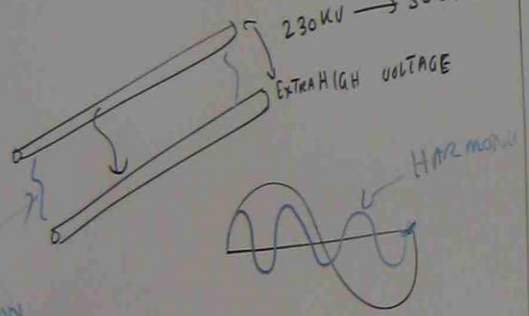
TEST(2) NEXT WEEK 30%.

REVISION AFTER THE BREAK

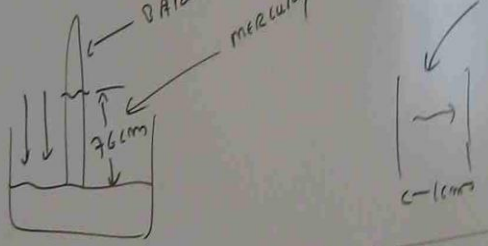
CORONA



CORONA FORMS WHEN THE VOLTAGE OF A CONDUCTOR PASSES THE DISRUPTIVE CRITICAL VOLTAGE. THIS OCCURS ON EACH CONDUCTOR AT EVERY HALF CYCLE AND CONTRIBUTES A TRIPLE HARMONIC TO CHARGING CURRENT

DISRUPTIVE CRITICAL VOLTAGE

THE BREAK DOWN STRENGTH OF AIR AT 76 cm (PRESSURE) PRESSURE AND 25°C IS 30 KV/cm (OR) 21.1 KV (rms)/cm.



$$E_g = m\,\delta\,g_b\,r\,\ln\frac{D}{r}$$

E_g = BREAK DOWN VOLTAGE TO NEUTRAL (KV)

m = CONSTANT FOR SURFACE

$m = 1.0$ SMOOTH WIRE

0.93 WEATHERED WIRE

0.87 STRANDED WIRE

$$\delta = \frac{3.92\,b}{273+T}$$

(BAROMETRIC NORMAL TEMPERATURE)

$T = °C$

b = THE HEIGHT OF MERCURY IN BAROMETER

r = RADIUS OF CONDUCTOR

D = DISTANCE BETWEEN CONDUCTORS

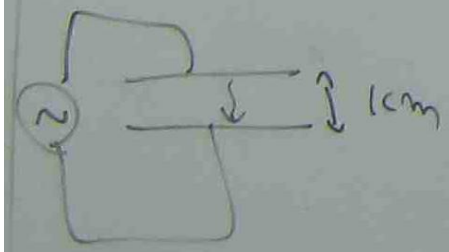
(GEOMETRIC MEAN DISTANCE)

CORONA

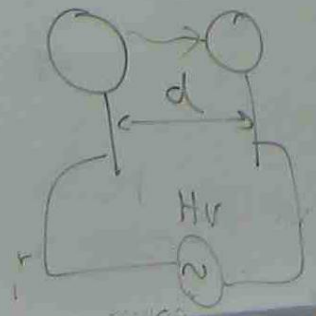
CORONA FORMS WHEN THE VOLTAGE of A CONDUCTOR PASSES THE DISRUPTIVE CRITICAL VOLTAGE. THIS OCCURS ON EACH CONDUCTOR AT EVERY HALF CYCLE AND CONTRIBUTES A TRIPLE HARMONIC TO THE CHARGING CURRENT.

DISRUPTIVE CRITICAL VOLTAGE

BREAK DOWN STRENGTH of AIR AT 76 cm PRESSURE 25°C IS 30 kV/cm (PEAK) (OR) 21.1kv (RMS)/cm

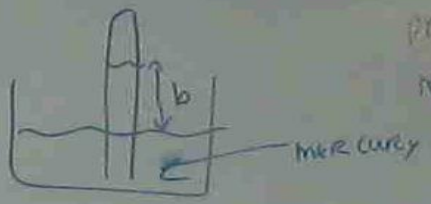


SPHERE TEST



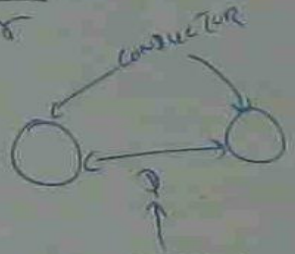
$$\delta = \frac{3.92\,b}{273+T}$$

b = BAROMETRIC PRESSURE OF MERCURY



E_g = BREAK DOWN VOLTAGE TO NEUTRAL

$$E_g = m\,\delta\,g_b\,r\,\ln\frac{D}{r}$$



$g_b = 21.1$

r = RADIUS OF CONDUCTOR

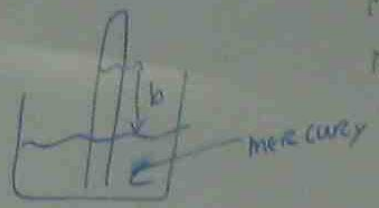
m = 1.0 FOR SMOOTH WIRE

0.93 FOR ROUGHENED (OR) WEATHERED WIRE

0.87 STRANDED WIRE

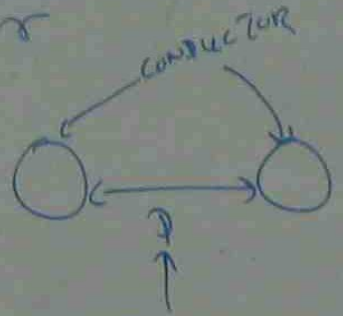
$$\delta = \frac{3.92\,b}{273+T}$$

b = BAROMETRIC PRESSURE OF MERCURY



E_g = BREAK DOWN VOLTAGE TO NEUTRAL

$$E_g = m\,\delta\,g_b\,r\,L_n\frac{D}{r}$$



$g_b = 21.1$

r = RADIUS OF CONDUCTOR

m = 1.0 FOR SMOOTH WIRE

0.93 FOR ROUGHENED (OR) WEATHERED WIRE

0.87 STRANDED WIRE

VISUAL CRITICAL VOLTAGE = $E_v = 21.1\, m\, \delta r \left(1 + \frac{0.3}{\sqrt{\delta r}}\right) \ln \frac{D}{r}$

KV RMS

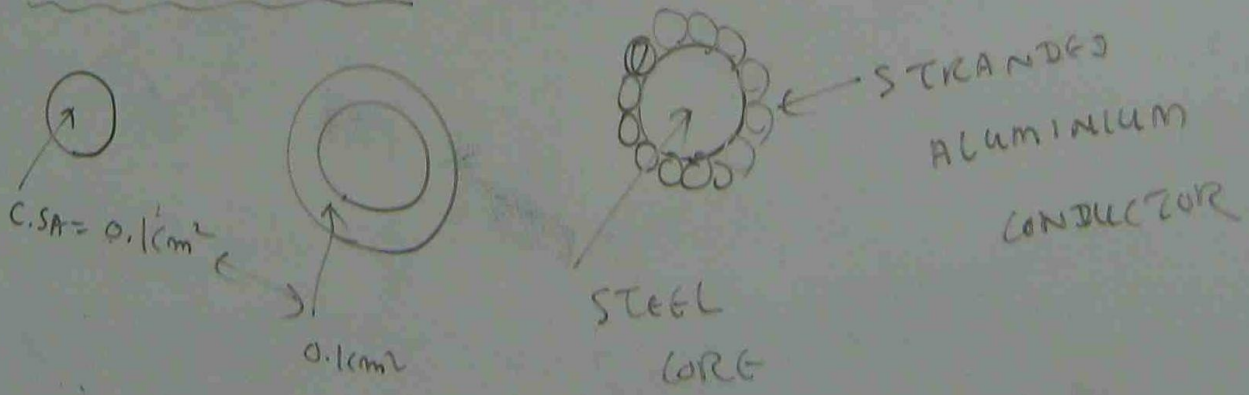
=

TO NEUTRAL

DISADVANTAGE OF CORONA

- POWER LOSS
- INTERFERENCE TO TELECOMMUNICATION SYSTEM.

AVOIDANCE OF CORONA



TO AVOID THE CORONA, THE DISTANCE BETWEEN CONDUCTOR NEEDS TO BE INCREASED TO INCREASE THE DISRUPTIVE CRITICAL VOLTAGE.

BUT SUCH . DISTANCE IS LIMITED BY COST.

IN PRACTICAL, HOLLOW CONDUCTORS ARE UTILIZED

STEEL CORE, ALUMINIUM STRANDED

CONDUCTORS → INCREASE THE STRENGTH

→ REDUCE THE POSSIBILITY FOR CORONA

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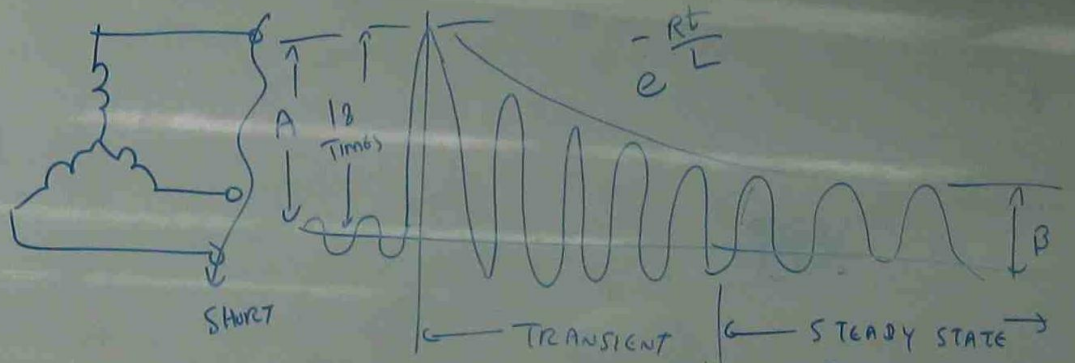
SHORT CIRCUIT CURRENT OF ALTERNATOR



$$i_{sc} = A e^{-\frac{Rt}{L}} + B$$

$$A = \frac{E}{\sqrt{R^2+\omega^2 L^2}} \sin\left(\theta - \tan^{-1}\frac{\omega L}{R}\right)$$

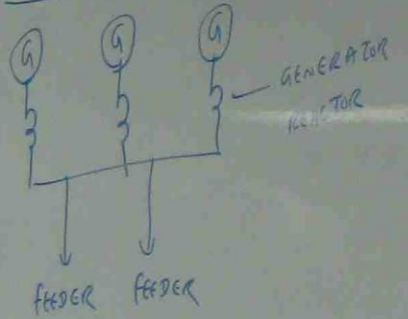
θ = POWER FACTOR ANGLE

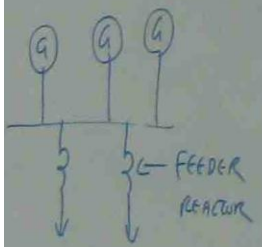
θ = angle between E and I

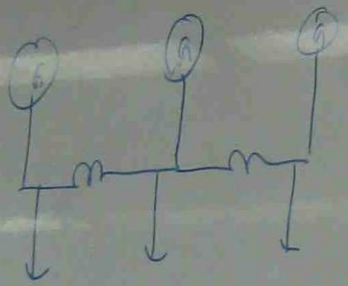
$$B = \frac{E}{\sqrt{R^2+\omega^2 L^2}} \sin\left(\omega t + \alpha - \tan^{-1}\frac{\omega L}{R}\right)$$

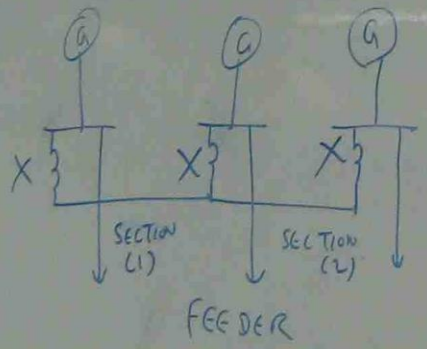
$$\omega = 2\pi f$$

CURRENT LIMITING REACTORS









$$X = \frac{(n-3)}{2n} \times G$$

$n > 3$

n = NUMBER OF SECTION

G = % INDUCTIVE REACTANCE OF GENERATOR

X = % INDUCTIVE REACTANCE OF REACTOR

VOLTAGE TRANSIENTS AND LINE SURGES

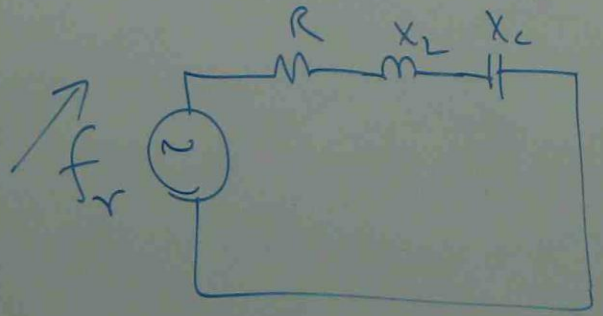
POWER LINE RESONANCE PRODUCES LINE VOLTAGE SURGE

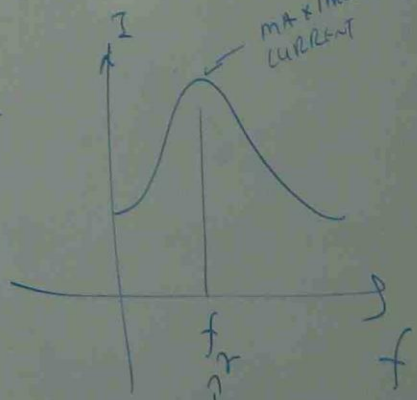
$$X_L = 2\pi f L$$

$$X_C = \frac{1}{2\pi f C}$$

AIR

300 Hz





$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

$f \rightarrow f_r \Rightarrow X_C = X_L$

Z = MINIMUM

$$I = \frac{E}{Z} \rightarrow I = MAX$$

CAUSE OF LINE SURGE

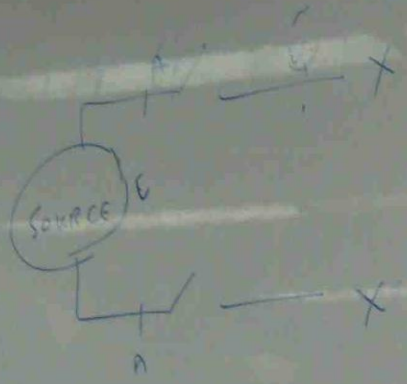
(1) RESONANCE

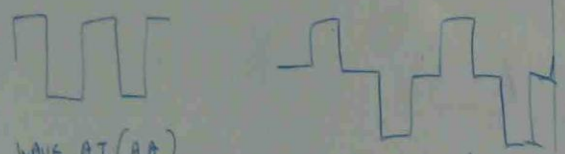
(2) SWITCHING

(3) INSULATION FAILURE

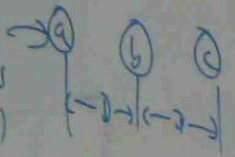
(4) ARCING TO EARTH

(5) LIGHTNING STRIKE





LINE SURGE CAN DAMAGE THE EQUIPMENTS. THE NATURE OF SURGE THE ORIGIN OF LINE SURGE AND PROTECTION SYSTEM NEEDS TO APPLY IN POWER SYSTEM.



SWITCHING VOLTAGE

SWITCHING EMF VELOCITY

$$v = \frac{1}{\sqrt{LC}}$$

LIGHT VELOCITY 3×10^{10} cm/s

L = INDUCTANCE

C = CAPACITANCE OF LINE

SWITCHING CURRENT

$$i = \frac{E}{\sqrt{C/L}} = \frac{E}{Z}$$

$$Z = \sqrt{\frac{L}{C}}$$

LINE IMPEDANCE

Z = SWITCHING IMPEDANCE (SURGE IMPEDANCE)

$$L = 4 \ln \frac{D}{r} \times 10^{-6} \text{ H/cm}$$

$$C = \frac{1}{4 \ln \frac{D}{r}} \text{ MF/cm}$$

400 → 600Ω (OVER HEAD LINE)

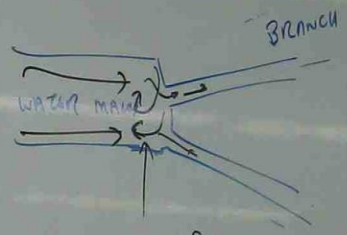
40 → 60Ω (CABLE)

VOLTAGE SURGE & PROTECTION

NORMAL

PRODUCED ENERGY = ABSORBED ENERGY AT LOAD + LOSSES

GENERATOR → LOAD

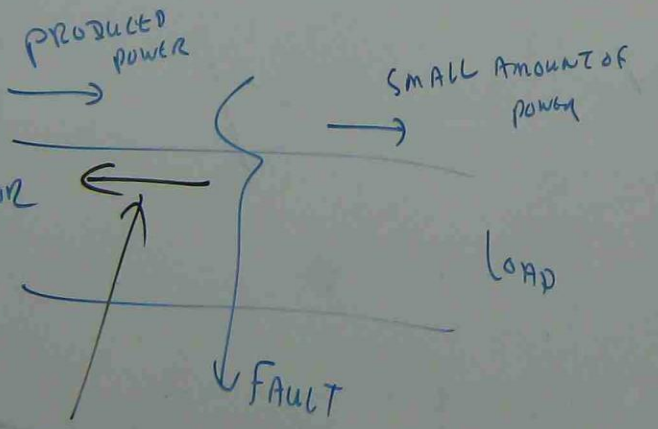


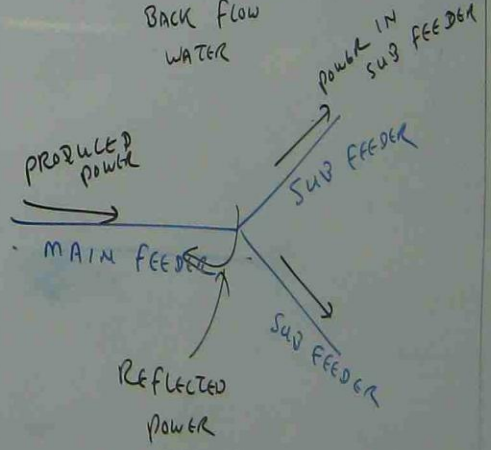
PROTECTION

ARCING HORN

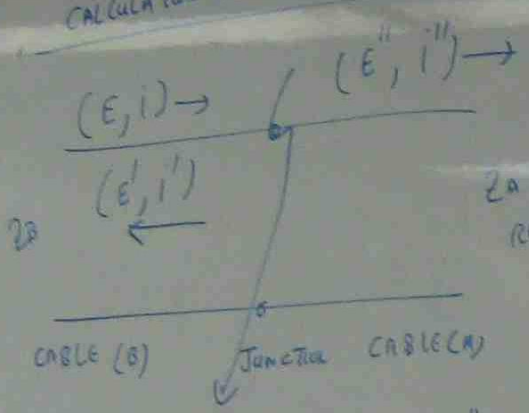
LIGHTNING ARRESTER

SURGE ABSORBER





CALCULATION OF VOLTAGE SURGE



$$i' = \frac{Z_B - Z_A}{Z_B + Z_A}\, i$$

$$E' = \frac{Z_B - Z_A}{Z_B + Z_A}\, E$$

E'' = MAXIMUM VOLTAGE AT JUNCTION

i'' = MAXIMUM CURRENT AT JUNCTION

E' = REFLECTED CREST VOLTAGE

E = NORMAL SYSTEM VOLTAGE

Z = NATURAL IMPEDANCE $= \sqrt{\frac{L}{C}}$

$$E'' = E + E'$$

PROBLEM

A TRANSMISSION LINE HAS 0.012 μF CAPACITANCE AND 1.5 mH INDUCTANCE. IT IS JOINED WITH A CABLE 0.3 μF CAPACITANCE AND 0.25 mH INDUCTANCE.

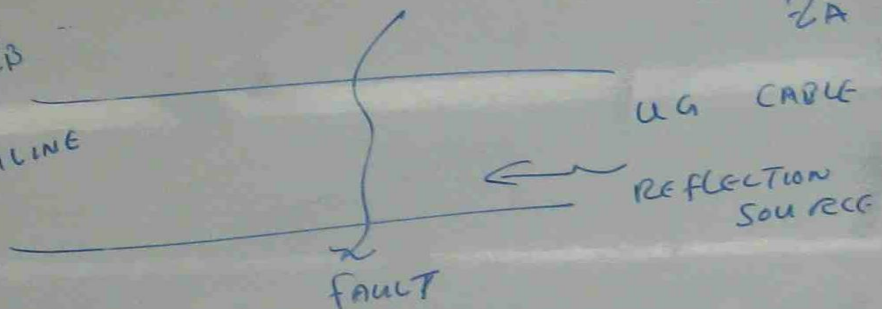
CALCULATE (a) NATURAL IMPEDANCE OF O.H LINE

(b) NATURAL IMPEDANCE OF U.G CABLE

(c) REFLECTED CREST VOLTAGE

(d) MAXIMUM VOLTAGE AT JUNCTION

LINE VOLTAGE = 50 kV



(a) OH LINE $Z_B = \sqrt{\frac{L}{C}} = \sqrt{\frac{1.5 \times 10^{-3}}{0.0125 \times 10^{-6}}} = 346.4\,\Omega$

(b) UG CABLE $Z_A = \sqrt{\frac{L}{C}} = \sqrt{\frac{0.25 \times 10^{-3}}{0.3 \times 10^{-6}}} = 28.9\,\Omega$

(c) $E^{1} = \frac{Z_B - Z_A}{Z_B + Z_A} E = \frac{346.4 - 28.9}{346.4 + 28.9} \times 50$

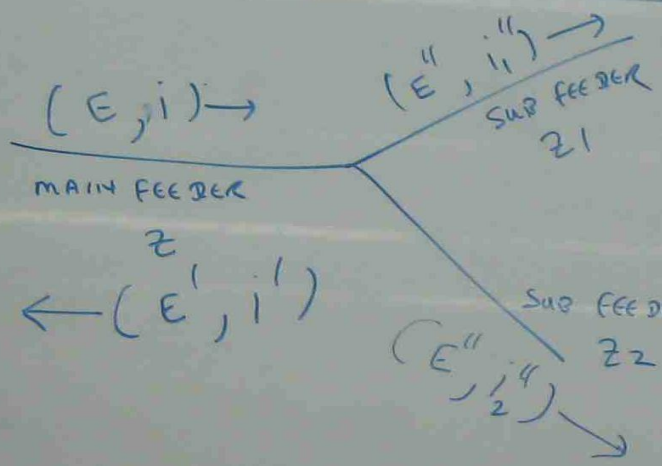
$= 42.3\ kV$

(d) $E^{11} = E + E^{1}$

$= 50 + 42.3$

$= 92.3\ kV$

REFLECTION AT JUNCTION



$$E' = E \frac{\left(\frac{1}{Z} - \frac{1}{Z_1} - \frac{1}{Z_2}\right)}{\frac{1}{Z} + \frac{1}{Z_1} + \frac{1}{Z_2}}$$

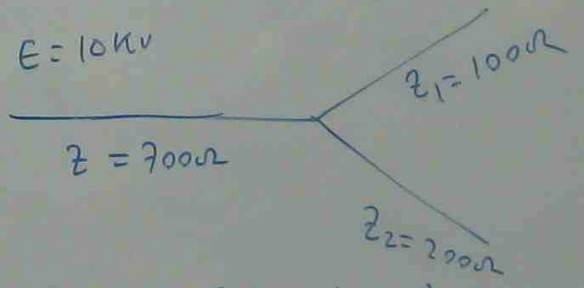
$$E'' = E + E'$$

$$i''_1 = \frac{E''}{Z_1}, \quad i''_2 = \frac{E''}{Z_2}$$

Pb

10 KV LINE WITH 700Ω IS CONNECTED TO 100Ω AND 200Ω LINES

CALCULATE (i) REFLECTED VOLTAGE (ii) MAXIMUM VOLTAGE AT JUNCTION (iii) MAXIMUM CURRENTS IN BRANCH LINES AND MAIN LINE.



$$E' = \frac{E\left(\frac{1}{Z} - \frac{1}{Z_1} - \frac{1}{Z_2}\right)}{\frac{1}{Z} + \frac{1}{Z_1} + \frac{1}{Z_2}}$$

$$= \frac{10{,}000\left(\frac{1}{700} - \frac{1}{100} - \frac{1}{200}\right)}{\frac{1}{700} + \frac{1}{100} + \frac{1}{200}}$$

$E' = -8260\,V$

$E'' = E + E' = 10{,}000 + (-8260)$

$= 1740\,V$

$I_1'' = \frac{E''}{Z_1} = \frac{1740}{100} = 17.4$ Amp

$I_2'' = \frac{E''}{Z_2} = \frac{1740}{200} = 4.7$ Amp

$I = I_1'' + I_2''$

$= 17.4 + 4.7 = 28.1$ Amp