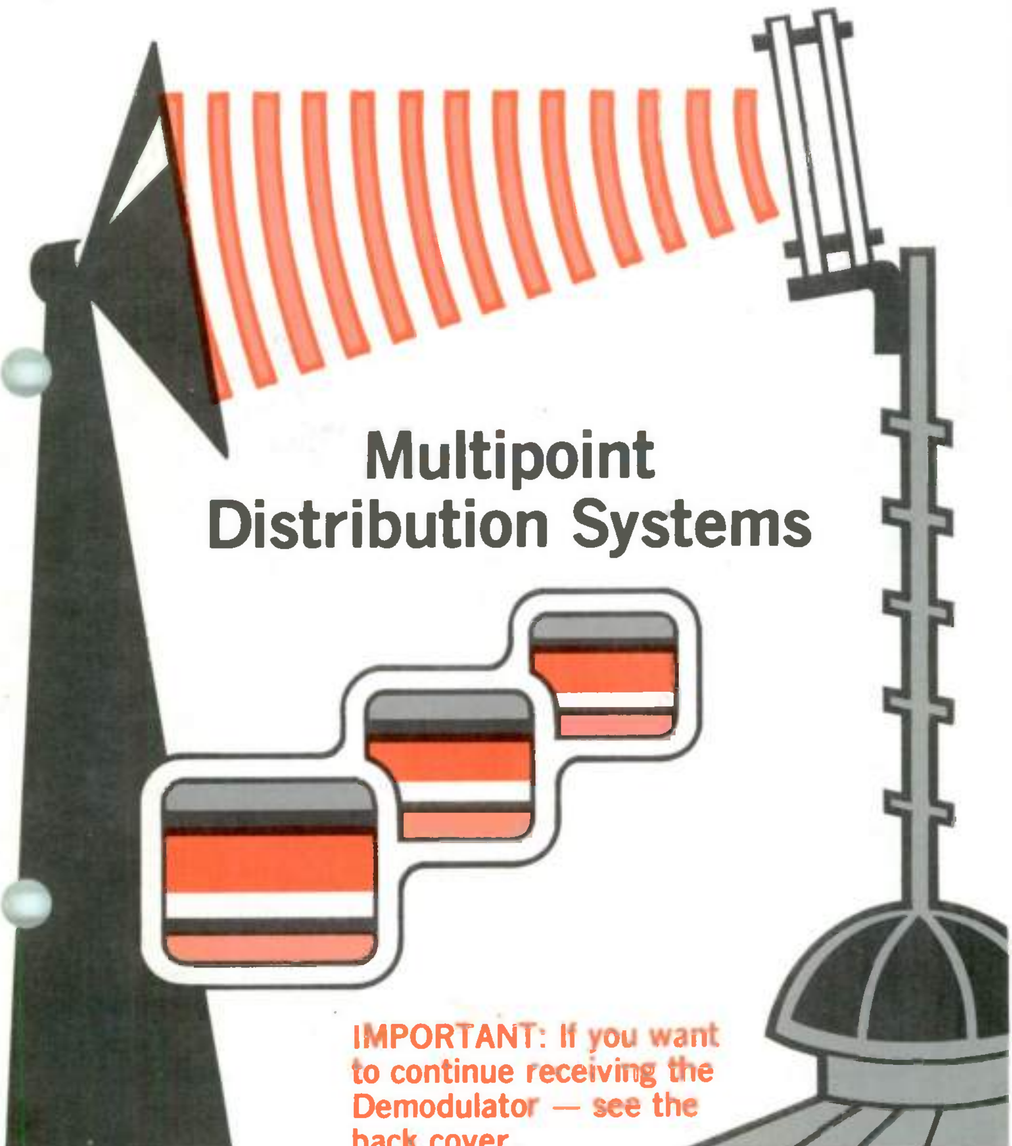
GTE
Communications
Transmission Systems

DEMODULATOR

JANUARY/FEBRUARY 1981

Multipoint Distribution Systems



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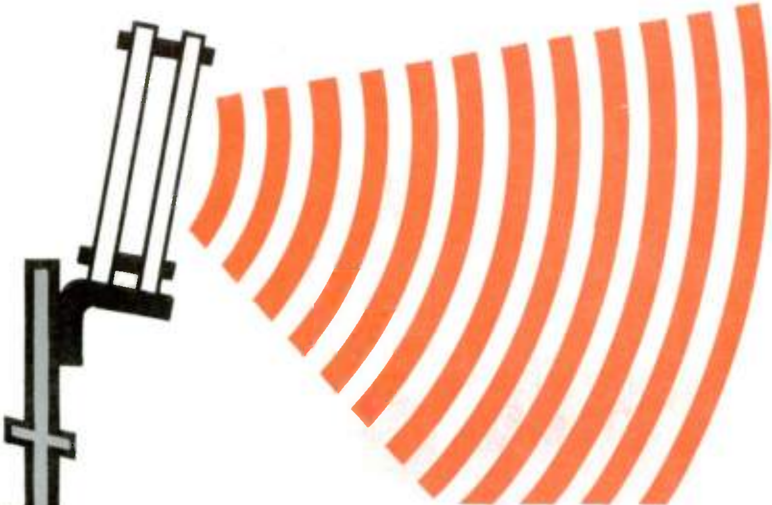

The frequency band from 2.15 to 2.162 GHz was allocated to Multipoint Distribution Systems (MDS) early in the 1960's. At that time, the allocation specified a per channel bandwidth of 3.5 MHz. In 1970, the FCC revised the allocation to include a 6 MHz bandwidth. This revision allowed MDS to develop primarily as a non-broadcast common carrier service delivering special television programs to specific locations. A commonplace MDS application is its use to provide a premium, pay-channel addition to a Master Antenna TV system.

In 1980 the FCC opened a proceeding which proposes to open the 2.5 to 2.69 GHz band to MDS on a shared basis with Instructional Fixed Television Services and Private Operational Fixed Microwave Services. If the proposal is adopted, two or more MDS channels could be allocated in the same area. MDS might then be able to provide local loops for two-way, high-speed data transmission. This issue of the Demodulator describes current MDS technology.

At the time of this writing, January 1981, Multipoint Distribution Systems provide two common carrier channels; channel A from 2150 to 2156 MHz and channel B from 2156 to 2162 MHz. Only one of the two channels is licensed for use in a given geographic area. The MDS signal is intercarrier, vestigial-sideband video with FM audio and NTSC color.

For channel A, the video carrier is at 2154.75 MHz which is 1.25 MHz below the channel's passband edge. The sound carrier is at 2150.25 MHz; 4.5 MHz below the video. The channel B video and sound are similarly spaced below the passband edge. This is the opposite of the way the transmission passband is used for standard TV broadcasts, so the MDS signal must be inverted to display the video on a standard TV set. The way this is accomplished is described in the discussion of the MDS receiver system.

A typical MDS system includes three parts; the transmitter, the station and the receiver. The following paragraphs discuss each part in turn.

Transmitter Subsystem

The transmitter consists of an up converter amplifier and an exciter. The exciter is similar to a CATV modulator. It accepts video and audio inputs to modulate an rf source. The output of the exciter is a modulated rf signal at a specific television VHF channel frequency.

The signal has the standard, 6 MHz-tv bandwidth with the aural carrier spaced 4.5 MHz above the visual carrier. The visual signal is passed through a vestigial sideband filter and the aural signal is passed through a preemphasis network. The exciter output must be stable in both frequency and level.

The up converter amplifier consists of a crystal controlled oscillator, a frequency multiplier chain, a microwave mixer and an output amplifier. The crystal oscillator provides a stable reference frequency which is multiplied up to the microwave carrier frequency (2156 MHz for channel A).

The multiplier output is connected to one input of a microwave mixer. The modulated rf exciter output is connected to the mixer's second input. The difference products previously described are picked off at the mixer output and passed to the amplifier section of the up converter amplifier.

MDS transmitters are rated at 10 watts or 100 watts. The 10 watt unit delivers 10 watts of video and 1 watt of audio to the antenna. The 100 watt unit delivers 100 watts of video and 10 watts of audio.

The 10 watt transmitter uses a traveling wave tube or a triode for the final stage. If a scrambler is used, the triode is preferred because it has better intermodulation characteristics. Also, the use of a scrambler requires a reduction of the aural and visual drives to avoid over modulation.

In any event, transmitter adjustments are critical and must be carefully done to avoid signal compression and undesirable color effects. For this reason periodic maintenance and transmitter alignments are scheduled on a frequent basis. Generally, transmitters operate unattended but a licensed operator is on duty at the station to log meter readings and maintain the station. Logs are kept to provide early warnings of gradual changes in operating parameters. Larger installations usually have standby equipment.

An additional amplifier stage is used for the 100 watt transmitter. The higher purchase price and operating costs of the 100 watt transmitter are generally overcome be savings that can be realized by using smaller receiving antennas for close installations and by the increased revenues resulting from serving a larger area. Of course, the power output and other transmitter parameters are controlled by the FCC under Rule Part 21, Subpart K (Multipoint Distribution Services).

Both omnidirectional and directional transmitting antennas are used for MDS. Omnidirectional antennas have a 360 degree radiation pattern so, they are suitable when the transmitting site is unobstructed and centrally located in the area to be served. This situation is illustrated in Figure 1.

Figure 2 shows a situation where a directional antenna, with a cardioid pattern, is applicable. This kind of installation is useful when a central location cannot be obtained or where natural terrain and population distribution make the use of a directional antenna desirable.

Two cardioid antennas can be used to provide essentially omnidirectional coverage. This is useful in areas where obstructions prevent the use of an omnidirectional antenna. The antennas should be located at opposite tower corners or opposite sides of the building. They must be cross polarized to avoid deep nulls where the patterns overlap.

In overlap areas, receiving antennas should be tried in both vertical and horizontal polarizations to see which produces the best results (highest signal level). Figure 3 illustrates this arrangement.

MDS Stations

Although MDS is a common carrier service, actual operations are more like television broadcasting. Therefore, the average MDS station resembles a scaled-down broadcast studio. The equipment includes a video monitor, video tape players with a time base corrector, a character generator, a source for background music and a control console with switching, fading and special-effects capabilities. Also, some stations are equipped with live studio cameras and some are equipped with automatic switchers. Many MDS operators use receive only earth stations (TVRO) to receive premium programming material from satellites.

It is often necessary to locate the MDS transmitter at a place where it is not possible or convenient to colocate play-back or TVRO facilities. In these cases, point-to-point, common-carrier microwave is commonly used to interconnect program sources with the transmitter.

One difference between MDS and

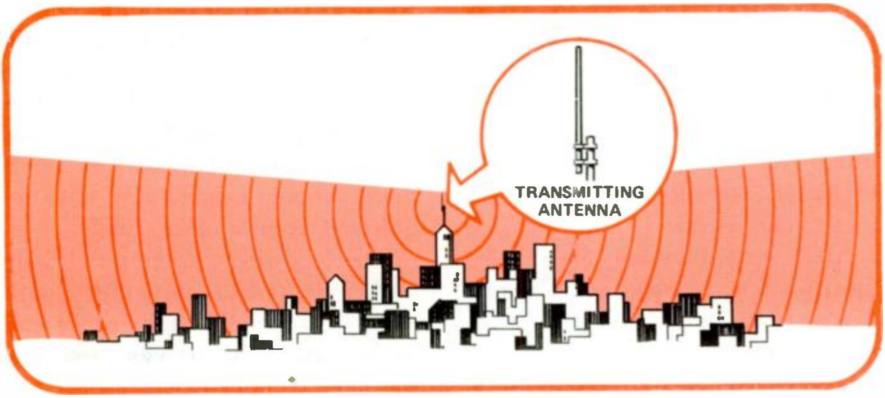

Figure 1. Centrally Located Omnidirectional Antenna.

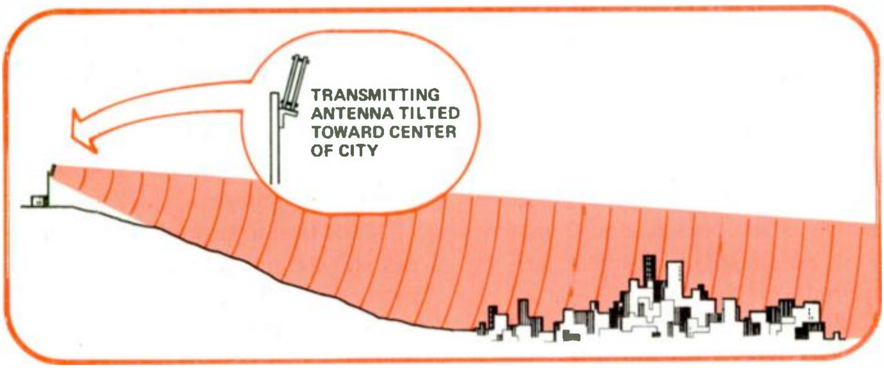

Figure 2. Use of Directional Antenna to Take Advantage of Terrain.

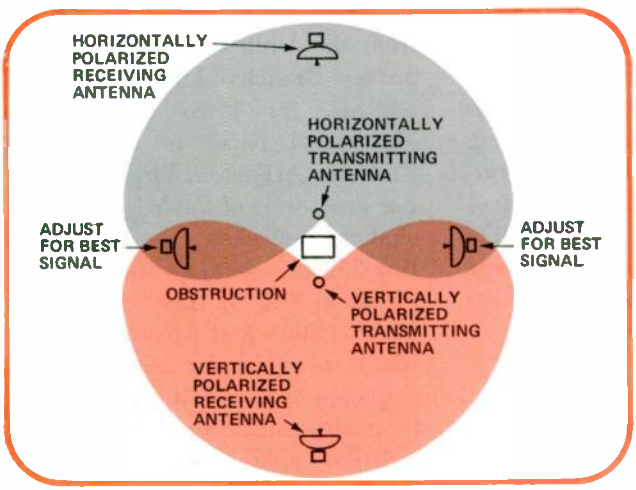

Figure 3. Antenna Polarizations for a Two Antenna System.

broadcast stations is that broadcast licensees normally choose programming to be transmitted. In MDS, the licensee leases the channel to customers who select the programming to be transmitted. The customer then sells the program service to end users.

MDS customers may be divided into two broad categories. The first category includes business people and educators.

These customers are interested in the transmission of specific programming material, usually during daylight hours. Frequently, they have prepared the program material and recorded it on video tape. The tapes are furnished to the MDS operator who broadcasts them at a specified time. Occasionally, these customers make live broadcasts which is the reason studio cameras and associated equipment are required.

The second category is composed of customers who are interested in receiving television transmissions which they distribute for a fee. These customers include hotels, motels, apartment houses and occasionally CATV companies.

The strongest demand for this kind of service is during the evening hours. The program material is principally entertainment, from sources such as prerecorded tapes, satellite transmissions and live or tape delayed material from local sports arenas.

The MDS Path

MDS transmissions are in the microwave region so, the signals are subject to the same kinds of atmospheric and interference problems as other transmissions in the same frequency band. Since transmissions are essentially line-of-sight, path surveys are necessary to determine antenna heights and other requirements for a clear path.

The following paragraphs briefly outline the tasks required for a path survey. The bibliography at the end of this article lists previous issues of the Demodulator which present extensive discussions of path surveys and interference problems.

The purpose of a path survey is to determine what size receiving antenna is required and how high it will have to be mounted to clear any obstacles in the path. The first step is to make a preliminary path selection using contour maps.

Maps that accurately show physical objects and terrain contours are required for this purpose. Seven and one-half minute (1:24,000) or 15 minute (1:62,500) maps are available for practically every area in the United States.

Indexes and maps are available from the United States Geological Survey, Branch of Distribution. The address, for areas east of the Mississippi River is 1200 South Ends St., Arlington, Virginia 22202. For areas west of the Mississippi including Louisiana, the address is Box 25286 Federal Center, Denver, Colorado 80225. The indexes list federal, state and private locations where maps are for sale. Once the maps are obtained, it is a good idea to mount them permanently to a wall or solid piece of plywood because they will be used to determine path loss to each receiver site.

Receiver Subsystem

Once the prospective path has been found to be clear of barriers such as buildings, mountains or high ridges, an engineering site survey is made. Figure 4 is a form for recording the survey data. The form is copied from an MDS Handbook published by Tanner Electronic

MDS ENGINEERING SITE SURVEY

Complex Name ____________ Dir. from XMTR. ____________

No. of Buildings ____________ Units/Building ____________ Total Units ____________

Units Occ. ____________ Res. Mgr. Apt. # ____________ Maintenance Apt. # ____________

Roof Type ____________

Line of Site: Yes _____ No _____ Roof Mount: Yes _____ No _____

MATV: Yes _____ No _____ Closed Circuit Channel ____________

Who Services MATV/Closed Circuit System ____________

Office Hrs. ____________ Maintenance People Available When ____________

Comments: ____________

____

____

SIGNAL SURVEY

Reading Received ____________ Height Above Ground ____________

Test Ch. Used ____________ Antenna Used ____________

Test Conv. Used ____________

Comments: ____________

____

____

TOWER CALCULATIONS DATA

Transmitter Height ____________ Ground Elevation at Receiver ____________

Obstruction Height ____________ Total Path Distance ____________

Obstruction Distance ____________ Calculated Path Ratio ____________

Correction Height for Local Obsts. ____________ Calculated Tower Height ____________

Comments: ____________

____

____

Figure 4. MDS Engineering Site Survey.

Systems Technology Company. TEST is Tanner's registered trademark.

The form is in three parts; a Contact Section, a Signal Survey Section and a Tower Calculations Data Section. The contact section is self-explanatory.

Four basic pieces of equipment are used to collect the information for the signal survey. They are: a calibrated down-converter and antenna, a battery operated TV set, a field strength meter and a crank up tower and/or telescoping antenna mast.

The data is gathered by increasing the antenna height while observing the field strength meter and television receiver. Of course, the receiving antenna must be pointed at the transmitting antenna. The field strength meter reading should increase with antenna height to a point where a further increase in antenna height does not produce higher signal levels.

However, reflections from ground waves and the roof will add and subtract from the direct signal as the antenna height is changed. So, peaks and dips in the meter reading may occur as close as 8 to 10 inches apart. The optimum height is the one which gives the highest peak reading. This reading and the height above ground should be recorded on the form although the antenna may be finally installed a few feet higher to compensate for beam bending due to refraction during temperature inversions.

The picture produced by the peak signal should also be observed and remarks about video quality recorded in the Comments section of the form. An alternative method for calculating the required antenna height is presented in Figure 5. This method could be used if detailed in-

THE FOLLOWING INSTRUCTIONS MAY BE USED TO DETERMINE OBSTRUCTION CLEARANCE BETWEEN THE TRANSMITTER AND A RECEIVER LOCATION. THE INSTRUCTIONS INCLUDE THE CALCULATION FOR THE CURVATURE OF THE EARTH AND THE FORMULA FOR THE FIRST FRESNEL ZONE RADIUS.

T = TRANSMITTER HEIGHT ABOVE MSL
R = RECEIVER TOWER BASE ABOVE MSL
O = OBSTRUCTION HEIGHT ABOVE MSL (INCLUDE TREES AND BUILDINGS)
D = PATH DISTANCE IN MILES

d_1 = DISTANCE FROM "T" TO "O"
d_2 = DISTANCE FROM "O" TO "R"
EB = EARTH BULGE
FH = FIRST FRESNEL ZONE RADIUS
TH = TOWER HEIGHT NEEDED

T = ____ FT R = ____ FT O = ____ FT

D = ____ MILES d_1 = ____ MILES d_2 = ____ MILES

EB = 2/3 $(d_1 \cdot d_2)$ = ____ FT

$FH = 1316 \frac{d_1 d_2}{(d_1 + d_2)} 2150$ = ____ FT

$TH = (O+EB+FH \frac{d_2}{d_1} (T\text{-}O\text{-}EB\text{-}FH)\text{-}R$ = ____ FT

EXAMPLE:

T = 1485 FT R = 1264 FT O = 1310 FT

D = 19 MILES d_1 = 17 MILES d_2 = 2 MILES

EB = 2/3 (17 X 2) = 22.7 FT

$FH = 1316 \left[\frac{17 \times 2}{(17+2)\ 2150}\right] = 19.7$ FT

TH = (1310+22.7+19.7)-2/17(1485-1310-22.7-19.7)-1264
= 1352.4 - 15.6 - 1264
= 72.8 FT

Figure 5. Antenna Height Work Sheet for MDS Systems.

formation abut the path is already at hand.

The receive antenna size requirement is established by subtracting the signal level of the test antenna and down converter from the desired signal level. The difference can be compensated for by selecting an antenna with sufficient gain (see Table 1). The desired signal level is the level required to produce an acceptable signal to noise ratio in the amplifying and distribution system to be connected to the receive down converter.

Table 1. Gain Versus Antenna Size.

PARABOLIC REFLECTOR DIAMETER	GAIN
6-FOOT	30 dB
4-FOOT	26 dB
2-FOOT	20 dB
*TEST CONE	17 dB
1-FOOT	13 dB

*CIRCULAR YOGI BUILT BY TEST® INC.

With all quantities expressed in dB, the signal to noise ratio is the absolute difference between the signal and the noise developed by the circuit carrying the signal. The minimum noise at room temperature, in a circuit with a 6 MHz bandwidth is −59 dBmV (decibels referenced to one millivolt). This is known as the thermal noise floor.

Additional noise is generated by active devices such as amplifiers. The amount of this noise is specified by the manufacturer as the noise figure of the device. If a manufacturer's specifications state a noise figure of 5 for a down converter, it means the down converter adds 5 dB of noise to the signal.

The type of noise we are concerned with can be seen by disconnecting the antenna from a television receiver. The noise or "snow" on the screen is generated in the receiver front end. When a signal is present, the noise is suppressed by the automatic gain control circuitry in the TV receiver. The stronger the signal, the lower the amount of visible noise.

The Television Allocation Study Organization (TASO) conducted a survey to determine the amount of random noise that could be tolerated in a television picture. The following table summarizes the results:

S/N Ratio (dB)	Picture Quality
17	Inferior
23	Marginal
28	Passable
34	Fine
44	Excellent

TASO defines S/N as the ratio of the rms voltage of the rf signal during synchronizing peaks divided by the rms noise voltage over a 6 Mc (sic) channel. Present day convention is to refer to this as the carrier to noise (C/N) ratio. Carrier to noise and signal to noise are not the same thing. For vestigial sideband TV, there is about a 4 dB difference between C/N and S/N.

Also, the CATV and MDS industries currently use a 4 MHz measurement bandwidth as recommended by the National Cable Television Association (NCTA). The following table showns criteria generally accepted in these industries:

C/N (dB)	Picture Quality
47	Noise just preceptible at close range: TASO fine.
43	Noise definitely preceptible but not objectionable: TASO passable.
40	Noise somewhat objectionable: TASO marginal.
36	Noise definitely objectionable: TASO inferior.

The Federal Communications Commission sets the minimum limit at 36 dB for CATV systems.

Figure 6 is used as an aid to understanding the following discussion of carrier to noise calculations and for other purposes later in this article. To calculate the C/N ratio for the MDS receiving system, it is necessary to determine the ratio for each piece of active equipment as it appears in the system. Referring to the figure, the down converter is the first active device.

−59	dBmV input noise
4.5	dB noise figure
−54.5	dBmV noise level
10.0	dBmV input signal level
64.5	dB C/N ratio (absolute difference between signal and noise).

If the receiving system is a home installation, the output of the antenna mounted down converter is connected directly to the antenna terminals of the television receiver. If the receiving system is for a large apartment complex, the down converter output is connected into the master antenna television (MATV) system through the AGC amplifier, as shown in Figure 6.

Assuming the down converter has 19 dB gain and the line between it and the amplifier is loss-less, the input to the amplifier is −29 dBmV. The C/N ratio at the amplifier output is:

−59	dBmV noise
8	dB noise figure
−51	dBmV noise level
29	dBmV input signal
80	dB C/N ratio

The next step is to determine the combined C/N for the receive head end. These ratios add on a power basis. The first step is to determine the difference between the input and output C/N ratio.

80	dB output S/N
64.5	dB input S/N
15.5	dB difference

This difference is used to enter the chart presented in Table 2. The number 0.12 is found on the 15.5 difference line. This number is subtracted from the worst carrier to noise ratio in the previous step to find the combined C/N ratio (64.5 − .12 = 64.38 dB).

The next step in determining the overall system carrier to noise ratio is to calculate the C/N for the first active stage in the distribution network. The combined C/N above is subtracted from the ratio of this first active stage. The difference is found in Table 2 and the appropriate number selected to subtract from the worst of the two C/N ratios. This yields the carrier to noise ratio at the output of the first active stage in the distribution. This process is repeated for each stage until the end of the distribution is reached. As can be seen, the major contributor to the resulting C/N is the noise figure of the MDS down converter.

In some cases, it may be easier to determine the distribution system's carrier to noise ratio by actual measurements. This is accomplished by first disconnecting and terminating the antenna input to the down converter. The signal level is read at the end of the distribution; using an rf millivolt meter with a known bandwidth. The antenna is reconnected to the input of the down converter and the level at the end is again measured.

The carrier to noise ratio is:

$$C/N = \frac{\text{Signal (dBmV)}}{\text{Noise (dBmV)}} - 10 \log \frac{4\text{ MHz}}{\text{Meter bandwidth}}$$

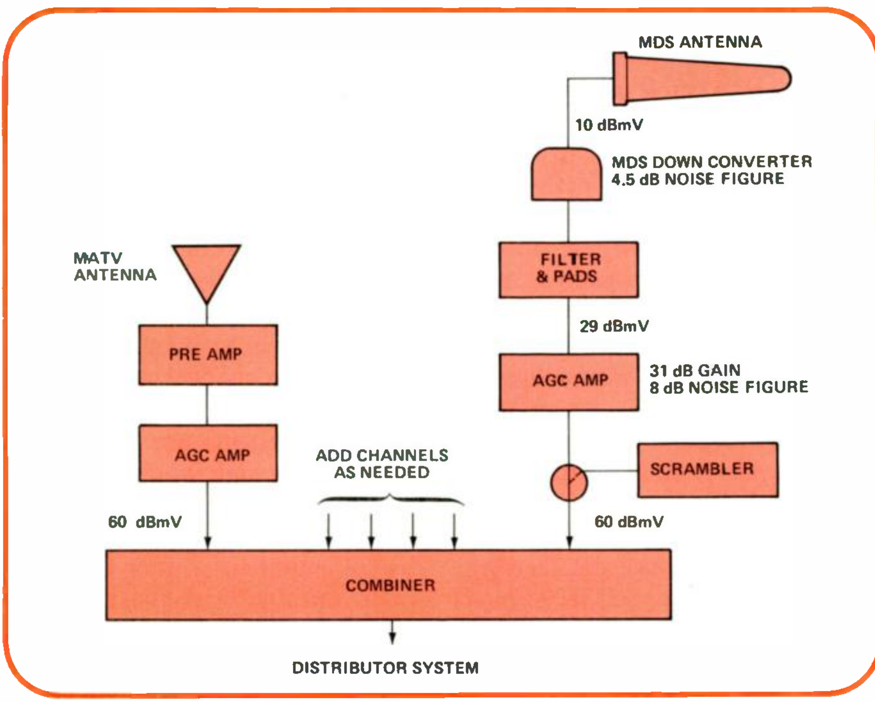

Figure 6. Combined MATV MDS Head End.

Table 2. Power Addition for dB Difference Between Levels.

dB DIFFER-ENCE	ADD TO HIGHER LEVEL									
	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0.0	3.01	2.96	2.91	2.86	2.82	2.77	2.72	2.67	2.63	2.58
1.0	2.54	2.50	2.45	2.41	2.37	2.33	2.28	2.24	2.20	2.16
2.0	2.13	2.09	2.05	2.01	1.97	1.94	1.90	1.87	1.83	1.80
3.0	1.76	1.73	1.70	1.67	1.64	1.60	1.57	1.54	1.51	1.48
4.0	1.46	1.43	1.40	1.37	1.35	1.32	1.29	1.27	1.24	1.22
5.0	1.19	1.17	1.15	1.12	1.10	1.08	1.06	1.04	1.01	0.99
6.0	0.97	0.95	0.93	0.91	0.90	0.88	0.86	0.84	0.82	0.81
7.0	0.79	0.77	0.76	0.74	0.72	0.71	0.70	0.68	0.67	0.65
8.0	0.64	0.62	0.61	0.60	0.59	0.57	0.56	0.55	0.54	0.53
9.0	0.51	0.50	0.49	0.48	0.47	0.46	0.45	0.44	0.43	0.42
10.0	0.41	0.40	0.39	0.39	0.38	0.37	0.36	0.35	0.35	0.34
11.0	0.33	0.32	0.31	0.31	0.30	0.30	0.29	0.28	0.28	0.27
12.0	0.26	0.26	0.25	0.25	0.24	0.24	0.23	0.23	0.22	0.22
13.0	0.21	0.21	0.20	0.20	0.19	0.19	0.19	0.18	0.18	0.17
14.0	0.17	0.16	0.16	0.16	0.15	0.15	0.15	0.15	0.14	0.14
15.0	0.13	0.13	0.13	0.13	0.12	0.12	0.12	0.12	0.11	0.11
16.0	0.10	0.10	0.10	0.10	0.10	0.09	0.09	0.09	0.09	0.09
17.0	0.08	0.08	0.08	0.08	0.08	0.08	0.07	0.07	0.07	0.07
18.0	0.07	0.07	0.07	0.06	0.06	0.06	0.06	0.06	0.06	0.06
19.0	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.04
20.0	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.03

Since, for our purpose, C/N is defined as the ratio of the signal to noise in a 4 MHz bandwidth, the last factor in the equation is used to correct the measurement bandwidth to 4 MHz.

From the foregoing discussion of C/N ratios, it can be deduced that the signal level presented to the down converter is critical to providing an acceptable carrier to noise ratio to the distribution system. Since antenna gain varies directly with antenna size, as shown in Table 1, it is apparent that the signal to the down converter can be controlled by antenna selection.

However, the cost and installation problems of antennas also increase with antenna size. So, it is good engineering practice to use an antenna which is adequate to maintain an overall system C/N of 38 dB minimum for a single TV installation, a 40 dB minimum for a master antenna TV (MATV) installation and a 44 dB minimum for a CATV system. These are minimums and should be viewed in the light of the previous discussion of C/N versus picture quality.

Figure 6 shows an MATV as well as MDS input to the combiner unit which feeds the distribution system. This is a common arrangement because MDS is frequently added to provide a pay channel on an existing MATV system.

MATV systems are designed to run at a very high level to overcome "local pickup" which causes ghosting on the unconverted channels. Use of amplifiers with 60 dBmV (1 volt) output is typical. These amplifiers often have a noise figure of approximately 10 dB.

In combined systems, the MDS leg employs these same amplifiers because the MDS signal to the combiner must match the MATV signal. To compensate for the amplifier noise, the operator is forced to use a large antenna to provide a maximum signal with the lowest possible noise at the input to the down converter. The signal input to the down converter can also be increased by stacking antennas. The antennas are interconnected through a hybrid combiner. A 3 dB increase in signal level is realized each time the number of antennas is doubled.

Ghosting and color shifting of the MDS television signals can occur as a result of reflections which arrive at the antenna delayed in time with the respect to the direct signal. This is known as "multipath distortion" in microwave terminology.

The first corrective action to try is to carefully orient the receive antenna for minimum interference. If this is not successful, a larger antenna dish might be used. This decreases the antenna beamwidth as well as increasing the gain. A third solution is to use two horizontally stacked antennas.

Down Converters

The following discussion refers to Figure 7. Four important characteristics of a down converter are its noise figure, transfer gain, image ratio and output frequency stability. The noise figure is primarily determined by the preamplifier and type of mixer used. The transfer gain is the total gain from the input to the output of the down converter (typically 30 to 35 dB). The image ratio is the ratio of the level of the desired signal at the mixer output to the level of the image frequency at the same point.

MDS mixers generally use point-contact diodes. The mixer may use a single diode as shown in Figure 8 or four diodes in a balanced configuration as shown in Figure 9. Hot-carrier diodes are frequently used for the balanced mixer. This type mixer has somewhat better noise figures and dynamic characteristics than the contact diode mixers.

The MDS signal is connected to one input of the mixer. The other input is from the local oscillator. For MDS applications the local oscil-

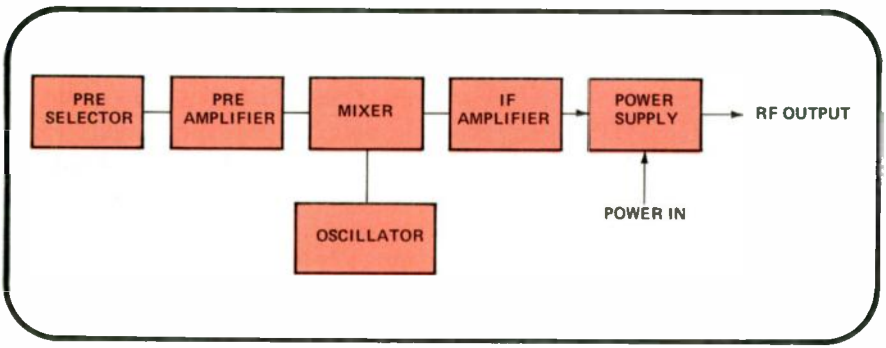

Figure 7. Down Converter Block Diagram.

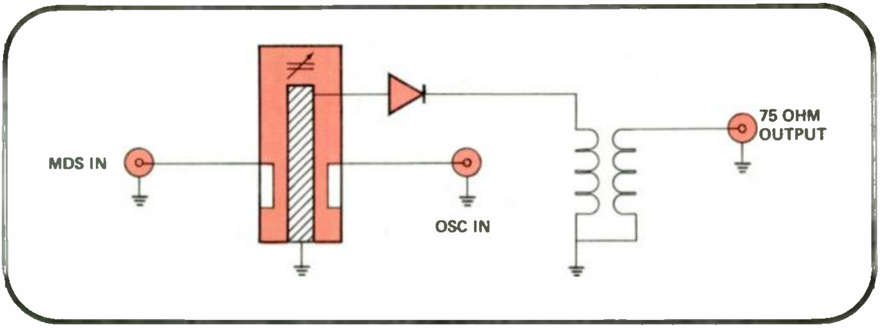

Figure 8. Single Diode Mixer.

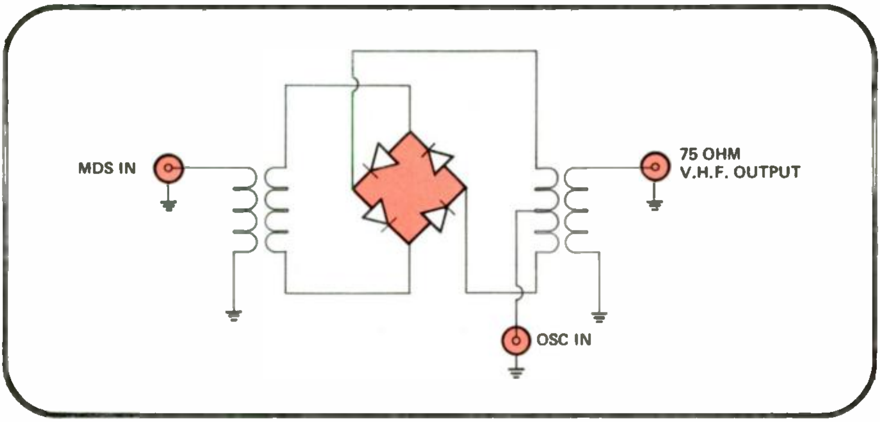

Figure 9. Balanced Mixer.

lator frequency is always higher than the signal frequency and the difference frequency is at the VHF television frequency to be sent to the distribution. Placing the L.O. frequency above the MDS signal accomplishes the inversion of the MDS signal necessary to properly display the video on a standard television set, as described in the transmitter discussion.

Two types of local oscillators are used in MDS down converters. One type uses a crystal controlled oscillator — multiplier combination. The second type is a free-running, voltage controlled oscillator (VCO).

The crystal controlled oscillator multiplier combination was originally designed for applications where frequency stability is important; Instructional Fixed Television Service for example. Frequency stability is not as important for MDS since only a single channel is being recovered.

The principal advantage of the VCO is the elimination of the multiplier stages. The oscillator frequency is over 2 GHz so the problem of beat frequencies in the VHF range is virtually eliminated.

Since fewer components are used, the VCO consumes less power and usually costs less than the crystal unit. However, the economic advantage is somewhat offset by a requirement for a more stringently regulated power supply, since the frequency is voltage dependent.

Because of this voltage dependency, the VCO lends itself to closed loop frequency control by varying the power supply voltage. The variations can be accomplished manually or automatically.

Manual "fine tuning" is quite acceptable for single TV installations but not for multiple installations. A frequency-locked automatic loop control system is more suitable for the multiple situation. In this configuration, the reference for the oscillator frequency is taken from the output VHF channel so the oscillator compensates for any small transmitter frequency inaccuracies.

Returning to Figure 7, the mixer is preceded by a preamplifier. The preamp compensates for mixer loss and path loss. It is used at locations distant from the transmitter. A good preamplifier has a low noise figure and is sharply tuned to the MDS frequency, to keep unwanted signals from entering the mixer.

Down converters are not always equipped with preamps. In strong signal areas preamps are not only unnecessary, they may cause excessive down converter output which will have to be reduced before application to the distribution system.

The purpose of the IF amplifier is to boost the signal from the mixer and provide additional selectivity. IF amplifiers are always used, whether or not the down converter has a preamplifier. Down converters with preamps will have a transfer gain of about 35 dB and a noise figure generally less than 5 dB. Down converters without preamps have somewhat higher noise figures and a transfer gain around 20 to 30 dB.

The preselector shown in Figure 7 is not a part of the down converter but is used when MDS receivers are located near airports or UHF TV stations. Also, preselectors are sometimes required if interference is experienced from industrial communications systems operating in the 2.13 to 2.15 GHz band.

The preselector is a bandpass filter which passes the MDS signal but attenuates other frequencies 50 dB or more. Down converter selectivity is usually sufficient to prevent interference from comparatively weak signals outside of its bandpass. However, the peak radiation from approach radar at airports is enormous and the radiation of a UHF transmitter is 40 dB higher than that of an MDS transmitter. Radiations of these magnitudes could swamp the down converter, if a preselector is not used.

The power supply feeds power up the cable to the down converter and passes the RF from the down converter to the distribution network. The power supply must provide a well regulated and filtered output to prevent down converter performance being affected by power line fluctuations and hum.

Figure 10 is a simplified diagram of an MDS power supply. Note the 6 to 1 step down line transformer. This transformer provides some regulation and surge protection. For example, a 20 volt surge across the primary will be reduced to about 3.4 volts across the secondary.

The three terminal regulator is an integrated circuit which provides an output voltage regulated to within 1%. The power supply for a down converter incorporating a VCO is essentially the same as the one in Figure 10 except that it includes a means for varying the output voltage to tune the oscillator.

The power supply is equipped with an A-B switch which is used to select signals from the MDS down converter or the customers TV antenna. For a single installation, MDS signals must be kept below 20 dBmV to avoid overloading most TV sets. Also, the signal must be kept low enough to avoid exceeding the isolation of the A-B switch. If this occurs, the MDS signal could be radiated by the TV antenna.

Some single family resident customers will want to connect the MDS signal to two television sets. This can be accomplished as shown in Figure 11. In this case, the A-B switches are installed on the back of the TV sets. If the power supply is equipped with an A-B switch, it should be placed permanently in the MDS position. If the signal level at the TV sets, is too low, due to cable and splitter losses, a small amplifier could be inserted between the power supply and the splitter as shown in the figure.

Multiple Dwelling Unit Distribution

The type of system used for multiple dwelling units (MDU) distribution is dependent upon the type of construction and the number of dwelling units. Installations for duplexes and fourplexes are easiest because they will seldom have or desire a MATV system.

The simplest installation for these units is the hard-wired system shown in Figure 12. This is an expansion of the single family installation feeding two TV sets. Each subscriber is pro-

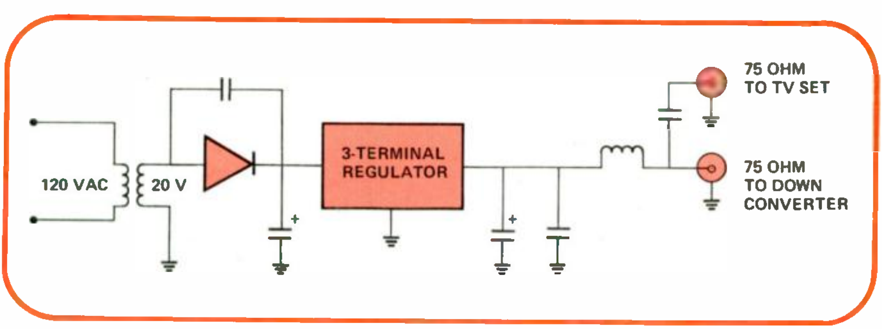

Figure 10. Down Converter Power Supply.

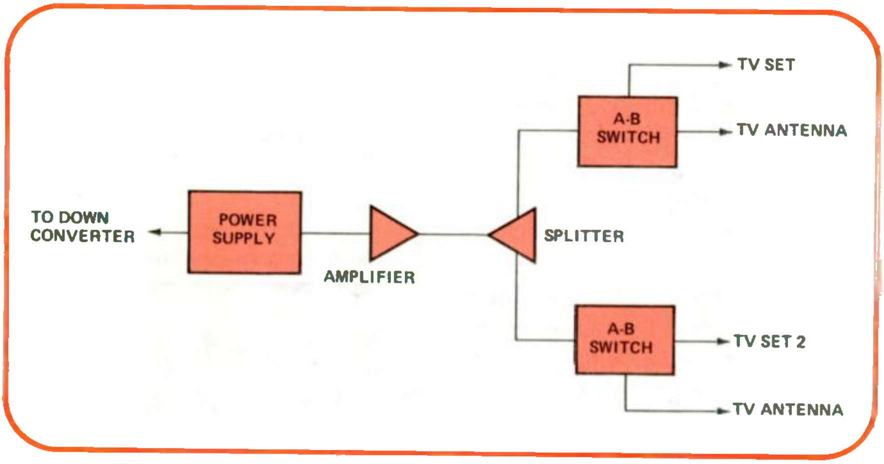

Figure 11.

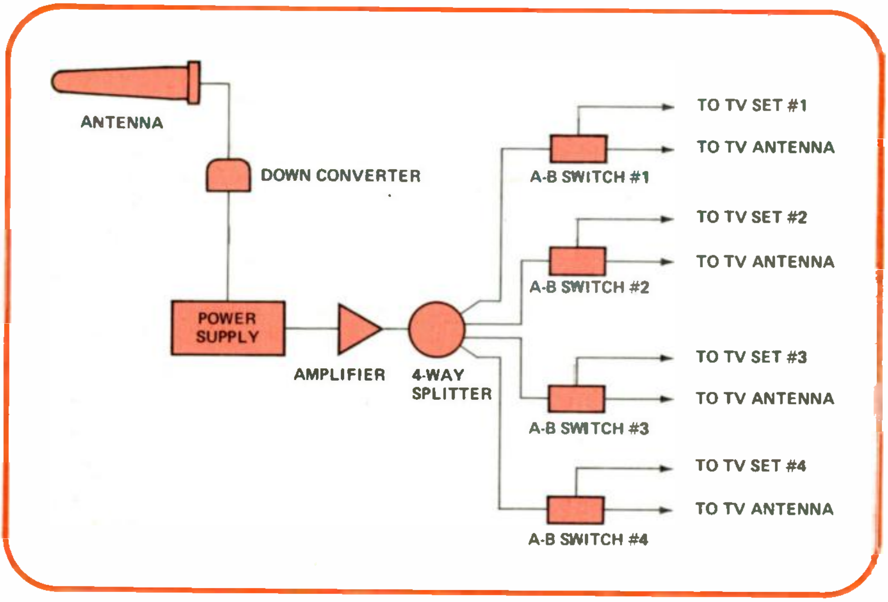

Figure 12. Four-Plex Installation.

vided with an A-B switch to select MDS or standard TV signals. Again, if the power supply is equipped with an A-B switch, it should be permanently placed in the MDS position.

The amplifier is used if it is required to overcome splitter and cable losses. As in the home installation, cable runs should be kept as short as practical because the RG59 cable used has relatively high attenuation (3.5 dB per hundred feet at the channel 13 frequency). This cable does have the advantages of small size and flexibility. The down converter used for multiple-unit MDS installations should have a crystal controlled oscillator or a VCO with an AFC circuit such as the one previously described.

MDS systems for larger multiple dwelling units will frequently be installed in conjunction with, or in addition to, existing MATV systems. Several factors must be considered in deciding whether or not to use an existing MATV system to distribute MDS programming. The condition of the MATV system, who will pay to update it and who will maintain it must be considered. One question which overrides the others is, "Will the property management permit building a separate MDS system in addition to an existing MATV distribution?". The following discussion assumes the MDS signals will use an existing MATV distribution. Methods for doing this are described beginning with the head end.

Three types of MATV head ends are in general use. One type uses a broadband antenna and an amplifier to boost the signals as shown in Figure 13 A. A second type uses separate antennas and strip amplifiers for each channel, as shown in Figure 13 B. The individual amplifiers outputs are connected to the distribution system through a combiner. The amplifiers in either type may or may not have automatic gain control. Bandpass filters or audio carrier adjustments are seldom used

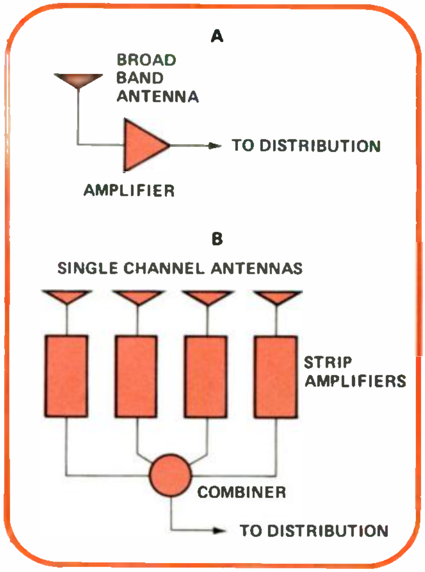

Figure 13. Typical MATV Head Ends.

in these two types so many of them have excessively high FM levels.

Figure 14 shows the third type which has a better design. Channel numbers are included to emphasize the purpose of the different elements. Note the bandpass filters, the FM trap and the UHF/VHF converter. AGC amplifiers are used and the directional coupler combining network provides high isolation and good impedance matching.

In combined systems, the MDS head end is configured as shown in Figure 6. The AGC amplifier is required because MDS signal levels will vary with weather conditions. The bandpass filter and directional coupler are required to reduce interference and provide isolation. Some types of scrambling equipment are connected at the output of the

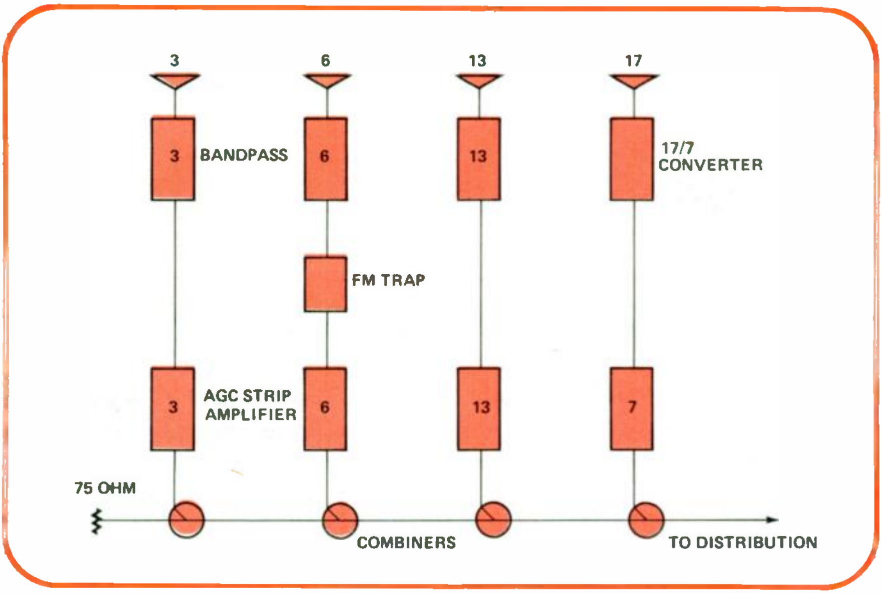

Figure 14. Better MATV Head End.

AGC amplifier. If the connection were made at the amplifier input, the amplifier would have to be derated. The amplifier is adjusted to the tilt built into the MATV system.

Returning to the distribution system, "loop-wired" systems are the ones most commonly encountered in MATV distribution. The name is derived from the fact that the cable loops into each apartment and back out again as shown in Figure 15. This type of system has low initial but high maintenance costs. The high maintenance cost is due to the fact that if the cable is broken at any point, subscribers downstream from the break will not receive signals. Also, the system will radiate and cause ghosts, due to the impedance mismatch at the break. Other problems may result from radiation from wall taps with 75 ohm inputs and 300 ohm outputs.

Amplifiers must be installed at intervals along the loop, to compensate for cable and tap insertion losses. The noise figure of the amplifiers determines how many amplifiers may be used and therefore how long the distribution may be before the C/N ratio becomes unsatisfactory. Although MATV distribution cannot be totally rebuilt, it is sometimes possible to improve the system's C/N ratio and channel capacity by changing out amplifiers. Older MATV systems have high gain amplifiers which are not usually rated for more than 6 or 7 channels and have noise figures of 12 dB or more.

Modern amplifiers are available with gains of 35 to 40 dB, a noise

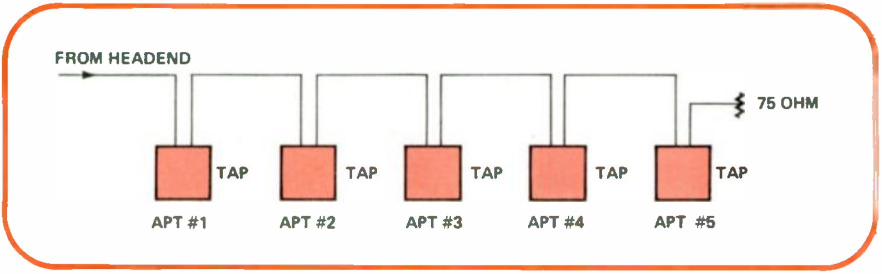

Figure 15. Loop-Wired Distribution.

figure less than 9 dB and a 12 channel rating. Also CATV amplifiers might be suitable in some applications. CATV amplifiers have a bandwidth which will accommodate at least 12 channels and a low noise figure, 6-8 dB. However, they are comparatively low-gain, on the order of 19-28 dB.

In addition to changing out the amplifiers, perhaps a trunk cable can be added to form a "sacred trunk" system similar to that shown in Figure 16. The advantages of this system over the loop wired system are: improved carrier to noise, essentially equal carrier to noise for the entire system, better tilt control and reduced maintenance.

The "sacred trunk" signals may be distributed in each building by the looped-wire or "home run method". The home run method is shown in Figure 17. If the buildings are small they may be served by the home run method without using amplifiers.

A method for converting an existing "loop-wired" system to a sacred cable system is illustrated in Figure 18. Note that the lines connecting the buildings have been cut and spliced to form the sacred trunk. The trunk has directional couplers inserted to feed the loops in each building. The required number of amplifiers has been significantly reduced.

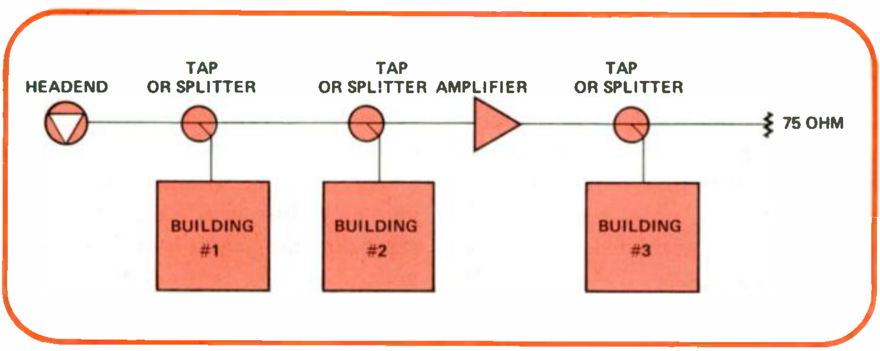

Figure 16. Sacred Trunk Distribution.

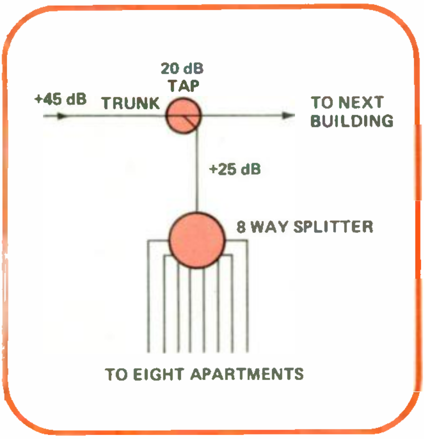

Figure 17. Home Run Building Distribution.

If the cable between buildings can be replaced, a substantial reduction in attenuation can be achieved by using .500 inch size CATV cable. This cable has 1/3 the attenuation of RG59 per unit length. The CATV cable also has better shielding and weather integrity than conventional coax.

In cases where it is necessary to "over-build" an MDS system instead of reworking the MATV, a sacred trunk system with home run distribution or a hard-wired home run system should be used, depending on the size of the installation. In either case, each subscriber's television set will have to be equipped with an A-B switch to provide switching between the MDS and MATV systems.

This concludes our discussion of MDS technology. We have only covered the high-lights. Readers who are interested in more detailed information are referred to the bibliography.

The possibility that the FCC may allocate more channels to MDS is mentioned in the introduction. If this occurs, whole new markets could open up for MDS. Two or

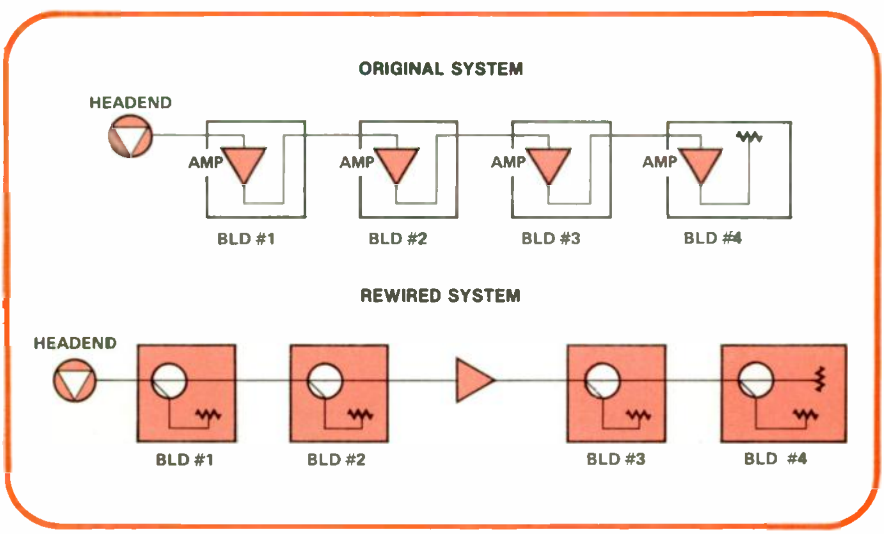

Figure 18. Looped-Wire to Sacred Trunk Conversion.

more MDS channels could be licensed in the same area. Local loops, capable of carrying up to 500 megabits per second of data, could be established. We will continue to watch this development and report on it in a future issue of the Demodulator.

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