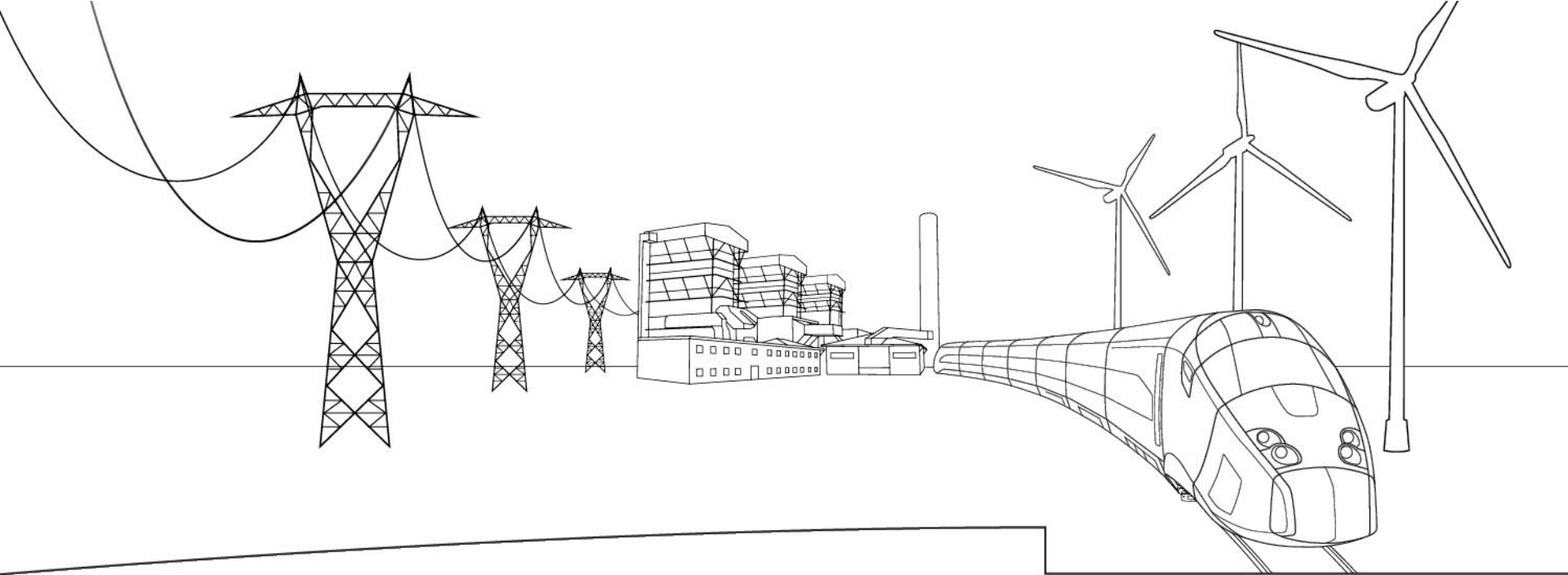




Transient Earth Fault Detection on compensated earthed systems

Sochi June 2015

HENGXU HA, hengxu.ha@alstom.com

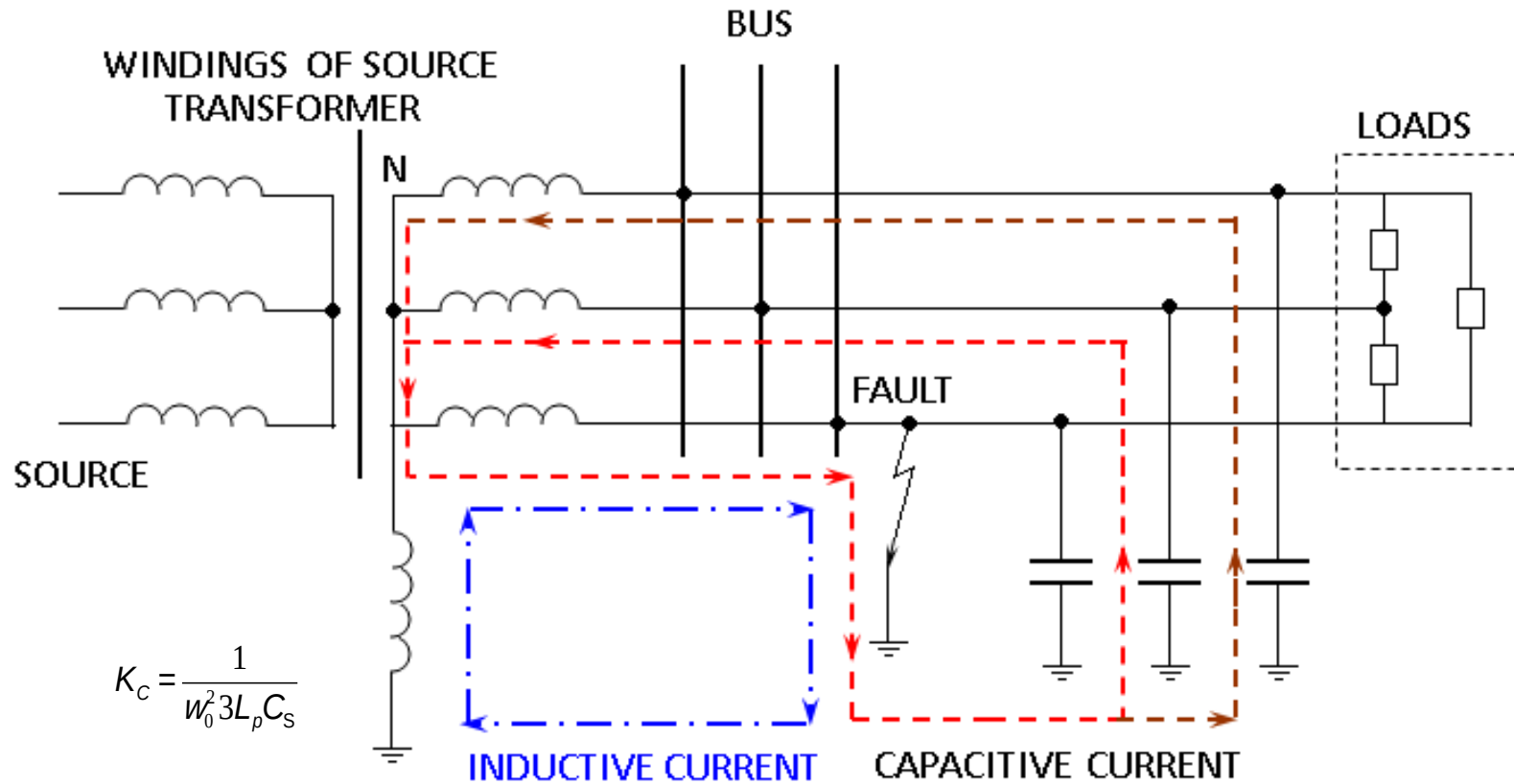
SANKARA SUBRAMANIAN, sankara.subramanian@alstom.com

KRISHNAKUMAR VENKATARAMAN, krishnakumar.venkataraman@alstom.com

ALSTOM GRID UK LTD UNITED KINGDOM

ALSTOM
Shaping the future

Problem description



Exist methods

✓ **Wattmeter**

✓ **Conductivity relay**



✓ **Poor sensitivity**

✓ **Transient high frequency components capturing**



✓ **Complex hardware**

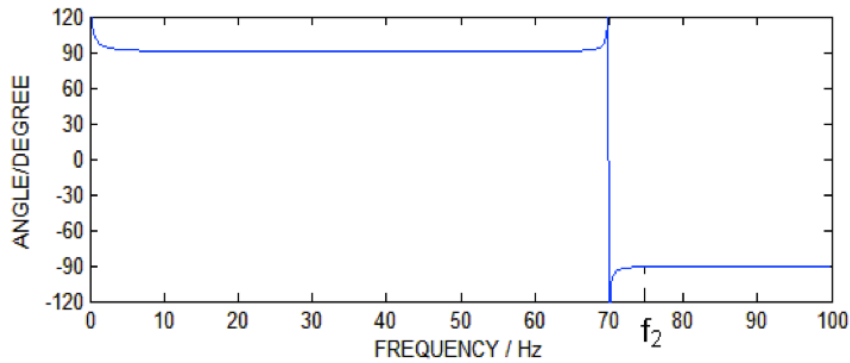
✓ **Standalone systems**



✓ **Cost**

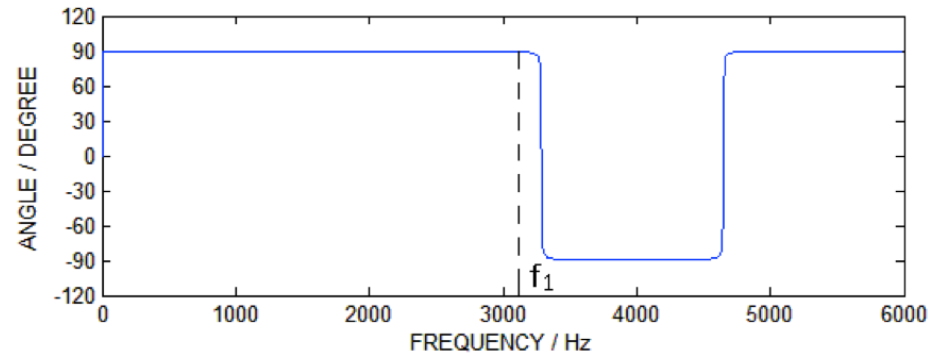
Frequency

Low border



$$w_2 > \sqrt{\frac{K_c}{(C_s - C_l)/C_s}} w_0$$

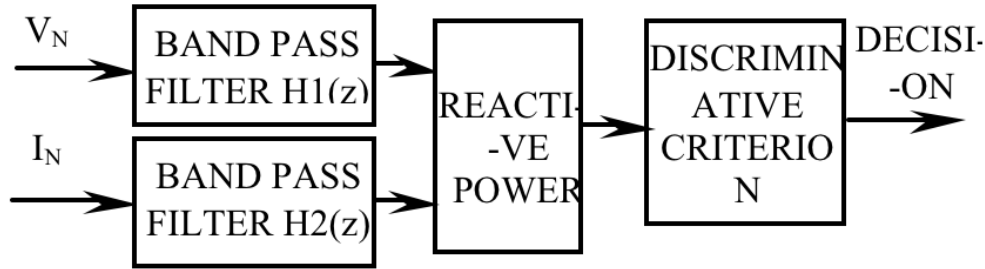
Top border



$$f_1 = \frac{1}{2p} \sqrt{2(c/d)^2 - (R/2L)^2} \gg \frac{\sqrt{2}c}{2pd}$$

220Hz is chosen

Cost-effective solution implemented in P14x Agile



$$\begin{cases} H_1(z) = \frac{(1-z)(1-z_0 z^{-1})(1-\bar{z}_0 z^{-1})}{(1-z_1 z^{-1})(1-\bar{z}_1 z^{-1})} \\ H_2(z) = \frac{(1+z)(1-z_0 z^{-1})(1-\bar{z}_0 z^{-1})}{(1-z_1 z^{-1})(1-\bar{z}_1 z^{-1})} \end{cases}$$

$$Q_{TRAN}(k) = \frac{1}{N} \sum_{n=1}^N \hat{u}(k-n+1) \hat{i}(n)$$

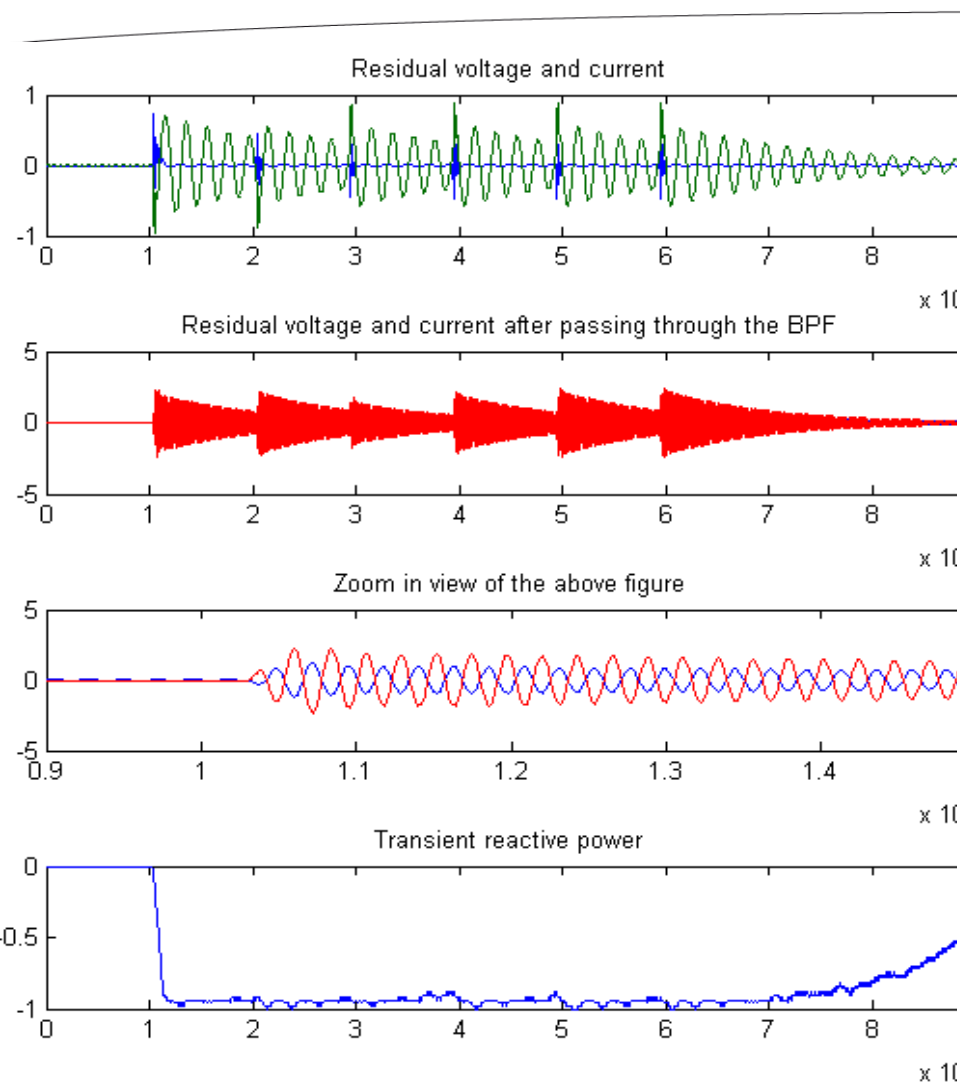
$$Q_{TRAN} < -0.1 \quad \text{Forward fault} \quad (11a)$$

$$Q_{TRAN} > 0.1 \quad \text{Reverse fault} \quad (11b)$$

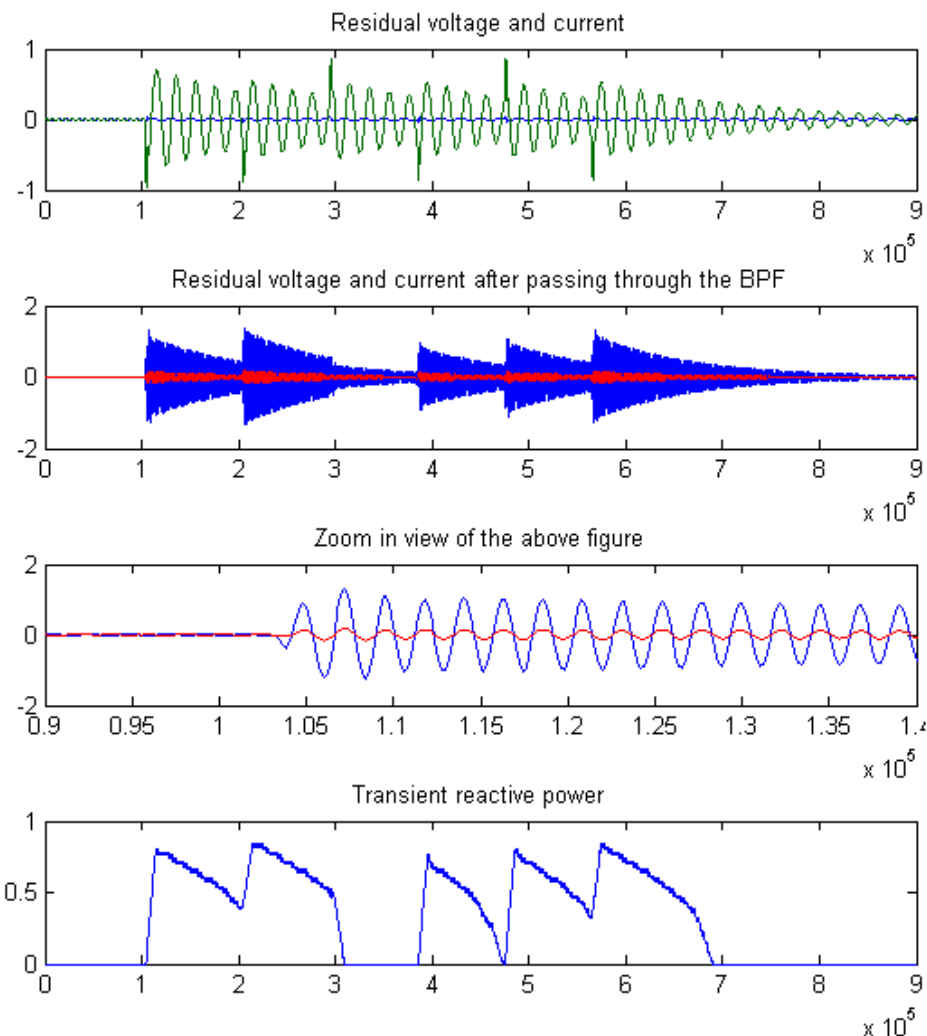
$$\text{Otherwise} \quad \text{No decision} \quad (11c)$$

Validation tests

internal fault

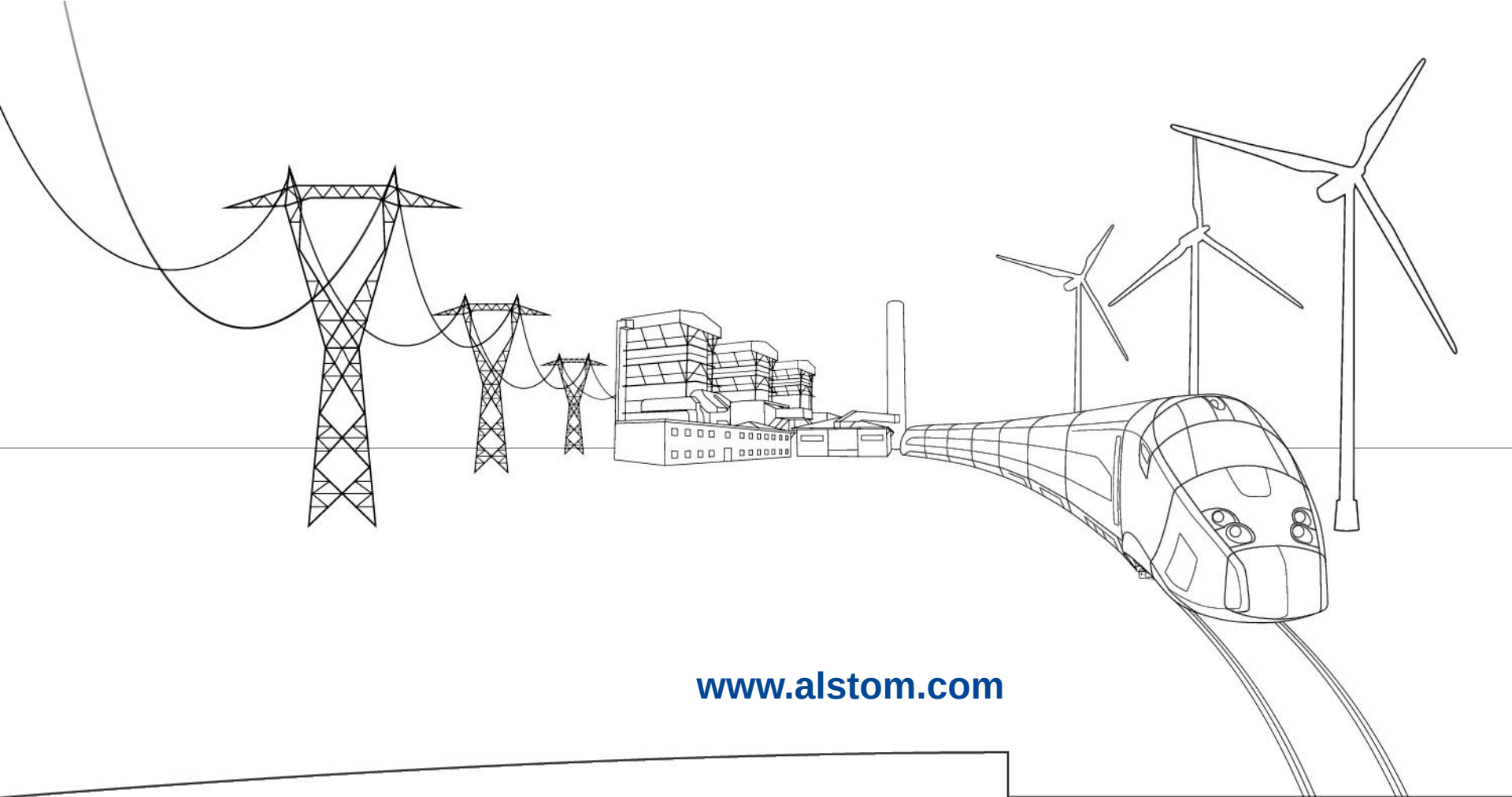


external fault



Russia qualification tests

Test	Compensation	Fault	direction	FA_TRAN	FA_STEADY	DIR_FWD	DIR_RVS	ALARM	
M_0_01	None	Direct Earth Fault (Steady)	External	N	Y	N	Y	Y	OK
M_0_02	Resonant	Direct Earth Fault (Steady)	External	N	Y	N	Y	Y	OK
M_0_03	None	Direct Earth Fault (Steady)	Internal	N	Y	Y	N	Y	OK
M_0_04	Resonant	Direct Earth Fault (Steady)	Internal	N	Y	Y	N	Y	OK
M_0_05	None	Arc Fault (Steady)	Internal	N	Y	Y	N	Y	OK
M_0_06	Resonant	Arc Fault (Trans)	Internal	Y	N	Y	N	Y	OK
M_0_07	None	Arc Fault (Steady)	External	N	Y	N	Y	Y	OK
M_0_08	Resonant	Arc Fault (Trans)	External	Y	N	N	Y	Y	OK
M_0_09	50% under compensation	Arc Fault (Steady)	External	N	Y	N	Y	Y	OK
M_0_10	50% under compensation	Arc Fault (Steady)	Internal	N	Y	Y	N	Y	OK



www.alstom.com



*With Alstom, preserve the environment.
Is printing this presentation really necessary?*

ALSTOM
Shaping the future