NATIONAL RADIO SYSTEMS COMMITTEE

THIS IS AN OUTDATED VERSION

NRSC-1
NRSC AM Preemphasis/ Deemphasis and Broadcast Audio Transmission Bandwidth Specifications
July, 1988

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Published by
©CONSUMER ELECTRONICS ASSOCIATION 2005
Technology & Standards Department
2500 Wilson Boulevard
Arlington, VA 22201

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§ 1. SCOPE

The National Radio Systems Committee (NRSC) is a joint Committee composed of all interested parties including representatives of AM broadcast stations, AM receiver manufacturers, and broadcast equipment manufacturers. This document describes an EIA Recommended Standard that specifies the preemphasis of AM broadcasts, the deemphasis of AM receivers, and the audio bandwidth of AM stations prior to modulation. The standard applies to AM monophonic and AM stereo L+R transmissions, and to dual bandwidth and single bandwidth AM receivers. Compliance with the standard is strictly voluntary. To the NRSC's knowledge, no industry group or entity is or will be adversely affected by issuance of this document. Every effort has been made to inform and accommodate any and all interested parties. The NRSC believes that implementation of the standard will reduce AM interference, increase useful AM service areas, and encourage the production of higher fidelity AM receivers.

A five year review provision is established.

§ 2. INTRODUCTION

On September 5, 1985, the NRSC adopted a resolution to study proposals to standardize AM transmission preemphasis and AM receiver deemphasis with the objective of establishing an industry-wide AM preemphasis/deemphasis voluntary standard. After twelve months of study, on September 10, 1986 the NRSC released a draft voluntary standard that proposed a specific AM preemphasis/deemphasis curve as well as a 10 kHz standard AM bandwidth. The bandwidth specification evolved from NRSC deliberation on the causes and cures of AM interference, and ways to technically encourage the production of higher fidelity AM receivers. After a three month public comment period, the NRSC, on January 10, 1987, formally adopted this standard and authorized its publication by the National Association of Broadcasters and the Electronic Industries Association.

The purpose of the NRSC voluntary standard is to create a transmission/reception system where (1) AM broadcast stations will know, with certainty, the likely audio response characteristics of AM receivers, and (2) AM receiver manufacturers will know, with certainty, the likely audio response characteristics of AM broadcasts. A "matching" of preemphasis and deemphasis is expected to improve the consumer's overall satisfaction with the technical quality of listening to AM radio. The NRSC believes that the public interest is served by establishing a compatible transmission/reception system and the accompanying improvement of AM broadcasts and AM receivers.

This document also describes a specification for the maximum audio bandwidth transmitted by AM broadcast stations. Implementation of a bandwidth specification will reduce second-adjacent channel interference and thereby lead to (1) a significant reduction of second-adjacent channel interference as perceived on "wideband" AM receivers; (2) a corresponding increase in the interference-free service areas of AM stations; and (3) an incentive for the further building of dual bandwidth AM "wideband" receivers.[1] Analysis by a subgroup of the NRSC has shown that there would be little if any detrimental effect on today's "narrowband" AM receivers upon the implementation of this voluntary standard.

§ 3. BASIC DEFINITIONS

A. Preemphasis. The boosting of high audio frequencies prior to modulation and transmission.

B. Deemphasis. The attenuation of high audio frequencies during the process of reception and demodulation.

C. "Narrow" receivers. A subjective term to describe receivers with typical combined RF, IF and AF response characteristics of -10 dB at 4.2 kHz, -20 dB at 6.0 kHz. Response characteristics of narrow AM receivers are known to vary widely.

D. "Wideband" receivers. A subjective term to describe receivers with typical combined RF, IF, and AF response of -6 dB

1. First Adjacent channel interference considerations may continue to discourage the building of single bandwidth "wideband" receivers; however, the extent and nature of this form of interference has not been fully studied by the NRSC.

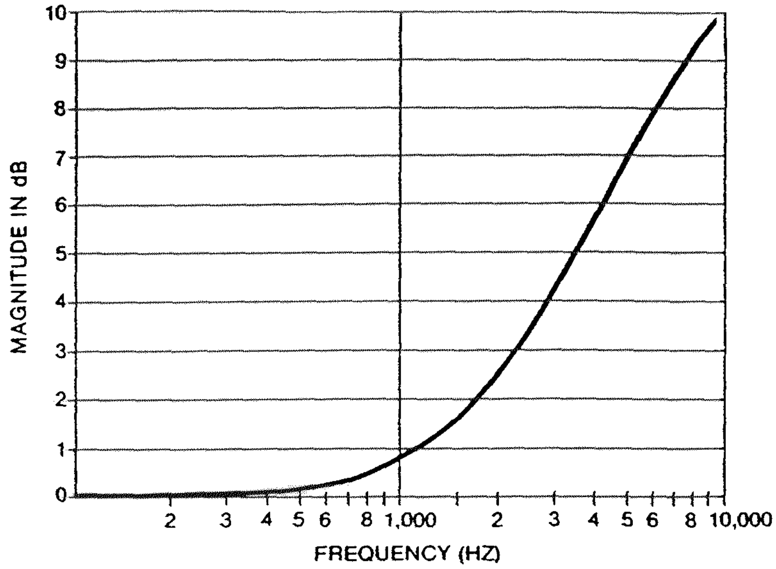

Figure 1. Modified 75µs AM Standard Preemphasis Curve

Technical Information

Frequency	Magnitude (dB)	Phase (deg)	Group Delay (sec)	Frequency	Magnitude (dB)	Phase (deg)	Group Delay (sec)
50	0.00	1.0	-5.6669E-005	5000	6.92	37.1	2.3048E-006
100	0.01	2.0	-5.6547E-005	5500	7.41	36.6	3.3525E-006
400	0.14	8.0	-5.4175E-005	6000	7.85	35.9	4.0592E-006
700	0.42	13.7	-4.9467E-005	6500	8.24	35.2	4.5169E-006
1000	0.81	18.7	-4.3318E-005	7000	8.58	34.3	4.7926E-006
1500	1.63	25.5	-3.2247E-005	7500	8.89	33.4	4.9357E-006
2000	2.54	30.4	-2.2343E-005	8000	9.16	32.5	4.9823E-006
2500	3.44	33.6	-1.4509E-005	8500	9.41	31.6	4.9595E-006
3000	4.28	35.7	-8.6612E-006	9000	9.62	30.8	4.8871E-006
3500	5.05	36.9	-4.4133E-006	9500	9.82	29.9	4.7801E-006
4000	5.75	37.4	-1.3702E-006	10000	10.00	29.0	4.6495E-006
4500	6.37	37.4	7.8900E-007				

at 6 kHz, -10 dB at 8 kHz. Response characteristics of wide AM receivers are known to vary widely.

E. "Excessive" Preemphasis. Preemphasis that produces no discernable benefit when received by a "narrow" receiver but increases interference to adjacent channel AM stations.

§ 4. AM TRANSMISSION PREEMPHASIS

§ 4.1. In General. AM preemphasis is the boosting of high audio frequencies prior to modulation and transmission. Today, most AM stations use preemphasis to varying extents. This preemphasis is employed in an attempt to compensate for the "narrow" response of most AM receivers. If AM preemphasis is not controlled, one station may interfere with AM receivers listening to neighboring stations located on adjacent AM channels. Whether such interference is objectionable will depend on (1) the response characteristics of the AM receiver, (2) the amount and nature of transmission preemphasis, (3) the extent to which the AM station is employing compression/ limiting techniques, and (4) whether the AM transmission system is bandlimited in the audio processor, transmitter or antenna.

Preemphasis is useful for improvement of the AM transmission-reception system audio response only to a limited extent for receivers using IF transformers. Many receivers using ceramic filters with narrow response characteristics can not be improved by use of excessive preemphasis. These receivers can not "hear" the transmission of preemphasized high audio frequencies. But excessive preemphasis will foster adjacent channel interference and cause wideband radios to sound shrill or strident.

§ 4.2. Description of the Modified 75 uS Preemphasis Curve. Each AM broadcast station shall broadcast with audio preemphasis as close as possible (within the capabilities of the station's transmission system) to the recommended standard, without exceeding it. The curve applies for audio frequencies up to 10 kHz.

The NRSC proposed standard AM transmission preemphasis curve is shown in Figure 1. The curve describes the recommended net transmission system static audio response of an AM station.

The recommended preemphasis curve is a single zero curve with a break frequency at 2122 Hz. It is similar to the 75 uS curve used for FM broadcasting. To reduce the peak boost at high frequencies, a single pole with a break frequency of 8700 Hz is employed. NRSC analysis has shown that the proposed curve is compatible with most existing AM receivers.

§ 4.3. Methods for Determining Performance. The NRSC AM preemphasis curve is a static curve, and cannot be measured dynamically. NRSC studies have shown that the dynamic and non-linear functions performed by most AM station audio processors will modify any given preemphasis curve. In addition, it is the audio response of the entire AM transmission system that indicates performance in accordance with the standard. For these reasons, measuring a station's preemphasis curve for the purpose of determining compliance with the NRSC standard shall be performed in accord with the following specifications:

§ 4.3.1. Use of Audio Tones. Compliance with the curve shall be measured by sweeping the station's transmission system with audio tones. The dynamic functions of the AM station's processor, but not the frequency shaping circuits, must be disabled (i.e., in "proof" mode).

§ 4.3.2. Location of Measurement. The net transmission system audio response is best measured by detecting the over-the-air signal. This will ensure that the AM transmitter and antenna combination is faithfully reproducing the preemphasized audio.[2] Alternatively, if the transmitter and antenna combination is reasonably broadband, performance can be determined by static measurement of the audio signal prior to modulation.

§ 5. AM RECEIVER DEEMPHASIS

§ 5.1. In General. Receiver deemphasis results from the selectivity

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2.However, the deemphasis characteristics of the device used to demodulate the AM transmission must be accounted for. Additionally, some AM stations with transmitter or antenna problems may not be able to pass preemphasized audio without introducing "splatter" interference and/or overmodulation. If a particular AM station transmission system cannot "handle" the NRSC recommended curve, it is suggested that a lower amount of preemphasis be used until the system problems are corrected to allow the NRSC curve to be faithfully implemented.

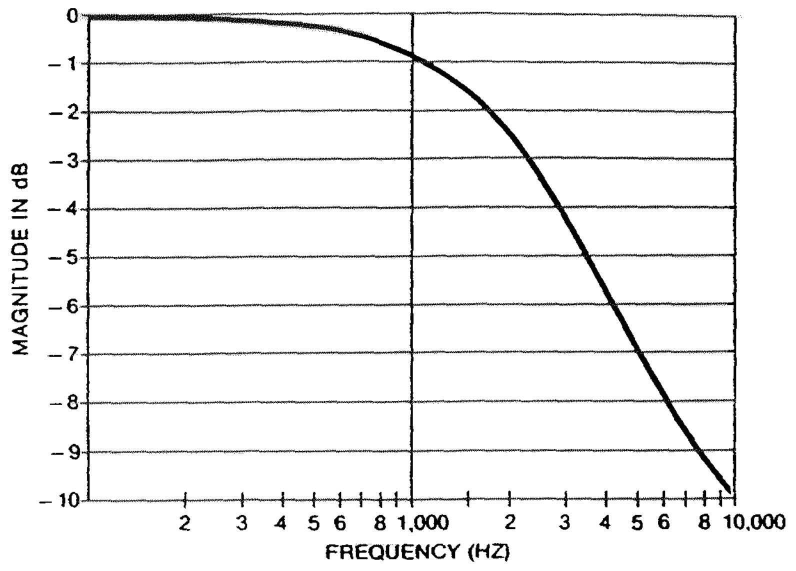

Figure 2. Modified 75µs AM Standard Deemphasis Curve

characteristics of a receiver's RF and IF stages and the response characteristics of the receiver AF section. A standard deemphasis curve permits AM stations to know, with certainty, the likely overall response characteristics of AM receivers.

§ 5.2. Description of the Standard Deemphasis Curve. AM receivers shall complement the recommended transmission preemphasis characteristic described in § 4 by incorporating a net receiver system audio response described in Figure 2. (The net system audio response of an AM receiver is the combined RF, IF, and AF audio response.) The NRSC deemphasis curve is characterized by a single pole at 2122 Hz and a single zero at 8700 Hz. It is the precise complement of the preemphasis standard described in § 4. The preemphasis/deemphasis voluntary standards apply only for audio frequencies below 10 kHz; the implementation of preemphasis/deemphasis standards produces a transmission/reception system that is essentially flat to nearly 10 kHz and limited only by the AM receiver's choice of bandwidth.

§ 5.3. Methods for Determining Performance. The deemphasis characteristic shall be determined by measuring the overall frequency response in accordance with International Electrotechnical Commission ("IEC") Publication 315.3, Clause 11.2:

(1) The receiver is brought under standard measuring conditions and the reference audio-frequency output voltage is noted. The modulation frequency is then varied and the output voltage at each frequency is noted and expressed in decibels relative to the reference voltage.

The modulation depth is adjusted at each frequency in accordance with the preemphasis characteristic of AM broadcast transmission. To avoid overmodulation at some frequencies it may be necessary to use a modulation factor of less than 30% at some frequencies.

(2) If overloading of the AF section of the receiver occurs, either the volume control attenuation should be increased or the modulation factor reduced, and a corresponding factor applied to the results.

(3) The measurements may be repeated with other values of RF input signal level and frequency.

The frequency response shall be measured for both monophonic and stereophonic reception, in accordance with the definition of the particular AM stereo system. For dual bandwidth receivers, the frequency response shall be measured in both bandwidth positions.

Results may be presented graphically, with modulation frequency plotted logarithmically as abscissa and the output in decibels as ordinate.

The frequency response can be stated as follows:

Selectivity	Frequency Response
Narrowband	50 Hz to 5000 Hz +/- X dB
Wideband or Stereo	50 Hz to 10,000 Hz +/- X dB

(Where X is the maximum deviation from the recommended frequency response, and 5000 Hz and 10,000 Hz are example frequency specifications.) The deviation X shall be of as low a value as practical. If a notch filter is used while the AM receiver is under test, the stated frequency response should be modified accordingly. Suggested modifications include (1) adding an appropriate footnote to the frequency response specification; and/or (2) lowering the upper limit value to the above "wideband" audio response specification.

§ 5.4. Notch Filters. A notch filter is a very selective filter that attenuates the spectrally pure carriers of first adjacent channel AM stations. Although an optional enhancement to an AM receiver, using notch filters is recommended. If used, the notch filter should (1) have as high a "Q" as is practical, (2) adequately suppress the interfering carriers, and (3) not unduly degrade the desired bandwidth performance of the AM receiver.

§ 6. 10 KHZ BANDWIDTH FOR AM TRANSMISSION

§ 6.1 In General. Each AM broadcast station shall modulate its transmitter with an audio bandwidth described by the specification in Figure 3. Appropriate and carefully designed audio low-pass filters as the final filtering prior to modulation can be used to implement this specification. The purpose of the bandwidth specification is to remove interference by controlling the occupied RF bandwidth of AM stations.[3]

§ 6.2. Description of the Standard. The audio bandwidth transmission standard is specified in Figure 3. The audio

3. It should be noted that the operation of non-linear AM Stereo systems theoretically may produce phase modulation components outside the desired RF bandwidth. The NRSC will examine this phenomena with the goal of determining whether such components exist and, if they do exist, whether they are objectionable. For a discussion of the detrimental effect of high audio frequencies on occupied RF bandwidth, see Klein, Modulation, Overmodulation, and Occupied Bandwidth: Recommendations for the AM Broadcast Industry, Proceedings of the 1987 NAB Engineering Conference, Dallas, Texas (April, 1987).

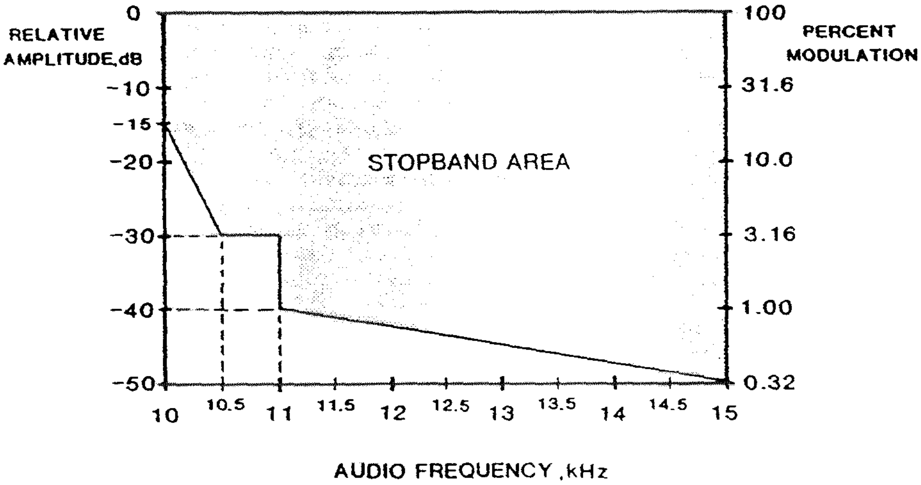

Figure 3. NRSC Stopband Specification
(Audio Envelope Input Spectrum To AM Transmitter)

envelope input spectrum to the AM transmitter shall be -15 dB at 10 kHz, smoothly decreasing to -30 dB at 10.5 kHz, then remaining at -30 dB from 10.5 kHz until 11.0 kHz. At 11.0 kHz, the audio bandwidth shall be -40 dB, smoothly decreasing to -50 dB at 15 kHz. Above 15 kHz, the audio bandwidth shall remain at least -50 dB. The reference level is 1 dB above a 200 Hz sine wave at 90% negative modulation. See Figure 3.

§ 6.3. Method for Determining Performance. An AM station is determined to be in compliance with the NRSC bandwidth characteristic by measurement of the station's audio bandwidth in accordance with the following parameters:

§ 6.3.1. Location of Measurement. Audio bandwidth measurements shall be obtained at the audio input terminals to the AM transmitter. For AM Stereo stations, audio bandwidth shall be measured at the L+R audio input terminals to the RF modulator. Note that the NRSC bandwidth standard characterizes an audio bandwidth that represents station program material that has been modified by possibly non-linear circuits in the station's audio processor. For this reason, the NRSC recommends use of a test signal that adequately characterizes typical audio program material, rather than relying on static audio test tones. However, it may still be useful to measure bandwidth statically at the time that AM preemphasis is measured.

§ 6.3.2. Use of Standard Test Signal. Audio bandwidth shall be measured using a test signal consisting of USASI (United States of America Standards Institute) noise that is pulsed by a frequency of 2.5 Hz at a duty cycle of 12.5%. See Figure 4. USASI noise is intended to simulate the long-term average spectra of typical audio program material. Pulsing of the noise is intended to simulate audio transients found in audio program material. USASI noise is a white noise source [4](i.e. noise with equal energy at all frequencies) that is filtered by (1) a 100 Hz, 6 dB per octave high-pass network and (2) a 320 Hz, 6 dB per octave low-pass network. See Figure 4. A pulsed USASI noise generator is shown in Figures 5 and 6. Using the attenuator pad, the ratio of peak-to-average amplitude shall be 20 dB at the audio output of the pulser. The station's audio processor must be in normal operating mode.

§ 6.3.3. Use of Standard Measurement Devices. A suitable swept-frequency or FFT (Fast Fourier Transform) spectrum analyzer shall be used to measure compliance with the NRSC bandwidth specification.

(a) Spectrum Analyzer Setup. When a swept-frequency audio spectrum analyzer is used to measure compliance with the NRSC bandwidth specification, the analyzer's setup shall consist of:

a. 300 Hz resolution bandwidth. [5]
b. 2 kHz/horizontal division.
c. 10 dB/vertical division.
d. Reference: 1 dB above 200 Hz (sine wave) 90% negative modulation.
e. Display: maximum peak hold (or equivalent function).

The analyzer's operating span and sensitivity are adjusted as necessary to determine compliance.

(b) Fast Fourier Transform Analyzer. When a FFT analyzer is used to measure compliance with the NRSC bandwidth specification, the analyzer's setup shall consist of:

a. Reference: 1 dB above 200 Hz (sine wave) 90% negative modulation.
b. Window: Hanning.
c. Horiz. span: 20 kHz.
d. Dynamic range: 80 dB or available range.
e. Display: Maximum peak hold (or equivalent function).

4. Acceptable white noise sources include GenRad Models 1382 and 1390B; Bruel & Kjaer Model 1405; and National Semiconductor IC No. MM 5837N.

5. Note: if the audio bandwidth under test fails to meet the NRSC specification when a 300 Hz resolution bandwidth is employed, a narrower resolution bandwidth, such as 100 Hz, may be used to determine compliance; however, the sweep rate and the video bandwidth of the analyzer must be adjusted according to the manufacturer's instructions in order to assure accurate representation of the resolution bandwidth employed. If in doubt, check with the analyzer operating manual or the manufacturer. Further Note: the NRSC may suggest a different or more precise measurement standard as the industry gains experience. Spectrum analyzers that are capable of 300 Hz resolution bandwidths at audio frequencies include, but are not limited to, Tektronix Models 5L4N and 7L5; Hewlett-Packard Models 3580A, 3582A, 3585A, 8553A or B, 8566A or B, 8568A or B, 71100A; Marconi Models 2370, 2382; Rhode/Schwarz/Polarad Model CSA-240M; and a Techron Model TEF System 12.

§ 7. FIVE YEAR REVIEW PROVISION

It is the goal of the NRSC to increase the fidelity of the AM transmission and reception system from its present state to a quality level that approaches the quality available via FM broadcasting. Towards this end, the voluntary standards described in this document shall be in effect for five (5) years from January 1987. During the five year period, this voluntary standard will be reviewed at least once a year to determine whether the fidelity goals of the NRSC are being realized.

§ 8. EFFECTIVE DATES

These dates serve only as objectives. AM Broadcast stations and AM receiver manufacturers are expected to make a good faith effort to implement the NRSC standard.

A. AM Broadcast Stations. The effective date of this standard is January 10, 1987.

B. AM Receiver Manufacturers. The effective date of this standard is January 10, 1988.

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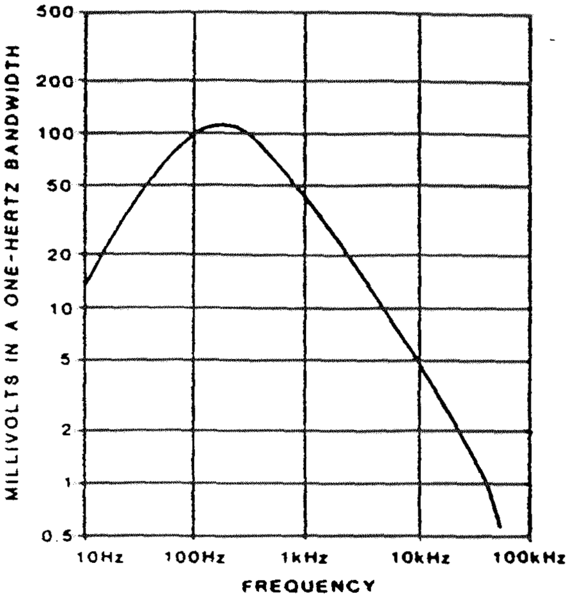

Figure 4. Spectra of USASI Noise

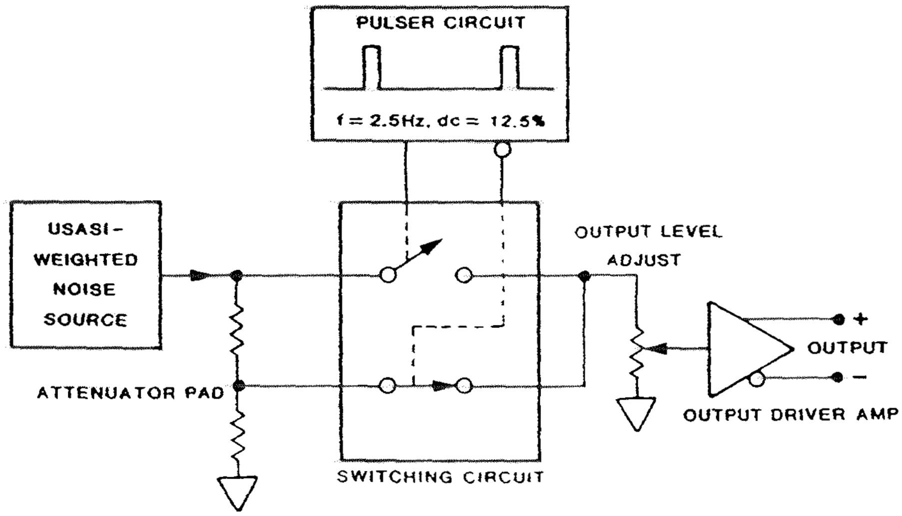

Figure 5. Pulsed-USASI Noise Generator

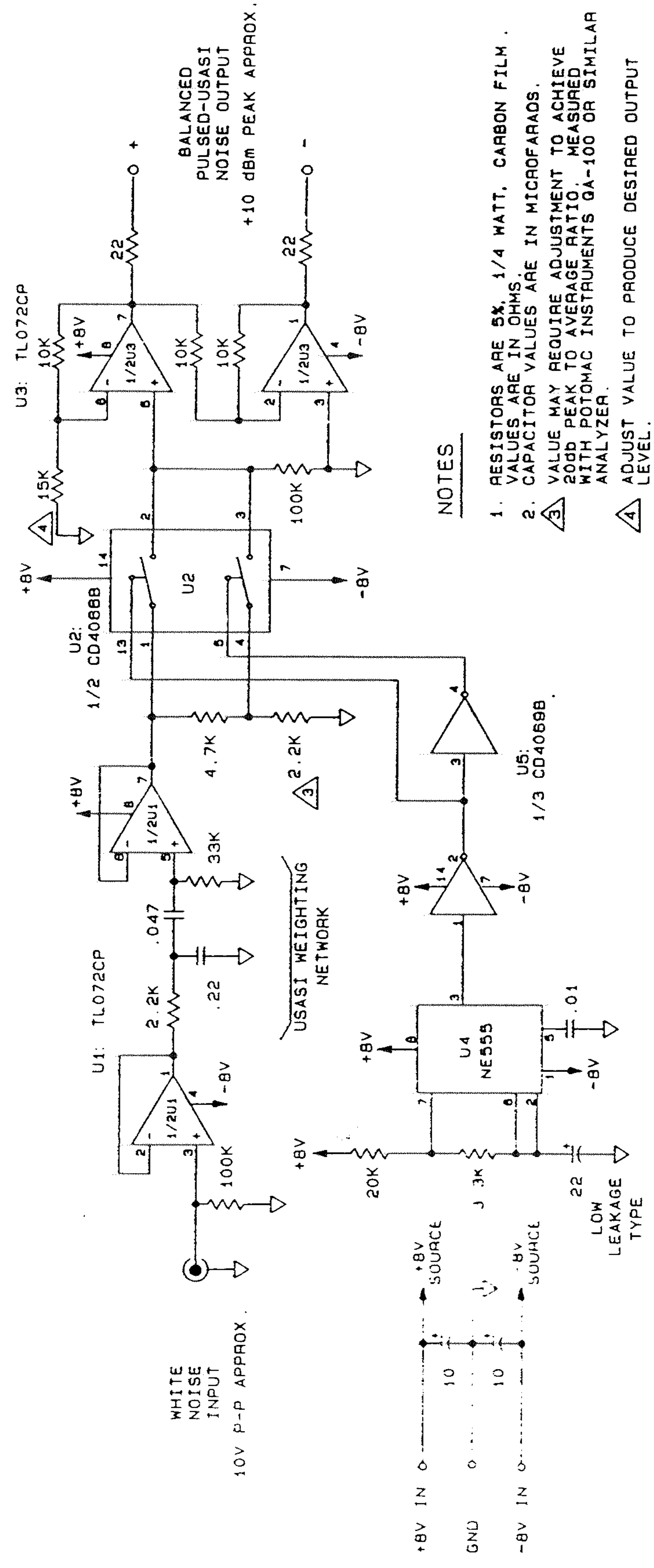

Figure 6. Application Circuit: USASI Noise Weighting/Pulser Circuit

NRSC Document Improvement Proposal

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