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SCA

for

FM
BROADCAST STATIONS

by

LEONARD E. HEDLUND

Vice President,
Research & Development
McMartin Industries, Inc.,
Omaha, Nebraska

SCA

subsidiary communications authorization

Federal Communications Commission Rules and Regulations provide for the utilization by FM broadcast stations of subcarriers transmitted along with the main channel programming.

This mode of operation, licensed under FCC Subsidiary Communications Authorization (SCA), can accrue advantages, of financial or special service nature to commercial and non-commercial FM broadcasters.

The grant of the SCA service is conditioned on the rendering of services satisfying the basic requirements that the program transmissions shall be of a broadcast nature of interest primarily to limited segments of the public wishing to subscribe thereto, or that the signals transmitted relate directly to the operation of FM broadcast stations.

The Commission specifically states that those programs of a broadcast nature may be background music, storecasting, detailed weather forecasting, special time signals, or other material of a broadcast nature expressly designed and intended for business, professional, educational, trade, labor, agricultural, or other groups engaged in any lawful activity. This is an extremely broad area of acceptibility; however, in practice by far the greatest utilization of SCA has been in the background music and storecasting categories since revenue to the FM broadcaster results from these commercial operations. These revenues have in many instances represented a major part of the income to the FM broadcaster. Other programming in current use relates to the dissemination of agricultural market information and recently, the broadcast of "radio talking book" material to the visually-handicapped. A number of educational institutions use their subchannels for "in-home" teaching purposes. FCC Rules to date have limited program transmissions to those of an aural nature; however, effective April 11, 1975, the Commission will implement rule-making to expand the permissible transmission to include slow-scan TV, teletype, facsimile and other non-aural, electronic services, identified as "visual services". The new Rules permit the transmission of non-aural SCA services with the condition that "the applicant submit full details of the proposed visual system, including the charactertistics of all filters and their location in the system, and the results of properly made measurements demonstrating that an FM station will not radiate out-of-band signals of undue strength or interfere with the basic FM service".

Typical examples of SCA use in the category of signal transmission directly related to the operation of FM broadcast stations include coded telemetry data for FM broadcast remote control operations and the relaying of sports and other specialized types of programming on a regional network basis.

The current FCC Rules pertaining to SCA engineering standards define very few parameters. The standards state only that the subchannel shall be frequency modulated, define the carrier frequency ranges for mono or stereo operation stipulate carrier injection levels for each main channel mode and specify permissible crosstalk levels from the SCA channel into the main channel. No standards for the performance of the subchannel itself are established. Audio frequency response, total harmonic distortion, preemphasis characteristics, signal-to-noise ratios, or crosstalk from the main channel programming into the subchannel are not specified. Thus, the Commission standards provide no indication of actual performance to be anticipated from the subchannel.

In actuality, a subcarrier multiplex channel is capable of surprisingly high-quality, low-noise operation, and is readily adaptable to accommodation of all present "visual" transmission systems presently in use. As a rule of thumb, if the anticipated non-aural information is presently capable of transmission over a wire circuit, it may be handled on a subchannel with relative ease.

The heart of the system is, of course, the basic subchannel carrier generating and modulation processing equipment. There are a number of SCA generators available on the market, and the Commission permits the use of SCA generators of any manufacture with any FM broadcast transmitter/exciter which has been type-accepted for SCA operation. In other words, type acceptance of SCA generators is not required.

Let us first consider the effect of adding a new channel, the 67 kiloHertz frequency-modulated subcarrier to an existing stereophonic FM broadcast system. Assuming that the 67 kHz subcarrier will be deviated ±6 kHz (61 to 73 kHz) we have present in the complete modulation spectrum, this energy plus the main channel mono audio portion, essentially 30-15,000 Hz; the stereo pilot carrier at 19,000 Hz; and the stereo suppressed-carrier double sideband AM information, which when fully modulated occupies the region from 23 to 53 kHz, centered around the 38 kHz suppressed carrier. This information spectrum is shown in Figure 1.

Several points become apparent. First, the addition of the SCA fully-modulated subcarrier indicates the need for flat frequency response of the transmission system to 73 kHz rather than to the 53 kHz limit for stereo operation.

If any non-linearities exist in the transmission system, troubles develop rather rapidly. These can result from improper neutralization or loading of any of the RF stages in the transmitter itself, high VSWR on the transmission line or narrow bandwidth characteristics in the antenna system.

Acceptable bandwidths are attainable with present day FM transmitters, but it is essential that the transmission system be routinely checked for maintenance of optimum bandwidth conditions. A spectrum analyzer, where available, provides the best means of detecting overall performance, however FCC Rules for type approval of stereo and SCA modulation monitors include the capability of measuring response within 1 dB accuracy from 50 Hertz to 75 kiloHertz. As a preliminary check, the overall response of the transmission system should be measured, using a spectrum analyzer or a type approved modulation monitor in conjunction with a signal generator covering the 50 to 75,000 Hz range. If non-linear response is detected at the transmitter output, the source of the defect can be isolated by temporarily connecting the monitor feed to preceding RF stages, or the exciter output itself. This procedure is also helpful in isolating crosstalk problems, particularly where neutralized tetrode IPA or PA stages follow the exciter. **Any** non-linearities in the transmission system will seriously affect both main to SCA and SCA to main channel crosstalk characteristics. Transmission line VSWR must be maintained at as reasonably low values as practical *(typically 1.1 to 1)* to assure optimum performance. Present day transmitting antenna designs usually provide adequate bandwidths. If however, antenna problems appear which result in increased VSWR readings, increased crosstalk between the stereo and SCA information will almost certainly occur.

A great deal of comment is heard relative to "birdies" and "whistles" which suddenly appear when a subchannel is added to a stereophonic operation. This condition, although potentially created in certain receiver designs, details of which will be given later, may also be generated in the transmitter part of the system. When present in the transmitter they may be detected by a type-approved modulation monitor as described above and **must** be corrected if a clean overall system is to result.

The addition of the 67 kHz subcarrier to an existing stereo system presents the possibility of generated beat frequencies of 9 kHz and/or 10 kHz; or of random "swishy" by-products, all of which are in the audible range. The source of the 10 kHz signal is from the third harmonic of the 19 kHz pilot carrier signal which falls at 57 kHz, 10 kHz below the 67 kHz subcarrier. Some earlier stereo generator designs also produced second harmonic content from the 38 kHz suppressed carrier switching circuitry. This second harmonic falls at 76 kHz and produces a 9 kHz product when intermixed with the 67 kHz subcarrier. The 9- or 10-kHz products appear as relatively clean "whistles" when no modulation is present. When the subchannel is modulated *(deviated ±6 kHz)* the products appear as "swishes" as the 67 kHz modulation sidebands are generated and beat with the pilot carrier third harmonic and/or the 38 kHz second harmonic.

If either 57 kHz or 76 kHz signals or any other spurious signals appear in the transmitter output, they must be eliminated. Suggested steps for optimum operation include:

- Insure that the 19 kHz pilot carrier is free of third harmonic content and does not exceed 10% injection level.
- 38 kHz carrier suppression must be at least 50 dB below a 100% modulation reference level.
- SCA carrier injection should be maintained at a 9½-10% level.
- A sharp 5 kHz low pass filter *(optional with some SCA generators)* should be inserted in the SCA program output circuitry. This prevents the appearance of harmonics of non-sinusoidal SCA program material above 5 kHz in the SCA generator output which can produce excessive SCA sidebands which would extend below the lower bandwidth limit assigned to the subchannel information and generate interference with the stereo information channel which has a 53 kHz upper limit.
- The left- and right-channel audio inputs of the stereo generator should incorporate 15 kHz low pass filters to insure that sideband signals of the stereo transmission do not extend beyond the 23 to 53 kHz *(38, ±15, kHz)* limits assigned to it.
- The SCA generator should include a 67 kHz bandpass filter in its output to insure that (a) the lower sidebands do not interfere with the 53 kHz upper stereo information frequency limit; and (b) that the upper sideband does not extend beyond the 75 kHz upper limit established by FCC Rules.
- Although modern FM transmitter and stereo/SCA generator design is capable of accommodating ±6 kHz deviation of the subchannel carrier, it is recognized that many broadcast systems utilize equipments of various ages and manufacturing designs. In a number of instances, it is worthwhile, if satisfactory performance cannot be realized with ±6 kHz deviation of the subcarrier, to consider reduction in deviation. Reducing the deviation to ±4 kHz results in a signal-to-noise increase of 4 dB in the subchannel transmission.

If the above precautions are taken, at worst minimal SCA interference will be transmitted. In most cases, a spectral display will prove that SCA interference is not being transmitted.

The station engaged in SCA and stereo transmission must, however, insure that it is transmitting a clean signal and this can be verified by a properly-operating monitor or spectrum analyzer. This can be done by removing all stereo modulation and measuring the SCA interference *(crosstalk)* into the main *(L&R)* channel and the stereo sub *(L-R)* channel. Any crosstalk or interference must be down at least 60 dB from 100-percent modulation into the main and stereo subchannels. If these parameters are met, the station knows that at least it is not contributing intermodulation products or SCA interference.

Stations transmitting SCA have one additional problem, that of the stereo information getting into the SCA channel.

This crosstalk interference is of great concern to the background-music operator and other users of the SCA channel. Clean SCA with stereo transmission requires optimum performance of the transmitter and associated equipment and in fact requires more demanding system and equipment linearity than for a stereo-only transmission.

In a stereo transmission, equal levels of signals are transmitted on the left and right channel. When SCA transmission is added, 90 percent of the total information is transmitted on the main and stereo channel with only 10 percent of the baseband modulation used for the SCA channel. Thus, the main and stereo channel is nine times greater in amplitude, requiring high transfer-characteristic linearity.

35 dB crosstalk *(separation)* between left and right audio channels of the stereo transmission is indeed excellent and hard to achieve at all frequencies, but this degree of crosstalk would be unusuable for SCA programming. Poor separation between the main and stereo channels is more attributable to phase error, time delay or amplitude error than nonlinear transfer characteristics.

In an SCA transmission, crosstalk can originate due to nonlinearities in the FM exciter, transmitter, transmitting and receiving antennas or multipath reception effects of the main channel section of the SCA receiver.

To preserve reasonably good phase linearity in an FM exciter the actual cutoff frequency of the 53 kHz lowpass filter following the modulator in stereo generators may be 60 kHz or higher, and stereo sidebands can extend well into the SCA channel. Thus, linear crosstalk from the stereo subchannel *(23-53 kHz)* can be transmitted into the SCA channel. This is characterized as a "monkey-chatter". This is not due to nonlinearities but is created by upper stereo AM sidebands exceeding the 53 kHz design limit and appearing in the 67 kHz SCA channel. Nonsinusoidal stereo program material in the 8-15 kHz region with high harmonic content can also produce AM sidebands of the stereo information which extend into the SCA channel. These amplitude-modulated signals will ride up and down the response curve of the SCA band-pass filter, creating a form of phase modulation which will be detected as noise in the recovered SCA audio. This type of transmitted interference is easily corrected by inserting sharp 15 kHz low-pass filters in the left and right audio channels of the stereo generator, preventing any stereo upper sideband components from exceeding 53 kHz.

The absence or malfunction of 15 kHz lowpass filters may be detected by fluctuation of the pilot injection level reading on the stereo monitor. This fluctuation is produced by harmonics of the program audio frequencies falling into the pass band of a highly selective 19 kHz filter used in the pilot injection level measuring circuitry of the monitor.

The above sources of crosstalk relate to direct, or linear, operating conditions.

The major, and most serious, cause of main or stereo crosstalk into the SCA channel is caused by nonlinear transfer characteristics *(intermodulation distortion)* which can originate in the exciter, power amplifier, transmitting and receiving antennas, or in the main channel portion of an SCA receiver.

An understanding of events occurring during the FM modulation process is necessary to better comprehend the crosstalk problem. The FM process is complex. An FM transmitter monaurally modulated 100 percent with a 600-Hz audio signal will create several hundred new carriers or sidebands above and below the center frequency. The strength of each of these carriers can be computed mathematically using Bessel functions. When a 67 kHz signal is added to the modulation process, two new carriers removed 67 kHz from the center frequency are produced. When these carriers are frequency modulated, additional new sidebands appear above and below these respective carriers. Any disturbance of these carriers or their sidebands will create intermodulation or crosstalk.

Most present-day FM exciters use the direct FM system operating at one-half the carrier frequency or at carrier frequency. The linearity of these modulated oscillators must be near perfect. The bandwidth of the RF amplifiers in the exciter following the modulated oscillator must be adequate to allow all of the upper and lower sidebands produced by the FM process to pass without deterioration. The correct phase relationship between the sidebands must be preserved. The shift in phase as the FM frequency changes must be a linear function. If the slightest regeneration is present, the phase shift will be more rapid above the center frequency than it is below, or vice versa, and intermodulation or crosstalk will occur. In effect, regeneration can be one of the most serious sources of crosstalk in the exciter. The pass band following the modulator must be at least 1 MHz wide for good linearity. The typical exciter illustrated in Figure 2 is designed with all of these parameters in mind, and with particular attention to proper filtering. 15 kHz low-pass filters are used in the left and right audio input channels of the stereo generator. A 53 kHz low-pass filter is inserted in the stereo generator output. A 5 kHz low-pass audio input and a 67 kHz bandpass output filter are used in conjunction with the SCA generator.

Proper coupling must be maintained between the exciter and the subsequent amplifier stage. The stage being driven must present a non-reactive load to the exciter. Any reactance existing between the exciter and power amplifier will produce phase shift due to non-linear response to signals appearing above and below the center frequency. Thus, the sidebands are altered from their original relationship to each other and crosstalk is produced. Improper neutralization of PA stages will cause regeneration and crosstalk.

A portion of the transmission system that is often overlooked is the transmitting antenna. Again, the transmitting antenna and transmission line must present to the transmitter a purely resistive load. A correctly tuned antenna system is capable of producing a VSWR close to unity, generally 1.1:1.

A further test of good antenna performance is to sweep it out and measure the change in reactance over a minimum of 1 MHz from the center operating frequency. A curve, representing the change in reactance, should be symmetrical on either side of the operating frequency if satisfactory multiplex operation is to result.

It is often taken for granted that the antenna can cause no problem. The antenna should be measured and adjusted especially if it has been in operation for a number of years, and SCA multiplex operation is now being initiated.

Some of the major causes of crosstalk in the transmitter end of SCA multiplexing have been outlined. Any station that follows good engineering procedures when converting to SCA operation will be rewarded with excellent results.

It was stated earlier that FCC Engineering Standards do not include performance characteristics for the SCA channel. As a guideline to what the anticipated performance of a subchannel might be, the following is typical of present-day SCA transmission with stereophonic main channel operation.

SCA Subcarrier: 67 kHz

SCA Frequency Response:	30-5000 Hz, ±1.5 dB
SCA Total Harmonic Distortion:	1.5%
Signal-to-Noise *(essentially crosstalk, main to SCA)*	−55 dB
Crosstalk, SCA to main	−60 dB

The optimum performance attainable with SCA operation in conjunction with monophonic main channel programming is most impressive.

A series of field tests were conducted in the late 1960's utilizing the facilities of KFAB-FM, Omaha, Nebraska. A subchannel frequency of 58 kHz was used and a maximum deviation of ±12 kHz was employed. The modulation of the main carrier by the subcarrier *(injection)* was 20%. The main channel had a measured frequency response which was flat, within 1.2 dB, from 50 to 15,000 Hertz. During all subchannel measurements the monophonic main channel was programmed with high quality recorded music. 75 microsecond preemphasis was used in both the main channel and subcarrier channel. Measurements taken with type approved monitoring equipment at the transmitter were:

Crosstalk *(subchannel into main)*	greater than −70 dB
Subchannel FM signal-to-noise ratio *(no main channel mod.)*	−70 dB

SCA channel total harmonic distortion

Freq. in Hz	**% Dist.**
50	.55
100	.46
400	.45
1000	.40
2500	.80
5000	.68
7500	.65
10000	.60
15000	1.20

SCA Frequency Response *(200 Hz ref.)*

Freq. in Hz	**Response (departure from 75 microsecond curve)**
50	0.0 dB
100	0.0
200	0.0
1000	+0.1
3800	0.0
5000	−0.6
10000	−2.0
15000	−0.7

Measurements were taken on a standard SCA receiver modified for ±12 kHz deviation, 15 kHz frequency response and 75 microsecond deemphasis. The receiver was located approximately 12 miles from the transmitter site and used a simple indoor dipole antenna, oriented for maximum signal. The antenna input signal was approximately 1 millivolt. The results were as follows:

Crosstalk *(subchannel into main)*	greater than −70 dB
Crosstalk *(main into SCA)*	During a 15-minute test period, the highest crosstalk measured was −55 dB with total main channel modulation not exceeding 100%
SCA signal-to-noise, plus crosstalk	−49 dB *(using 400 Hz @100% modulation as reference)*
SCA signal-to-noise *(No main channel modulation)*	−57 dB

SCA Channel total harmonic distortion

Freq. in Hz	% Dist.
50	.50
100	.55
400	.60
1000	.60
2500	.60
5000	.60
7500	.90
10000	.80
15000	1.30

SCA Channel Frequency Response *(200 Hz ref.)*

Freq. in Hz	Response (departure from 75 microsecond curve)
50	−0.2 dB
100	0.0
200	0.0
1000	−0.4
3800	−2.0
5000	−2.6
10000	−1.2
15000	+0.4

While the applications for an SCA channel capable of this high degree of performance are extremely limited, the test date is of interest since it does demonstrate the subchannel capability, as well as the relative values of degradation contributed by the receiving equipment portion of the complete transmission system.

Generally, the introduction of SCA multiplex operation as an adjunct to an existing FM broadcast station operation suddenly involves the station engineering personnel with a "whole new ball game" — the SCA receiver. Frequently, the SCA operation involves the leasing of the facility by a third party interested primarily in the results produced at the receiving location, for which he assesses a fee. The SCA receivers used by the subchannel lessee are frequently selected, purchased, installed and serviced by his own separate organization, completely unrelated to the FM station licensee.

Herein lies the potential for unbelievable misunderstandings! Are problems which may occur in the overall system produced by the transmitting end — or by the receiving end? Two points become of extreme importance to the station engineer. First, be certain the transmitting end is clean and technically sound; and second, and equally important, understand the technical aspects of the receiving process, particularly as it relates to the possibility of "crosstalk" problems, which are the most frequent complaint, and which may be produced by effects in the receiving process with which previously you have not had to be concerned.

The receiving antenna, multipath effects and the SCA receiver itself can generate nonlinear crosstalk.

The SCA receiving antenna, even for line-of-sight situations, should be as highly-directional as possible and "cut-to-frequency." The antenna directivity characteristic is essential to insure maximum direct path signal intensity and to minimize reception of secondary signals reflected from structures in metropolitan areas or from terrain irregularities in mountainous environments. Reflected signals alter the phase relationship of the transmitted sidebands of a carrier produced by a transmitter with good linearity. Bear in mind that the programming to be recovered by the SCA receiver is carried on a subchannel with one-tenth of the signal strength of your transmitted signal.

The generally-accepted standard SCA receiving antenna is of either 3- or 5-element, single-bay, Yagi configuration; occasionally supplemented by an additional bay for "fringe-area" installations. Coaxial transmission line, of 50- or 75-ohm surge impedance is essential to minimize secondary feedline pick up.

The block diagram of a typical SCA receiver is shown in Figure 3.

The SCA receiver must amplify the RF carrier and detect it without seriously disturbing the original signal and its sideband information. To do this, most of the signal amplification and selectivity is achieved in the main IF amplifier section of the SCA receiver. Fortunately, present day detectors are of sufficient bandwidth with good linearity and contribute very little to crosstalk. The problem has resolved itself to the band-pass IF filter or filters which must pass the modulated signal with sidebands undisturbed.

The requirement for an IF band-pass filter that will not create intermodulation products and maintain good selectivity is costly and hard to achieve. The bandwidth must be adequate, and the phase linearity must be such that minimum disturbance of the upper and lower sidebands will occur. The bandwidth must be adequate to minimize the unwanted conversion of the FM signal to AM in the IF system which would produce a side product of intermodulation into the SCA carrier. Even though the signal is hard-limited, the intermodulation product will show up as phase shift and will be detected by the FM detector and end up as crosstalk in the SCA audio.

The 67 kHz band-pass filter must have adequate selectivity to prevent linear crosstalk as previously described.

If intermodulation occurs anywhere in the transmission or receiver system, crosstalk results and there is no way to remove the main or stereo channel from the SCA channel.

A serious problem that occurred in early solid state receivers was front end overload. Receivers using bipolar devices in the RF amplifier were very susceptible to this type of interference. This phenomenon was caused by strong RF signals, many channels removed from the desired signal, driving the base-emitter junction of the RF amplifier into conduction. Thus the RF amplifier became an excellent mixer rather than an amplifier. This was evidenced by an apparent lack of receiver sensitivity and high noise. Removing the antenna, inserting pads, or short circuiting the antenna input restored the receiver to normal operation. The more sensitive the receiver, the greater the susceptibility to this type of overload. Forward AGC reduced the gain but this lowered the input impedance of the device drastically, which in turn reduced front end selectivity causing additional problems.

The advent of the JFET and especially the MOSFET transistor has greatly enhanced the overload characteristics of present day receivers. MOSFET's, when used with good preselection, can operate with input signals up to 0.3 volts or greater with very low intermodulation products, thus fully utilizing the selectivity characteristics of the IF system.

Another source of intermodulation, or crosstalk, in receivers can occur in the IF amplifier limiters. Symmetrical limiters preserve the zero time axis crossing of the IF signal while providing hard amplitude limiting. This results in practically zero amplitude-to-phase modulation conversion and non intermodulation products.

The SCA receiver shown in Figure 3 utilizes three direct coupled symmetrical limiters. Exceptionally good AM rejection results and normally cannot be measured with commercial AM-FM signal generators because of the inherent incidental phase modulation of the AM-FM generator. The exceptionally wide bandwidth of the cascaded limiters also minimizes the effects of multipath distortion.

When initiating SCA transmission another potential problem exists. A few of the regular listeners will complain of "birdies" or "whistles" in the stereo signal they receive. The station transmissions will be clean, the SCA program is satisfactory, and the reported "birdies" or "whistles" do not appear on the majority of stereo receivers in the station listening area.

This type of interference is generated by design deficiencies which exist in some FM stereo tuners/receivers, presently in use. It is created by generation of a 57 kHz signal *(third harmonic of the 19 kHz pilot carrier)* in a switching-type stereo demodulator, utilizing diode switches. In an identical manner to the previous caution relating to third harmonic generation in the station stereo generator, this 57 kHz signal produces a 10 kHz product when beat with the 67 kHz subcarrier which is included in the composite input signal to the stereo demodulator. When the subchannel is FM modulated, the reported "squishy" sound results. **This effect is generated in the listener's receiver!**

Square-wave switching demodulators, although capable of excellent stereo separation and stability are the worst offenders.

A number of current stereo receivers utilize these demodulator designs but minimize SCA interference by use of a filter preceding the diode-switching demodulator. These filters ideally should provide a flat passband and linear phase response up to 53 kHz and infinite attenuation from 60 to 75 kHz. Filters providing these characteristics are relatively expensive and compromise designs vary from simple, low-cost to fairly exotic versions, at the sacrifice of stereo separation at the higher audio frequencies. Unfortunately, some receivers, even those in the higher price range, and of otherwise highest quality have poor or no SCA filters!

An additional potential source of "receiver-generated" interference is in the 38 kHz regenerated stages where the 19 kHz pilot carrier is amplified, doubled in frequency and injected into the stereo demodulator. This regenerated 38 kHz signal must be absolutely free of any 19 or 76 kHz component. The presence of a second harmonic signal at 76 kHz will intermodulate with the 67 kHz subcarrier producing an audible 9 kHz "whistle" in the recovered stereo audio output.

Fortunately, integrated circuit chips incorporating phase lock loop stereo demodulator designs have been developed and are being used in more and more new consumer-electronics receiver designs. These inherently offer excellent SCA rejection and superior stereo separation at the higher audio frequencies.

A good deal of publicity has been generated on the subject of quadraphonic *(four-channel)* FM broadcasting as a supplemental service to existing stereophonic transmission. This has caused concern as to the effect on SCA channels.

First, the present FCC Rules pertaining to stereo broadcasting permit the use of matrix-type four channel encoder/decoder systems which are fully compatible with present stereo systems. The use of matrix four-channel systems presents no conflict with the SCA channel since the channel interrelationships are identical to those for current stereo/SCA transmission.

Under the auspices of the Electronic Industries Association (EIA) a National Quadraphonic Radio Committee (NQRC) was established for the purpose of evaluating discrete quadraphonic systems developed by five proponents. The five systems were tested in "on-air" tests late in 1974, using the facilities of K-101 in San Francisco. **The EIA/NQRC tests included measurements to insure compatability with SCA transmission.** All proposed systems met this criteria. Some of the proposed systems retain the present 67 kHz SCA carrier frequency, while others contemplate the use of an SCA channel at 95 kHz. While a 95 kHz SCA carrier would require a 4 to 5 dB greater signal level in fringe areas, the quality of reproduction and signal-to-noise ratios are equivalent to those obtained with a 67 kHz subcarrier frequency.

All of the proposed systems require bandwidths in excess of the present FCC, ±75 kHz limitation, hence adoption of any of the proposed systems involves a change in the present rules. The substantial technical data compiled during the K-101 tests will be the basis on which the Commission will consider the establishment of engineering standards and rules pertaining to an FM broadcast quadraphonic system. Since all of the proposed systems under consideration do accommodate an SCA channel, there is no danger that this mode of transmission will become extinct. At worst, the subchannel frequency **may** be changed to other than its present 67 kHz location.

The material discussed to this point has been limited to the broadcasting of aural SCA material. The FCC rule changes permitting non-aural uses of SCA open the door to many new SCA uses.

Most of the "visual" transmission modes, such as slow-scan TV, facsimile, teletype, etc., are readily accommodated by an SCA channel. Most of the modes above are regularly transmitted over low grade telephone circuits. The response, distortion and signal-to-noise capabilities of an SCA channel substantially exceed those of wire circuits; thus the revision of Commission rules to permit transmission of non-aural services opens a new dimension to the SCA field.

There are no "mysteries" in accommodating these new transmission modes since Special Temporary Authorizations (STA's) have been granted by the Commission during the past few years permitting successful on-air testing of SCA transmissions of slow-scan TV, multichannel teletype, visual display systems and an aural/visual electronic blackboard system. The technology exists for these new and interesting modes of broadcasting. As the new modes are implemented, more and more FM broadcasters will have the opportunity to utilize SCA transmissions.

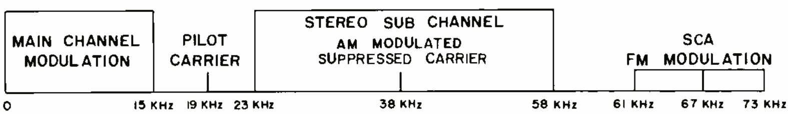

Figure 1 Complete FM Spectrum of a Stereo and SCA Transmission

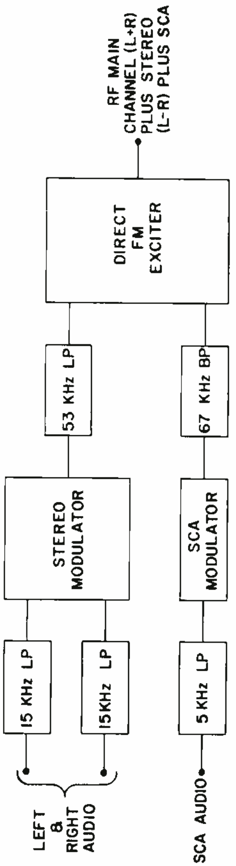

Figure 2 Block Diagram of a Typical FM Exciter

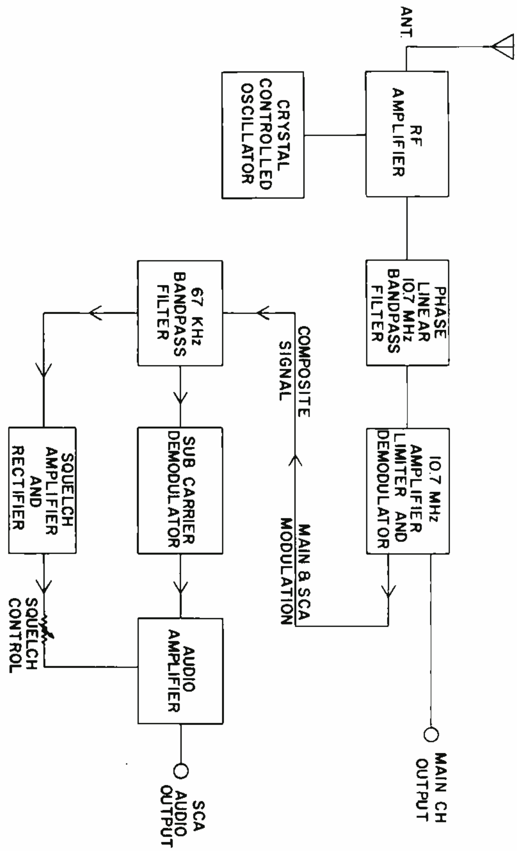

Figure 3 Block Diagram of a Typical SCA Receiver

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