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50-323 Diablo Canyon Nuclear Power Plant, Unit 2, Pacific Ga 05000323
AUTH.NAME AUTHOR AFFILIATION
CRANE,P.A. Pacific Gas & Electric Co.
RECIP.NAME RECIPIENT AFFILIATION
ENGELKEN,R.H. Region 5, San Francisco, Office of the Director

SUBJECT: Final deficiency rept re Hagan Model 118 low level amplifiers indicating improper output voltages,initially reported on 810206.Transistors 2N699 in Location Q14 will be replaced.Technical analysis encl.

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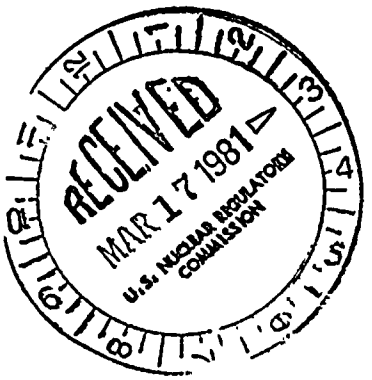
March 9, 1981



Mr. R. H. Engelken, Director
Office of Inspection and Enforcement
Region V
U. S. Nuclear Regulatory Commission
1990 N. California Boulevard
Walnut Creek Plaza, Suite 202
Walnut Creek, CA 94596

Re: Docket No. 50-275
Docket No. 50-323
Diablo Canyon Units 1 and 2

Dear Mr. Engelken:

This letter is being submitted to the NRC as a final report on a situation at Diablo Canyon Units 1 and 2 pursuant to 10 CFR 50.55(e). Initial notification was made to Dennis Kirsch on February 6, 1981.

During recent testing of the delta T input to the Reactor Protection System, the output of four of seven Hagan Model 118 low level amplifiers was noted to be approximately 60% of full scale when the input was open-circuited (simulated open RTD) rather than full scale as intended.

The problem has been narrowed down to the chopper section of these Hagan modules. Signal tracing on one of the failed amplifiers showed that the demodulated output of the chopper section was not operating as desired.

An amplifier, operating properly, should have a voltage of approximately -.005 VDC at the output of the chopper section with an RTD connected and at Reactor Coolant System operating temperature. When this RTD is open-circuited, the output of the chopper section goes to approximately -.6 VDC causing the amplifier to saturate and drive the indication off scale thereby indicating an equipment problem.

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The chopper stage on the problem modules produced an output voltage of approximately -.005 VDC both during proper RTD operation and when the RTD was open-circuited. With the RTD open-circuited, the chopper stage transistor (Q14), would not conduct sufficiently to shift the signal at its emitter to produce the proper negative value to force the proper module output.

The problem modules all had 2N699 transistors as Q14. The modules which functioned properly had Sprague 2N4383 transistors. Both transistors are the devices originally installed by the manufacturer.

The safety implications of this problem involve the Reactor Protection System reactor coolant delta T and T AVG inputs, the RCS overpressurization temperature inputs, and the pressurizer vapor temperature protection input. Since modules within similar loops may be interchanged, any of the problem modules could have been used in any of the similar temperature loops. The attached table shows all the Reactor Protection System inputs that could be affected and provides an analysis of the specific safety implications.

The present solution to the problem is to replace all 2N699 transistors in the Q14 location with 2N4383 transistors or an approved equivalent. In the interim Westinghouse is supplying Diablo Canyon Power Plant with enough Sprague 2N4383 transistors to replace the applicable 2N699 transistors in all Class IA installations. However, the 2N4383 device is no longer in production and Sprague has recommended an equivalent device, the TP4384, as a replacement. Westinghouse is presently reviewing this problem for an ultimate solution. We will notify you if the permanent solution differs from the solution outlined above.

A detailed technical analysis of this situation is attached to provide sufficient information to permit analysis and evaluation of this deficiency by the staff. If you have any questions, please contact our licensing staff.

Sincerely,

Philip A. Crane, Jr.

Attachments

CC w/attachments: Director
Office of Inspection and Enforcement
U. S. Nuclear Regulatory Commission
Washington, DC 20555

Service List

SAFETY IMPLICATION TABLE

Module	Service	Safety Function(s) Affected	Safety Implication
TM-411A TM-421A TM-431A TM-441A	Hot Leg Manifolds ΔT Protection	1) Over Power ΔT Reactor Trip 2) Over Temperature ΔT Reactor Trip 3) Feedwater Isolation	Note 1 Note 2 Note 3
TM-411B TM-421B TM-431B TM-441B	Cold Leg Manifolds ΔT Protection	1) Over Power ΔT Reactor Trip 2) Over Temperature ΔT Reactor Trip 3) Feedwater Isolation	Note 1 Note 2 Note 3
TM-413B	RCP 1-1 Discharge to Loop 1 Cold Leg	Interlock with Reactor Coolant High Press to Open PORV	Failure of the associated RTD could prevent automatic opening of PORV on RCS overpressure
TM-423B	RCP 1-2 Discharge to Loop 2 Cold Leg	Interlock with Reactor Coolant High Press to Open PORV	Failure of the associated RTD could prevent automatic opening of PORV on RCS overpressure
TM-454	Pressurizer Vapor Temperature Protection	Interlock with RC Press to Open/Block RHR pp Suction Valve	Failure of the associated RTD could prevent automatic opening of RHR pumps suction valve

RCHowe
3/6/81

NOTES

1. Failure of the associated RTD could prevent a reactor trip in response to reactor overpower operation.

2. Failure of the associated RTD could prevent a reactor trip in response to reactor coolant overtemperature.

3. Failure of the associated RTD could prevent feedwater isolation on low coolant leg T_{avg} causing an excessive reactor vessel cooldown rate.

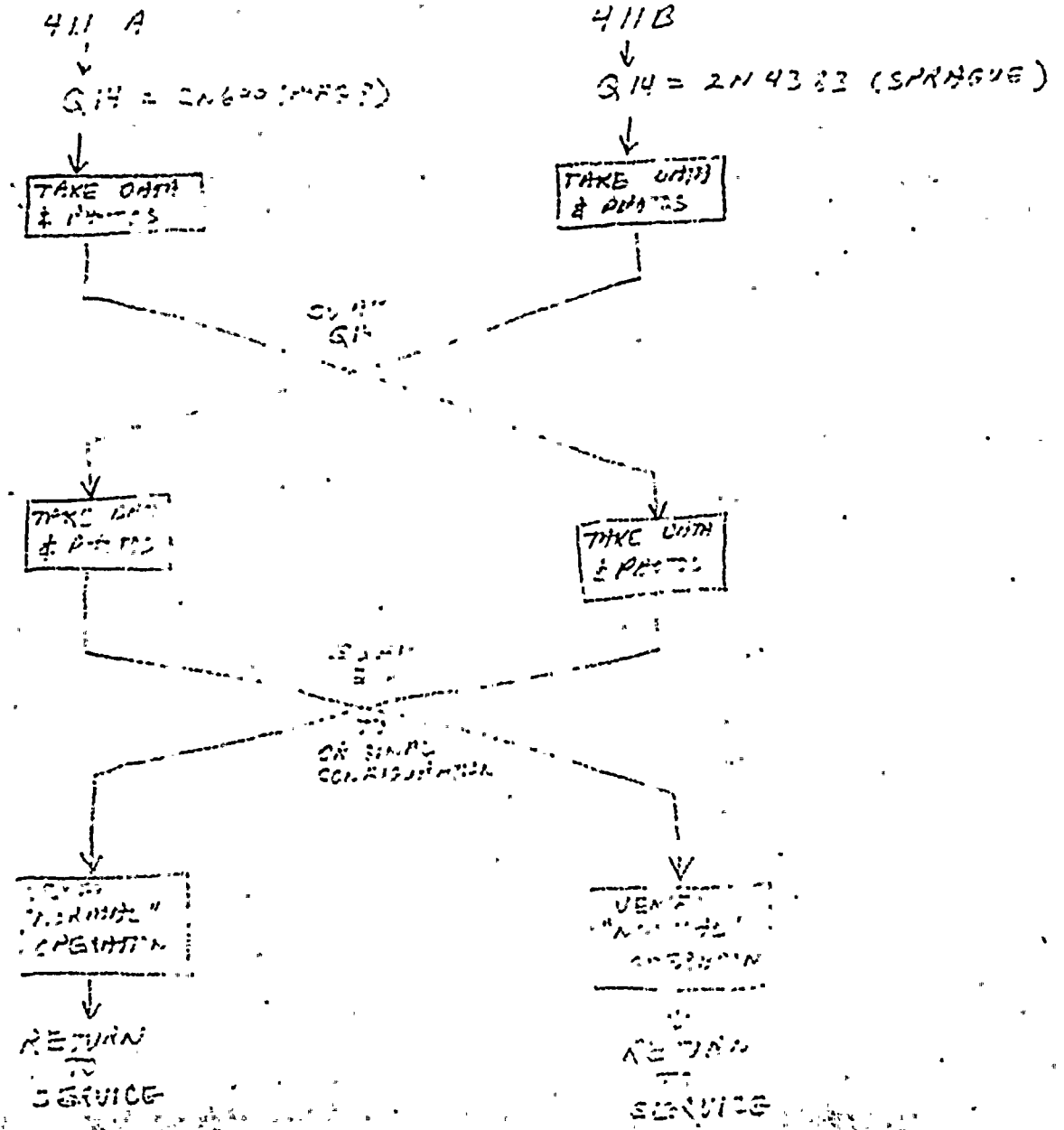
ATTACHMENT

Technical Analysis of

Two Hagen Model 118 Low Level Amplifier Chopper Sections

TEST SEQUENCE

1. TEST TM-4118 TM-4118 OUTPUT WITH [redacted] RESISTANCE AND SIMULATED OPEN RTU.
2. USE ONE 2N699 AND ONE 2N4383 AND ALTERNATELY INSTALL IN EACH MODULE IN Q14 POSITION.
3. REPEAT ITEM 1 AND TAKE PHOTOS.
4. SWAP THE TWO X-SISTORS WHILE HOLDING CTRL CONDITIONS UNCHANGED.
5. REPEAT ITEM 1 AND TAKE PHOTOS.



6. TAKE SIMILAR DATA & PHOTOS USING SPARE MODULE S/N E305 WITH RCA 2N697 IN Q14 POSITION.

DM	DIABLO CANYON MV/I OPEN RTU OUTPUT PROGRAM	B.M
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CHKD.		SHEET NO. SHEETS
C.K.		DRAWING NUMBER REF # 663230-'3' REV.
DATE 2-19-81	SCALE	

REF: DCC-81-TI-PC123 & NCR 81-TI-C01

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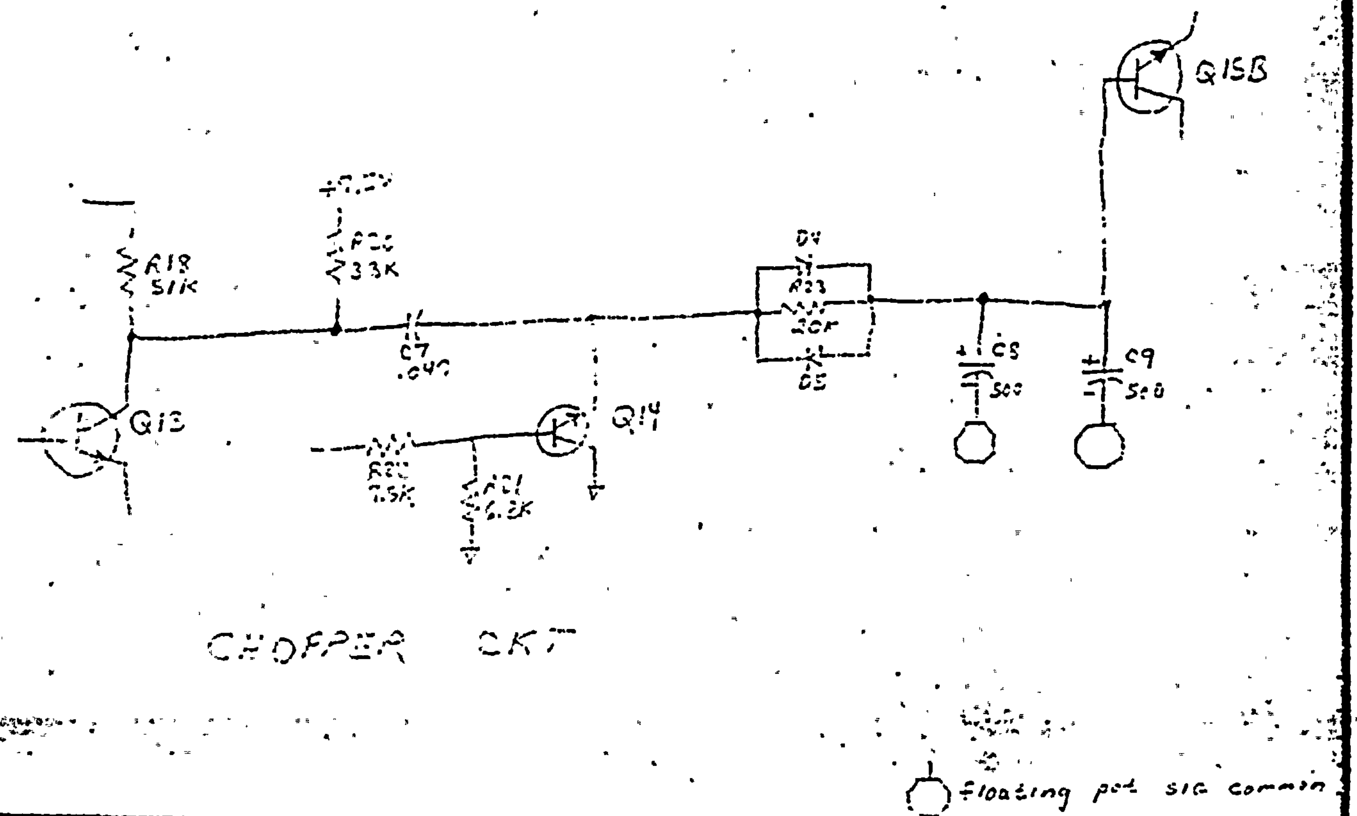
TEST DATA

MODULE S/N	INPUT NORMAL: Voltage across Q14 (Input RTD)	INPUT NORMAL: Output volts (input RTD)	INPUT OPEN: Voltage across Q14 (input open)	INPUT OPEN: Output volts (input open)	
SPARE E-305	-.[illegible]	[illegible]	-.539	▲6.43	Q14 - RCA 2N699
TM-411A E-257	-.[illegible]	[illegible]	-.[illegible]	*3.62	Q14 - (MFG ?) 2N699
TM-411A E-23?	[illegible]	[illegible]	-.6[illegible]	6.43	Q14 - SPRAGUE 2N4353
TM-411B S??	-.[illegible]	[illegible]	-.6[illegible]	6.92	→ SAME X-SISTOR
TM-411B E??	-.[illegible]	[illegible]	-.[illegible]	*[illegible]	→ SAME X-SISTOR

* OUTPUT DOES NOT SATURATE WHEN RTD FAILS OPEN

▲ PERFORMANCE QUESTIONABLE – SEE PHOTOS



CHOPPER CKT

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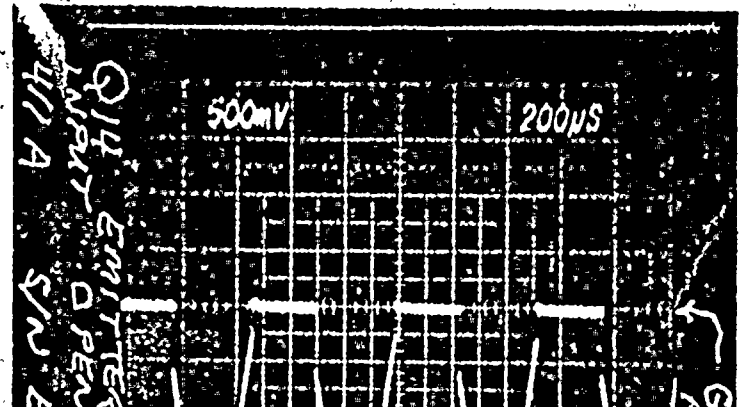

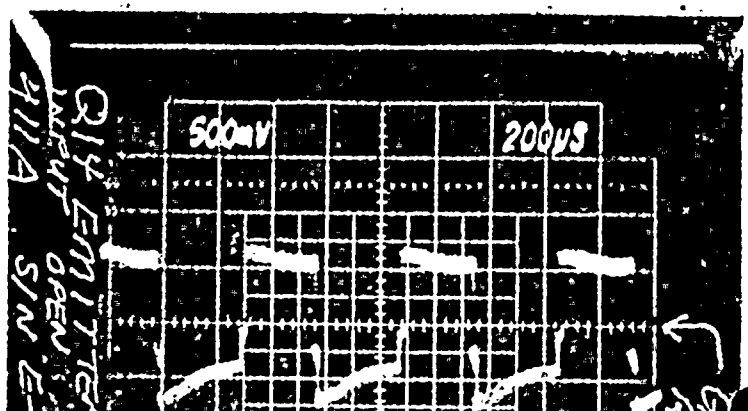

1TM-411A

S/N E-289 (using HIGH β 2N4383 in Q14 position)

The output waveform at the emitter of transistor Q14 indicating that the x-sender is conducting due to a positive voltage at it's base. The conductance of Q14 shifts the average value of the chopper waveform negative with respect to floating pot sig common. The demodulated signal (waveform) is then filtered, producing a negative voltage across C8 and C9 which is fed to the high frequency differential amplifier section (Q15 & 16). This imbalance drives the module output high.

SAME MODULE USING DIFFERENT TRANSISTOR FOR Q14

1TM-411A

S/N E-289 (USING 2N699 WITH β=40 IN Q14 POSITION — ORIGINAL TRANSISTOR)

The waveform at the emitter of Q14 indicate no average value shift.

The waveform (clipping) at the base of Q14 strongly suggests that some base current is present. <see photos next page>

To test whether sufficient drive could be obtained from the 2N699, resistor R22 was paralleled with another resistor to produce the waveform conditions shown on the left. An equivalent resistance of 6kΩ appeared to work adequately, although the maximum Emitte-Base voltage (5V @ 25°C) was being approached.

ADDED CHANNEL MODULE CIRCUIT ATD OUTPUT PROBLEM
REF: DCO-81-TP-0023 & NCR 81-TP-021

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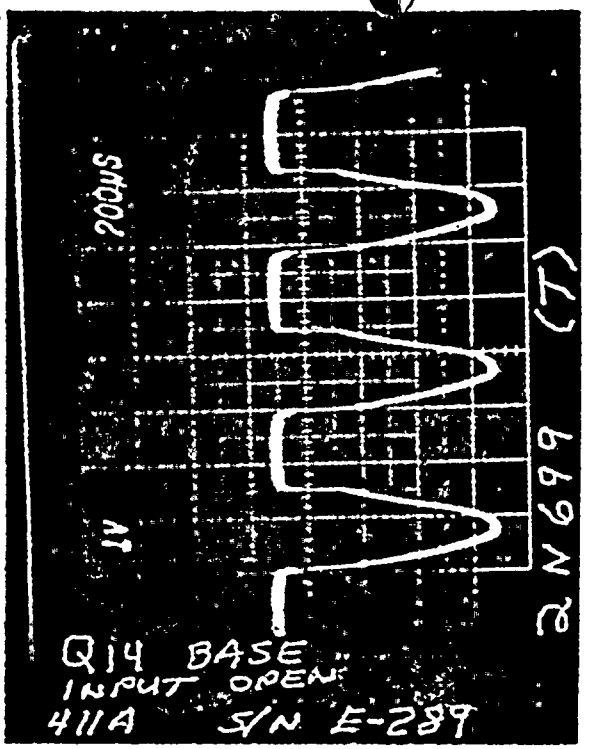
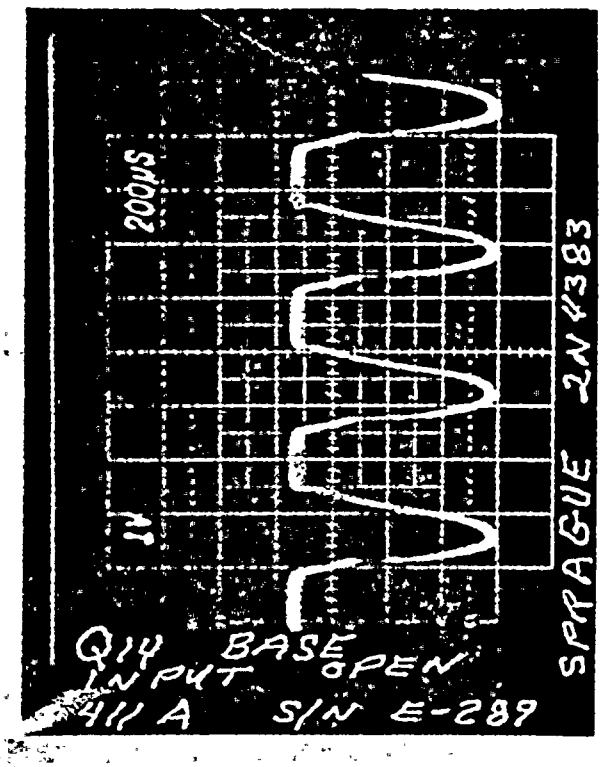


1 TM - 411 A
S/N E-289

Base drive waveform to
Q14 using 2N699

SAME MODULE
USING DIFFERENT
X-STORS FOR Q14



1 TM - 411 A
S/N E-289

Base drive waveform to
Q14 using 2N4383

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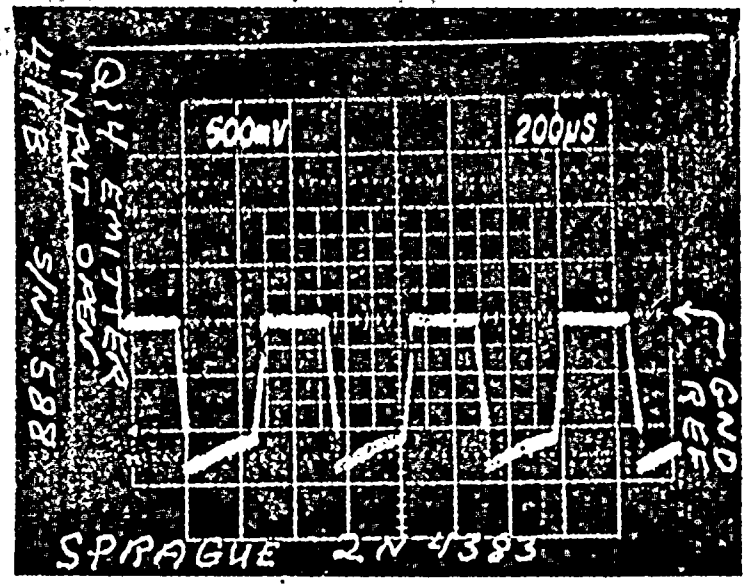
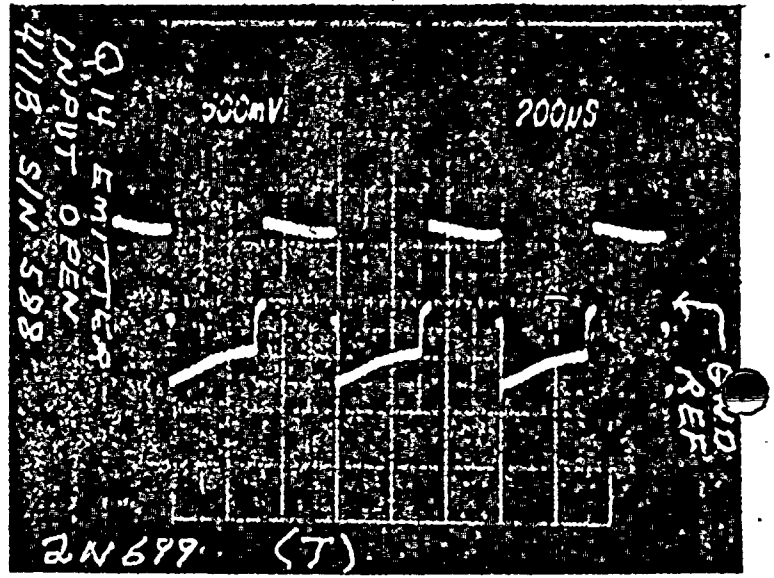
NVE problem





1TM-411B S/N 588

SAME MODULE USING DIFFERENT X-SISTORS FOR Q14

1TM-411B S/N 588

Emitter waveform for Q14 using 2N4383. NOTE shift in waveform average value.

Emitter waveform for Q14 using 2N699. Again insufficient base drive is suggested.

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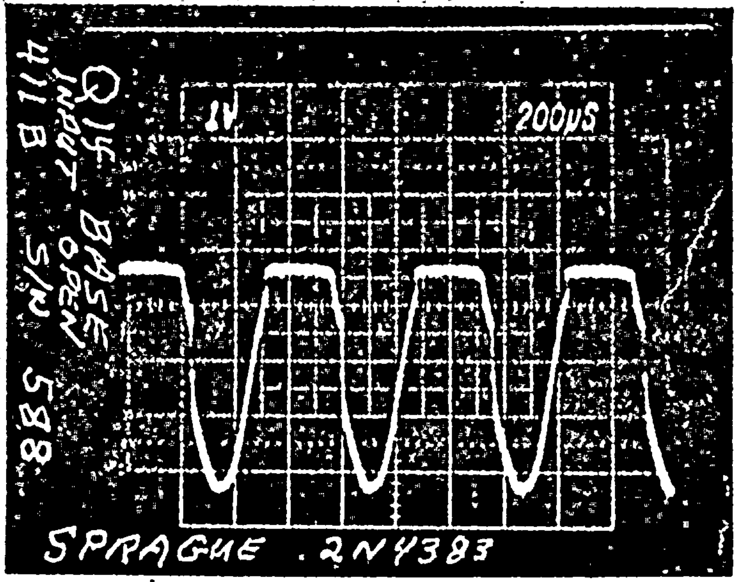

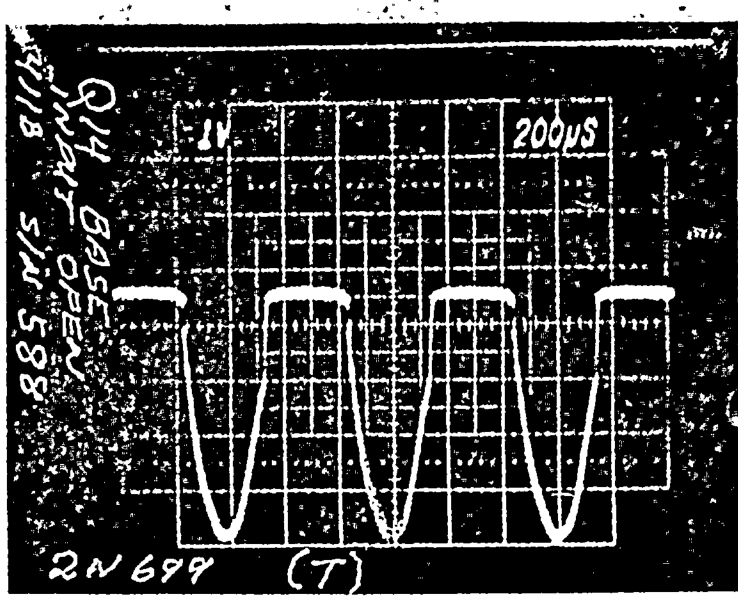

1TM-411B
S/N 588

SAME MODULE USING
DIFFERENT X-SISTOR FOR Q14

1TM-411B
S/N 588

Base drive waveform for Q14 using 2N4383.

Base drive waveform for Q14 using 2N699.

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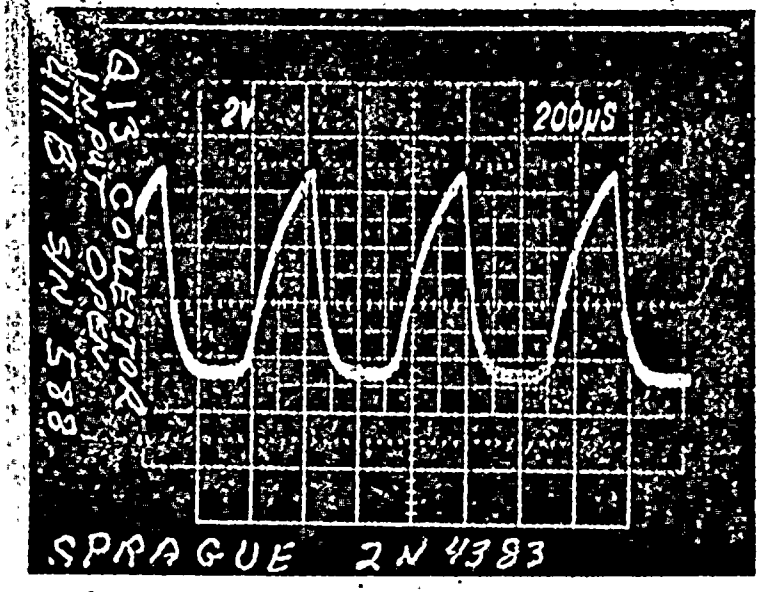

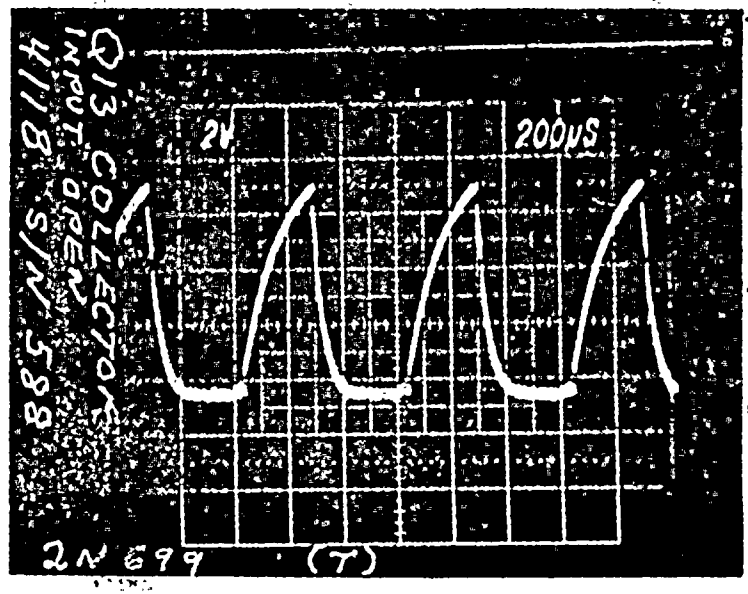

17 m-4113
S/N 588

SAME MODULE USING
DIFFERENT T-SISTOR FOR Q14

17m-4113
S/N 588

Output waveform from Q13 collector which is fed across C9 to Q14 (2N 4383)

Output waveform from Q13 collector which is fed across C7 to Q14 (2N 699)

These waveforms appear to be identical and unaffected by Q14

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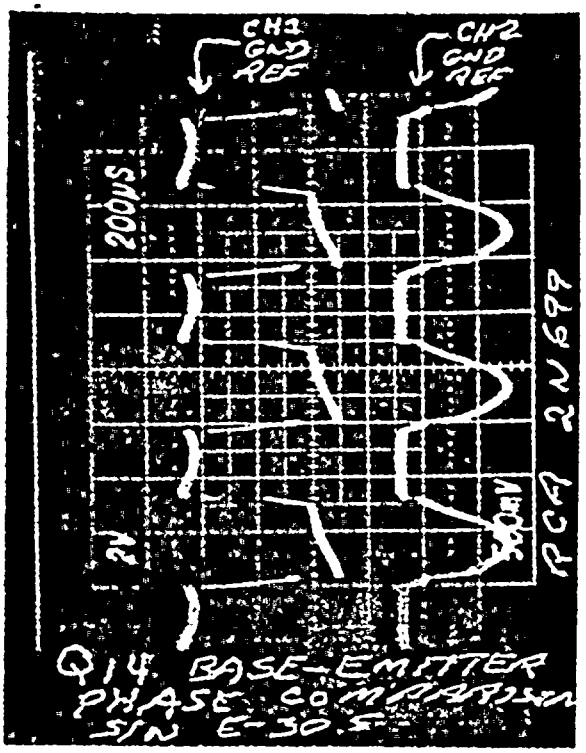
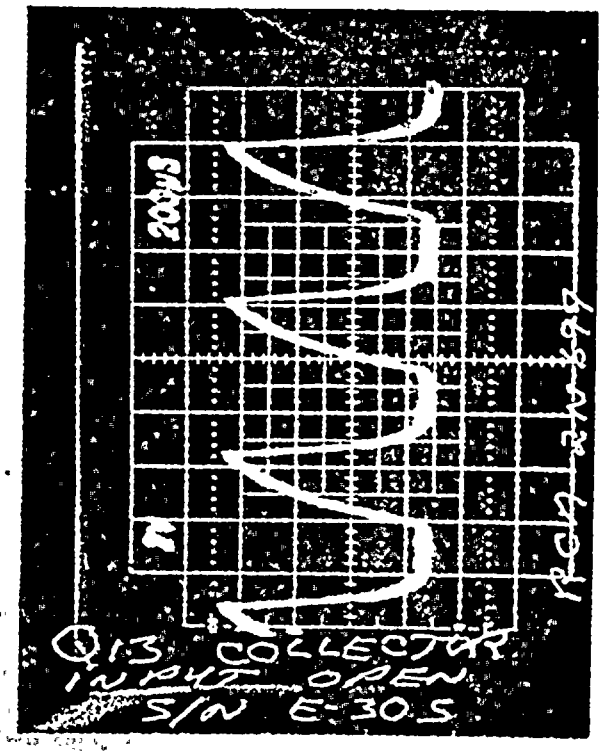


The phase inversion between the base drive signal and the emitter signal of Q14

SYNTEC MODULE S/N E-305



The waveform observed at the collector of Q13.

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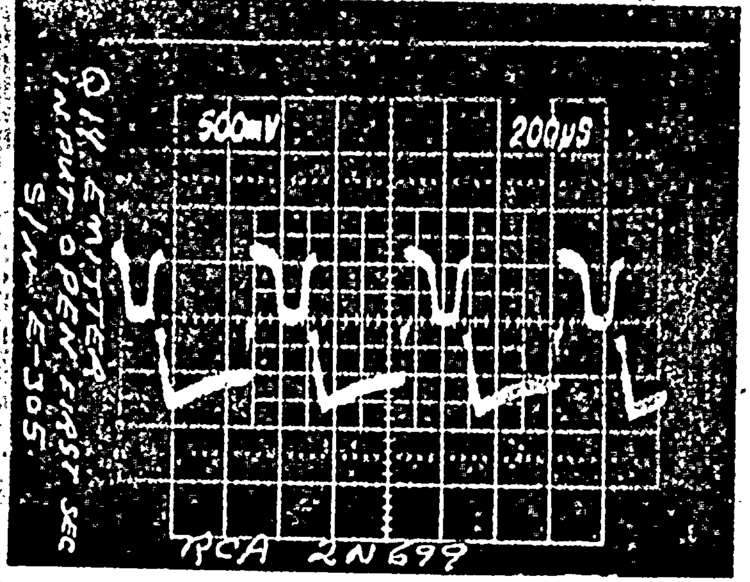

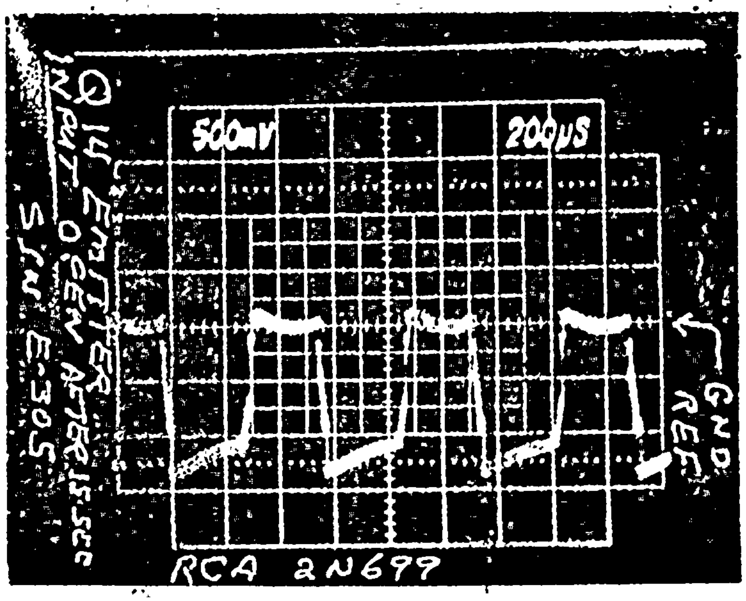

Both these waveforms were observed at the emitter of Q14. The first photo represents the waveform at the moment that input resistance is opened. The second photo represents the waveform after stabilization. This characteristic possibly represents marginal performance. No such delay was observed in those modules, where a 2N2343 was used for Q14.

This conclusion is further supported by the fact that an RCA 2N699 was installed in TM-411A and appeared to function properly on the bench. However, after installation in the HAGAN racks and left overnight, the output was NOT saturated after the RTD was simulated as open.

SPARE MODULE S/N E-305

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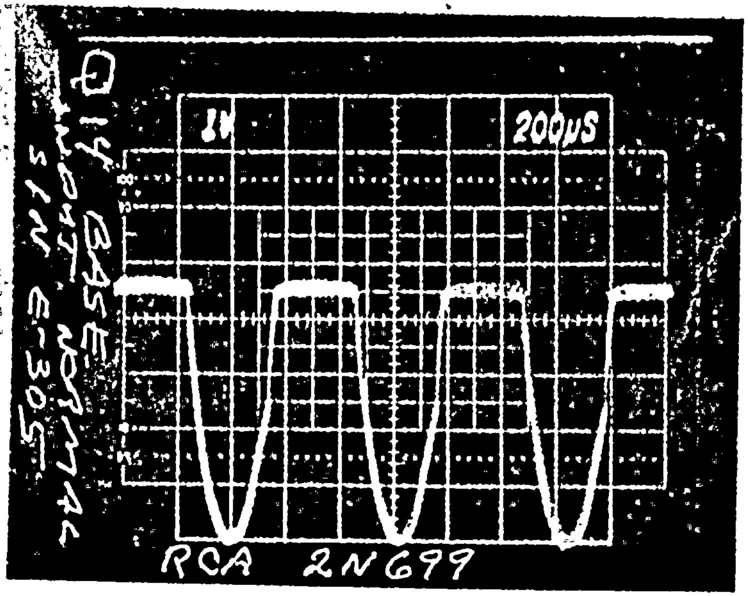
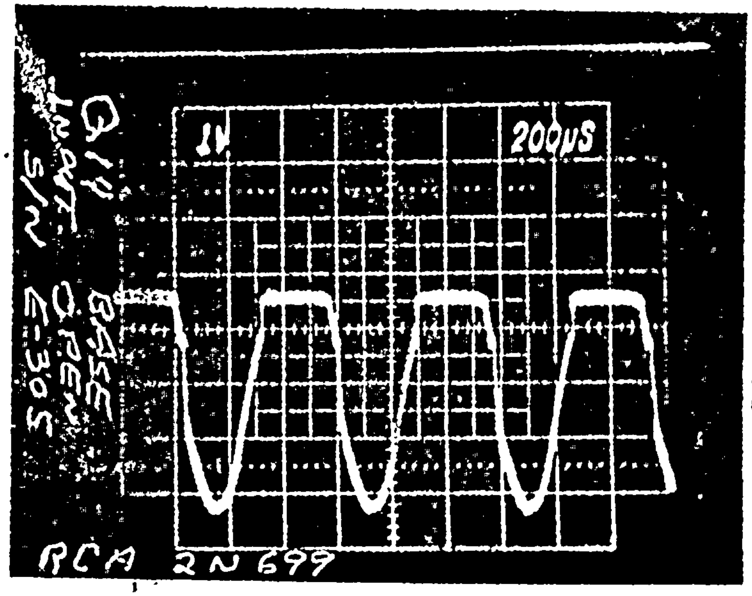


Base drive waveform to Q14 with an input resistance of 43Ω.



Base drive waveform to Q14 with an open input resistance to the module.

A very similar set of waveforms was observed using a Sprague 2N4383 transistor at position Q14.

SPARE MODULE S/N E-305

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DATE 2-19-91	SCALE

MV/I PROBLEM

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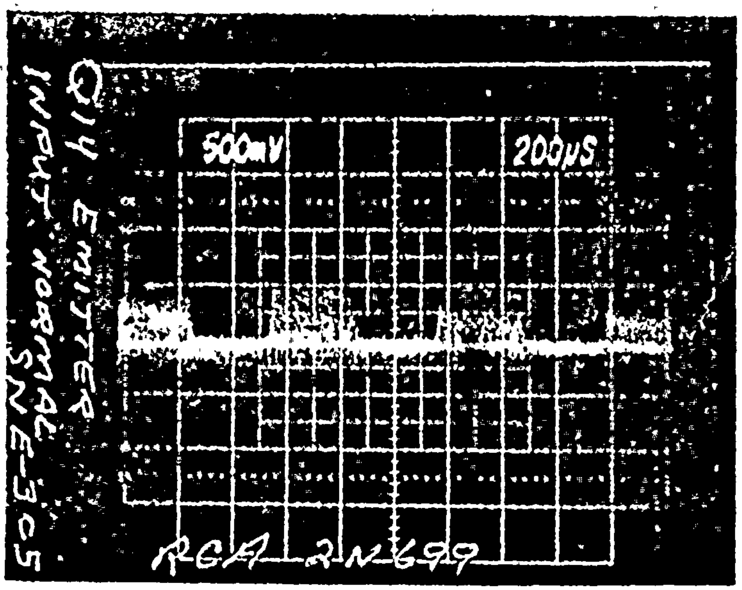
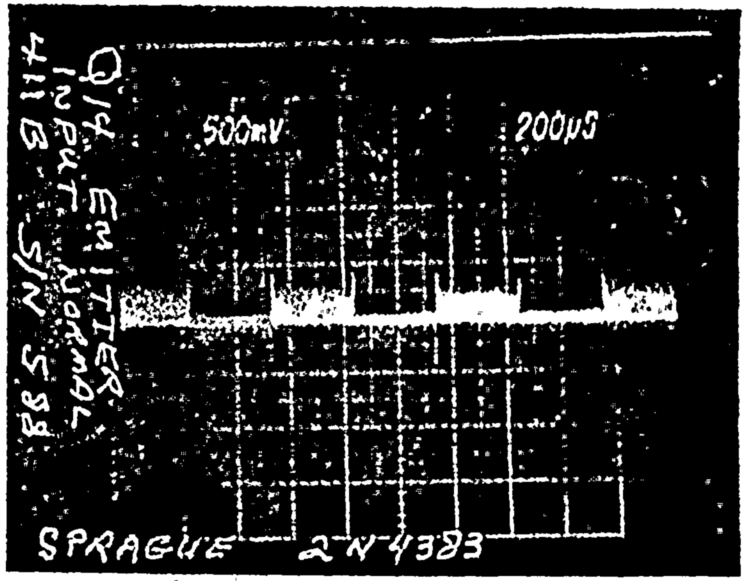


Q14 emitter waveform with the module R10 simulated input resistance of 433Ω.

SAME MODULE S/N E-305



SAME

TM-411B S/N 588

There was no observable difference in the Q14 emitter waveform with either the 2N699 or the 2N4383 with the input resistance of 433Ω.

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