T3 – THE THREE-PHASE HV/LV TRANSFORMER

The objective of this tutorial is to become familiar with the concepts specific to the transformer.

The studied device is a three-phase HV/LV transformer with an apparent power of 1000 kVA, powered at the primary side by a HV phase voltage between of 20 kV and providing the LV network with a phase voltage of 400 V. A datasheet is provided; it gives the values necessary for the calculations.

Transformer connection

The code of the transformer connection is Dyn11.

1) **Indicate** the meaning of each character.
2) **Draw** the diagram of the transformer windings.
3) **Draw** the voltage diagram to find the hourly index.

Determination of the elements of the Kapp's secondary equivalent model

Test at no load

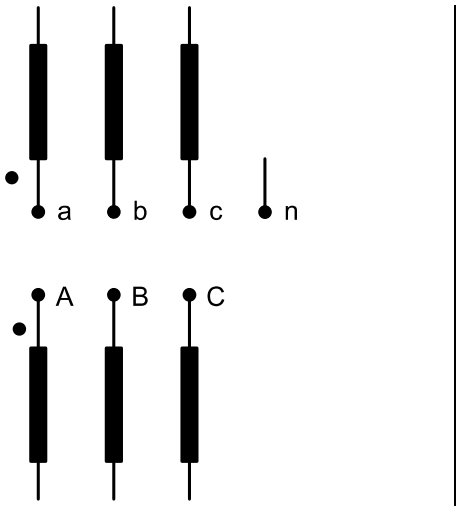
4) **Determine** in the provided datasheet the values necessary for the determination of R_F, X_M, the transformation ratio and the ratio of winding turn numbers.
5) **Calculate** the values of R_F, X_M, the transformation ratio and the ratio of winding turn numbers.

Short circuit test

6) **Determine,** in the provided datasheet, the values necessary for the calculations of R_S and X_S.
7) **Calculate** the values of R_S and X_S.

Verification of transformer parameters

8) For each of the following cases, **calculate** the transformer efficiency and the voltage drop between phase and neutral in Volts and %, and **compare** the results to the values given in the documentation :
   - 100% load and cos φ = 1
   - 75% load and cos φ = 1
   - 100% load and cos φ = 0.8
   - 75% load and cos φ = 0.8
9) **Calculate** the current at the secondary side for which the efficiency is optimal.
10) **Calculate** the voltage drop at the secondary side of the transformer for a load of 850 kW and a power factor of 0.866.



SN	Kva	160	250	400	630	800	1000	1250	1600	2000	2500	3150
U1N	V	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000
U20	V	410	410	410	410	410	410	410	410	410	410	410
P10	W	241	345	494	690	747	885	1092	1380	1667	2012	2530
P1CC	W	2585	3575	5060	7150	9240	11550	12100	15400	19800	24200	30250
U1CC%	%	4	4	4	4	6	6	6	6	6	6	6
I10%	%	0,5	0,5	0,4	0,3	0,3	0,3	0,2	0,3	0,2	0,2	0,2
Ie/In		9	9	9	9	6	7	5,5	5,9	6,5	6,5	6,5
Tps	dry	0,16	0,17	0,23	0,24	0,5	0,4	0,53	0,45	0,46	0,41	0,52
Eta/Cos(phi)=1/ load 100%	%	98,264	98,456	99,03	98,771	98,767	98,772	98,956	98,962	98,938	98,962	98,97
Eta/Cos(phi)=1/load 75%	%	98,607	98,759	99,221	99,013	99,019	99,025	99,165	99,17	99,154	99,174	99,179
Eta/Cos(phi)=0,8/ load 100%	%	97,84	98,078	98,79	98,468	98,464	98,469	98,698	98,706	98,676	98,706	98,716
Eta/Cos(phi)=0,8/ load 75%	%	98,265	98,454	99,028	98,769	98,777	98,785	98,958	98,965	98,944	98,969	98,976
I1N	Has	4,6	7,2	11,5	18,2	23,1	28,9	36,1	46,2	57,7	72,2	90,9
I2N	Has	225	352	563	887	1127	1408	1760	2253	2816	3520	4436
S10	GOES	800	1250	1600	1890	2400	3000	2500	4800	4000	5000	6300
Q10	VAR	763	1201	1522	1760	2281	2866	2249	4597	3636	4577	5770
Cos(phi10)		0,301	0,276	0,309	0,365	0,311	0,295	0,437	0,288	0,417	0,402	0,402
Tan(phi10)		3,165	3,482	3,081	2,550	3,053	3,239	2,059	3,331	2,181	2,275	2,281
RF	kOhm	4979	3478	2429	1739	1606	1356	1099	870	720	596	474
LP	kOhm	1573	999	789	682	526	419	534	261	330	262	208
m		0,0205	0,0205	0,0205	0,0205	0,0205	0,0205	0,0205	0,0205	0,0205	0,0205	0,0205
ms		0,01184	0,01184	0,01184	0,01184	0,01184	0,01184	0,01184	0,01184	0,01184	0,01184	0,01184
S1CC	GOES	6400	10000	16000	25200	48000	60000	75000	96000	120000	150000	189000
Q1CC	VAR	5855	9339	15179	24164	47102	58878	74017	94757	118355	148035	186563
RS	mOhm	16,97	9,62	5,32	3,03	2,43	1,94	1,30	1,01	0,83	0,65	0,51
XS	mOhm	38,44	25,12	15,95	10,23	12,37	9,90	7,96	6,22	4,97	3,98	3,16
Cos(phi1cc)		0,404	0,358	0,316	0,284	0,193	0,193	0,161	0,160	0,165	0,161	0,160
Tan(phi1cc)		2,265	2,612	3,000	3,380	5,098	5,098	6,117	6,153	5,978	6,117	6,167
I2CC	Has	5633	8801	14082	22179	18776	23470	29337	37551	46939	58674	73929
IOPT	Has	69	109	176	276	320	390	529	674	817	1015	1283
IOPT/I2N	%	30,53	31,07	31,25	31,07	28,43	27,68	30,04	29,93	29,02	28,83	28,92
I85%	Has	221	346	553	871	1106	1382	1728	2211	2764	3455	4354
DV2	V	7,50	7,22	6,95	6,74	9,16	9,16	8,83	8,82	8,87	8,83	8,81
DU2%	%	3,17	3,05	2,94	2,85	3,87	3,87	3,73	3,72	3,75	3,73	3,72