VLBA ACQUISITION MEMO #186

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

HAYSTACK OBSERVATORY

WESTFORD, MASSACHUSETTS 01886

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Area Code 508
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To: VLBA Data Recording Group

From: Alan E.E. Rogers

Subject: Tests of a new pre-amp configuration

The present VLBA recorder pre-amp uses an emitter-follower, followed by a common emitter stage. This configuration has the following independent noise voltage contributions (referred to the input) for low input impedance:

1]	1st 2N3906 at 1 ma	1 nV/√Hz
2]	50Ω emitter resistor	0.9 nV/√Hz
3]	2nd 2N3906	1 nV/√Hz
	rss	1.7 nV/√Hz

Simply eliminating the first stage and removing the emitter resistor eliminates the first two sources of noise and lowers the noise floor to 1 nV/√Hz or 4.5 dB improvement. This has been tested on the VLBA REC #3 by removing the emitter-follower transistor and replacing it with a jumper. Also removed were the oscillation damping circuit and the 3.3K bias resistor. The emitter resistor was reduced to 10 ohms and the collector resistor was reduced to 470 ohms to lower the gain and provide about the right capacitance (via the collector-base feedback) to resonate the head at 4.5 MHz. With this circuit, the SNR at frequencies below 1 MHz is improved by about 5 dB. At higher frequencies the SNR improvement is less since at these frequencies the thermal and tape noise from the head are starting to dominate the transistor noise. Since the head was resonant at bandedge the equalizer was simplified to the circuit shown in Figure 1. The overall broadband SNR improved by 5 dB to 23 dB[1].

Cascode pre-amp

While the emitter-follower could be changed to a common emitter circuit without changing the pc boards, I suggest a completely new design using the "cascode" configuration to provide noise floor improvement plus a lower input capacitance. The large input capacitance is the result of magnification of the collector-base stray capacitance owing to the voltage amplification. The

[1]Using D1K tape at 56 Kbi (160 IPS playback).

cascode circuit plus an emitter-follower can provide the same frequency response and gain as the present circuit so that the equalizer will be unchanged. It is probably more flexible not to resonate the head at bandedge - but to keep the resonance above bandedge as in the emitter-follower pre-amp. Further noise floor reduction could be made by using a transistor with larger area (and hence larger capacitance) than the 2N3906 or by connecting many 2N3906s in parallel - but this will force a lower head resonance.

Tests have been made using the cascode follower circuits shown in Figure 2. Feedback has been added to reduce the Q of the head resonance (as is used in some VCR preamps) without the noise penalty that results from placing a resistor in parallel with the head.

The SNR is improved by about 5 dB on the average throughout the band, although the larger improvement tends to be at frequencies below 1 MHz. The broadband SNR is improved by 5 dB. When the broadband SNR is measured at the differential input to the comparator, some of the low frequency noise is cancelled by the DC restoration circuit and the SNR advantage of the better pre-amp is estimated to be reduced by 1 dB, to 4 dB. Component values were chosen to have virtually identical signal response to emitter-follower pre-amp. Figure 3 shows the noise level for each pre-amp (signal levels are the same to within 1 dB) with the tape stopped. With D1K running on blank tape the noise level is evident with cascode preamp at frequencies above 1 MHz. With Fuji S-VHS tape the degaussed tape noise was not detectable with either pre-amp.

At present, there is no plan to replace the emitter-follower pre-amp in the VLBA recorder with a lower noise pre-amp. However, if the headblock assembly has to be improved for other reasons (like circuitry changes to solve record cross-talk), then consideration should be given to including a better pre-amp. Also, our need for better SNR may depend somewhat on our selection of tape - although in general an improved SNR margin is highly desirable.

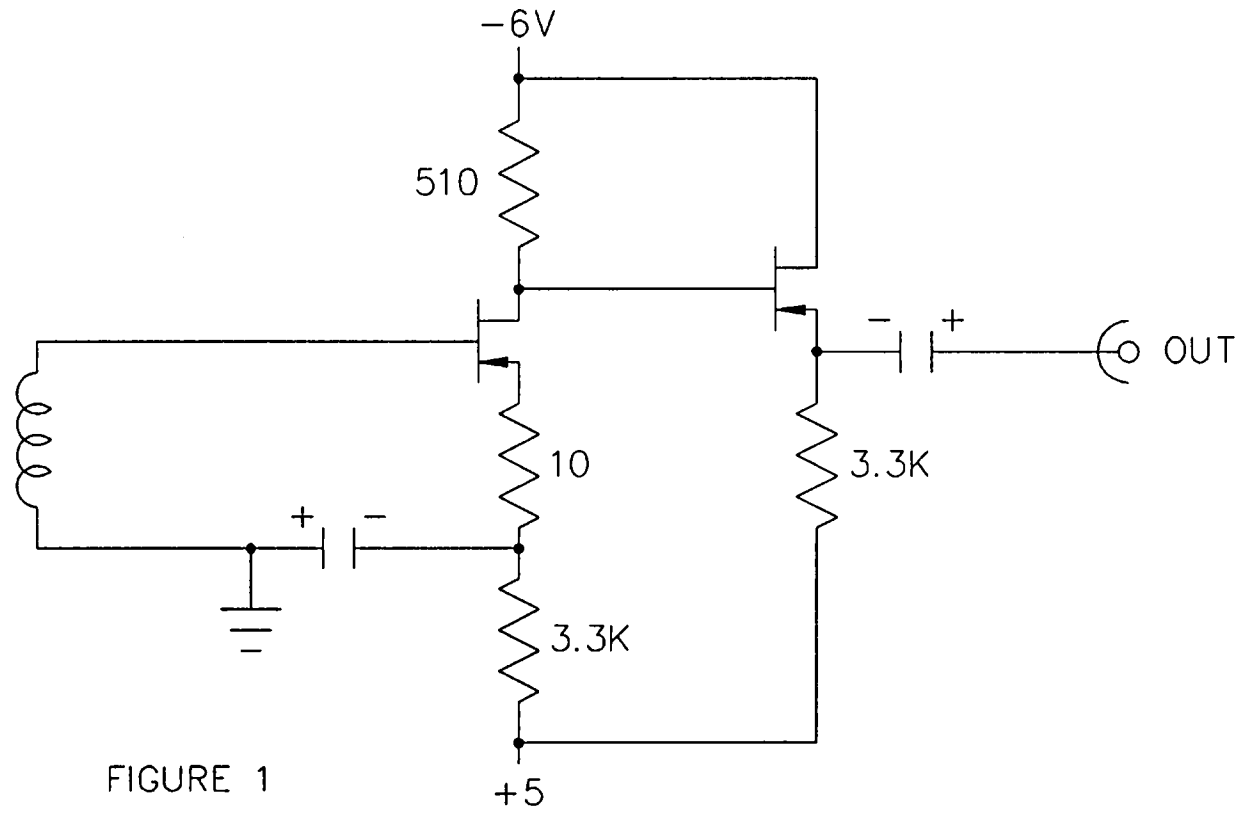


FIGURE 1

SHOP NOTES: UNLESS OTHERWISE SPECIFIED

1. DIMENSIONS ARE IN INCHES
2. TOLERANCE ON DIMENSIONS
   FRACTIONAL ± 1/64
   DECIMAL .XX ± .01
   DECIMAL .XXX ± .005
   ANGULAR ± 0°30'
3. SURFACE ROUGHNESS PER MIL-STD-10 ✓
4. REMOVE BURRS AND BREAK SHARP EDGES 1/64 MAX.
5. SCREW THREADS PER MIL-STD-9
6. ALL DIMENSIONS TO APPLY BEFORE PLATING OR CONVERSION COATING.

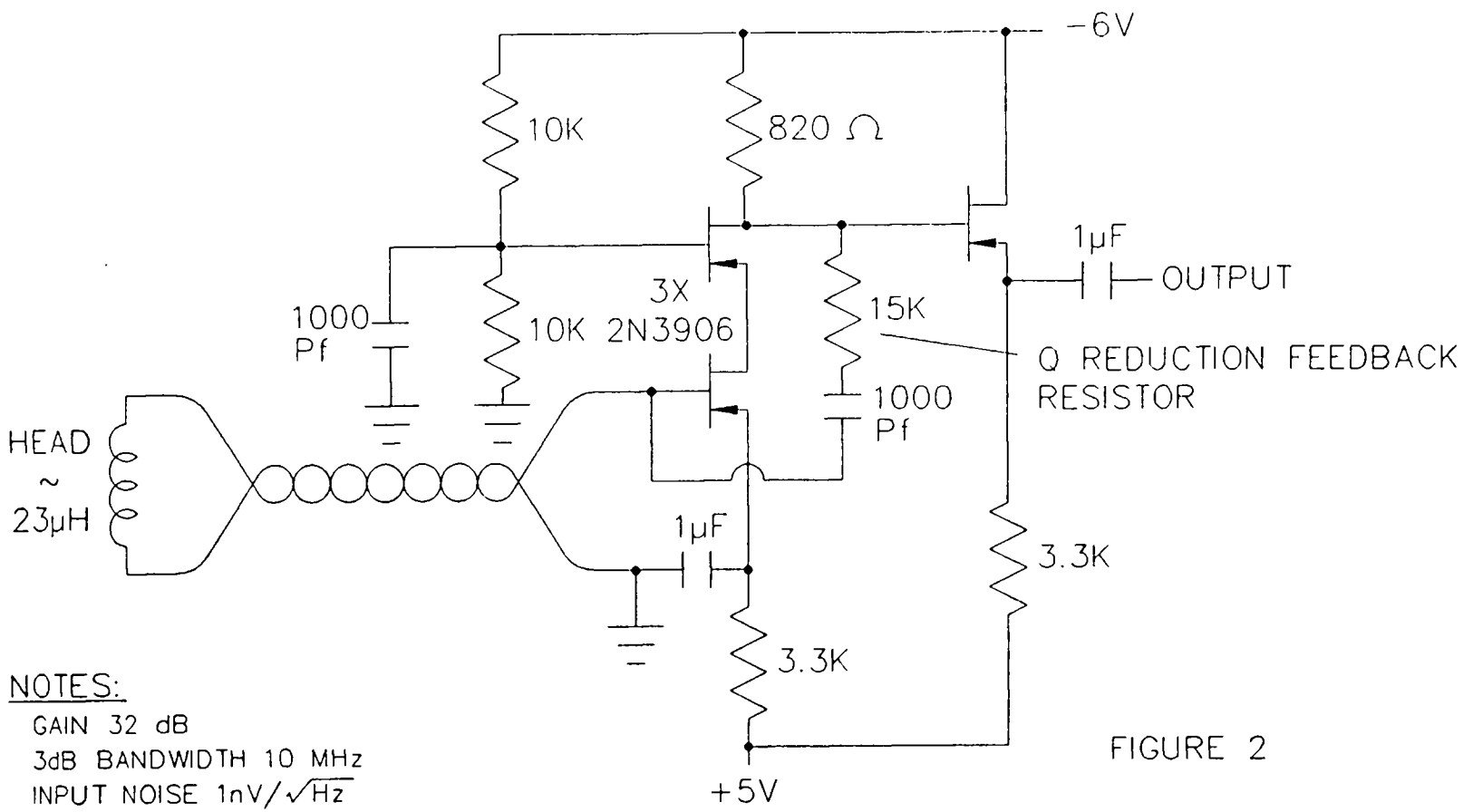
USED ON	
NEXT ASSEMBLY	
WEIGHT	
SCALE	NONE
CLASSIFICATION	

DRAWN FOR	A.E.ROGERS	DATE	1/90
DRAWN BY	C.KOSTKA		1/90
CHECKED BY			
APPROVALS: PROJECT			
APPROVALS: ENGINEER			
APPROVALS: MATL. & PROCESS			
APPROVALS: STRUCTURES			
APPROVALS: THERMAL			
APPROVALS: MECH. ANALYSIS			

NORTHEAST RADIO OBSERVATORY CORPORATION
HAYSTACK OBSERVATORY
WESTFORD, MASSACHUSETTS

COMMOM EMITTER PRE-AMP

FILE NAME	DWG. SIZE	DWG. NO.	REV.
CMEMPAMP	A		



NOTES:

GAIN 32 dB

3dB BANDWIDTH 10 MHz

INPUT NOISE $1nV/\sqrt{Hz}$

FIGURE 2

SHOP NOTES: UNLESS OTHERWISE SPECIFIED

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   DECIMAL .XX ± .01
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NEXT ASSEMBLY

WEIGHT

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CLASSIFICATION

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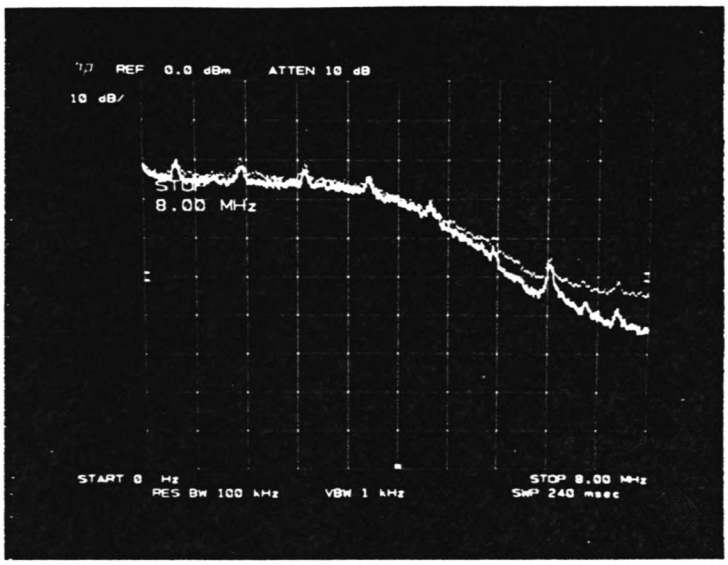
APPROVALS

PROJECT	
ENGINEER	
MATL & PROCESS	
STRUCTURES	
THERMAL	
MECH ANALYSIS	

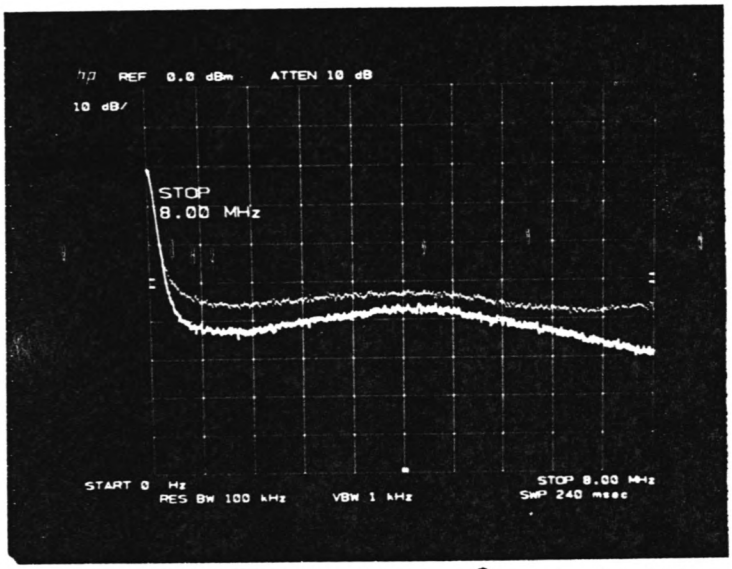
NORTHEAST RADIO OBSERVATORY CORPORATION
HAYSTACK OBSERVATORY
WESTFORD, MASSACHUSETTS

CASCODE PRE-AMP

FILE NAME	DWG. SIZE	DWG. NO.	REV.
CSPREAMP	A		



D 2 K UPPER = EMITTER, LOWER = CASCODE



NOISE UPPER = Emitter Fow. LW = CASCODE

Figure 3. Signal and noise level comparisons
Emitter-follower vs Cascode Preamp.