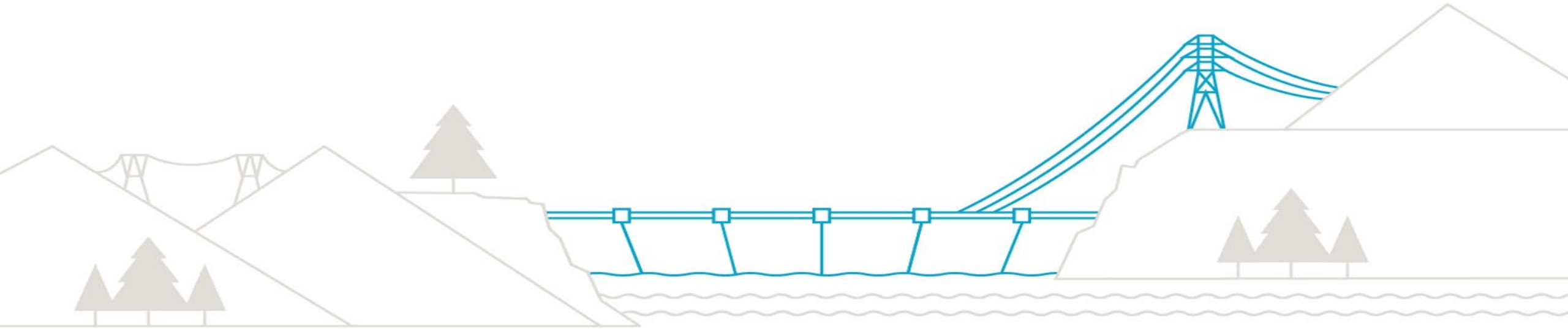

January 26, 2024

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# Outline

- Potier Reactance
- $K_{is}$ compensation in GENTPJ
- $K_w$ compensation in GENROU
- Comparative analysis

# Potier Reactance

- Based on the Potier method proposed in year 1900
- Higher value than the stator leakage reactance
- More accurate on-load field current calculation than stator leakage reactance
- Well-known and well-accepted
- Practical method to obtain from field measurements

# Potier Reactance

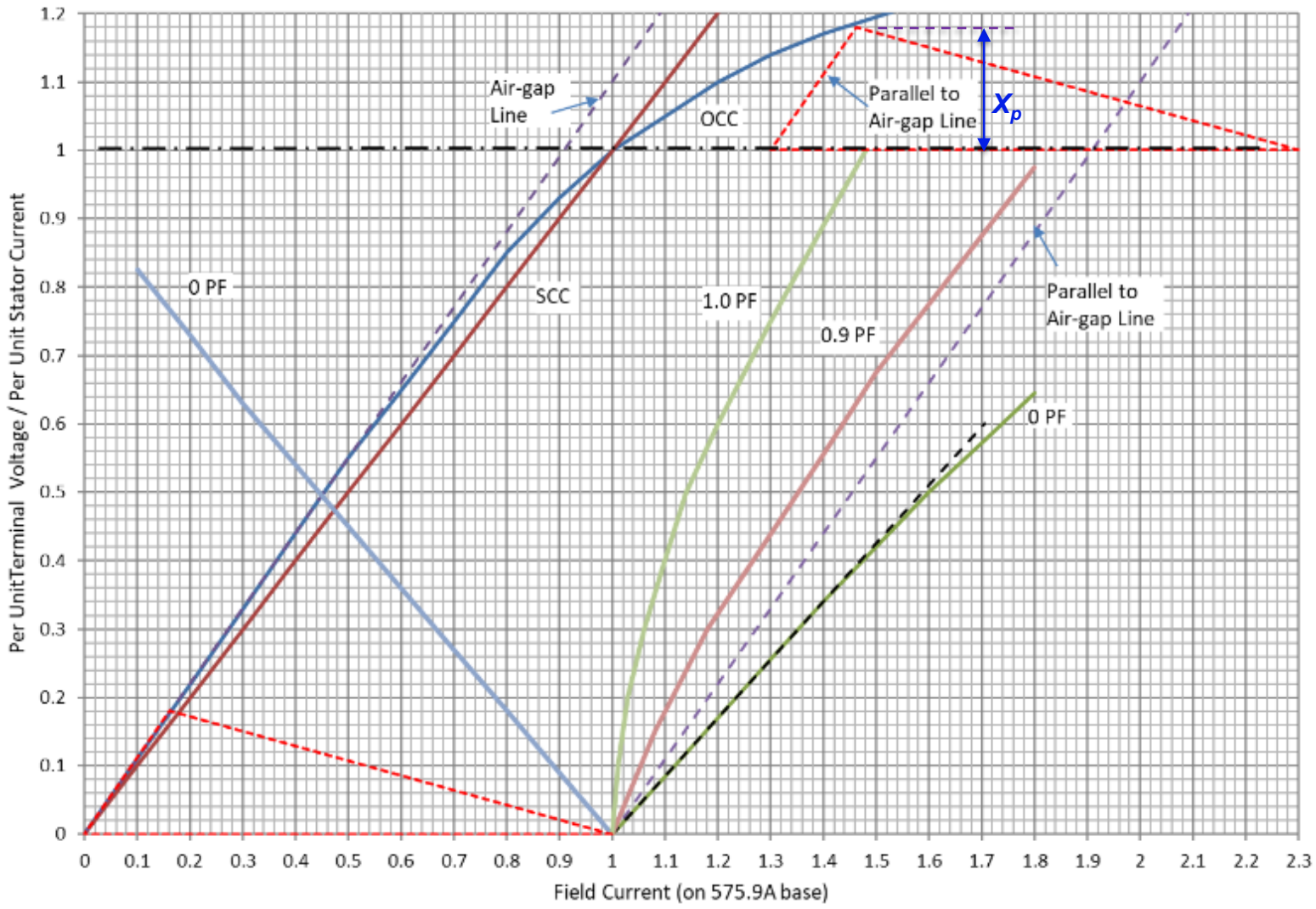
- "Reactance taking into account the leakage of the field winding, on load and in the over-excited region, which is used in place of the armature leakage reactance to calculate the excitation on load by means of the Potier method"

  – *IEC 60050, International Electrotechnical Vocabulary (IEV). 411-50-13*

- Determined from the open-circuit saturation curve and from the rated current zero-power-factor overexcited saturation curve, or from normal machine operation

  – *Section 6.2.2.1 & 6.2.2.2 of IEEE Std 115-2019*

# Potier Reactance




$$\dot{E}_l = \dot{V}_t + \dot{I}_a R_a + j\dot{I}_a X_l$$

$$S_d = f_{sat}(E_l)$$

$$X_p > X_l$$

$$\dot{E}_p = \dot{V}_t + \dot{I}_a R_a + j\dot{I}_a X_p$$
$$= \dot{E}_l + j\dot{I}_a (X_p - X_l)$$

$$S_d = f_{sat}(E_p)$$



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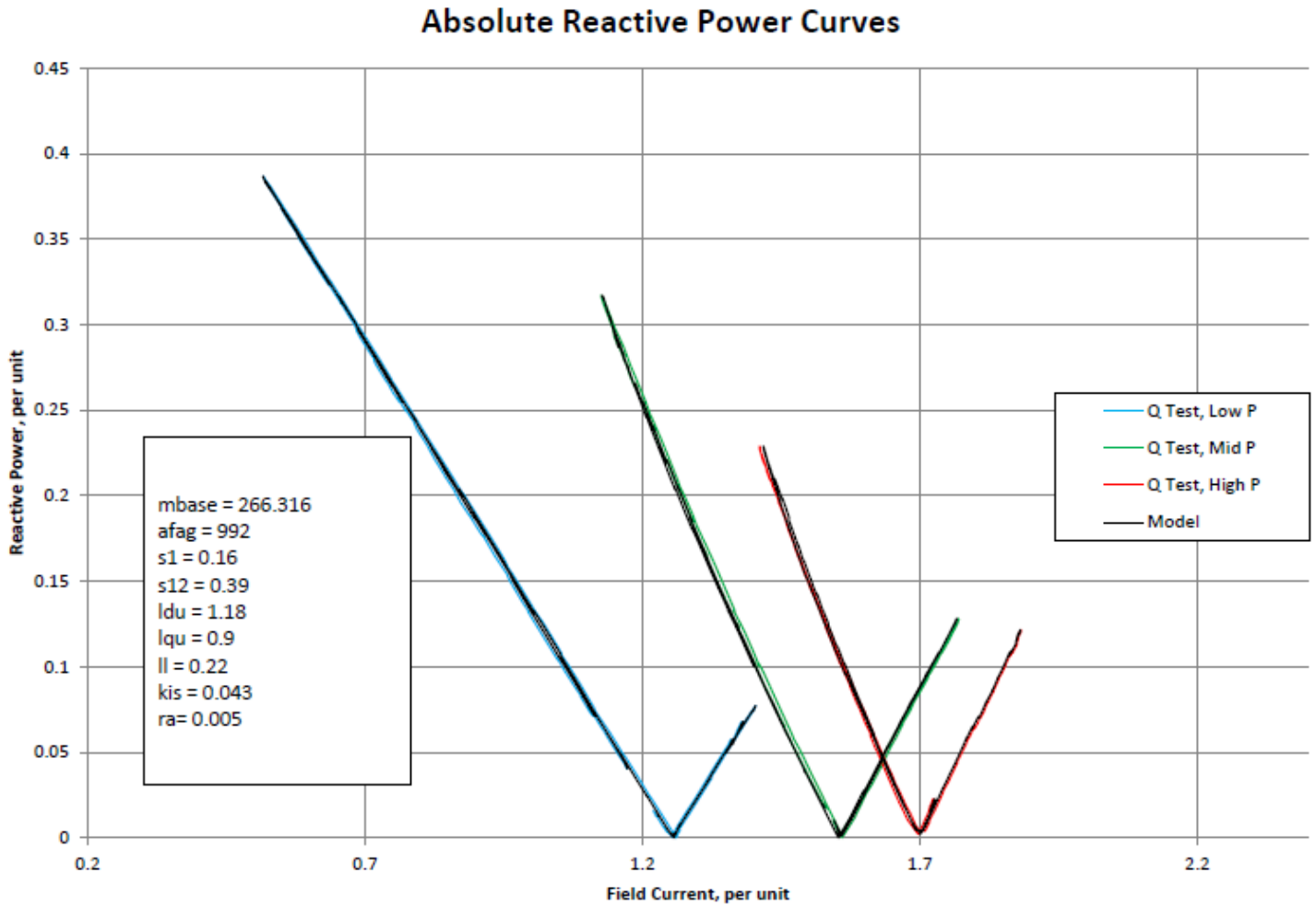
# $K_{is}$ compensation in GENTPJ




$$\dot{E}_l = \dot{V}_t + \dot{I}_a R_a + j\dot{I}_a X_l$$

$$K_{is} > 0$$

2009

$$S_d = f_{sat}(E_l + K_{is} * sign(I_d) {I_a}^2)$$

2012

$$S_d = f_{sat}(E_l + K_{is} I_a)$$

$$S_d = f_{sat}(|\dot{E}_l + j\dot{I}_a(X_p - X_l)|)$$



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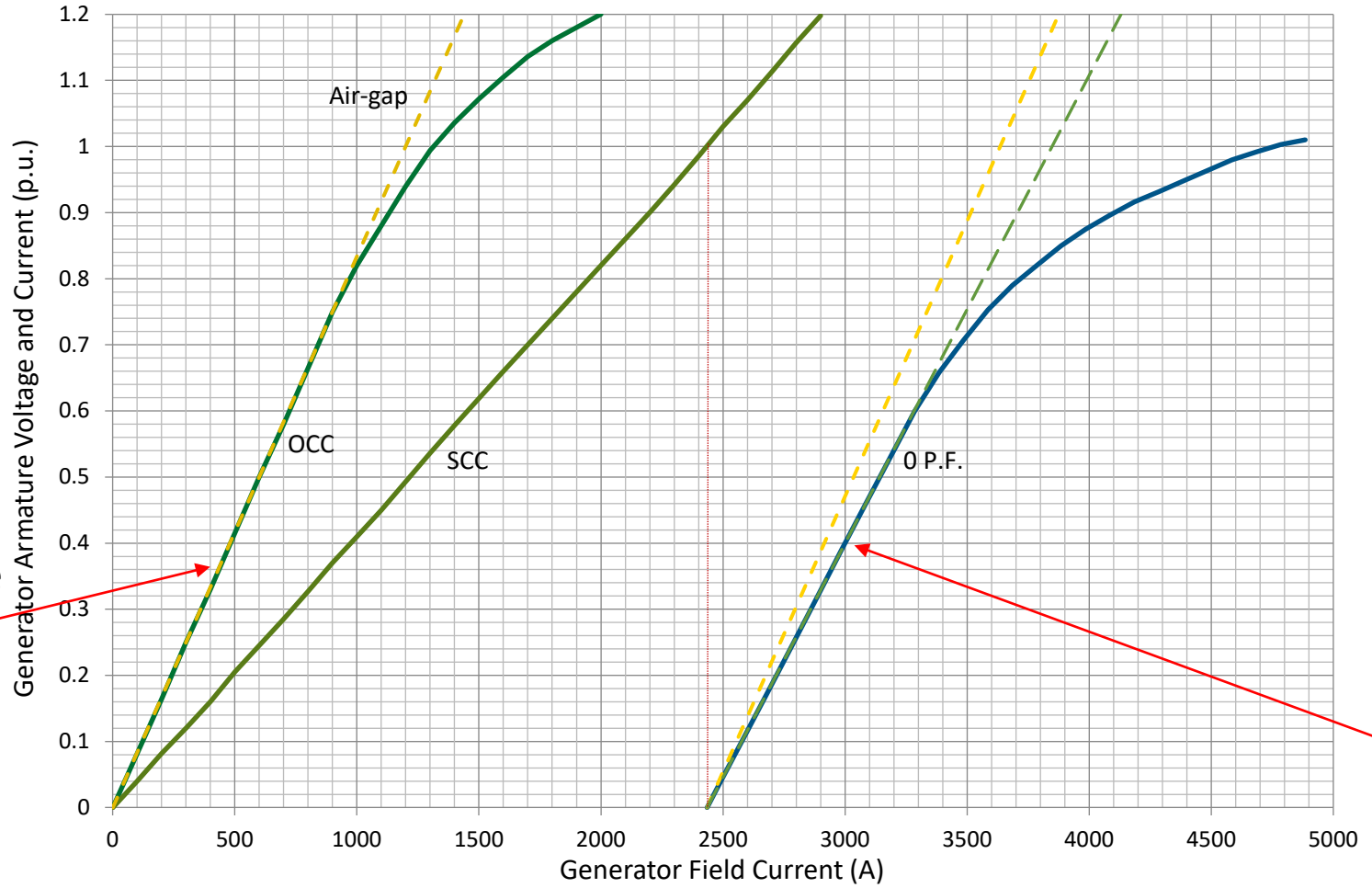
# $K_w$ Compensation in GENQEC




$$\dot{E}_l = \dot{V}_t + \dot{I}_a R_a + j\dot{I}_a X_l$$

$$S_a = f_{sat}(E_l)$$

$$K_w > 0$$

$$\frac{1 + f_{sat}(E_l)}{1 - K_w I_a}$$

Rotor to Stator mutual inductance

$L_{afd0}$

Rotor to Stator mutual inductance

$L_{afd0} - \Delta L$



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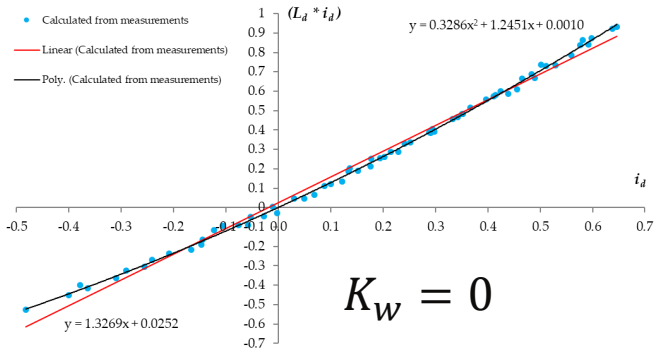
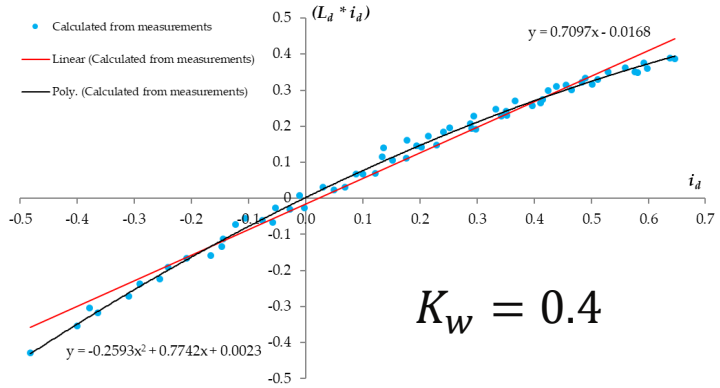
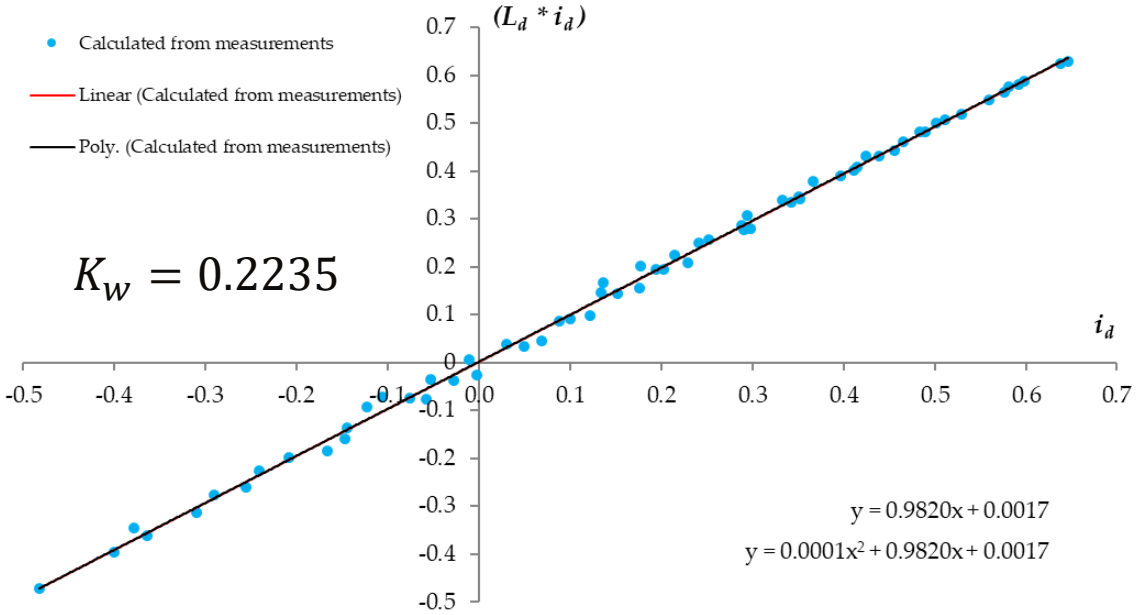
# GENQEC Field Compensation Factor $K_w$




$K_w = 0$




$K_w = 0.4$




$K_w = 0.2235$



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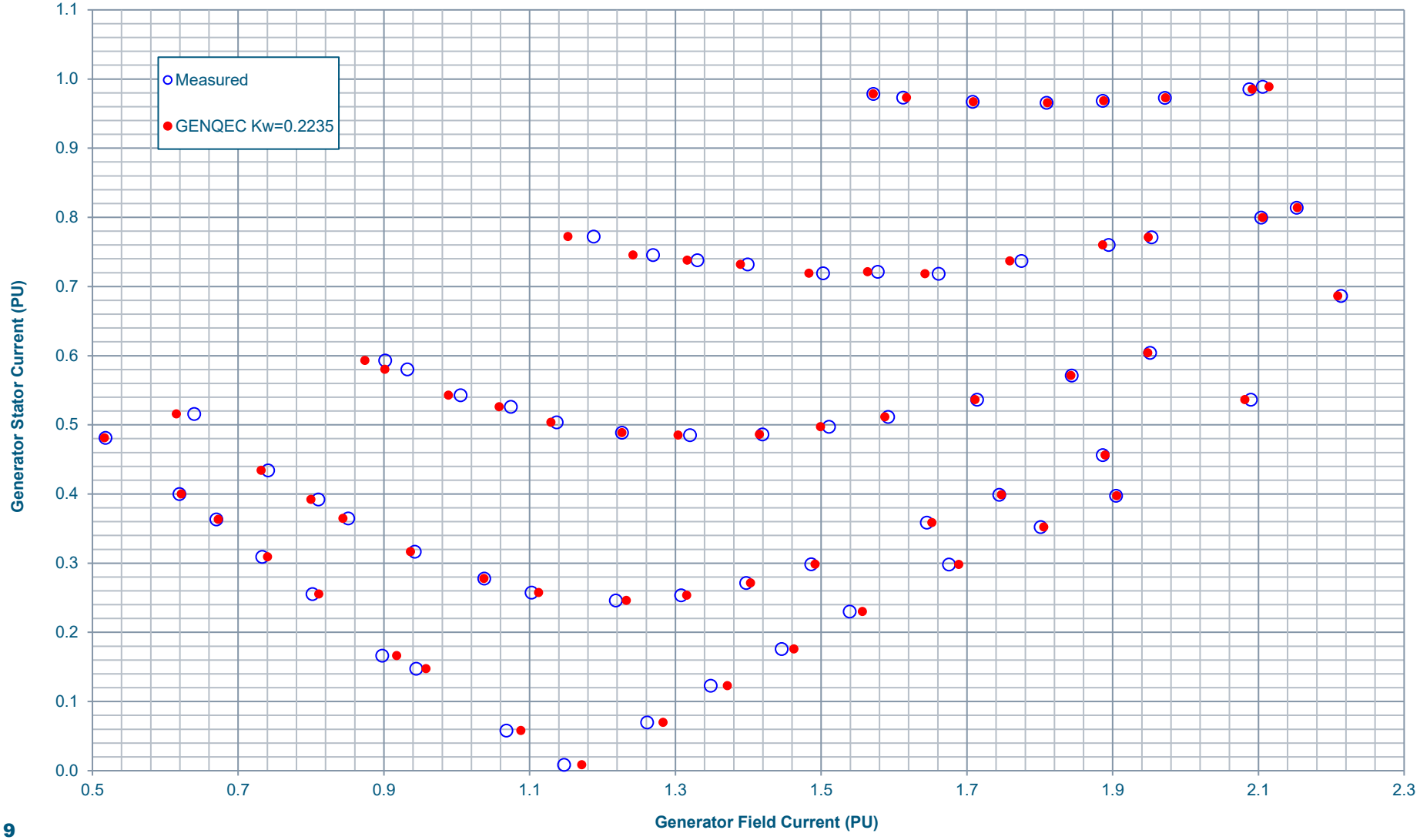
# GENQEC $K_w$ Compensation



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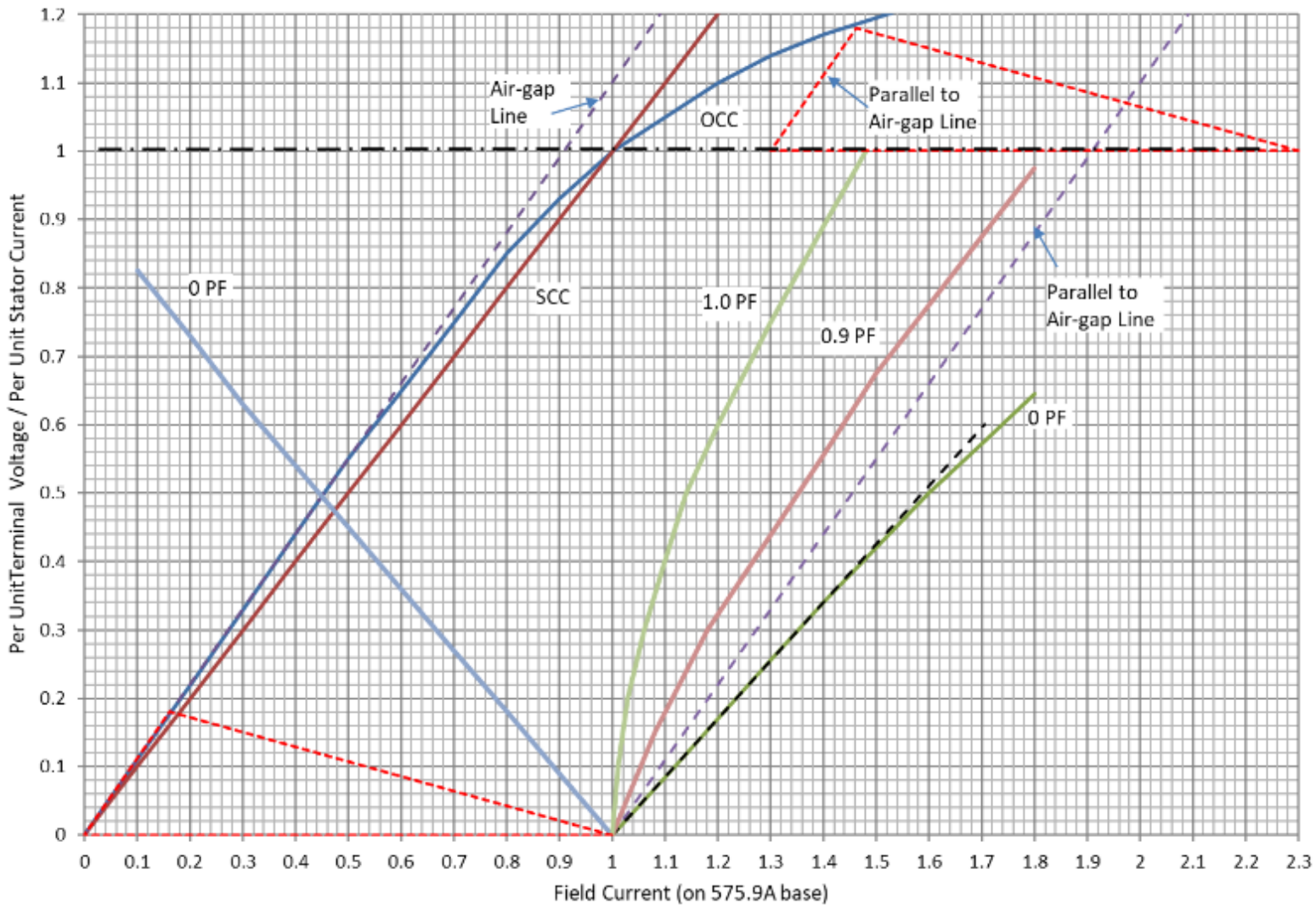
# Comparative Analysis




$$\dot{E}_l = \dot{V}_t + \dot{I}_a R_a + j\dot{I}_a X_l$$

Potier Reactance

$$f_{sat}(|\dot{E_l} + j\dot{I}_a(X_p - X_l)|)$$

GENTPJ Kis – 2009

$$f_{sat}(E_l + K_{is} * sign(I_d){I_a}^2)$$

GENTPJ Kis – 2012

$$f_{sat}(E_l + K_{is} I_a)$$

GENQEC Kw

$$\frac{1 + f_{sat}(E_l)}{1 - K_w I_a} - 1$$

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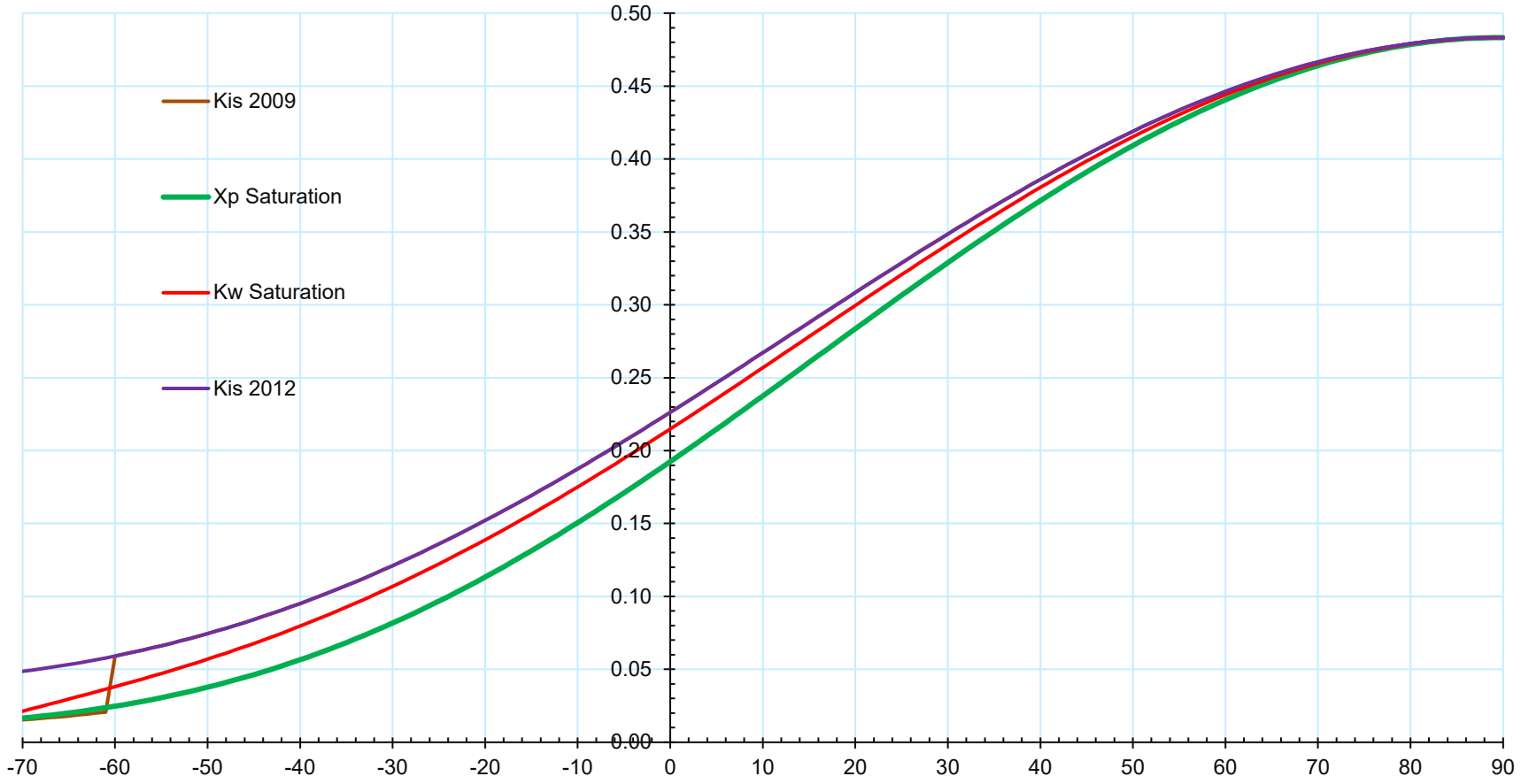
# Comparative Analysis

Effective Saturation Factor on Field Current Calculation



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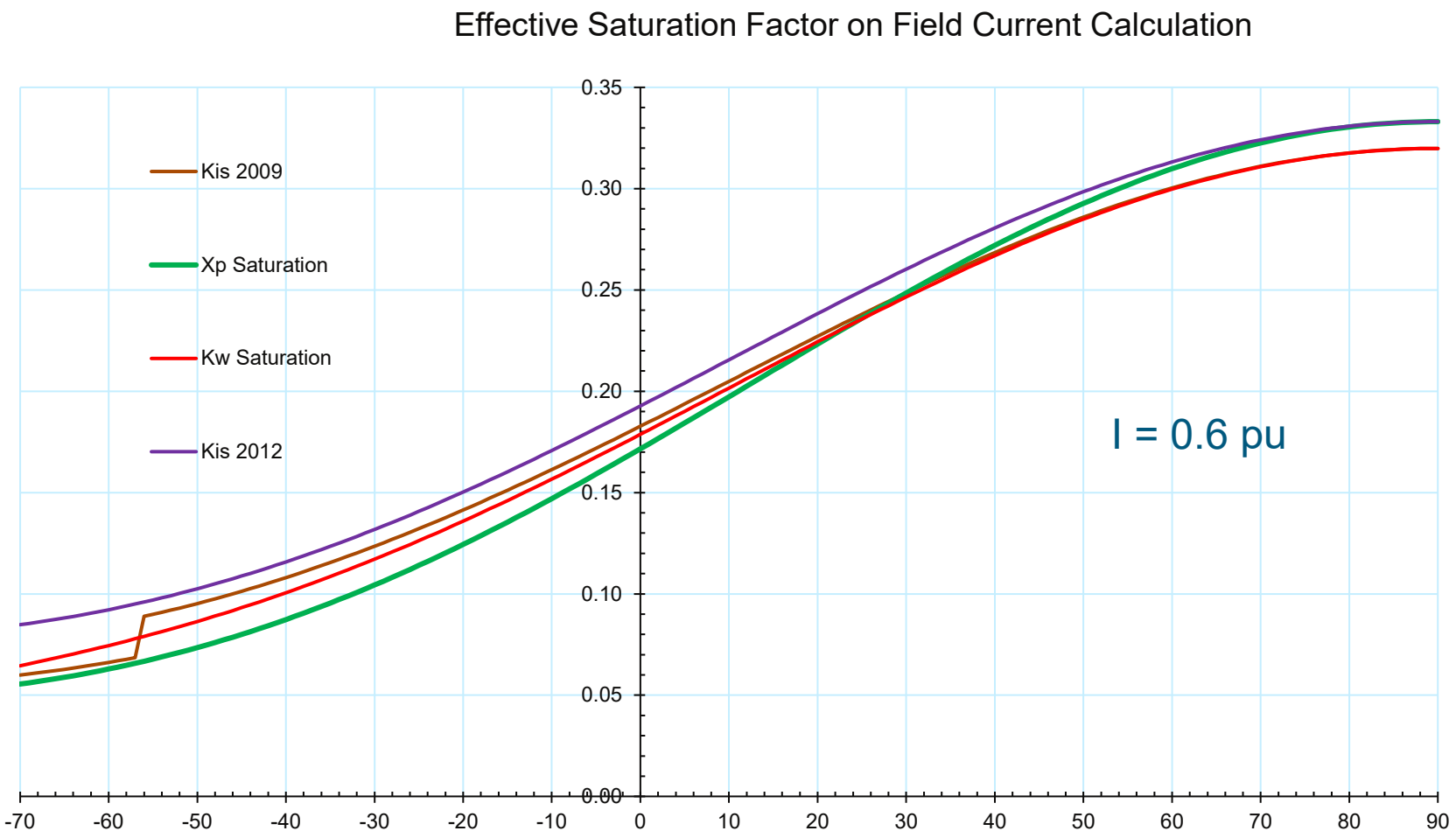
# Comparative Analysis



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# Comparative Analysis

| Ia | Kis-2009 | Kis-2012 | Kw |
|---|---|---|---|
| 1 | 4.00 | 4.52 | 2.38 |
| 0.9 | 3.17 | 4.20 | 2.02 |
| 0.8 | 2.64 | 3.86 | 1.86 |
| 0.7 | 2.27 | 3.49 | 1.74 |
| 0.6 | 1.96 | 3.09 | 1.62 |
| 0.5 | 1.67 | 2.66 | 1.47 |
| 0.4 | 1.38 | 2.20 | 1.28 |
| 0.3 | 1.08 | 1.70 | 1.04 |
| 0.2 | 0.76 | 1.17 | 0.74 |
| 0.1 | 0.40 | 0.60 | 0.40 |
| 0 | 0 | 0 | 0 |

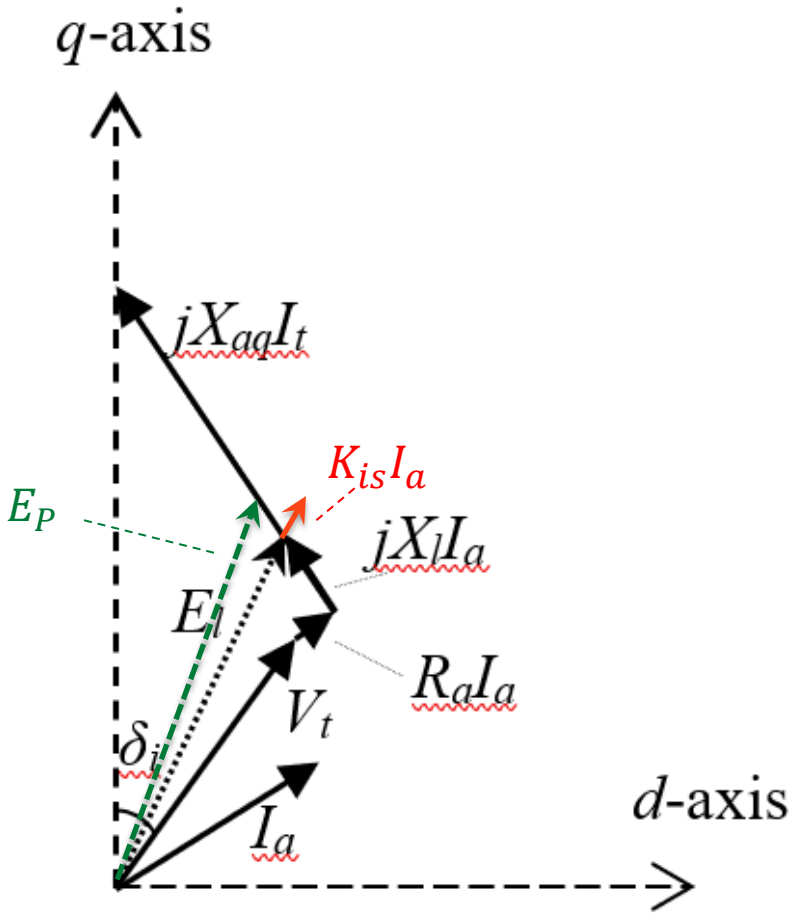
Vt=1.0 pu

| Ia | Kis-2009 | Kis-2012 | Kw |
|---|---|---|---|
| 1 | 3.53 | 3.84 | 2.25 |
| 0.9 | 2.82 | 3.58 | 1.88 |
| 0.8 | 2.36 | 3.30 | 1.71 |
| 0.7 | 2.04 | 2.99 | 1.58 |
| 0.6 | 1.76 | 2.66 | 1.46 |
| 0.5 | 1.50 | 2.29 | 1.31 |
| 0.4 | 1.24 | 1.90 | 1.14 |
| 0.3 | 0.97 | 1.48 | 0.92 |
| 0.2 | 0.67 | 1.02 | 0.66 |
| 0.1 | 0.35 | 0.53 | 0.35 |
| 0 | 0 | 0 | 0 |

Vt=0.95 pu

| Ia | Kis-2009 | Kis-2012 | Kw |
|---|---|---|---|
| 1 | 2.99 | 3.16 | 2.09 |
| 0.9 | 2.40 | 2.96 | 1.73 |
| 0.8 | 2.03 | 2.74 | 1.54 |
| 0.7 | 1.77 | 2.50 | 1.41 |
| 0.6 | 1.54 | 2.23 | 1.29 |
| 0.5 | 1.32 | 1.93 | 1.15 |
| 0.4 | 1.09 | 1.61 | 0.99 |
| 0.3 | 0.85 | 1.25 | 0.80 |
| 0.2 | 0.59 | 0.87 | 0.57 |
| 0.1 | 0.31 | 0.45 | 0.30 |
| 0 | 0 | 0 | 0 |

# Summary

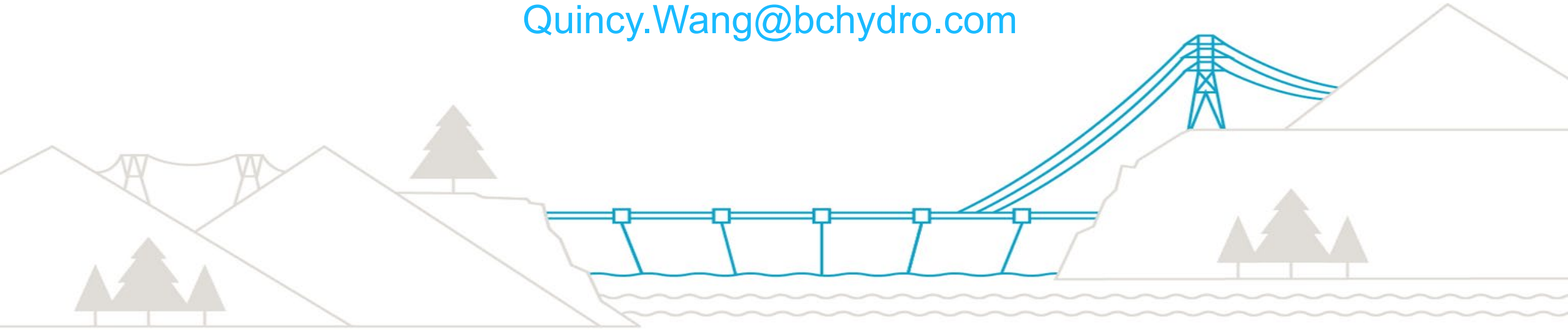



$$\dot{E}_l = \dot{V}_t + \dot{I}_a R_a + j\dot{I}_a X_l$$

| | |
|---|---|
| Potier Reactance | $f_{sat}(\lvert\dot{E}_l + j\dot{I}_a(X_P - X_l)\rvert)$ |
| GENTPJ Kis – 2009 | $f_{sat}(E_l + K_{is} * sign(I_d){I_a}^2)$ |
| GENTPJ Kis – 2012 | $f_{sat}(E_l + K_{is}I_a)$ |
| GENQEC Kw | $\frac{1 + f_{sat}(E_l)}{1 - K_w I_a} - 1$ |

# Thank You !

Quincy.Wang@bchydro.com



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