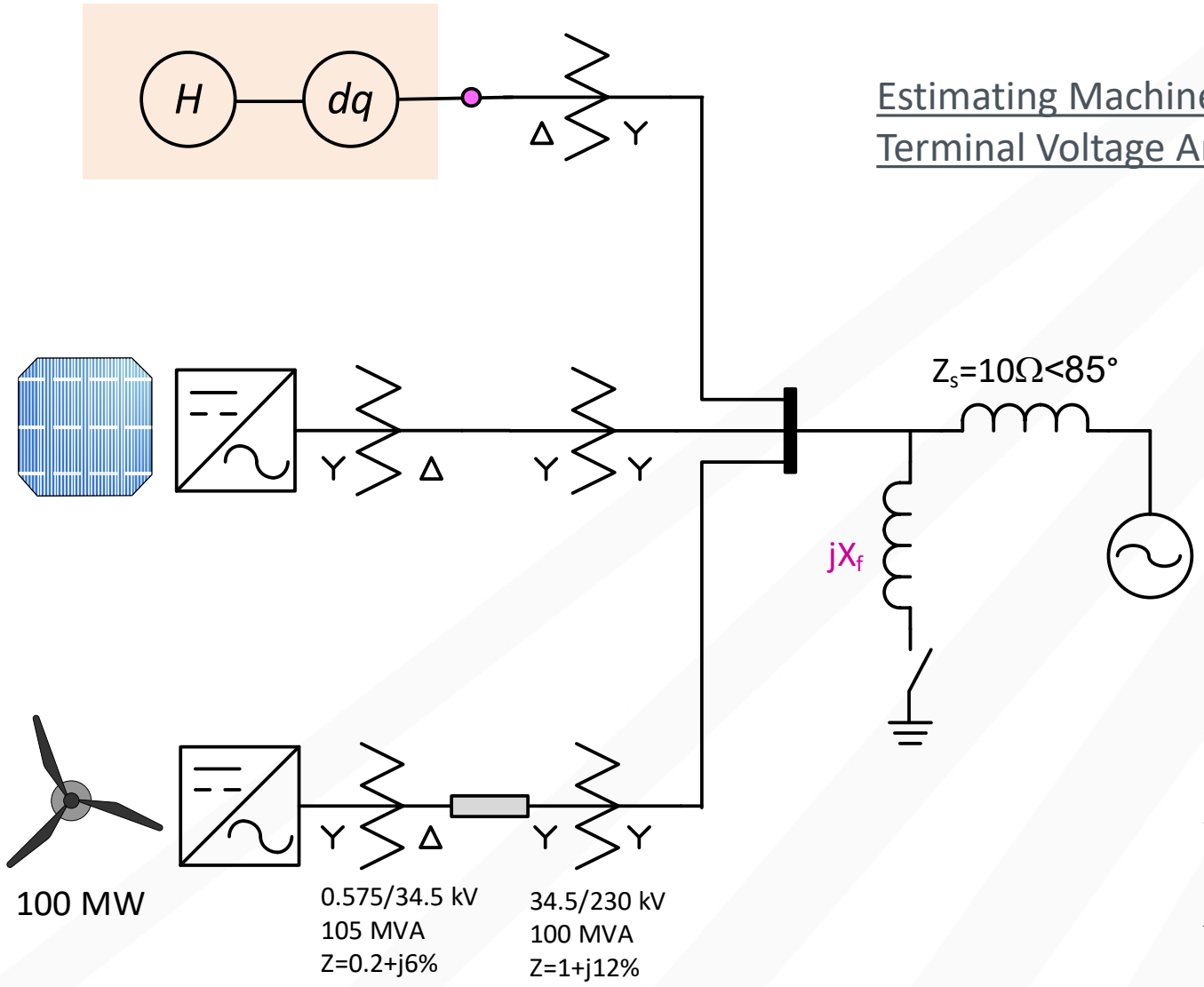
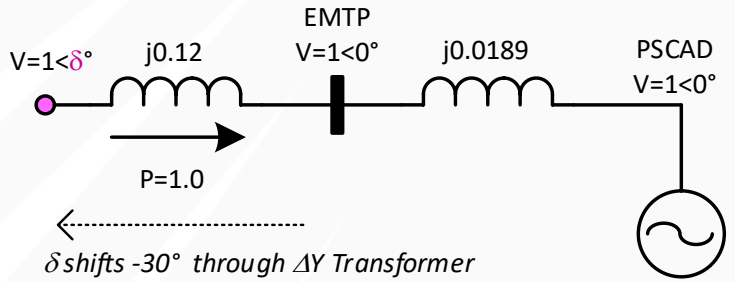
Comparing Machine and IBR Responses in EMT Simulation



Estimating Machine Terminal Voltage Angle

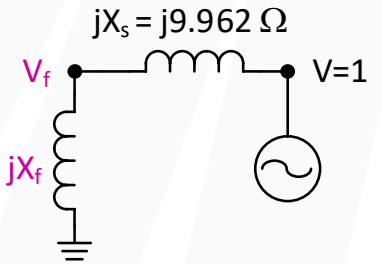


$$P = V_1 V_2 \sin\delta / X$$

$$\delta_{EMTP} = \arcsin(0.12) - 30° = -23.108°$$

$$\delta_{PSCAD} = \arcsin(0.1389) - 30° = -22.016°$$

Estimating Fault Reactance



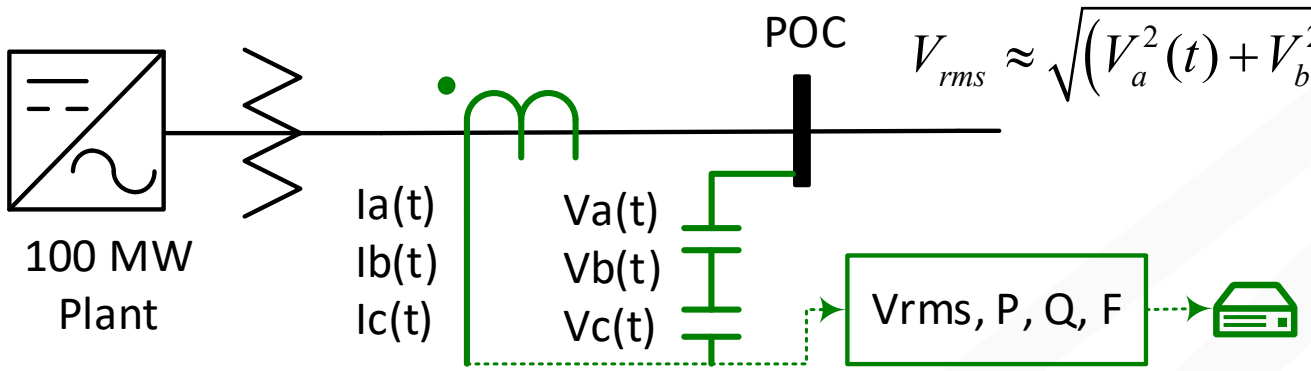
$$V_f = X_f / \left(X_f + X_s \right)$$

$$X_f = 9.962 / \left(1 - V_f \right)$$

Vf [pu]	Xf [Ω]	Lf [H]
0.01	0.1006	0.00027
0.25	3.3206	0.00881
0.50	9.9619	0.02642
0.80	39.8478	0.10570

Machine electrical parameters (R, X, T) from https://doi.org/10.1109/T-PAS.1977.32485

Instrumenting a Plant with 10-channel COMTRADE Recorder



$$V_{rms} \approx \sqrt{\left(V_a^2(t) + V_b^2(t) + V_c^2(t)\right)/3}$$

Example: conversion of EMTP COMTRADE to (PSCAD) kV

$$kV = V / primary = (Ax + B) / primary = 11.4624x / 1000$$

When x ranges ± 32767, kV ranges ± 375.6 kV

Preparing for COMTRADE C37.111-2013 primary channels with units of kV, kA, MW, Mvar, and Hz

PSCAD Index	Name	Location	PSCAD Units	EMTP Units	EMTP Min	EMTP Max	EMTP A	EMTP B	EMTP Primary	EMTP Secondary
1	VA	POC	kV	V	-375588	375588	11.46239898	0	1E+03	1
2	VB	POC	kV	V	-375588	375588	11.46239898	0	1E+03	1
3	VC	POC	kV	V	-375588	375588	11.46239898	0	1E+03	1
4	IA	Plant	kA	A	-2130	2130	0.065004153	0	1E+03	1
5	IB	Plant	kA	A	-2130	2130	0.065004153	0	1E+03	1
6	IC	Plant	kA	A	-2130	2130	0.065004153	0	1E+03	1
7	Vrms	POC	kV	V	0	265581	4.052570022	132790.6	1E+03	1
8	P	Plant	MW	W	-3E+08	3E+08	9155.552843	0	1E+06	1
9	Q	Plant	Mvar	var	-3E+08	3E+08	9155.552843	0	1E+06	1
10	F	POC	Hz	Hz	55	65	0.000152593	60	1E+00	1

Data Min	-32767
Data Max	32767
S plant	1.00E+08
V POC	2.30E+05
Ibase	251.0219
Vscale	1
Iscale	1
Sscale	1
VpuMax	2
IpuMax	6
SpuMax	3

Spreadsheet calculations in https://doi.org/10.1109/T-PAS.1977.32485

See COMTRADE standard at https://doi.org/10.1109/IEEESTD.2013.6512503 and summary at https://doi.org/10.1109/PESMG.2013.6672932