\sigma = 1 - \frac{1}{(1+\sigma_1)(1+\sigma_2)}$	$\sigma_1 = \frac{L_{\sigma 1}}{L_{h1}}$	$\sigma_2 = \frac{L'_{\sigma 2}}{L_{h1}}$

Motor data braking		Starting Pt. 0	Saddle Pt. 1	Power Pt. 2	Type Pt. 3	Pull-Out Pt. 4	Max Pt. 5
f_1	[Hz]	-0.9	64.1	64.1	74.5	176.6	121.9
U_1 (ph/ph.)	[V]	51	1884	1884	2183	2183	2183
I_1	[A]	367	360	360	314	330	310
cos φ	[1]	0.972	-0.878	-0.878	-0.873	-0.818	-0.884
P_2	[kW]	0.	-1077	-1077	-1077	-1077	-1077
T	[Nm]	-5275	-5275	-5275	-4557	-1918	-2782
T_K	[Nm]	-5301	-12903	-12903	-12750	-2224	-4704
n	[rpm]	0.	1950	1950	2257	5362	3697
f_2	[Hz]	-0.86	-0.86	-0.86	-0.74	-2.17	-1.28
s	[%]	100.00	-1.35	-1.35	-1.00	-1.23	-1.05
I_μ	[A]	98	98	98	98	32	50
R_1	[Ω]	0.0428	0.0436	0.0436	0.0439	0.0490	0.0458
R'_r (s=0)	[Ω]	0.0440	0.0440	0.0440	0.0440	0.0435	0.0435
L'_σ	[mH]	1.798	1.798	1.798	1.798	1.785	1.785
L_μ	[mH]	27.468	27.468	27.468	27.468	31.653	31.650
U_d	[V]	2800	2800	2800	2800	2800	2800
B_{Loco}	[kN]	-200.0	-200.0	-200.0	-172.8	-72.7	-105.5
v_{Loco}	[km/h]	0.0	158.2	158.2	183.1	435.2	300.0

Meaning of the symbols

U_d = Intermediate voltage

U_1 = Motor voltage (rms)

U-conv.:	star / 2-point (GTO)	$U_1 = U_d\ (\sqrt{6}\,/\,\pi)$	(phase to phase)
	star / 3-point (GTO)	$U_1 = U_d\ (\sqrt{6}\,/\,\pi) \cdot \cos(\pi\,/\,12)$	(phase to phase)
	open / 2-point (GTO)	$U_1 = U_d\ (\sqrt{8}\,/\,\pi) \cdot \cos(\pi\,/\,12)$	(phase voltage)
	star / 2-point (IGBT 0.7)	$U_1 = U_d \cdot 0.7$	(phase to phase)
	star / 2-point (IGBT)	$U_1 = U_d\ (\sqrt{6}\,/\,\pi)$	(phase to phase)
I-conv.:	star	$U_1 = U_d\ (\pi\sqrt{2}\,/\,3) \cdot (8\,/\cos\varphi)$	(phase to phase)

U_i = Internal motor voltage (rms)

I_1 = Stator current (rms)
I_μ = Magnetisation current (rms)
$\cos\varphi$ = Power factor
P_2 = Power at motorshaft
T = Torque at motorshaft
T_K = Break down torque at motor shaft
T_E = Demagnetisation time constant
s = Slip
n = Motor speed
$n_{max\ worn}$ = Max. motor speed at worn wheel
$n_{o.speed\ min}$ = Min. overspeed
$n_{protection}$ = Motor speed level for protection

R_1 = Stator winding resistance
R'_2 = Rotor winding resistance, refered to stator
R'_r = Rotor winding resistance, refered to stator
L'_σ = Leakage inductivity
L_μ = Magnetisation inductivity
L_{h1} = Main inductivity

a = Modulation ratio
L_{kos} = short circuit inductivity for current harmonics
$Bogie_{comp.}$ = Bogie compensation factor

D_{wheel} = Wheel diameter (half worn)
$D_{wheel\ worn}$ = Wheel diameter (worn)
ΔD_{wheel} = Max allowed wheel diameter difference %

f_1 = Stator frequency
$f_{1max\ worn}$ = Max. stator frequency at worn wheels
f_2 = Rotor frequency
$\overline{f_T}$ = Average cycle frequency
f_p = Pulse frequency

p = Number of pole pairs
k_w = Turns per phase
w = Winding factor
$\hat{\Phi}$ = Magn. flux per pole (peak value)
Ψ_{h1} = Magn. flux phase to phase (rms)
$\underline{\Psi}$ = Magn. flux space vector
($|\underline{\Psi}| = 3/2 \cdot \sqrt{2} \cdot U_i\,/\,(2\,\pi\,f_1)$)

i_G = Gear ratio
η_G = Gear efficiency

$Z_{Vehicle}$ = Tractive effort per Vehicle
$B_{Vehicle}$ = Braking effort per Vehicle
$v_{Vehicle}$ = Velocity