False Applications of Reliable Relaying Principles Revisited

Roger Hedding ABB Inc.

Original Paper

"False Applications of Reliable Relaying Principles " presented to Texas A&M Relay Conference in April 1997 by the late Walter A. Elmore.

Good to review sound relaying principles

Is paper still valid for today's microprocessor relaying systems ?

THE FOLLOWING “TRUTHS” DEAL WITH EXCITATION CURRENT, ERROR CURRENTS, AND DC OFFSET

The Excitation Curve supplied with current transformers relates instantaneous secondary voltage and exciting current

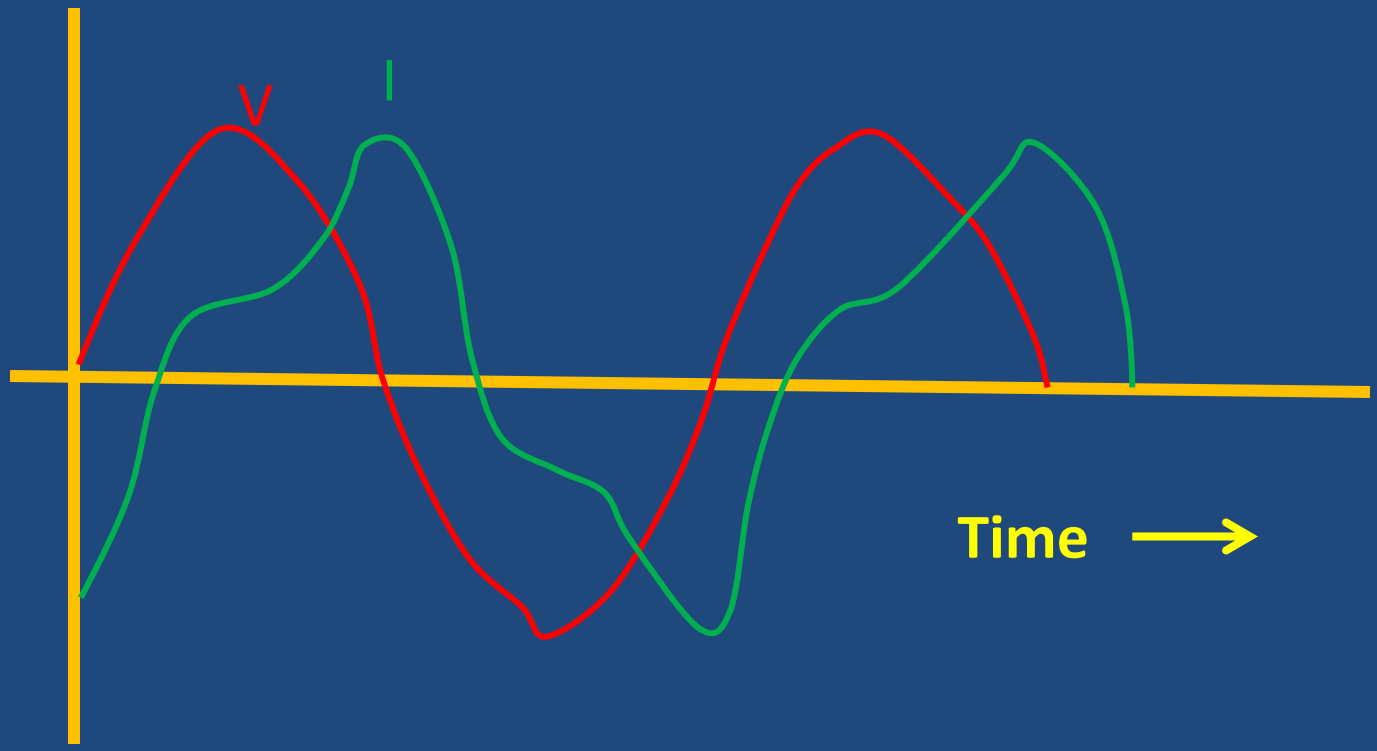
False

Excitation curve

I Contains harmonics

RMS Secondary excitation voltage vs RMS excitation current

Excitation Current



HOW CAN WE USE THIS CURVE ?

Experience has shown that it's reasonable to use the RMS - RMS assumption.

ANSI Standard C57.13 - 2008 allows this approach

FOR C CLASS CURRENT TRANSFORMERS, THE MAXIMUM ERROR WITH NO MORE THAN RATED SECONDARY BURDEN IS 10%.

False

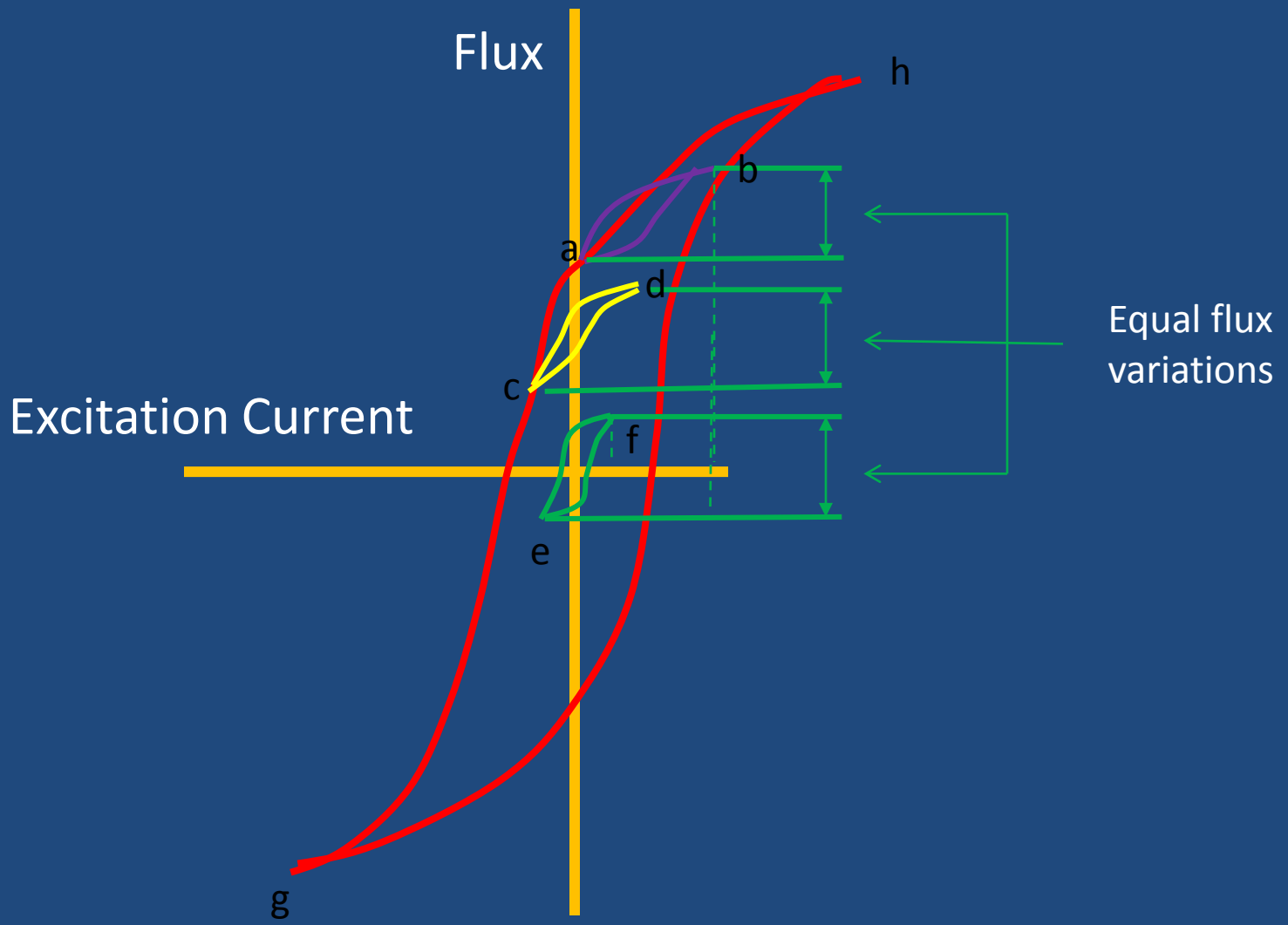
WHEN IS THIS TRUE ?

Symmetrical currents

No DC components

From 5 – 100 amps secondary

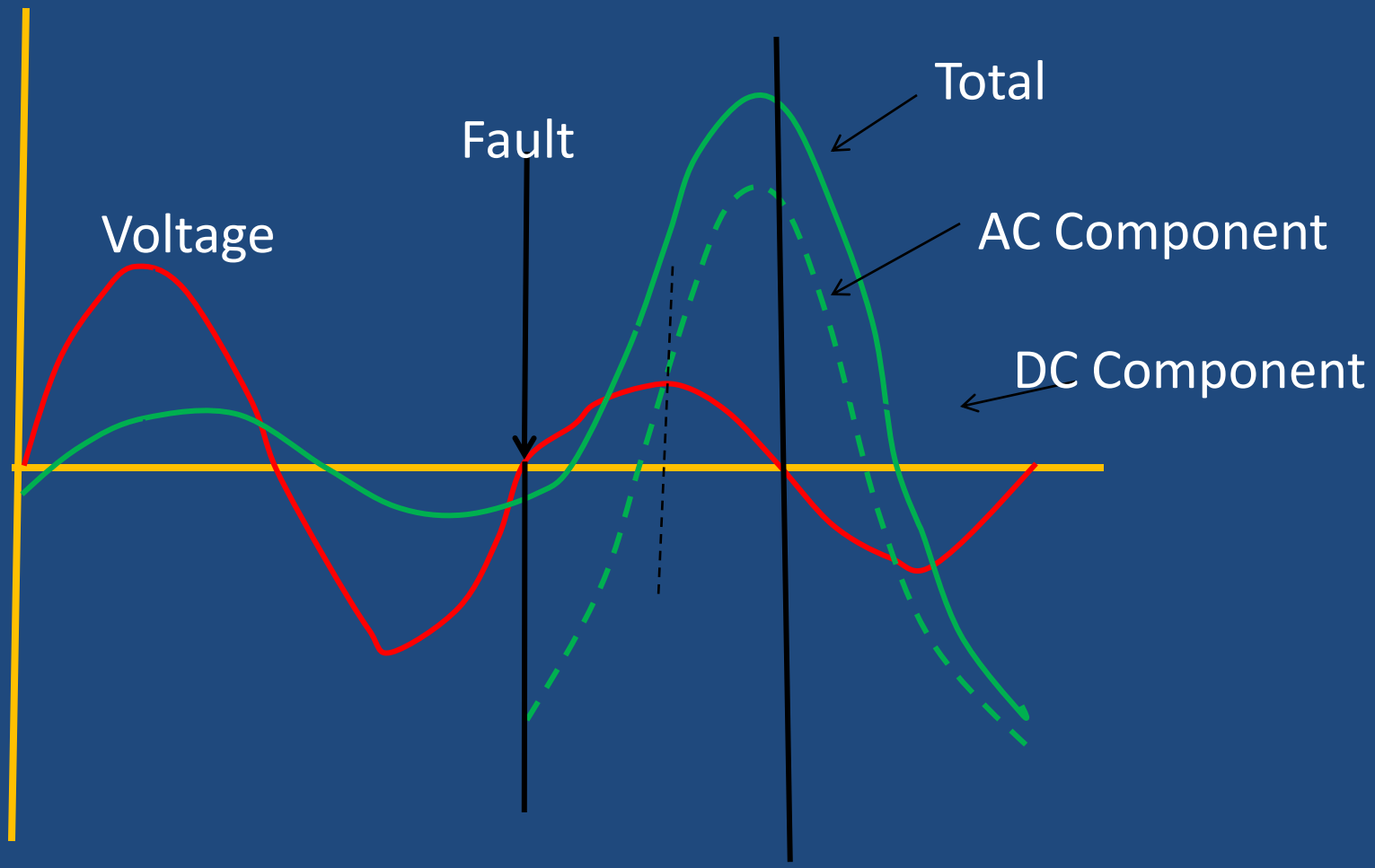
For a CT having no residual flux



Effects of residual flux on ct excitation current

Fault current having a dc offset is initially very high

False



No change in current at fault inception

Third harmonic is always zero sequence in character

False

Third Harmonic is always zero sequence in character

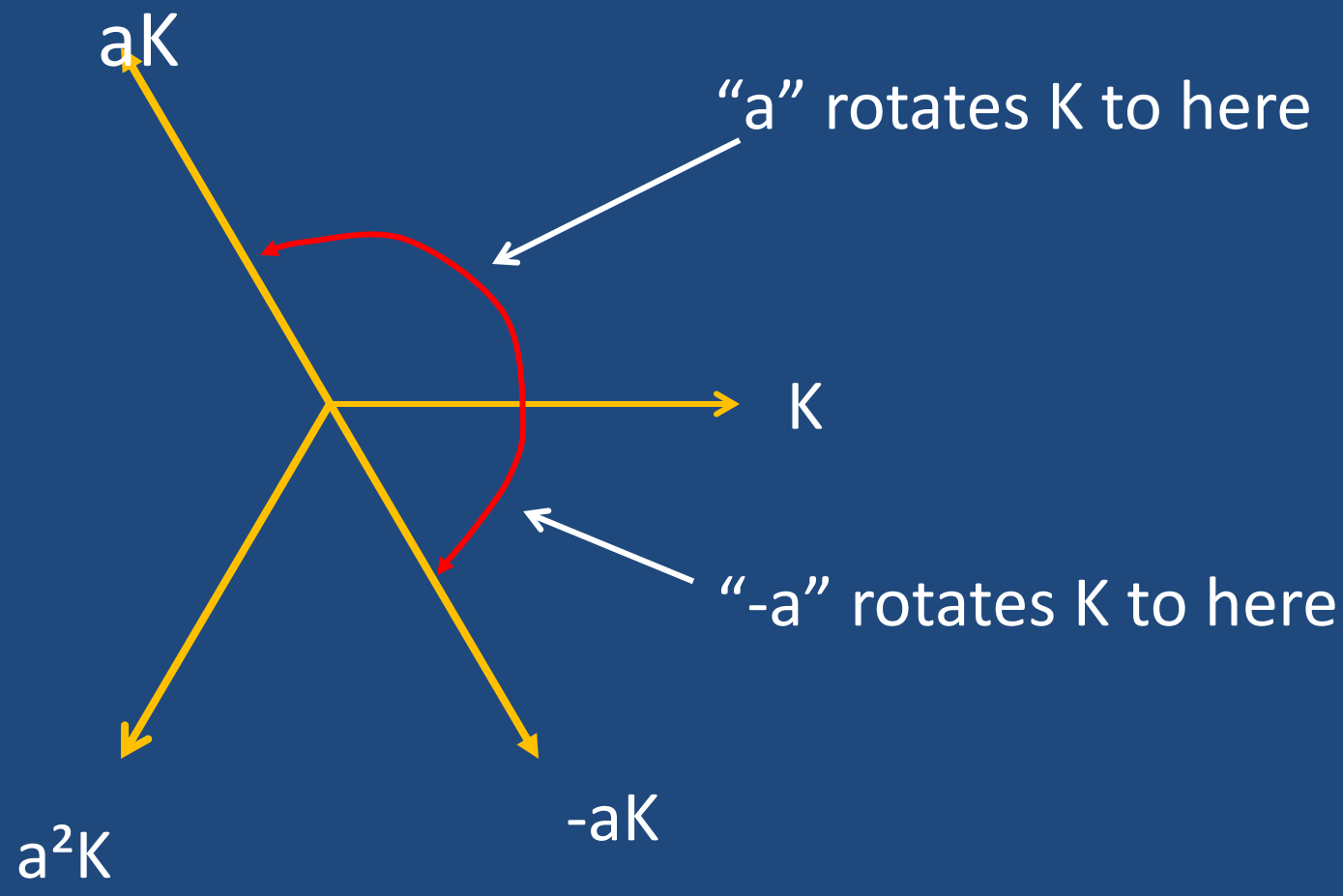
True only if same level of third harmonic current is generated in each phase

Non linear single phase load generates third harmonic voltage but also contains positive, negative, and zero sequence characteristics in the same way phase to ground fault does.

SymmetricaL Components

Since operator “a” rotates a phasor 120° in the counter clockwise direction, operator “-a” rotates a phasor 120° in the clockwise direction.

False



Effects of “a” on rotation

Seventh harmonic is positive sequence in character and therefore will have no effect on a negative Sequence voltage relay.

False then, now true with respect to microprocessor relays.

Why Then?

- Nearly all negative sequence filters were designed for 60Hz
- At high frequencies, the filter output voltage was nearly the same whether the character of the high frequency is positive or negative sequence
- A filter designed for 60Hz will produce an output for a high frequency even though the fundamental is purely positive sequence

NumericaL Design

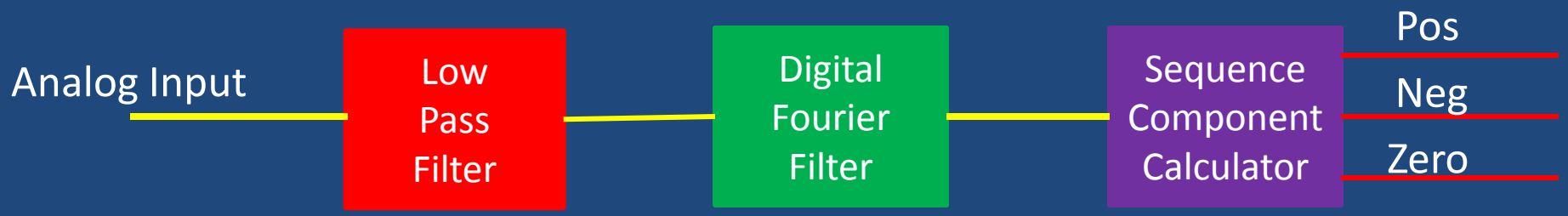
Analog input goes through low pass filter with a cutoff frequency of around 500Hz.

Individual phasors for the three phases are calculated using full cycle digital Fourier filter

Positive, Negative, and zero sequence phasors using classical matrix formulas

7th Harmonic will have negligible influence on sequence components calculated

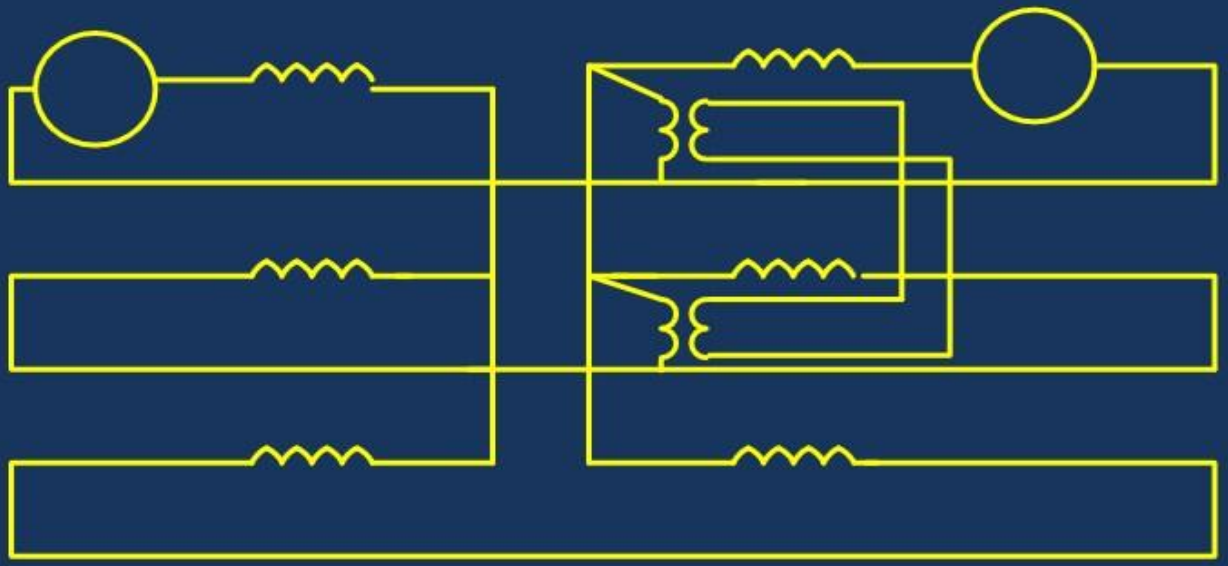
Numerical Sequence Component calculator



Faults that do not involve ground produce no zero sequence current.

False

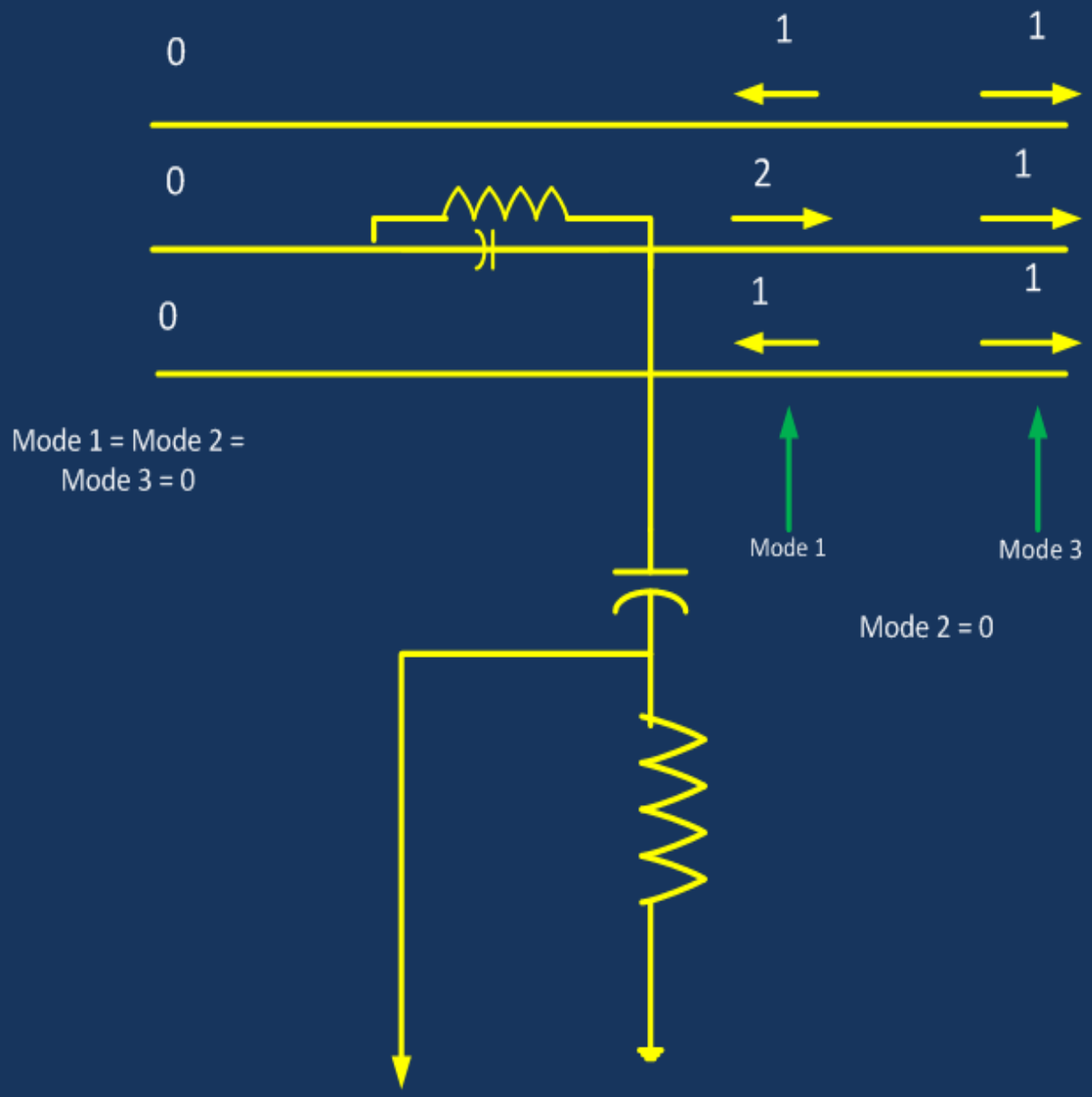
One line Diagram



Interconnection for “A” Open

With center phase coupling and center phase trapping, the carrier signal is Confined to the coupled phase.

False

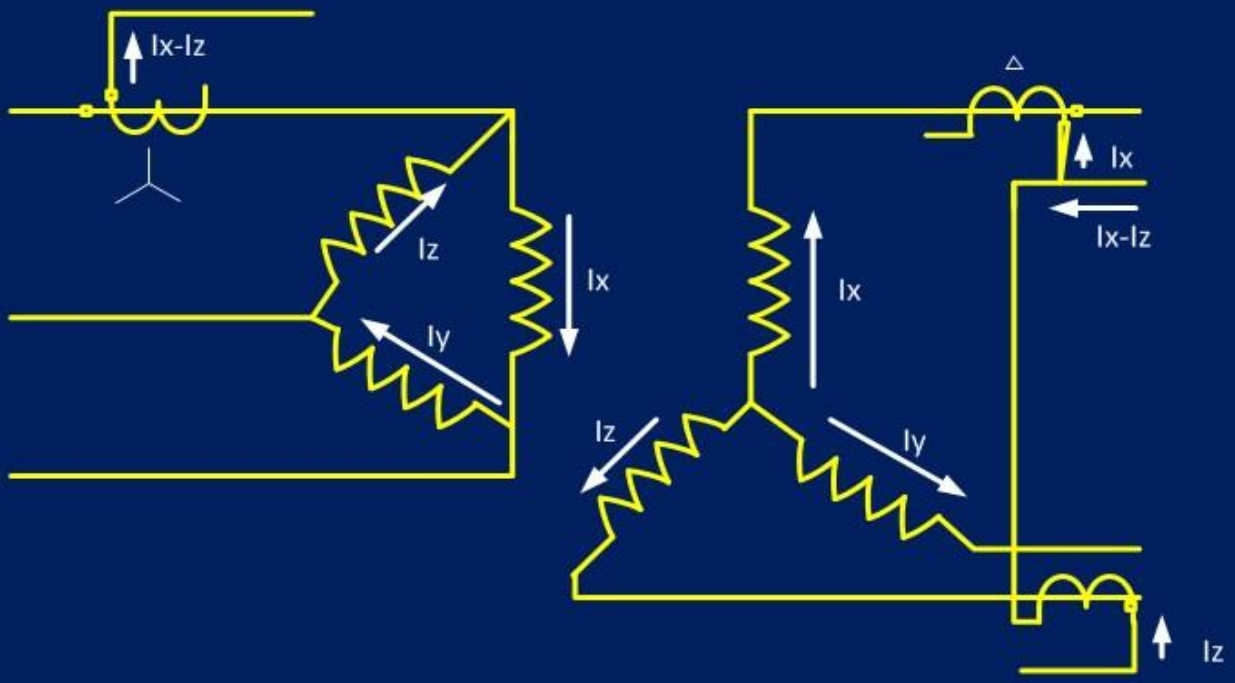


Signal on Adjacent line due to Local Transmitter

Phase sequence is important in connecting the differential relays for a power transformer

False

Phase sequence doesn’t matter



Partial circuit for Transformer Differential

NUMERICAL DIFFERENTIAL RELAY

Current transformers usually are Wye connected

Phase compensation setting are used to compensate for phase shift across transformer

Phase sequence doesn’t effect setting

The Instantaneous trip protecting a Transformer Must always be set above inrush current

False

Numerical relays

Inrush high in harmonic content

Harmonics and DC can be stripped out via Fourier Filtering

Result : Instantaneous only responsive to fundamental current

An autotransformer neutral is always a Reliable source of zero sequence polarizing Current for ground relays.

(Reliable means that the current is always Up the neutral when zero sequence current Is flowing to a ground fault, irrespective of fault location.)

False

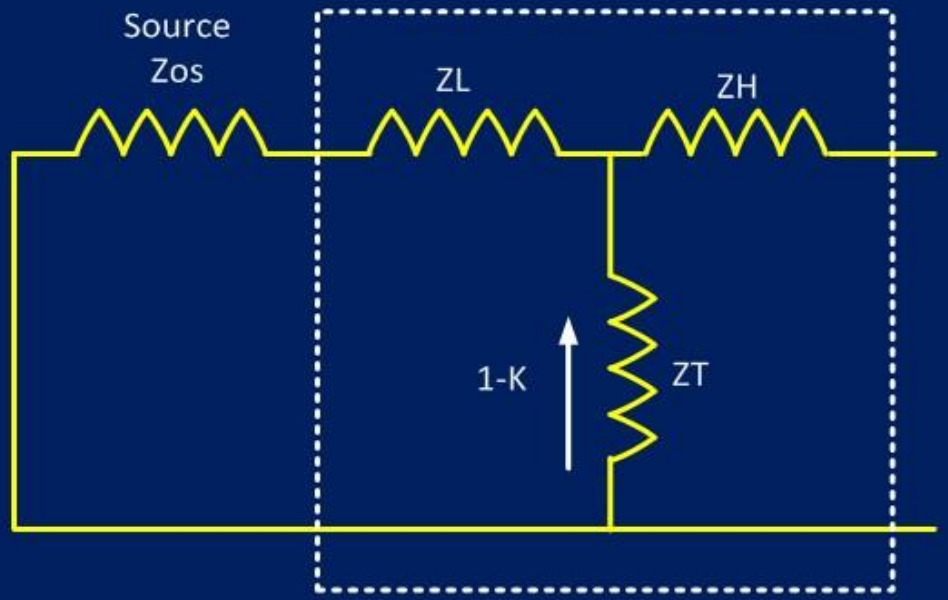
2 Winding autotransformer

Current always down the neutral for a fault on the high voltage system

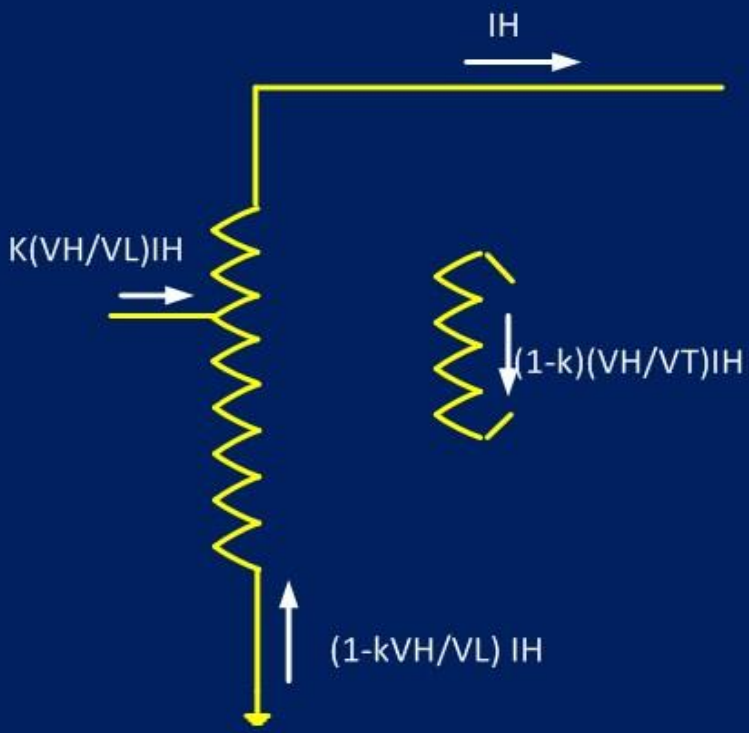
Current always up the neutral for faults on the low voltage system

Autotransformers with tertiary

Neutral current may be a reliable polarizing source



3 Winding
Autotransformer

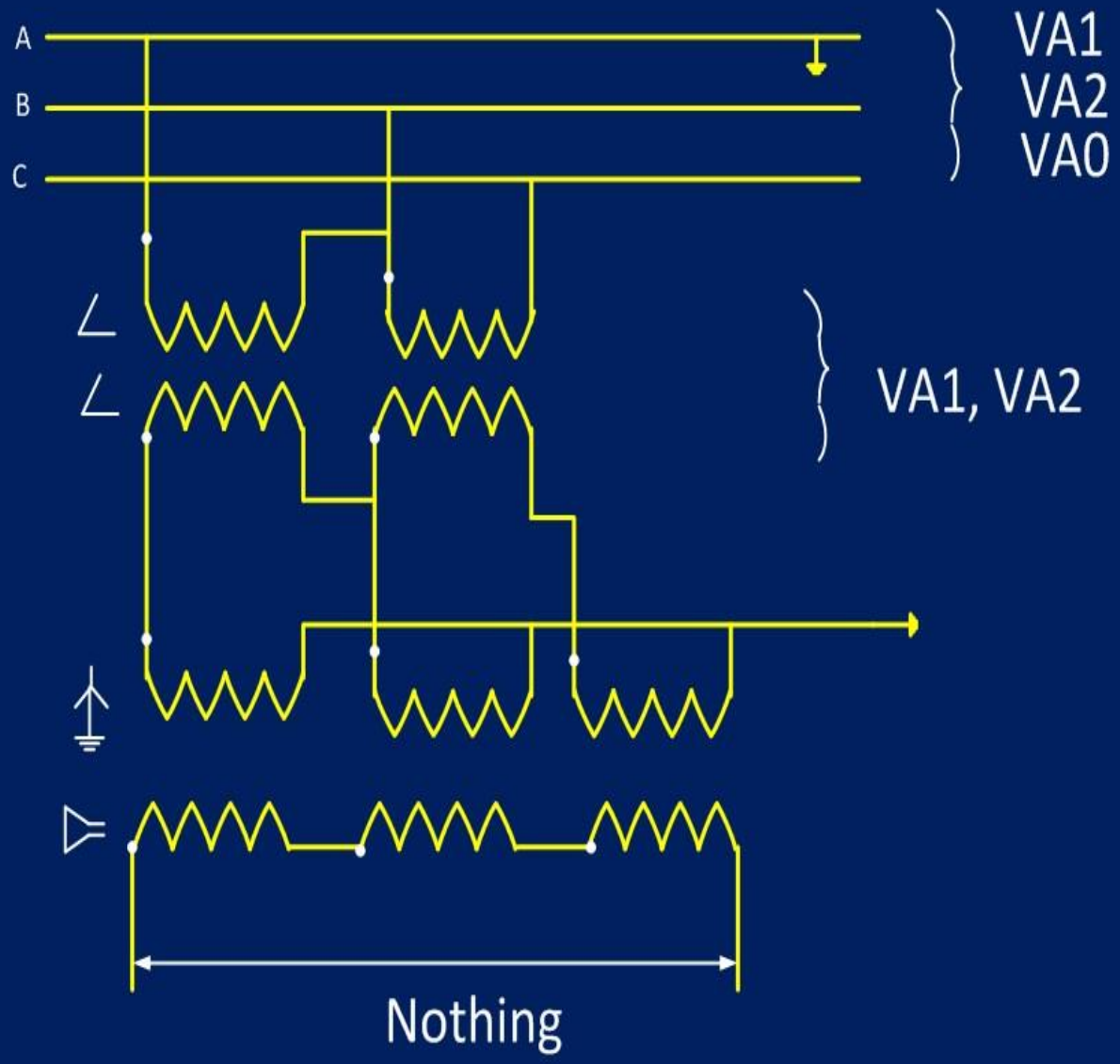


k is current distribution factor

Neutral is good polarizing source if : kVH/VL<1

Wye –ground – Broken Delta transformers Always provide a reliable source of Polarizing voltage

False


A
B
C
VA1
VA2
VA0
VA1, VA2
Nothing

Parallel line compensation is always Good for ground distance relays

False

Parallel Line Compensation

Eliminates error in ground distance relay caused by zero sequence mutual inductance

Parallel Line Compensation

Why a problem ?

Zero Sequence current in adjacent line increases the reach of the ground relay for faults on the protected line

Adjacent line I0 is limited only by source impedance for a 0% fault. Not line impedance

Compensation may be overpowering, causing relay to have false sense of direction to the fault

Conclusions

Original paper correct in nearly every case

- Current transformers still obey the laws of physics
- Fortescue's rules of Symmetrical components still apply
- Power line carrier modal analysis is the same
- Kirchoff's law still applies to differential relays
- Life's Beautiful !


Questions ?