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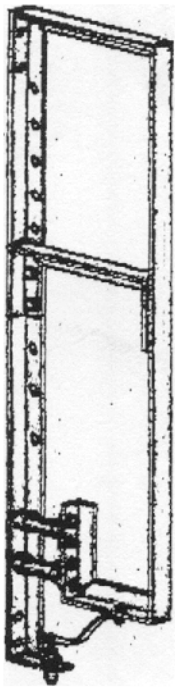
TYPE 601 FIXED SAMPLING LOOP



DESCRIPTION

THE ELECTRONICS RESEARCH, INC. TYPE 601 FIXED SAMPLING LOOP IS FABRICATED FROM STAINLESS STEEL ANGLE STOCK, AND THE LOOP CORNERS ARE MITERED AND WELDED. THE SENSITIVITY IS ADJUSTABLE BY VARYING THE FIXED POSITION OF THE SHORTING BAR PROVIDED. THE USE OF STAINLESS STEEL ASSURES GOOD ELECTRICAL CONTACT, AND FREEDOM FROM CORROSION.

THE ERI TYPE 601 FIXED SAMPLING LOOP PROVIDES A MEANS FOR ACCURATELY SAMPLING THE RADIO FREQUENCY ENERGY IN THE TOWERS OF AN AM DIRECTIONAL ANTENNA ARRAY. THE SAMPLE CURRENT IS FED, VIA A WELL-SHIELDED COAXIAL CABLE, TO AN ANTENNA (PHASE) MONITOR WHERE THE AMPLITUDE AND PHASE ARE COMPARED TO A SAMPLE OF CURRENT FROM A GIVEN REFERENCE TOWER, ONE SAMPLING LOOP BEING MOUNTED ON EACH OF THE TOWERS IN THE ARRAY.

THE VERTICAL MEMBERS OF THE LOOP ARE PROVIDED WITH A NUMBER OF HOLES IN ORDER TO PERMIT A WIDE RANGE OF SHORTING BAR ADJUSTMENT, SO THAT NO FIELD MODIFICATION SHOULD BE NECESSARY. THE SHORTING BAR IS FIRMLY BOLTED ACROSS THE LOOP BY THE USE OF FOUR STAINLESS STEEL BOLTS. A GOOD LONG-TERM ELECTRICAL CONTACT BETWEEN THE SHORTING BAR AND THE LOOP IS ASSURED IF THE ORIGINAL CONNECTIONS ARE CLEAN AND THE BOLTS FIRMLY TIGHTENED.

THE ERI TYPE 601 FIXED SAMPLING LOOP IS AVAILABLE IN TWO SIZES. THE ERI TYPE 601-48 HAS A LOOP SIZE OF 48 INCHES BY 12 INCHES (121.92 CM BY 30.48 CM), AND THE ERI TYPE 601-91 HAS A LOOP SIZE OF 91 INCHES BY 12 INCHES (231.14 CM BY 30.48 CM).

THE LOWER END OF THE SAMPLING LOOP IS FITTED WITH A HIGH QUALITY, WEATHERPROOF, GLAZED CERAMIC END TERMINAL. THIS END TERMINAL HAS A TYPE N FEMALE JACK (UG-23, WITH TEFLON INSULATION) WHICH WILL MATE WITH A TYPE N MALE PLUG (UG-21); HOWEVER, THE MALE PLUG IS NOT FURNISHED.

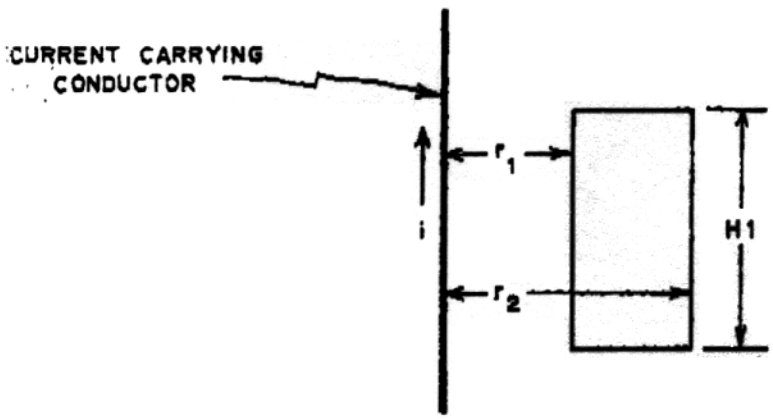
MOUNTING

THE ERI TYPE 601 FIXED SAMPLING LOOP MAY BE MOUNTED DIRECTLY ON A TOWER LEG BY THE USE OF TWO SPECIAL TOWER LEG ADAPTORS. THE TOWER LEG ADAPTORS ARE NOT SUPPLIED, BUT SUCH ADAPTORS, FOR EITHER ROUND LEG OR ANGLE LEG TOWERS, ARE READILY AVAILABLE FROM SUPPLIERS. FIVE 9/16 INCH (14.29 CM) HOLES ARE PROVIDED ON ONE EDGE OF THE LOOP FOR MOUNTING PURPOSES.

MOUNTING THE LOOP DIRECTLY ON THE TOWER LEG NECESSITATES THE USE OF AN ISOLATION CHOKE OR FILTER, CONNECTED IN SERIES WITH THE COAXIAL SAMPLING LINE. SUCH AN ISOLATION CHOKE NORMALLY HAS AN INDUCTANCE VALUE OF 100 MICROHENRIES, OR GREATER, THUS PRESENTING A HIGH VALUE OF SHUNTING IMPEDANCE ACROSS THE BASE INSULATOR OF AN INSULATED TOWER.

THE SAMPLING LOOP MAY ALSO BE MOUNTED ON STAND-OFF INSULATORS. IN THIS CASE, THE INSULATORS ARE ATTACHED TO THE LEG OF THE TOWER BY THE USE OF SUITABLE TOWER LEG ADAPTORS.

THE SAMPLING LOOP IS NORMALLY MOUNTED APPROXIMATELY 15 FEET (4.57 METERS), OR SO, ABOVE THE TOWER BASE FOR TOWERS WHICH ARE A QUARTER-WAVE, OR LESS, IN HEIGHT. IN THE CASE OF TALLER TOWERS, THE SAMPLING LOOP IS NORMALLY MOUNTED AT A CURRENT LOOP, OR MAXIMUM CURRENT POINT, ON THE TOWER. THE TOWER LEG FOR MOUNTING IS SELECTED SO THAT THERE WILL BE A MINIMUM SIGNAL INTRODUCED INTO THE SAMPLING LOOP FROM THE OTHER TOWERS OF THE ARRAY.



FIGURE

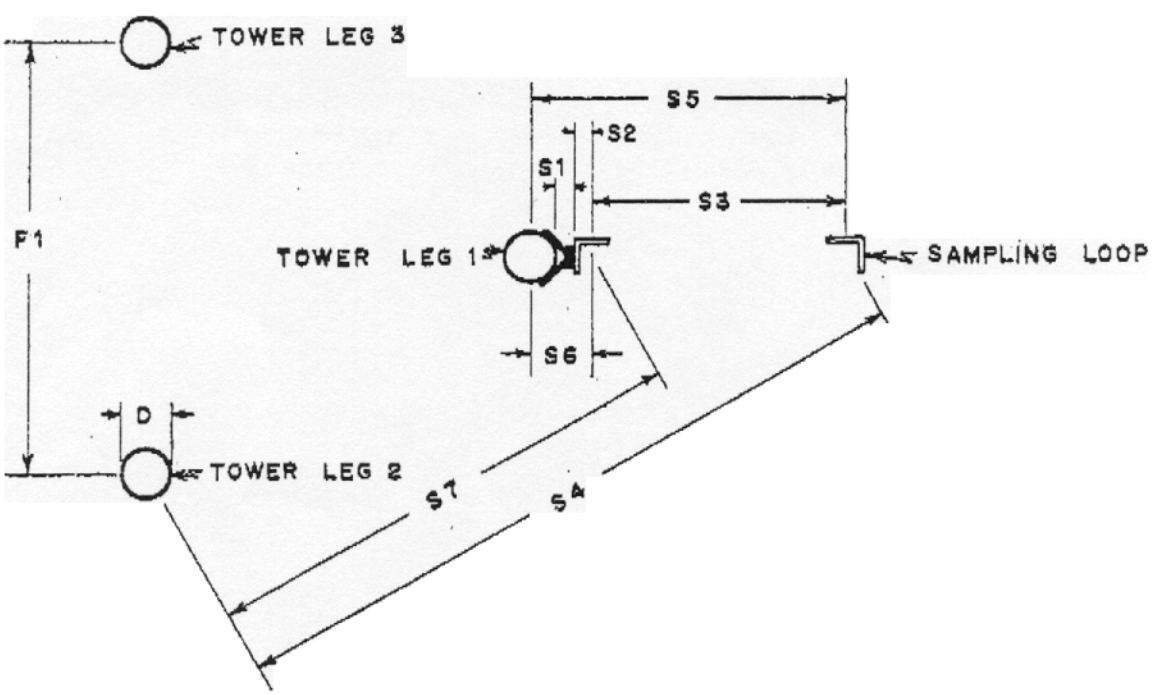


FIGURE 2

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CALCULATION OF THE VOLTAGE INDUCED IN A RECTANGULAR SAMPLING LOOP MOUNTED ON A TRIANGULAR TOWER HAVING TUBULAR LEGS

THE BASIC PICTURE OF A SAMPLING LOOP IS SHOWN IN FIGURE 1, AND A TYPICAL SAMPLING LOOP MOUNT IS SHOWN IN FIGURE 2. OUR PURPOSE IS TO CALCULATE THE VOLTAGE INDUCED IN THE SAMPLING LOOP. (THE DERIVATION OF THE EQUATION WILL BE SHOWN LATER.)

ASSUME THE LOOP IS ORIENTED AS SHOWN IN FIGURE 2, AND ASSUME THAT ONE-THIRD OF THE TOWER CURRENT GOES THROUGH EACH OF THE TOWER LEGS.

THE VOLTAGE INDUCED IN THE SAMPLING LOOP WITH I AMPERES OF TOWER CURRENT AT THE MOUNTING HEIGHT OF THE LOOP ON THE TOWER MAY BE CALCULATED USING THE EQUATION:

$$V = /3 \times I \times F \times .257 \times 10^{-6} \times H1 \times (\text{LN } S5/S6 + 2 \text{ LN } S4/S7). \qquad (1)$$

WHERE I = TOWER CURRENT IN AMPERES.
F = FREQUENCY IN HERTZ.
H1 = HEIGHT (LENGTH) OF THE SAMPLING LOOP IN METERS.
D = DIAMETER OF THE TOWER LEG.
F1 = CENTER TO CENTER LEG SPACING OF THE TOWER.
S1 = SEPARATION OF THE LOOP FROM THE SURFACE OF THE TOWER LEG DUE TO THE MOUNTING BRACKET.
S2 = HALF OF THE WIDTH OF THE ANGLE STOCK USED IN THE LOOP.
S3 = NOMINAL CENTER TO CENTER DIMENSION OF THE LOOP.
S4 = $r_2 = ((F1/2)^2 + (F1 \sin 60° + D/2 + S1 + S2 + S3)^2)^{1/2}$, USED WITH REFERENCE TO TOWER LEGS 2 AND 3.
S5 = $r_2 = D/2 + S1 + S2 + S3$, USED WITH REFERENCE TO TOWER LEG 1.
S6 = $r_1 = D/2 + S1 + S2$, USED WITH REFERENCE TO TOWER LEG 1.
S7 = $r_1 = ((F1/2)^2 + (F1 \sin 60° + D/2 + S1 + S2)^2)^{1/2}$, USED WITH REFERENCE TO TOWER LEGS 2 AND 3.

EXAMPLE: (LET US ASSUME I = 1 AMPERE, F = 1170×10^3 HERTZ.)
D = 2 INCHES (DIAMETER OF THE TOWER LEG.)
F1 = 18 INCHES (CENTER TO CENTER LEG SPACING OF THE TOWER.)
S1 = 0.75 INCHES (SEPARATION OF THE LOOP FROM THE TOWER LEG - ANDREW 13550 ADAPTOR.)
S2 = 0.75 INCHES (HALF THE WIDTH OF THE ANGLE STOCK IN THE LOOP.)
S3 = 10.5 INCHES (ERI TYPE 601-48 OR ERI TYPE 601-91 SAMPLING LOOP.)
S4 = $((9)^2 + (18 \sin 60° + 1 + .75 + .75 + 10.5)^2)^{1/2} = 29.97$ INCHES.
S5 = 1 + .75 + .75 + 10.5 = 13 INCHES.
S6 = 1 + .75 + .75 = 2.5 INCHES.
S7 = $((9)^2 + (18 \sin 60° + 1 + .75 + .75)^2)^{1/2} = 20.20$ INCHES.
H1 = 1.219 METERS = LENGTH OF THE ERI TYPE 601-48 SAMPLING LOOP. (THE ERI TYPE 601-91 SAMPLING LOOP HAS A LENGTH OF 2.311 METERS.)

$$V = 1/3 \times 1 \times 1170 \times 10^3 \times 1.257 \times 10^{-6} \times 1.219 (\text{LN } 13/2.5 + 2 \text{ LN } 29.97/20.20)$$

V = 1.46 VOLTS/AMPERE OF TOWER CURRENT.

THE INTERNAL IMPEDANCE OF THE ERI TYPE 601-48 SAMPLING LOOP IS ESSENTIALLY 0 + j10 AT 1,000 KILOHERTZ, AND IS PROPORTIONAL TO FREQUENCY SO THAT IT CAN GENERALLY BE NEGLECTED. THE INTERNAL IMPEDANCE OF THE ERI TYPE 601-91 IS ESSENTIALLY 0 + j19 AT 1,000 KILOHERTZ.

IN THE EXAMPLE, THE VOLTAGE/AMPERE OF TOWER CURRENT DELIVERED TO A 50 OHM SAMPLING LINE WOULD BE $1.46 \times 50/(50^2 + 11.7^2)^{1/2} = 1.42$ VOLTS. (NOTE: THE REACTIVE COMPONENT OF THE TYPE 601 SAMPLING LOOP HAS BEEN CONSIDERED IN THIS CASE.)

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EQUATION (1) HAS BEEN FOUND TO BE QUITE ACCURATE WHEN THE TOWER CURRENT AT THE MOUNTING HEIGHT OF THE LOOP IS KNOWN.

DERIVATION OF EQUATION (1) *:

CALCULATE THE VOLTAGE INDUCED BY DETERMINING THE FLUX OF THE MAGNETIC FIELD **B** THROUGH THE LOOP. CALL THIS FLUX Φ. THE INDUCED VOLTAGE WILL THEN BE $j\omega\Phi$.

USE MAXWELL'S LAW, CURL **H** = **J** + $\dot{\mathbf{D}}$ (2)**

FROM THIS, $\frac{2\pi r B}{\mu_o} = I$, $B = \frac{I\mu_o}{2\pi}\frac{1}{r}$

$\Phi = \int^{\text{OVER AREA OF LOOP}} B$, $\Phi = \frac{I\mu_o(H1)}{2\pi}\ \text{Ln}\ \frac{r_2}{r_1}$

TERMS USED IN BASIC DERIVATION:

H1 = HEIGHT (LENGTH) OF THE SAMPLING LOOP IN METERS.
H = $B/(\mu\mu_o)$ = MAGNETIC FIELD VECTOR.
B = MAGNETIC FIELD.
D = DISPLACEMENT FIELD = $\xi\xi_o\mathbf{E}$
I = CURRENT IN AMPERES.
F = FREQUENCY IN HERTZ.
μ_o = PERMEABILITY OF FREE SPACE = $4\pi 10^{-7} = 1.257 \times 10^{-6}$ HENRY PER METER.
r_1 = SPACING FROM THE TOWER LEG TO THE LEG OF THE LOOP CLOSEST TO THE TOWER LEG.
r_2 = SPACING FROM THE TOWER LEG TO THE LEG OF THE LOOP FARTHEST FROM THE TOWER LEG.

FROM (2) $2\pi F\Phi = I \times F \times 1.257 \times 10^{-6} \times H1 \times \text{LN}\ r_2/r_1$

ADD CONTRIBUTIONS FROM THE THREE TOWER LEGS SHOWN IN FIGURE 2.

CONSIDER LEG 1:
r_2 = S5 = D/2 + S1 + S2 + S3.
r_1 = S6 = D/2 + S1 + S2.

CONSIDER LEGS 2 AND 3:
r_2 = S4 = $((F1/2)^2 + (F1 \sin 60° + D/2 + S1 + S2 + S3)^2)^{1/2}$
r_1 = S7 = $((F1/2)^2 + (F1 \sin 60° + D/2 + S1 + S2)^2)^{1/2}$

ALSO, CONSIDER THAT ONLY ONE-THIRD OF THE TOWER CURRENT GOES THROUGH EACH TOWER LEG.

THEREFORE, COMBINING THE ABOVE, THE VOLTAGE INDUCED IN THE LOOP WITH I AMPERES OF TOWER CURRENT AT THE MOUNTING HEIGHT OF THE LOOP ON THE TOWER WILL BE AS FOLLOWS:

$V = 1/3 \times I \times F \times .257 \times 10^{-6} \times H1 \times (\text{LN}\ S5/S6 + 2\ \text{LN}\ S4/S7)$

* THESE CALCULATIONS WERE FURNISHED BY MR. ROBERT M. SILLIMAN, PRESIDENT, ELECTRONICS RESEARCH, INC., 108 MARKET STREET, NEWBURGH, INDIANA 47630.

** NOTE: **J** IS THE CURRENT IN THIS EQUATION.