SECTION VII

C.A.T.V. Ingress/Egress Monitoring Techniques

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"THE EVALUATION OF INGRESS AND EGRESS PROBLEMS IN THE C.A.T.V. SUB LOW FREQUENCY SPECTRUM"

#18 ST - 36100 - 8 - 1367

March 28, 1980

CONTENTS

7.0 INTRODUCTION

Independent of the original quality of construction and material the long term performance of a two-way CATV system is dependent on the on-going maintenance and debugging procedures used. It is therefore very important to develop and practise on a continuing basis effective ingress/egress monitoring techniques in order to isolate and repair areas of deteriorated shielding effectiveness. The exact requirements for shielding and therefore the appropriate monitoring technique may depend on the application, e.g. system operating levels, immunity to interference, error correction techniques and reliability desired--all can affect the shielding level required.

7.1 SHIELDING EFFECTIVENESS MONITORING TECHNIQUES

Three different techniques for identifying leakage and ingress sources are discussed. These are:

- Time Domain Reflectometry
- Radiation Monitoring
- Transmitter Patrol

The segmentation of the CATV plant makes the process of locating return ingress problems easier. Using switches in the bridger return path, ingress sources can be isolated to individual bridger areas or individual trunks. Signal intrusion can be monitored with a spectrum analyzer at the head-end. Once the general area of the plant causing the problem is identified, some technique must be used to further isolate the source of the problem.

7.2 TIME DOMAIN REFLECTOMETRY

Since a Time Domain Reflectometer (T.D.R.) can be used to isolate discontinuities in the cable plant, it can be expected to identify loose connections or cable breakages, or cracks which may be a cause of ingress. Certainly severe problems can be located using this method. However, tests have indicated that a large degradation in shielding can occur and remain undetected by the T.D.R. This affect was experienced during the evaluation of connectors for this study. The shielding of sample 38 854 studied in Section 2 - Corrosion Shielding of CATV Connectors deteriorated from 130 dB to 70 dB while the T.D.R. display remained virtually unchanged (see figure 2.20, 2.21, 2.22). This severely limits the usefulness of this method for identifying the location of shielding problems. The T.D.R. method is, therefore, not recommended for determining sources of ingress.

7.3 RADIATION MONITORING

Many CATV systems conduct routine radiation monitoring patrols. A VHF carrier is inserted on the CATV system and an antenna and receiver external to the system detect the presence of fields caused by radiation of the inserted carrier. A commonly used radiation monitoring procedure is described in Appendix 7.1.

The level of field strength detected by this technique is calculated in Appendix 7.2 while the shieldings of the system which caused this field strength are calculated in Appendix 7.3.

Radiation monitoring requires only one man so is a relatively inexpensive and efficient means of finding some shielding problems.

7.4 TRANSMITTER PATROL

A reciprocal technique of radiation monitoring is using a transmitter patrol. A VHF or HF transmitter can be used.

Using VHF, the transmitter is moved along adjacent to the CATV plant while a receiver is connected at the end of the CATV line. Only distribution faults, not drop faults, tend to be found using this technique due to the tap to output isolation of a multitap. See Appendix 7.4 for calculations of the plant shieldings which can be detected.

Using HF, the transmitter is also moved along adjacent to the CATV plant but the receiver can be connected at the CATV head end or hub. Both distribution and drop faults are found using this technique. See Appendix 7.5 for calculations of plant shieldings which can be detected.

Either technique of transmitter patrol requires two men, one at the transmitter and one at the receiver. This technique is thus relatively expensive.

7.5 Comparison of Monitoring Techniques and Recommendations

Time Domain Reflectometry, while it is useful in finding severe connector problems, is not necessarily sensitive enough to adequately isolate shielding problems.

A comparison of the sensitivity of each of the other monitoring techniques is shown in Table 7.1.

Table 7.1

Thresholds of Detectable Shielding

CATV Plant Area	Detectable Shielding (dB) Using		
	Radiation Monitoring	VHF Transmitter	HF Transmitter
Trunk	49. - 69.	43 - 63	78 - 88
Distribution	39. - 89.	23 - 73	68 - 88
Drop	39. - 59.	3 - 53	53 - 73

The HF transmitter technique is most sensitive and has the most constant sensitivity of the compared methods. It must be noted that both radiation monitoring and the VHF transmitter technique use VHF while the HF transmitter technique uses HF. A shielding discontinuity may result in very different shielding effectiveness at HF and VHF.

There are uses for all three of the monitoring techniques described. Radiation monitoring is the least expensive technique as it only requires one man and can be conducted before the installation of an HF system. It has been noted in previous work that unsatisfactory ingress problems can occur with no shielding problem detected by the radiation monitor.

The VHF transmitter technique requires two men and can also be used before the installation of an HF system. However, the sensitivity of this technique varies widely on both distribution plant and drops.

The HF transmitter technique requires two men and can not be used before the installation of an HF CATV system. The sensitivity of this technique is relatively constant.

In order for a CATV system to use either the VHF or HF transmitter technique on a routine basis, a frequency must be assigned in both the VHF and HF bands for CATV shielding maintenance.

Since different CATV systems may use different frequencies and/or signal formats, standard CATV test frequencies may be undesirable. From a CATV operators viewpoint, standardization of test frequencies is not important. The ability to conduct shielding tests is important. These shielding tests, if conducted on a regular basis, should greatly reduce the interference between CATV and off-air signals.

APPENDIX 7.1

Typical Radiation Monitoring Procedure

Requirement

Broadcast Procedure 23 - minimum technical standards for C.A.T.V. systems.

Maximum E.M. Radiation: 20 μv/m. at 3 m. (10 ft.)

at frequencies: a) 54 MHz to 108 MHz
b) 174 MHz to 216 MHz

Maximum E.M. radiation: 10 μv/m. at 3 m. (10 ft.) at frequencies 108 MHz to 174 MHz.

The 10 μv/m. specification is used since this applies to the mid band where the ingress and egress problems cause the most problems.

Test Method

This test method is based upon the comparison of a detected signal radiating from a test antenna at a given fixed frequency via a special highly selective receiver and the actual measurements made with test equipment used to determine conformance to B.P. 23 radiation standards.

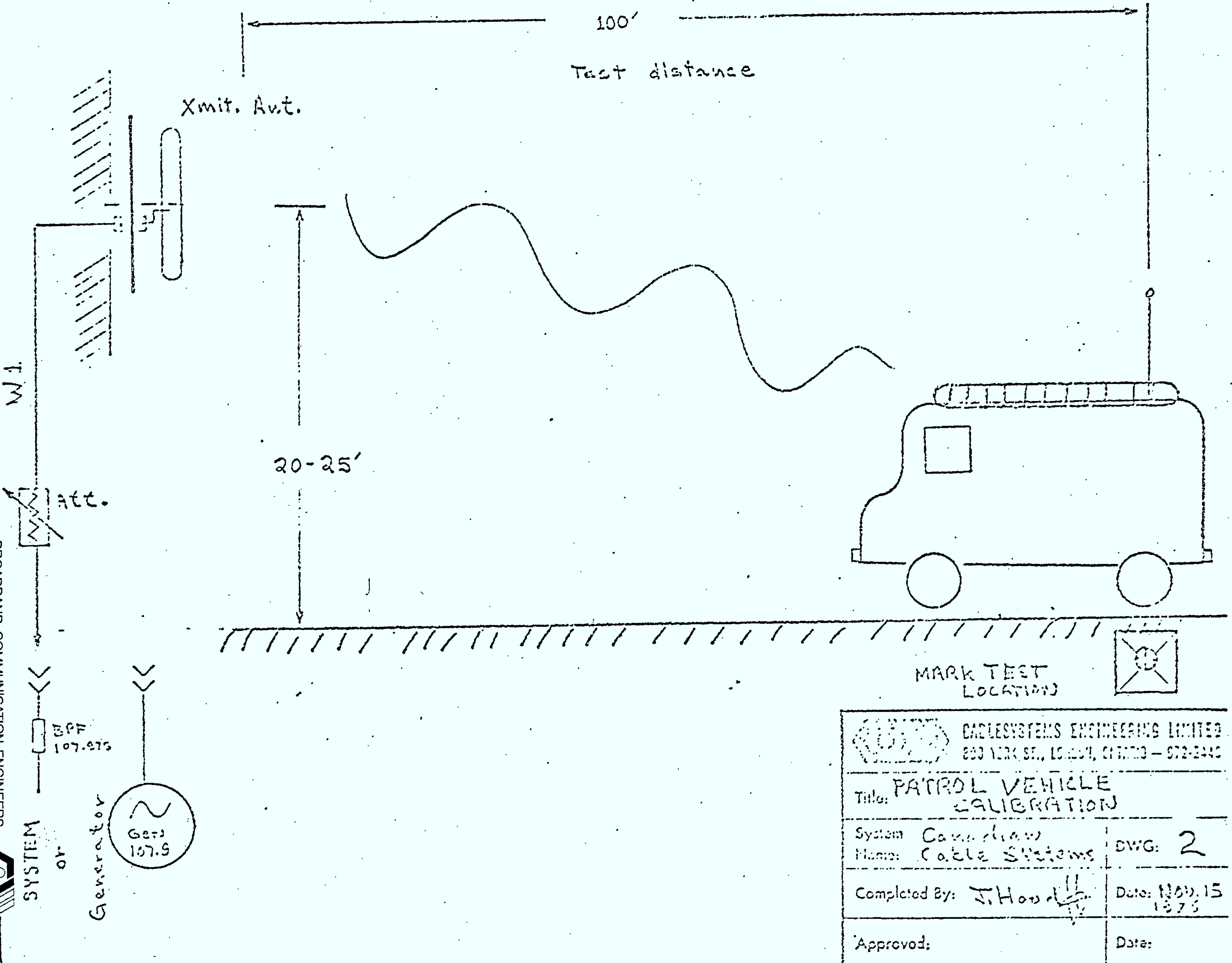
EQUIPMENT REQUIRED

Reference Designation	Description	Quantity	Mfg. & Model #	Notes
Ant.	Dipole Antenna & Tripod	1	Singer KT-105A	or equiv. or see Appendix B.
FSM	Signal Level Meter	1	Stoddart NM 30A	or equivalent
	or			
Spectrum Analyzer	Spectrum Analyzer included. IF unit, RF unit and display unit	1	Hewlett-Packard HP 8554B/ 8552B	or equivalent
BPF	Tuneable Band Pass filter 54-216 MHz	1	Telonic	or equivalent
Amp. RF	Wide band RF Amplifier 20 dB gain, 4 dB noise figure	1	HP 8447A	or equivalent
Att. Var.	Variable Attentuator 40 dB minimum	2		
Trans-mitting Ant.	2 Element F.M. Antenna	1	Delhi 2 YFM	or equivalent
xfmr	Matching Transformer	1	Jerrold TD 374A	or equivalent
Generator	FM generator crystal control, pulsed 600 hz tone	1	Jerrold MCG 107.975	or equivalent
Patrol Receiver	FM Receiver 107 MHz high sensitivity	1	C E	
Patrol Antenna	1/4 λ F.M. (auto) Special	1	C E	
W 1	Required length/type RG 59/u Co-axial 100% cable attenuation $\approx 0.30\sqrt{107.9} + 0.002\ (107.975)$		Amphenol 21-1159	or equivalent
W 2	50Ω coaxial cable & BNC cables	15 ft.	Amphenol RG 58/u	or equivalent

Test Procedure

1. Set up equipment in an open area as indicated in Drawing and free from system interference.
2. Signal source can be a fed from the system or MCG generator.
3. Signal level at the antenna is -0.5 dBmV. The cable should be 100% shielded type of known length.
4. Field strength received at the 100 ft. location should be ≈5μv. Theoretical calculations for this value are shown in Appendix A. The 100 ft. location has been selected to avoid errors due to the near field effect. This location should be marked with paint or stake, etc.
5. With patrol receiver at this location (see Drawing 2), with full gain (no squelch) a clear tone should be heard.
6. Actuate the 10 dB receiver attenuator and the tone should be heard possibly with a noisy background.
7. Increase the squelch level until the tone is just cancelled.
8. Increase the drive antenna power by 3 dB - squelch should just open.
9. Increase the drive antenna power a further 5 dB.
10. Actuate the 10 dB receiver attenuator and the tone should be squelched.

The Patrol System is now calibrated to detect out of specification emissions 50 feet from their source.



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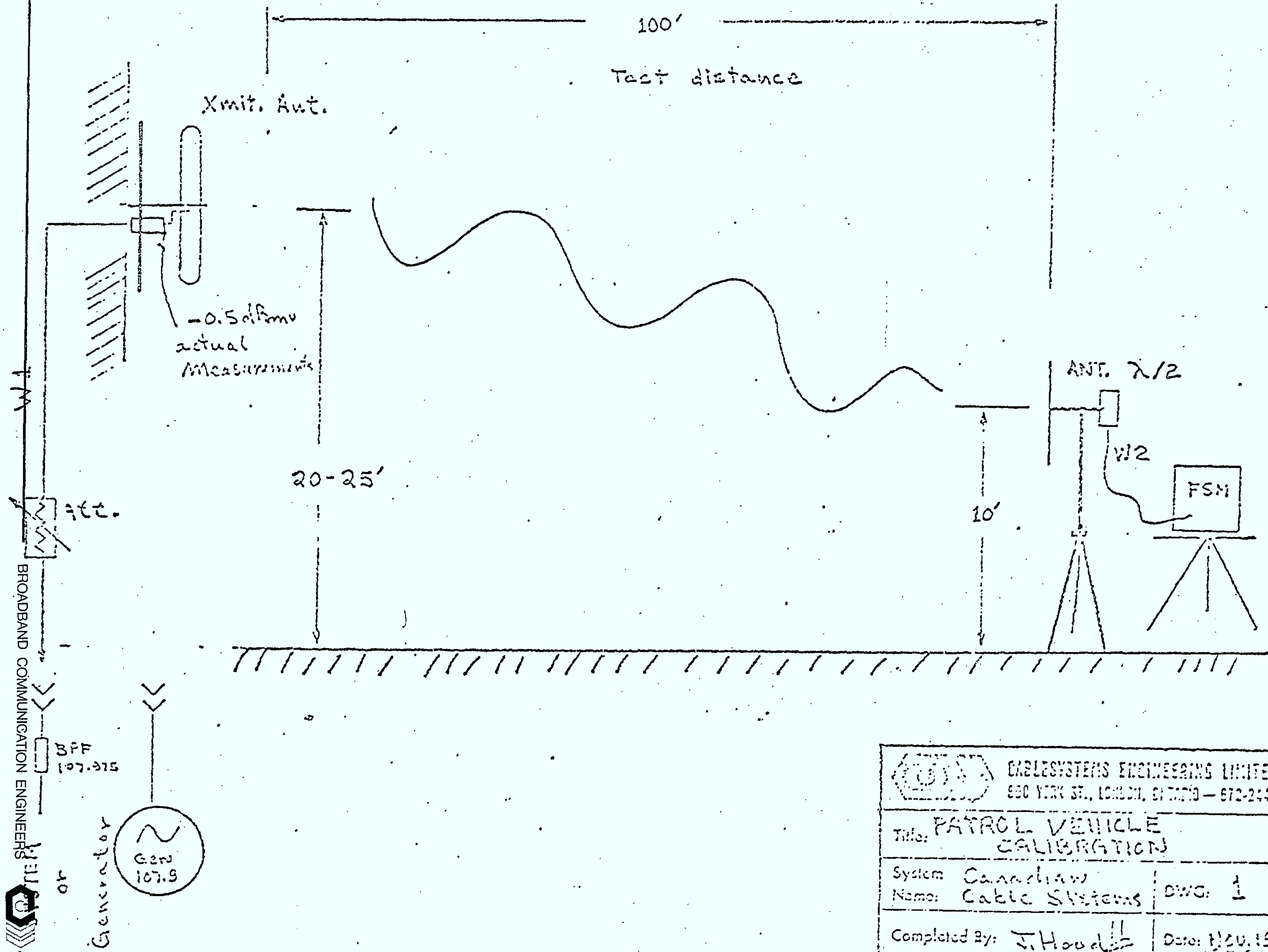

CABLESYSTEMS ENGINEERING LIMITED
850 YORK ST., LONDON, ONTARIO — 672-2440

Title: PATROL VEHICLE CALIBRATION

System Name: Canadian Cable Systems | DWG: 1

Completed By: J. Hood | Date: Nov. 15 1978

Approved: | Date:

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APPENDIX 7.2

Determination of Minimum Detectable Radiation

Assume that the maximum input sensitivity of a radiation monitor is 1μV across 75Ω. The power intercepted (Pr) by the antenna to give an input signal of 1μV is given by:

$Pr = V^2/75 = (1 \times 10^{-6})^2/75 = 1.33 \times 10^{-14}$ Watts.

Assume that the receiving antenna is a λ/2 dipole of G = 1.64. The power density P_d (in Watts/m^2) is given by: P_d = Pr/antenna area. Where antenna area = $G\ \lambda^2/4\pi$. Assuming the radiation carrier frequency is 108MHz, λ = 2.78 m. $\lambda^2 = 7.73$

Therefore, $P_d = (1.33 \times 10^{-14} \times 4\pi) / 1.64 \times 7.73 = 1.32 \times 0^{-14}$ Watts/m^2

The field strength for any given power density is:

$E = (120\pi \times P_d)^{1/2}$ where 120π is known as the resistance of free space.

This yields: $E = (120\pi \times 1.32 \times 10^{-14})^{1/2} = 2.23 \times 10^{-6}$ V/m = 2.23μV/m

Therefore the minimum radiation the monitor can detect is 2.23μV/m.

The most stringent B.P.23 specification for radiation is: 10μV/m at 3 m. The radiation monitor is 20 log 10/2.23 = 20 log 4.48 = 13.03dB more sensitive than minimum required or it can detect out of specification emissions at a maximun distance of 3 x 4.48 = 13.45m (44.14 feet).

APPENDIX 7.3

Determination of CATV Plant Shielding
Effectiveness For Minimum Detectable
Radiation At 3 Meters

For an isotropic radiator the relationship between transmitted power, P, (W) and field strength, E, (V/m) at any distance, R, (m) is: $E = (30 \times P_t)^{1/2}/R$.

In this case $E = 2.23 \times 10^{-6}$ V/m and R = 3m. The power transmitted to give a field strength of 2.23×10^{-6} V/m at 3m is given from $P_t = (E \times R)^2/30 = (2.23 \times 10^{-6} \times 3)^2/30 = 1.49 \times 10^{-12}$ Watts.

The power transmitted, P_t, can be expressed in dBm.

1.49×10^{-12} Watts $= 1.49 \times 10^{-9}$ mW

$[P_t]$ dBm $= 10 \times \log_{10} 1.49 \times 10^{-9} = 88.26$dBm

The radiated power P_t from the cable plant is a function of signal level within the co-axial cable and shielding effectiveness. The forward signal level range in each section of the cable plant is known and the shielding effectiveness for minimum detectable radiation can be calculated.

Trunk: Typical signal level range is + 10 to + 30 dBmV

a) at + 10dBmV (-38.75dBm)
shielding effectiveness = -38.75 - (-88.26) = 49.51dB

b) at + 30dBmV (-18.75dBm)
shielding effectiveness = -18.75 - (-88.26) = 69.51dB

Distribution: Typical signal level range is 0 to + 50 dBmV

a) at 0dBmV (-48.75dBm)
shielding effectiveness = -48.75-(-88.26)=39.51dB

b) at + 50dBmV (+ 1.25dBm)
shielding effectiveness = + 1.25-(-88.26)=89.51dB

Drop: Typical signal level range is 0 to + 20dBmV

a) at 0 dBmV (-48.75dBm)
shielding effectiveness = - 48.75 - (-88.26) = 39.51dB

b) at + 20dBmV (-28.75 dBm)
shielding effectiveness = - 28.75 - (-88.26) = 59.51dB

APPENDIX 7.4

Determination of Maximum Detectable Effective Shielding Using VHF Transmitter at 30 Meters From the CATV Plant

Assuming the effective radiated power from the VHF transmitter is 10 W (+40dBm)and the path loss .

$$P.L. = -27.55 + 20 \log_{10} R = 20 \log_{10} f$$

If R = 30m and f = 150MHz

Then P.L. = 45.5dB

The RFI level is:

(RFI = +40 - 45.5 - Shielding effectiveness + 48.75 - System loss dBmV)

System Loss = Attenuation (dB) from point of ingress to point of measurement

Shielding effectiveness = +40 - 45.5 + 48.75 - System loss - RFI

Since the minimum detectable RFI level RFImin. is independent of where the ingress occurs and System loss can be calculated if the point of ingress is known, the maximum shielding effectiveness which is detectable can be calculated.

Assume RFImin. = -30dBmV

If point of ingress is Trunk I/P, System loss = 10dB

∴ S.E.min (Tr. I/P) = 63.25dB

If point of ingress is Trunk O/P, System loss = 30 dB

S.E.min (Tr. O/P) = 43.25dB

If point of ingress is distribution line range of System loss = 0 - 50dB

(S.e. min (Dist.) = 73.25dBmax. or 23.25dBmin).

For a drop, range of System loss = 20 - 70dB

(S.E.min.(drop) = 53.25dBmax. or 3.25dBmin.)

APPENDIX 7.5

Determination of Maximum Detectable Effective Shielding Using HF Transmitter at 30 Meters From the CATV Plant

Assuming the effective radiated power from the HF transmitter is 10W (+40dBm), and the path loss P.L. = $-27.55 + 20 \log_{10} R + 20 \log_{10} f$

If R = 30m and f = 27MHz

Then P.L. = 30.62dB

The RFI level is

RFI = +40 - 30.62 - S.E. + 48.75 - System Loss

Where System Loss = Attenuation (dB) from point of Ingress to point of Measurement

S.E. = 40 - 30.62 + 48.75 - System Loss - RFI

Since the minimum detectable RFI level RFImin. is known, and system losses can be calculated if the point of ingress is known, the minimum shielding effectiveness which is detectable can be calculated.

Assume RFImin. = -30dBmV and unity system gain from Trunk HF I/P to test point

If point of ingress is Trunk HF I/P, system loss is 0dB

S.E.max. = 88.13dB

If point of ingress is Trunk HF O/P, system loss is 10dB

S.E.max. = 78.13dB

If point of ingress is distribution line, range of system loss is 0 - 20dB

S.E.max.(dist.) = 88.13dBmax.
68.13dBmin.

If point of ingress is d drop, range of system loss is 15 - 35dB,

(S.E.max.(drop) = 73.13dBmax.
53.13dBmin.)