Chapter 19: Radiated Emissions and Susceptibility

19.1 The ignition system of a car is interfering with the AM radio in the car. Is this conducted or radiated interference? Explain.

19.2 A vacuum cleaner is interfering with a TV set. Is this conducted or radiated interference? Explain.

19.3 In reference to the discussion in this chapter concerning emissions from a twin-lead line, determine a better *approximation* for the total electric field than

$$E_{\theta totals} \approx M_s \frac{e^{-j\beta_o r}}{r}\left(I_{1s}e^{-j\beta_o\Delta} + I_{2s}e^{j\beta_o\Delta}\right)F(\theta)$$

19.4 In reference to the discussion in this chapter concerning emissions from a twin-lead line, determine a better *approximation* for the total electric field in the far field from a pair of differential-mode currents than

$$E_{\theta totals} \approx \frac{d\eta_o \pi I_{Ds} l_{th}}{\lambda_o^2}\frac{e^{-j\beta_o r}}{r}\sin^2\theta\sin\phi$$

19.5 In reference to the discussion in this chapter concerning emissions from a twin-lead line, determine a better *approximation* for the total electric field in the far field from a pair of common-mode currents than

$$E_{\theta totals} \approx j\frac{\eta_o\beta_o}{2\pi} l_{th}\frac{e^{-j\beta_o r}}{r} I_{Cs}\sin\theta$$

19.6 Using superposition, determine the expression for the short-circuit current for the Hertzian dipole using the susceptibility model developed for the twin-lead line. However, unlike the discussion in this chapter, assume that the "load" is on the right side of the circuit model instead of the left side. Then, simplify the expression for lower frequencies. Which term in the approximate expression is the correction term?

19.7 Referring to Figure 1, verify that for electrically-short lines that the voltage across the source resistor is also independent of the capacitance and inductance of the line:

$$V_s = -\frac{R_s}{R_{Ld}+R_s}V_{Is} + \frac{R_{Ld}}{R_s+R_{Ld}}R_s I_{Is}$$

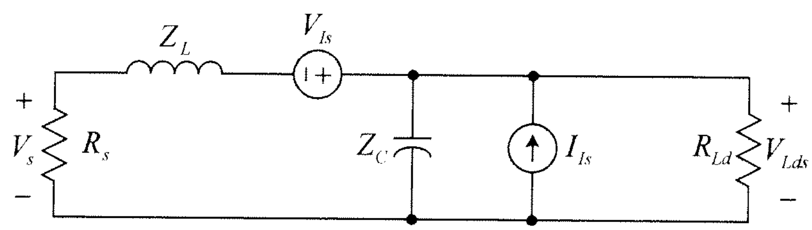


Figure 1

Use the same assumptions as given in this chapter.

19.8 Starting with the electrically-long susceptibility model provided in this chapter, determine the current in the source and load terminations for an electrically-short lossless twin-lead line when the source and load impedance are matched (i.e., equal) to the characteristic impedance of the twin-lead line. Then, as in this chapter, assume that the electric field components are described by

$$E_{zs}^{inc}(0,z) \approx E_{zo}^{inc},\ \ E_{zs}^{inc}(d,z) \approx E_{zo}^{inc}(1 - j\beta d)$$
$$E_{xs}^{inc}(x,0) \approx E_{xo}^{inc},\ \ E_{xs}^{inc}(x,l_{th}) \approx E_{xo}^{inc}$$

and further simplify the expressions to obtain a first-order approximation for each of the currents. Are these currents zero? Why are these currents not zero considering that the source and load are matched?

19.9 For each of the given Poynting vectors and polarization angles, determine e_x, e_y, e_z, β_x, β_y, and β_z,. Then, substitute these results into

$$\vec{E}_{is} = E_{os}\left(e_x\hat{a}_x + e_y\hat{a}_y + e_z\hat{a}_z\right)e^{-j\beta_x x}e^{-j\beta_y y}e^{-j\beta_z z}$$

and sketch both the Poynting vector and electric field.

a) $\theta_E = 180^\circ$, $\theta_P = 45^\circ$, $\phi_P = 90^\circ$
b) $\theta_E = 45^\circ$, $\theta_P = 90^\circ$, $\phi_P = 0^\circ$
c) $\theta_E = 0^\circ$, $\theta_P = 135^\circ$, $\phi_P = -45^\circ$
d) $\theta_E = 0^\circ$, $\theta_P = 135^\circ$, $\phi_P = 45^\circ$

19.10 Imagine that a sinusoidal current with an amplitude of I and a frequency of f is injected into the "output" leads of a tightly wound coil with N turns. Each turn has a radius of a, and the total axial length of the coil is L. The relative permeability of the core is one. Using the reciprocity theorem, determine the induced voltage across a single open-circuited loop passing through the window of this current probe. State all assumptions. [Heller]

19.11 Determine the expression for the output voltage for a resistively loaded current probe if the test wire carrying a sinusoidal current is centered in the window of the probe and the probe consists of a circular cross-section, air-core N-turn coil.

When is this probe acting like a 1:N ideal transformer? Determine the output if the load consists of a series RC integrator circuit.

19.12. A current probe has a transfer impedance of 0 dB ±2 dB over the frequency range 50 kHz to 200 MHz. What is the minimum and maximum voltage output over this frequency range for a 1 mA input current? State all assumptions.

19.13 A current probe has a transfer impedance greater than 0 dB over a limited frequency range. Is this possible? Explain.

19.14 A current probe consists of 50 turns on an air-core toroid. The toroid has an inner radius of 1.6 cm, an outer radius is 2.5 cm, and a height of 1.4 cm. Over what frequency range is this current probe acting like an ideal current transformer? If the coil is wrapped on a ferrite with a relative permeability of about 125, will the self inductance increase by about 125? Will the mutual inductance increase by about 125?

19.15 What simple experiment can be performed to determine whether the parasitic capacitance between a current probe and the circuit under test is significant? [Smith, '93]

ECE-640 WEEK 6 [redacted]

16-1 COUPLING FOR IGNITION NOISE INTERFERS WITH AM RADIO

AM BAND 530 - 1600 KHZ

NEAR OR FAR?

λ FOR 530 KHZ 566 m

λ FOR 1600 KHZ = 187 m = NEAR FIELD ON SAME CAR

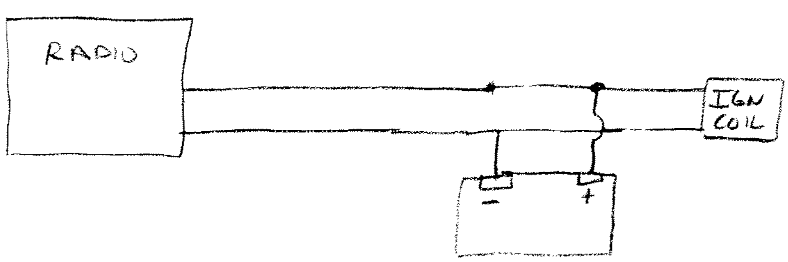
<u>RADIATED COUPLING MOST LIKELY</u>

- IGNITION WIRES, ARC IN DISTRIBUTOR, OR ARC ON PLUG COULD RADIATE & BE PICKED UP TWO WAYS
  1) BY CAR ANTENNA ('FRONT' DOOR)
  2) BY POWER OR SPEAKER WIRES ('BACK' DOOR)

& NOISE GETS INTO RADIO AUDIO CIRCUIT AT AM FREQ, IF, OR AUDIO FREQ

<u>CONDUCTED COUPLING POSSIBLE</u>

- COIL CURRENTS WITH HIGH LEVELS AND FAST FALL TIMES COULD CONDUCT BACK THRU COMMON POWER SUPPLY OR GROUNDS.



[redacted]

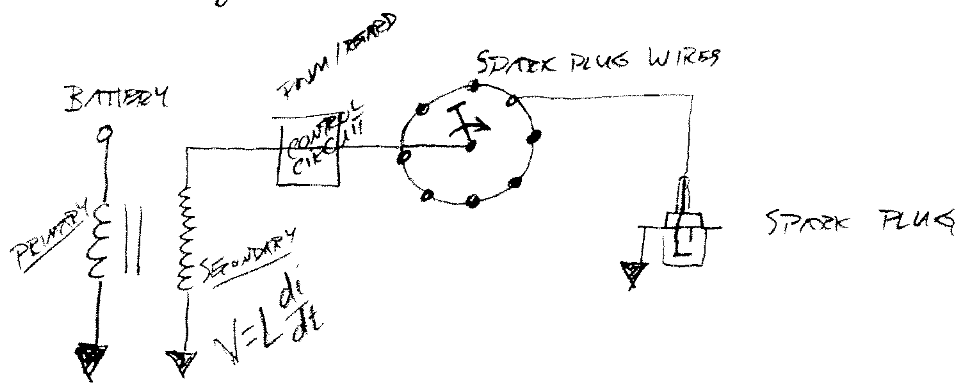
Ken Kaiser

PROBLEM 16.2

IS IGNITION SPARK NOISE OR IGNITION COIL NOISE MOST LIKELY RADIATED INTERFEREN

THE SPARK NOISE IS RADIATED BECAUSE THERE IS NO CONDUCTION PATH FOR THE SPARK TO TRAVEL TO THE RADIO BY, UNLESS THERE IS A SHORT FROM THE SPARK PLUG WIRE TO THE ENGINE.
THE IGNITION COIL NOISE IS BOTH RADIATED AND CONDUCTED FOR DISTRIBUTOR EQUIPED GM CARS. REFERENCE THE HEI - IGNITION SYSTEM. FROM THIS, NOISE WOULD BE RADIATED FROM THE CHARGE AND DISCHARGE OF THE IGNITION COIL. GM ALSO PUT A RADIO NOISE CONDENSER (CAPACITOR) FROM THE BATTERY LEAD TO GROUND TO SURPRESS THE LINE NOISE GENERATED BY THE HEI SYSTEM.
AS FAR AS NEWER CARS ARE CONSERNED MOST HAVE GONE TO A DISTRIBUTORLESS SYSTEM AND I BELIEVE THEY HAVE BEEN ABLE TO ELIMINATE THE CONDUCTED NOISE FROM THE IGNITION SYSTEM.

16-11 Is ignition spark noise or ignition coil noise most likely to be radiated interference?



IGNITION SPARK NOISE - HIGH FREQUENCY COMPONENTS DUE TO ARCING.

EXPANDING / COLLAPSING MAGNETIC FIELDS CONTAINED WITHIN COIL, NOT AS MUCH TRANSMITTED ENERGY.

16-2

The coupling from the ignition system to the radio could be conductive or radiated. To determine the cause use an independant power source to power the radio. If the noise quits there was conductive coupling through the power cord, which could also be eliminated by "coiling" to make a common mode choke.

If the noise is believed to be radiated coupling, the antenna could be moved away from the ignition system or the cable between the antenna could be "coiled" creating a choke. If the noise diminishes radiated coupling was present.

[redacted]

Section 16
#3

A vacuum cleaner is interfering with a TV set. Radiated or Conducted interference?

Radiated Interference — is caused by emissions transmitted via the air

Conducted Interference — is caused by emissions transmitted via conductors which physically connect the receiver & emitter.

Most of this interference would be caused by radiated emissions from the vacuum. The conducted interference is usually not significant, except for cases such as lightening. [Paul, p. 450]

Conduct interferance due to shared grounds. Radiated emissions are small. This is proven by moving the vacuum further away would not decrease the interferance in a typical $1/r^2$ or $1/r^3$ manner.

Vacuum Cleaner Interference w/ T.V. Set.

Interference from a vacuum cleaner is caused by arcing in the brushes of the DC Motor.

The interference enters the TV set through the Antenna picking up radiated interference.

The radiated energy can come directly from the motor or ~~from~~ can radiate from house wiring if initially conducted through the power cord.

sec 16-4 [redacted]

Ken Kaiser

$$E_{\theta\,total} = M_s e^{-j\beta_0 r}\left(\frac{I_{1s}\, e^{-j\beta_0 \Delta}}{r+\Delta} + \frac{I_{2s}\, e^{+j\beta_0 \Delta}}{r-\Delta}\right) F(\theta)$$

$$\frac{1}{r+\Delta} = \frac{1}{r\left(1+\frac{\Delta}{r}\right)}$$

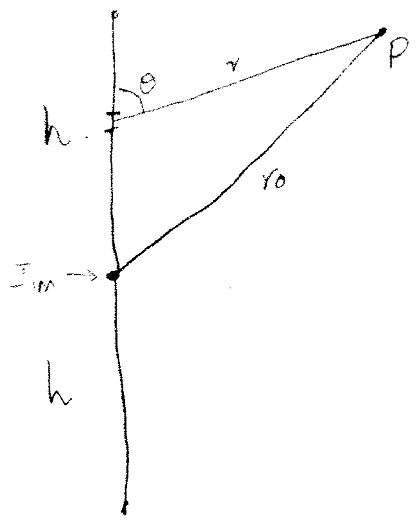
$$(1+x)^n \approx 1 + nx$$

$$\frac{1}{r}\left(1+\frac{\Delta}{r}\right)^{-1} \approx \frac{1}{r}\left(1-\frac{\Delta}{r}\right)$$

$$E_{\theta\,total} \approx M_s \frac{e^{-j\beta_0 r}}{r}\left(\left(1-\frac{\Delta}{r}\right)e^{-j\beta_0 \Delta} + \left(1+\frac{\Delta}{r}\right)e^{-j\beta_0 \Delta}\right) F(\theta)$$

Ken Kaiser [redacted]

16.4)



The current on the antenna will vary gradually along the wire & will approach zero at the ends. It should satisfy the requirement of continuity.

A good approximation for thin dipoles is the standing wave type described by the following equation

$$I(z) = I_{Lm} \sin\beta(h-z) \quad (0<z<h)$$
$$I(z) = I_{Lm} \sin\beta(h+z) \quad (0>z>-h)$$

– $I(z)$ is positive in the a_z direction

– I_{Lm} is the loop current magnitude.

Assuming $\beta h > \pi/2$, the maximum value of the current at the input terminal I_{Im} is related to I_{Lm} as

$$I_{Im} = I_{Lm} \sin\beta h$$

To find resultant far field the antenna is assumed to consist of a succession of current segments $I(z)\,dz$, and the resultant incremental fields are summed by integration

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$$H_{\phi f} = \int_0^h \frac{I_{Lm}\,\beta \sin\beta(h-z)\sin\theta\, dz}{4\pi r} e^{-j\beta r}$$

$$+ \int_{-h}^{0} \frac{I_{Lm}\,\beta \sin\beta(h+z)\sin\theta\, dz}{4\pi r} e^{-j\beta r}$$

where, $r = \sqrt{r_0^2 - 2r_0 z\cos\theta + z^2} \approx r_0 - z\cos\theta$

The effect of a changing value of r in the denominator for $r_0 >> h$ is slight. so eqn (1) is modified as

$$H_{\phi f} = \int_0^h \frac{I_{Lm}\,\beta \sin\beta(h-z)\sin\theta \exp(j\beta z\cos\theta)\, dz}{4\pi r_0} e^{-j\beta r_0}$$

$$+ \int_{-h}^{0} \frac{I_{Lm}\,\beta \sin\beta(h+z)\sin\theta\, e^{j\beta z\cos\theta}\, dz}{4\pi r_0} e^{-j\beta r_0}$$

$$\therefore H_{\phi f} = \frac{I_{Lm}\left[\cos(\beta h\cos\theta) - \cos\beta h\right]}{2\pi r_0 \sin\theta} e^{-j\beta r_0}$$

$$E_{\theta f} = \eta_0 H_{\phi f} = \frac{I_{Lm}\,\eta_0\left[\cos(\beta h\cos\theta) - \cos\beta h\right]}{2\pi r_0 \sin\theta} e^{-j\beta r_0}$$

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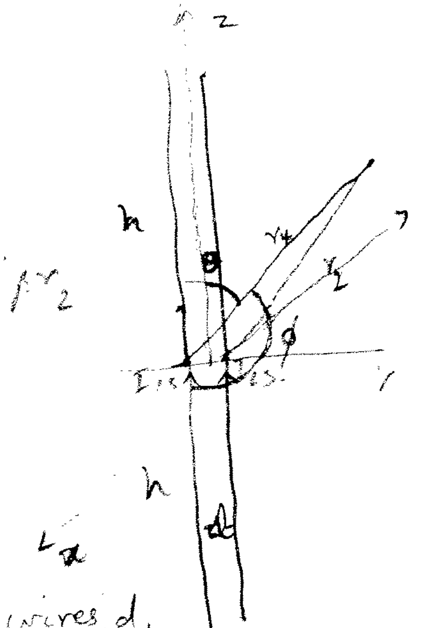
$$E_{\theta f_1} = \frac{I_{1s}\,\eta_0\left[\cos(\beta h\cos\theta) - \cos\beta h\right]}{2\pi r_1 \sin\theta}\, e^{-j\beta r_1}$$



$$E_{\theta f_2} = \frac{I_{2s}\,\eta_0\left[\cos(\beta h\cos\theta) - \cos\beta h\right]}{2\pi r_2 \sin\theta}\, e^{-j\beta r_2}$$

$$E_{\theta\,totals} = E_{\theta f_1} + E_{\theta f_2}$$

$$r_1 = r + \Delta \quad \& \quad r_2 = r - \Delta$$

Δ is a function of the spacing of the wires, d, and the position of the far-field of interest

$$\Delta = \tfrac{1}{2} d \sin\theta \sin\phi$$

If $\theta = 0^\circ$, then $\Delta = 0$

$$\therefore \quad E_{\theta\,totals} = \frac{I_{1s}\,\eta_0\left[\cos(\beta h\cos\theta) - \cos\beta h\right] e^{-j\beta(r+\Delta)}}{2\pi(r+\Delta)\sin\theta} + \frac{I_{2s}\,\eta_0\left[\cos(\beta h\cos\theta) - \cos\beta h\right] e^{-j\beta(r-\Delta)}}{2\pi(r-\Delta)\sin\theta}$$

One further approximation is that the denominator terms of $r+\Delta)$ & $r-\Delta)$ are approx as r but the exponential is kept undisturbed

$$\therefore E_{\theta\,totals} \approx \frac{\eta_0\, e^{-j\beta_0 r}}{2\pi r \sin\theta}\left(\cos(\beta h \cos\theta) - \cos\beta h\right) \times \left[\frac{I_{1s} e^{-j\beta_0\Delta} - I_{2s} e^{+j\beta_0\Delta}}{1}\right]$$

If the current are equal & opposite

$$I_{1S} = -I_{2S} = I_{DS}$$

$$E_{\theta_{total}} \approx \frac{\eta_0 e^{-j\beta_0 r}}{2\pi r \sin\theta} \left(\cos(\beta h \cos\theta) - \cos\beta h\right) I_{DS} \times \left[e^{-j\beta_0 \Delta} - e^{j\beta_0 \Delta}\right]$$

$$= \frac{\eta_0 e^{-j\beta_0 r}}{2\pi r \sin\theta} \left[\cos(\beta h \cos\theta) - \cos\beta h\right] I_{DS} \times \left[\cos(\beta_0 \Delta) - j\sin(\beta_0 \Delta) - \cos(\beta_0 \Delta) - j\sin(\beta_0 \Delta)\right]$$

$$= \frac{\eta_0 e^{-j\beta_0 r}}{2\pi r \sin\theta} \left[\cos(\beta h \cos\theta) - \cos\beta h\right] . I_{DS} \sin(\beta_0 \Delta)$$

Since the spacing between the wires are also electrically small, $d/\lambda_0 << 1$. d $\sin(\beta_0 \Delta) \approx \beta_0 \Delta$

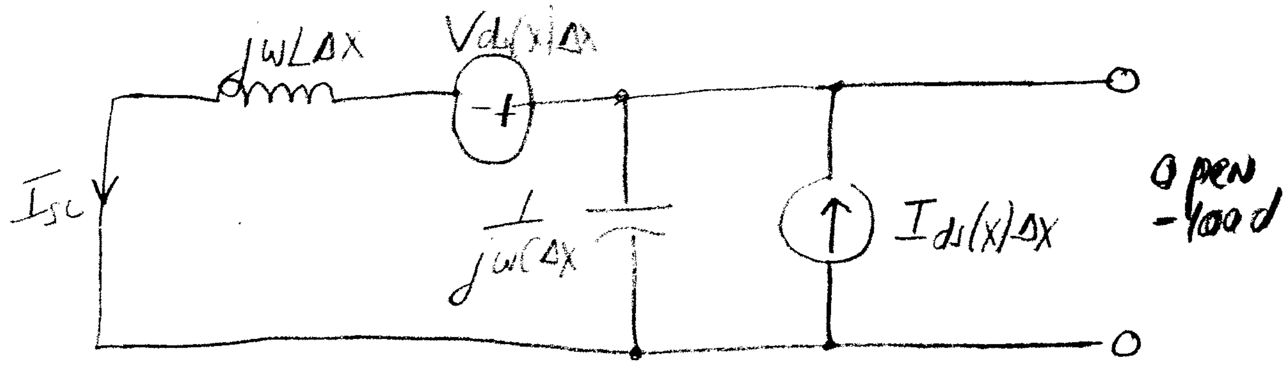
$$\therefore \sin(\beta_0 \Delta) = \beta_0 \Delta = \beta_0 \frac{1}{2} d \sin\theta \sin\phi = \pi \frac{d}{\lambda_0} \sin\theta \sin\phi$$

The far-field is then

$$E_{\theta_{total}} \approx \frac{\eta_0 e^{-j\beta_0 r}}{2\pi r \sin\theta} \left[\cos(\beta h \cos\theta) - \cos\beta h\right] . I_{DS} . \pi \frac{d}{\lambda_0} \sin\theta \sin\phi$$

-5

Problem 6
Using superposition, determine the expression for the short-circuit current for the Hertzian dipole using the susceptibility model developed for the twin-lead line. However, unlike the discussion in this chapter, assume that the "load" is on the right side of the circuit model instead of the left side. Then, simplify the expression for lower frequencies. Which term in the approximate expression is the correction term?



$$I_{sc} = -\frac{V_{ds}(x)\Delta x}{j\omega L\Delta x + \frac{1}{j\omega C\Delta x}} + I_{ds}(x)\Delta x \times \frac{\frac{1}{j\omega C\Delta x}}{\frac{1}{j\omega C\Delta x} + j\omega L\Delta x}$$

$$= \frac{-V_{ds}(x)\Delta x\, j\omega C\Delta x}{1 - \omega^2 LC(\Delta x)^2} + I_{ds}(x)\Delta x \frac{1}{1 - \omega^2 LC(\Delta x)^2}$$

$$= \frac{I_{ds}(x)\Delta x - V_{ds}(x) j\omega C(\Delta x)^2}{1 - \left(\frac{\omega}{\frac{1}{LC(\Delta x)^2}}\right)^2}, \quad \omega_c = \frac{1}{(L\Delta x)(C\Delta x)}$$

$$\approx I_{ds}(x)\Delta x - V_{ds}(x)\Delta x\,(j\omega(C\Delta x)) \quad \text{if } \omega \ll \omega_c$$

correction term

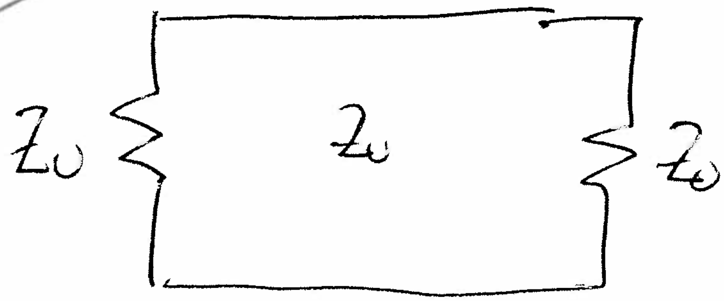
$C\frac{dV}{dt}$ → $Cj\omega V$

V_{ds} function of H_{zs}

Problem

Ken Kaiser

Radiated Emission



$$D \approx 2Z_0^2\left(1 - \frac{\beta^2 l^2}{2}\right) + j2Z_0^2 \beta l$$

Using Mathcad

ignoring higher order terms

For $I_s(z=0)$

$$\approx j\frac{d\beta l}{-2Z_0} E_{z0} - \frac{2j\, d\beta l}{-2Z_0} E_{x0}$$

$$= j\frac{d\beta l}{2Z_0}\left(2E_{x0} - E_{z0}\right)$$

For $I_s(z=l)$

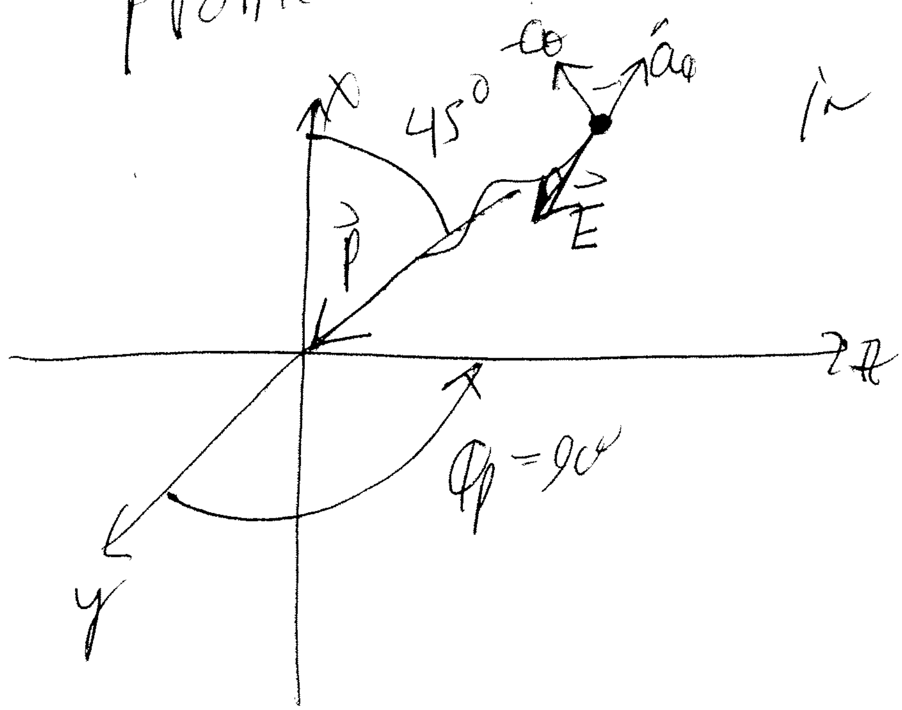
$$\approx \frac{j\, d\beta l}{-2Z_0} E_{z0} + \frac{2j\, d\beta l}{-2Z_0} E_{x0}$$

$$-j\frac{d\beta l}{2Z_0}\left(+2E_x \; \text{~~+ E}_{z0}\text{~~}\right)$$

Radiated Emission

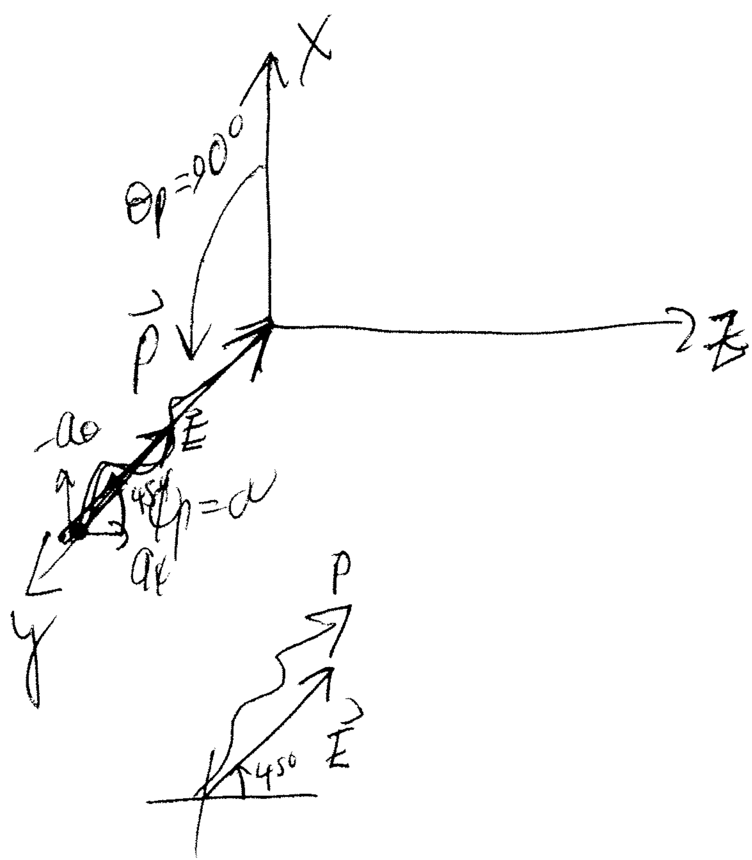
Problem1

a)

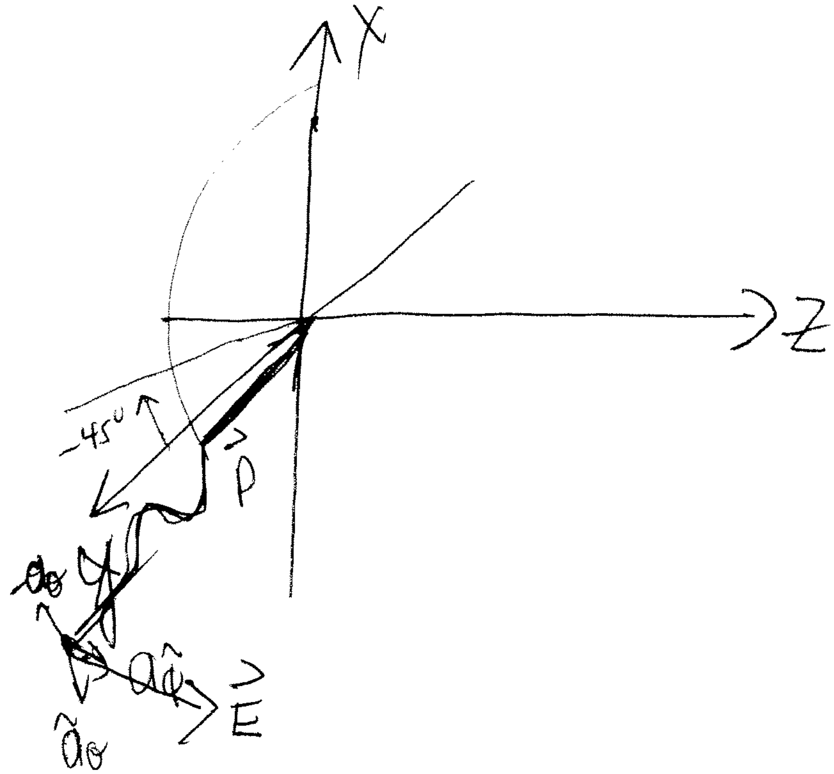


in xz plane

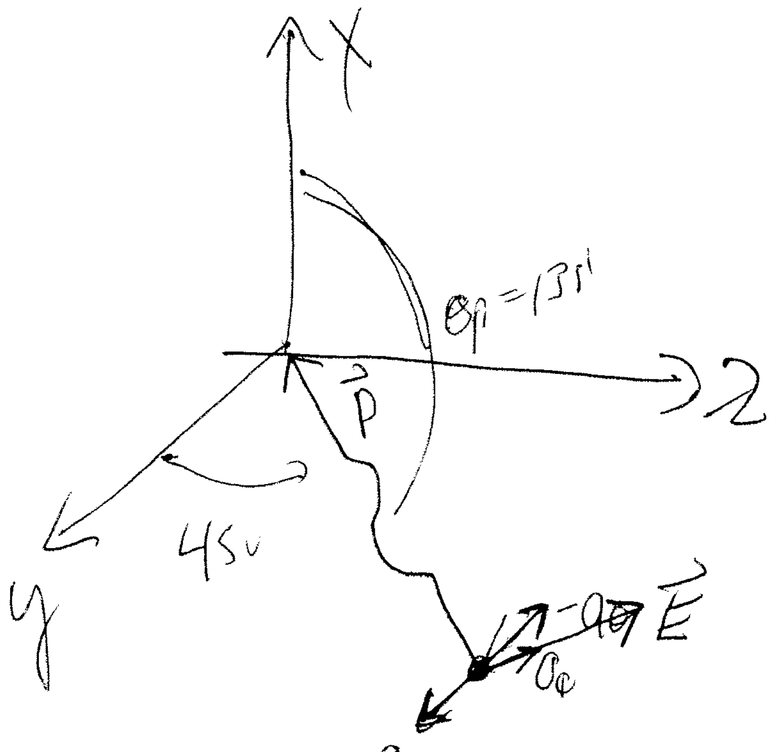
b)



c|


X
Z
-45°
$\vec{P}$
y
$\hat{a}_\theta$
$a_{\hat{\phi}}$
$\vec{E}$

d|


X
Z
$\theta_p = 135°$
$\vec{P}$
45°
y
$-a_\theta$
$\vec{E}$
a_ϕ
a_θ

+2

Problem 7
A current probe has a transfer impedance of 0 dB ±2 dB over the frequency range 50 kHz to 200 MHz. What is the minimum and maximum voltage output over this frequency range for a 1 mA input current? State all assumptions.

$Z_{TIR} = 20\log\left|\frac{V_s}{I_s}\right| = \pm 2\,dB$

$\log\left|\frac{V_s}{I_s}\right| = \frac{\pm 2}{20}$, $\frac{V_s}{I_s} = 10^{\pm\frac{1}{10}}$

$V_s = I_s 10^{\pm\frac{1}{10}} = (10^{-3})10^{\pm\frac{1}{10}} = 1.3\,mV$ to $.79\,mV$

assumption - same load impedance as when tested

+1

Problem 8
Why should an ordinary diode, when reversed biased, not be used as a voltage suppressor?

breakdown voltage is not very predictable

+1

Problem 9
As discussed in class, Jerry our senior (and only) technician has recommended to our current ee senior design students to use this device to control the power to Christmas lights. What is this device?

SCR or triac

+1

Problem 10
In the instructor's early informative years, he was a CB operator. A friend of his was also a CB operator. How did this friend increase the power (illegally) transmitted? What was one consequence of this illegal operation?

overmodulating signal - [illegible]
distortion and interference to other channels

Ken Kaiser 15.8

Problem 15_8 a current probe has a transfer impedance of 0 db +-2db over the frequency range 50khz to 200 mhz. what is the minimum and maximum voltage output over this frequency range for a 1 mA input current?

$\log\left(\left|\frac{V_s}{I_s}\right|\right)=\frac{2dB}{20}$ and $\log\left(\left|\frac{V_s}{I_s}\right|\right)=\frac{-2dB}{20}$

$\frac{V_s}{I_s}=10^{\frac{2dB}{20}}$ $\frac{V_s}{I_s}=10^{\frac{-2dB}{20}}$

$V_s=I_s\cdot(1.26)$ $V_s=I_s\cdot\left(\frac{1}{1.26}\right)$

$V_{smax}:=1.26mV$ $V_{smin}:=0.794\ mV$

The maximum ouput voltage when the current is 1 mA is 1.26 mV, and the minimum voltage is 0.794 mV.

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15.10

Problem 15.10

A current probe consists of 50 turns on an air core torroid. The torroid has an inner radius of 1.6 cm, outer radius is 2.5 cm, and height of 1.4 cm. Over what frequency range is this current probe acting like an ideal current transformer? If the coil is wrapped on a ferrite with a relative permeability of about 125 over a wide frequency range, will the self inductance increase by about 125? Will the mutual inductance increase by about 125?

Question 1: Over what frequency range is this current probe acting like an ideal current transformer?

Given:

$N := 50$

$b := .016$

$a := .025$

$s := .014$

Known:

$j := \sqrt{-1}$

$u_o := 4 \cdot \pi \cdot 10^{-7}$

Assume for general case for checking purposes :

$R_L := 50$

Varying:

$x := 1, 2 .. 100$

$\omega(x) := \left(x + 1 - 10 \cdot \mathrm{floor}\left(\frac{x}{10}\right)\right) \cdot 10^{\mathrm{floor}\left(\frac{x}{10}\right)}$

$y := -100, -1 .. 0$

Transfer function of current:

$M := \frac{N \cdot u_o \cdot s}{2 \cdot \pi} \cdot \ln\left(\frac{a}{b}\right) \qquad L := \frac{N^2 \cdot u_o \cdot s}{2 \cdot \pi} \cdot \ln\left(\frac{a}{b}\right)$

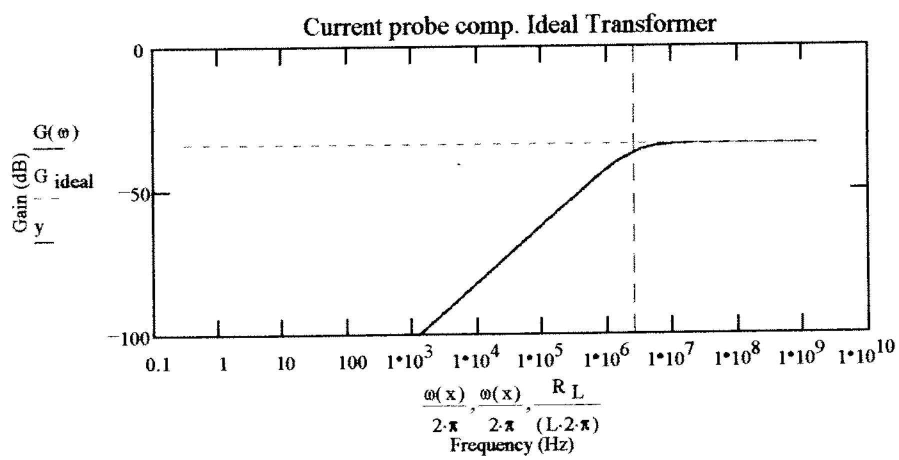
$G(\omega) := 20 \cdot \log\left(\left|\frac{j \cdot \omega(x) \cdot M}{j \cdot \omega(x) \cdot L + R_L}\right|\right)$

Into standard form:

$G(\omega) := 20 \cdot \log\left[\left|\frac{j \cdot \omega(x) \cdot \frac{M}{R_L}}{\frac{j \cdot \omega(x) \cdot L}{R_L} + 1}\right|\right]$

Ideal transformer:

$G_{ideal} := 20 \cdot \log\left(\frac{1}{N}\right)$



The probe will act like a Ideal current transformer above the frequency defined by the relationship: RL/(L*2*π). This value checks out in the above graph and shows that the calculations are correct.

Question 2&3: If the coil is wrapped on a ferrite with a relative permeability of about 125 over a wide frequency range, will the self inductance increase by about 125? Will the mutual inductance increase by about 125?

$$L = \frac{N^2 \cdot u_o \cdot s}{2 \cdot \pi} \cdot \ln\left(\frac{a}{b}\right) \qquad M = \frac{N \cdot u_o \cdot s}{2 \cdot \pi} \cdot \ln\left(\frac{a}{b}\right)$$

From looking at these equations you would think that a linear increase in the permeability would linearly increase the self inductance and mutual inductance but this is not necessarily true. Placing a ferrite torroid around the wire will distort the magnetic fields around the wire, thus the magnetic fields will not be purely circumferential. All of our calculations up to this point assumed air was our core material which doesn't distort the magnetic field. This distortion in the magnetic field should be taken into account. Introducing a ferrite core into the system that has a saturation flux density will also affect the output.

The permeability is a function of B and H: B = u H. But this is a nonlinear relationship. H is a function of current and if we increase or current on our line to a high enough point you will saturate the ferrite material and you will not be getting a relative permeability of 125. Even more than that since the relative permeability is (somewhat) dependent on where our B vs. H curve is we where not assured for our certain case of the amount of current through our wire would produce the H field to correspond to this specific value of our relative permeability. After we put this torrid into our system we could be at 100 or 150 permeability dependent on the environment we are putting this torrid into. The company needs to give us more information on our torrid (i.e. what test conditions they used to get 125) to find out if it would work for our system.

You will not get 125 gain in L and M just be putting a magnetic material in the air core torrid. There are to many variables that have not been specified that should have been to assure the proper gain in L and M that are required.

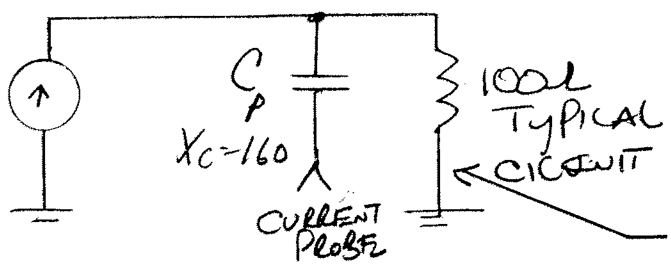
PROBLEM 16.7

Ken Kaiser [redacted]

A CURRENT PROBE IS USED AROUND A CIRCUIT WIRE. HOW CAN ANOTHER CURRENT PROBE BE USED TO DETERMINE THE EFFECT OF PARASITIC CAPACITANCE BETWEEN THIS CURRENT PROBE AND THE CIRCUIT? HOW CAN A NULL EXPERIMENT BE PERFORMED TO DETERMINE THE EFFECT OF THE ELECTRIC FIELD ON THE PROBE MEASUREMENT?

· ONE COMMERICALLY AVAILABLE PROBE HAS A PROBE TO CIRCUIT CAPACITANCE OF 1pF ; PROBES BW = 1GHZ

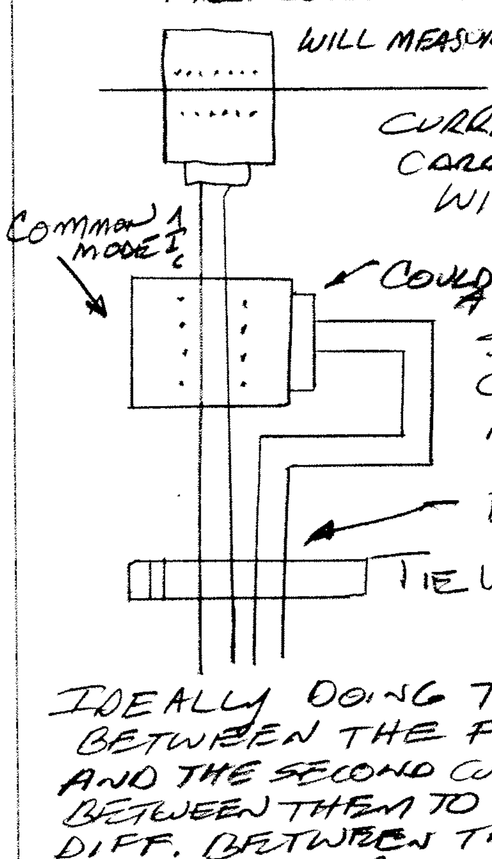
@ 1GHZ $X_C = 160$



PROBE WILL LOAD THE CIRCUIT UNDER TEST

SHOULD MEASURE ON THE GROUND SIDE of LOAD IF POSSIBLE (USE PROBE AT POINTS WITH LOW VOLTAGES)

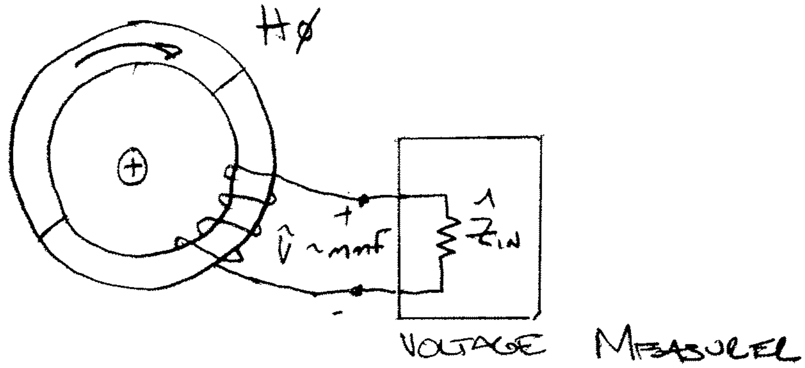
THIS CAPACITANCE CAN INJECT SIGNIFICANT AMOUNTS OF HIGH FREQUENCY CURRENT INTO A CIRCUIT.



· THE SECOND CURRENT PROBE IS USED TO MEASURE THE "COMMON MODE" CURRENT INJECTED INTO THE CIRCUIT BY THE FIRST PROBE. THE DISTANCE BETWEEN THE TWO PROBES SHOULD BE MINIMIZED TO REDUCE RADIATED SOURCES OF ERROR AND ERROR CAUSED BY PHASE SHIFTS BETWEEN THE TWO PROBES.

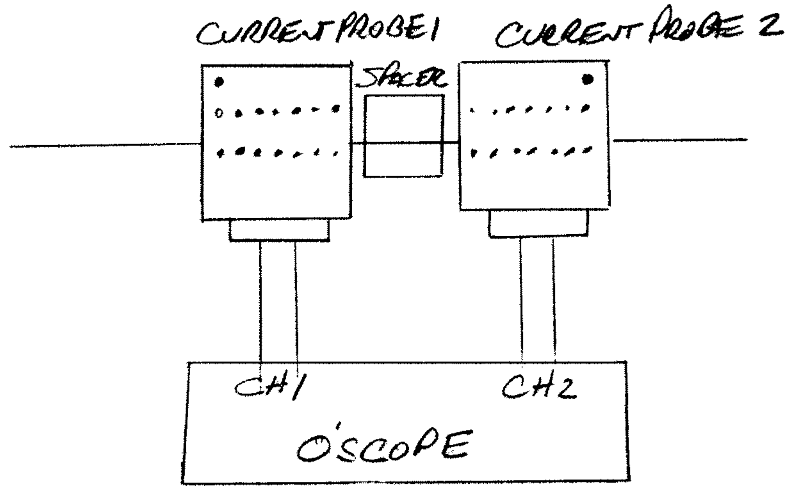
BETWEEN THEM THUS MINIMIZE THE VOLTAGE BETWEEN THE TWO BODIES.

IDEALLY DOING THIS WILL REDUCE THE CURRENT FLOWING BETWEEN THE FIRST PROBE'S CABLE AND THE SECOND AND THE SECOND CURRENT PROBE BODY THROUGH THE CAP. BETWEEN THEM TO ZERO BY ELIMINATING THE PONTENTIAL DIFF. BETWEEN THE SECOND PROBE AND THE CABLE OF THE FIRST PROBE



THE PROBE MEASURES THE TOTAL OR NET COMMON-MODE CURRENT IN THE CABLE AND THE MAGNETIC FLUXES DUE TO THE DIFFERENTIAL MODE CURRENTS CANCEL OUT IN THE CORE. THUS THE CURRENT PROBE WILL NOT MEASURE DIFFENTIAL-MODE CURRENTS UNLESS IT IS PLACED AROUND EACH INDIVIDUAL WIRE.

- NULL EXPERIMENT USING TWO CURRENT PROBES



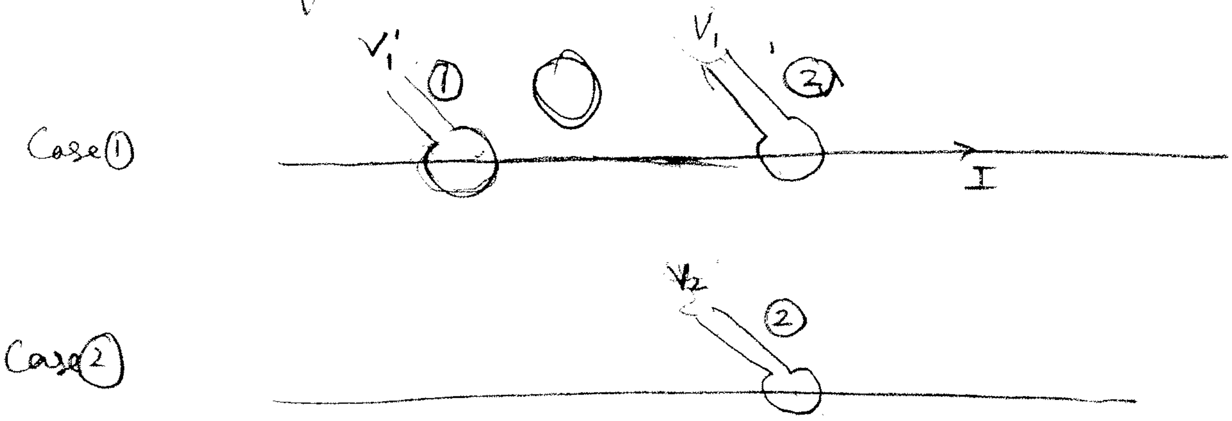
- PHYSICALLY REVERSED CURRENT PROBES CONNECTED TO TWO CHANNELS OF AN O'SCOPE, THE TRACES WILL BE MIRROR IMAGES OF EACH OTHER PROVIDED THERE IS NO COMMON MODE INTERFERENCE TO THE MEASUREMENT & THE PROBES ARE VERY CLOSE TO EACH OTHER.

- COMMON MODE INTERFERENCE WILL RESULT IN THE TWO TRACES NOT APPEARING AS MIRROR IMAGES.

- FOR EXAMPLE, CAP. COUPLING FROM THE WIRE TO THE PROBE WILL MAKE THE TWO TRACES MOVE IN THE SAME DIRECTION, BOTH UP OR DOWN, WHEREAS A REAL CURRENT WILL MAKE ONE TRACE MOVE UP AND THE OTHER DOWN.

16.19) To determine the effect of parasitic capacitance of the current probe, the following method can be used.

Two readings in sucession can be taken by probe (2)



The difference in voltage $(V_1 - V_2)$ is directly related to the change in the impedance of the wire brought about by introduction of probe (1).

To determine the effect of the probe (1) on the probe (2), the same experiment can be followed for different values of the current. The difference $(V_1 - V_2)$ w r t the current will form a calibration curve. Based on this curve, the reading scale can be defined

(Null Expt) To determine the effect of the electric field, the voltage across the probe should be measured when the current flowing the line is zero. This voltage might be some other time varying noise.

Probe off of a circuit
a record