ENGINEERING STATEMENT

For Type Certification of

Racal NCS, Inc.

Model No. Tracs TDMA

FCC ID: OSPTRACS

I am an Electronics Engineer, a principal in the firm of Hyak Laboratories, Inc., Springfield, Virginia. My education and experience are a matter of record with the Federal Communications Commission.

Hyak Laboratories, Inc. has been authorized by Racal NCS, Inc., to make type certification measurements on the Tracs TDMA transceiver. These tests made by me or under my supervision in our Springfield laboratory.

Test data and documentation required by the FCC for type certification are included in this report. The data verifies that the above mentioned transceiver meets FCC requirements and type certification is requested.

Rowland S. Johnson

Dated: October 12, 1999

A. INTRODUCTION

The following data are submitted in connection with this request for type certification of the Tracs TDMA transceiver in accordance with Part 2, Subpart J of the FCC Rules.

The Tracs TDMA is a VHF, non-voice, 25/12.5 kHz channel, 10 watt transceiver intended for data-link applications in the 136-174 MHz band, operating under Subpart D, Industrial Radio Services, using time division multiple access, (TDMA) Gaussian minimum shift keying (GMSK).

Tracs TDMA is a high speed, intelligent network radio datalink which operates in the VHF/UHF band to provide an addressable network datalink with integrated position reporting from an internal or external GPS receiver. It is primarily intended for vehicle and vessel tracking applications although it can be used for general data communication.

B. GENERAL INFORMATION REQUIRED FOR TYPE CERTIFICATION
(Paragraph 2.983 of the Rules)

1. Name of applicant: Racal NCS, Inc.

2. Identification of equipment: FCC ID: OSPTRACS

   a. The equipment identification label is submitted as a separate exhibit.
   b. Photographs of the equipment are submitted as a separate exhibit.

3. Quantity production is planned.

4. Technical description:

   a. 16k9F1D or 11k1F1D emission
   b. Frequency range: 136 - 174 MHz
   c. Operating power of transmitter is fixed at the factory at 10 watts, and can be Programmed to 500 mW.
   d. Maximum power permitted under Part 90 of the FCC is 350 watts, and the Tracs TDMA fully complied with those power limitations.
   e. The dc voltage and dc currents at final amplifier:

      Collector voltage: 10.0 V
      Collector current: 1.9 mA

   f. Function of each active semiconductor device: See Appendix 1.
   g. Circuit diagrams (6) are submitted as a separate exhibit.
   h. User instruction book is submitted as a separate exhibit.
   i. Transmitter tune-up procedure is submitted as a separate exhibit.
   j. A description of circuits for stabilizing frequency. See Appendix 3.

B. GENERAL INFORMATION...(Continued)

k. A description of circuits and devices employed for suppression of spurious radiation And for limiting modulation. See Exhibit 4.
l. Not applicable.

5. Data for 2.985 through 2.997 follow this section.

6. Transient frequency behavior of the equipment is included in Appendix 2.

7. RF Power Output (Paragraph 2.985(a) of the Rules)

RF power output was measured with a Bird 4421 RF power meter and a Narda 765-20 attenuator as a 50 ohm dummy load. Maximum power measured was 9.8W, minimum 0.5W. The transmitter was tuned according to the procedure of Exhibit 4 with a supply voltage of 13.8 Vdc.

C. MODULATION CHARACTERISTICS

1. The Tracs TDMA has no provisions for voice input and is intended only for data transmission. The requirements 2.987(a)(b), 90.211(c) and 90.211(d) do not apply.

2. Occupied Bandwidth
(Paragraphs 2.989(c) and 90.209(c) or (d) of the Rules)

Figures 1a and 1b; 2a and 2b are plots of the sideband envelope of the transmitter for both 25 and 12.5 kHz channels at rated Hi/Lo power level, taken from a Advantest R3361A spectrum analyzer.

CW reference level was 0 dBm (top of screen) for each plot, with modulation corresponding to 19.2/9.6 kps channel efficiency respectively per 90.203(j)(3), and consisted of internally generated random data.

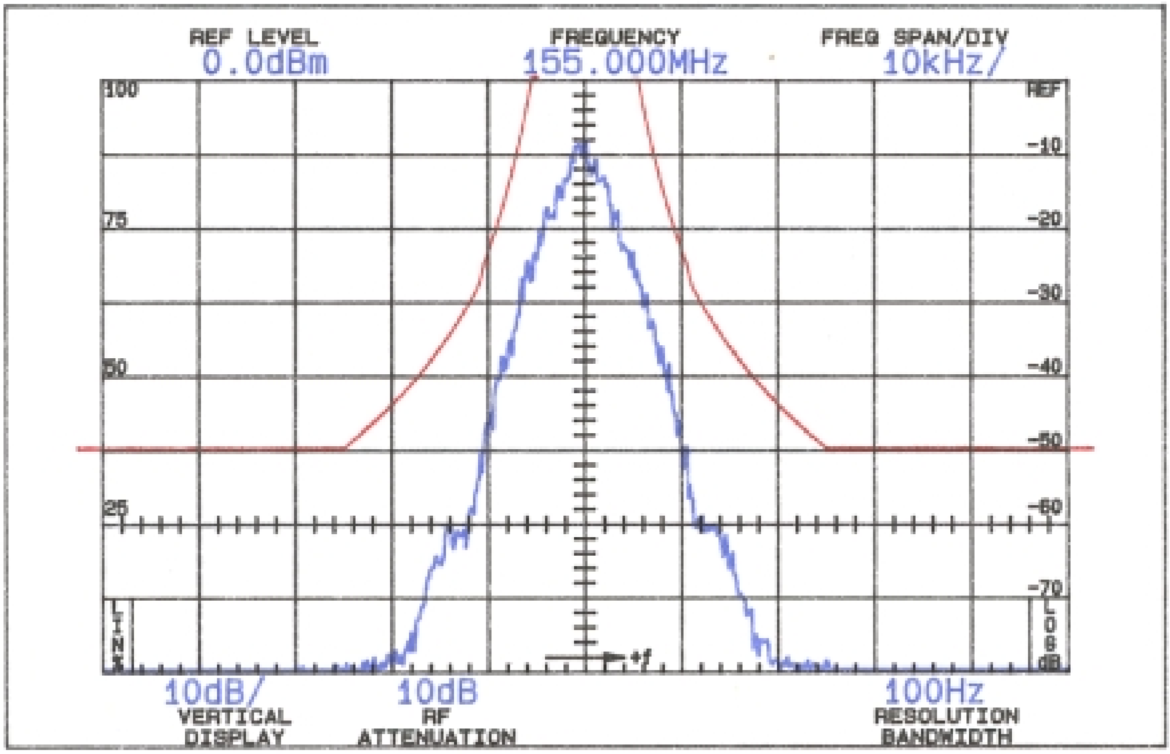
The plots are within the limits imposed by Paragraph 90.209(c)/90.209(d) for frequency modulation. The horizontal scale (frequency) is 10 kHz per division and the vertical scale (amplitude) is a logarithmic presentation equal to 10 dB per division.

Resolution bandwidth was 100 Hz; video bandwidth was 100 kHz.

Emission designator was determined by measurement of the spectrum occupied by 99% of the emitted power, using an HP 8569E spectrum analyzer.

FIGURE 1a

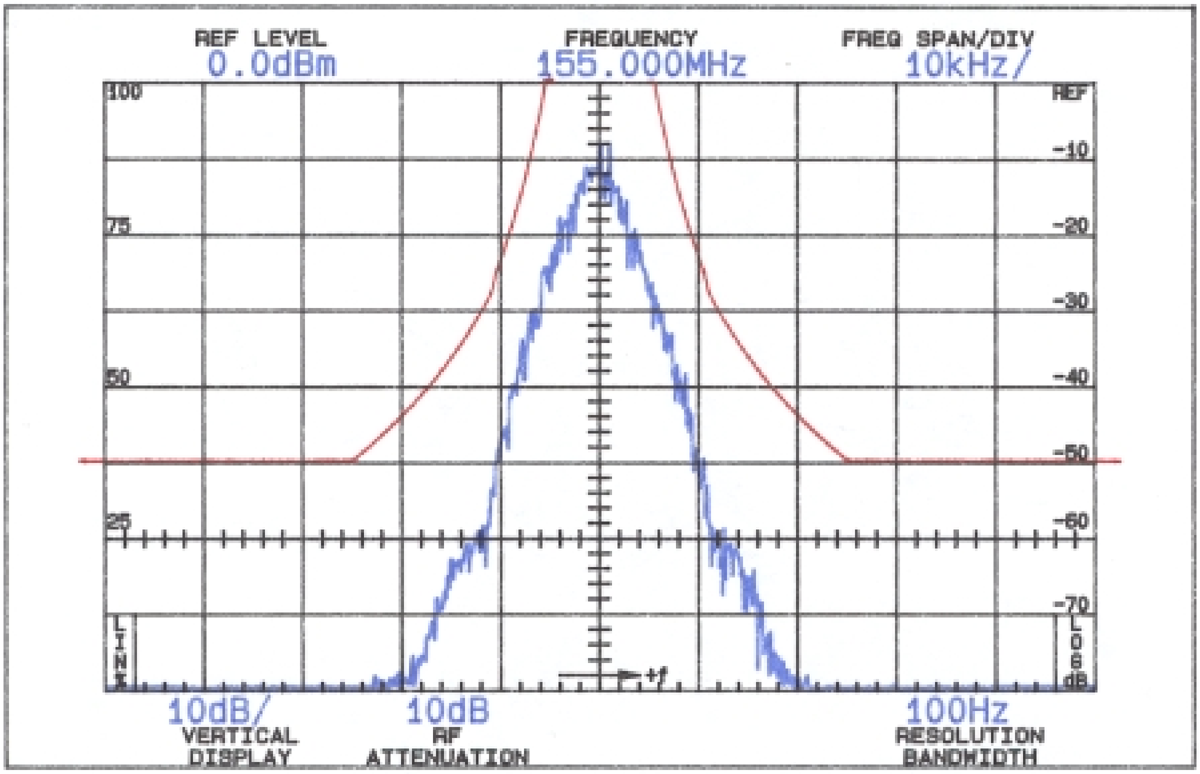
OCCUPIED BANDWIDTH
25 kHz, 10 watt



	ATTENUATION IN dB Required
(1) On any frequency of more than 5 kHz but less than 10 kHz: At least 83 Log_{10} (fd/5) decibels.	25
(2) On any frequency of more than 10 kHz up to and including 250% (50 kHz) of the authorized 20 kHz bandwidth: At least 29 Log_{10} $(fd^2/11)$ decibels or 50 decibels, whichever is the lesser attenuation.	50
(3) On any frequency removed from the assigned frequency by more than 250% of the authorized bandwidth (over 50 kHz).	43+10 LogP = 53 (P = 9.8W)

FIGURE 1b

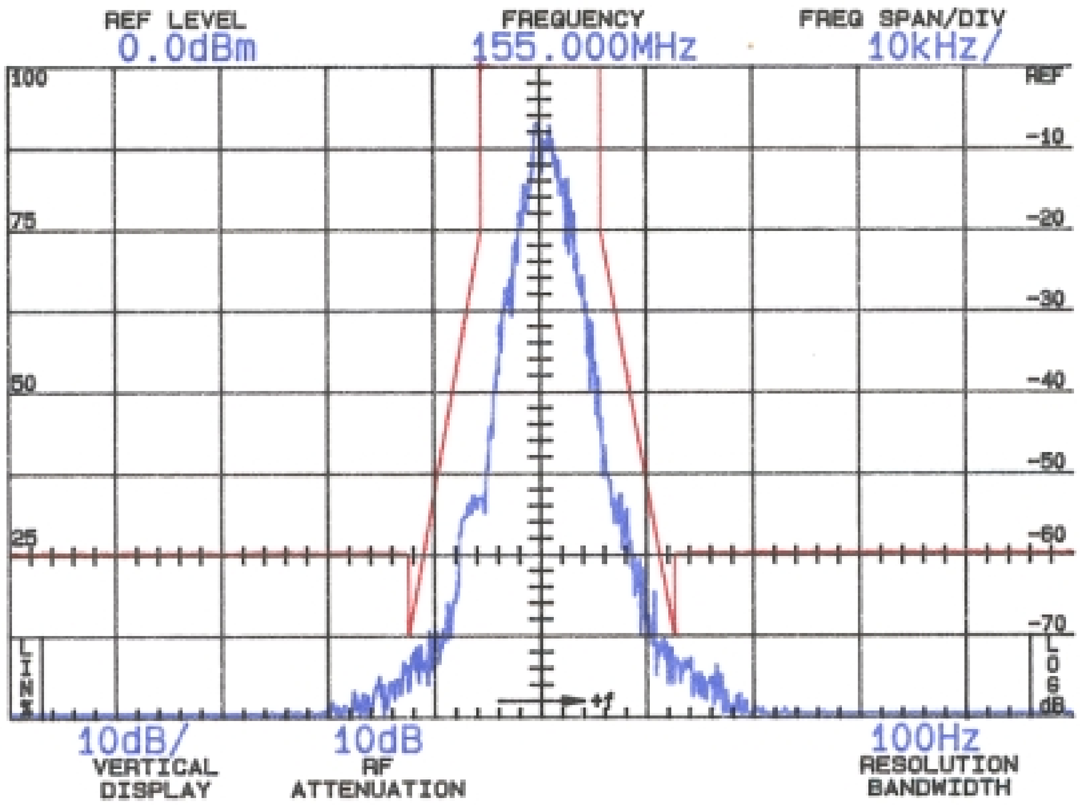
OCCUPIED BANDWIDTH
25 kHz, 0.5 watt



	ATTENUATION IN dB Required
(1) On any frequency of more than 5 kHz but less than 10 kHz: At least 83 Log_{10} (fd/5) decibels.	25
(2) On any frequency of more than 10 kHz up to and including 250% (50 kHz) of the authorized 20 kHz bandwidth: At least 29 Log_{10} (fd^2/11) decibels or 50 decibels, whichever is the lesser attenuation.	50
(3) On any frequency removed from the assigned frequency by more than 250% of the authorized bandwidth (over 50 kHz).	43+10 LogP = 40 (P = 0.5W)

FIGURE 2a

OCCUPIED BANDWIDTH
12.5 kHz, 10 watt

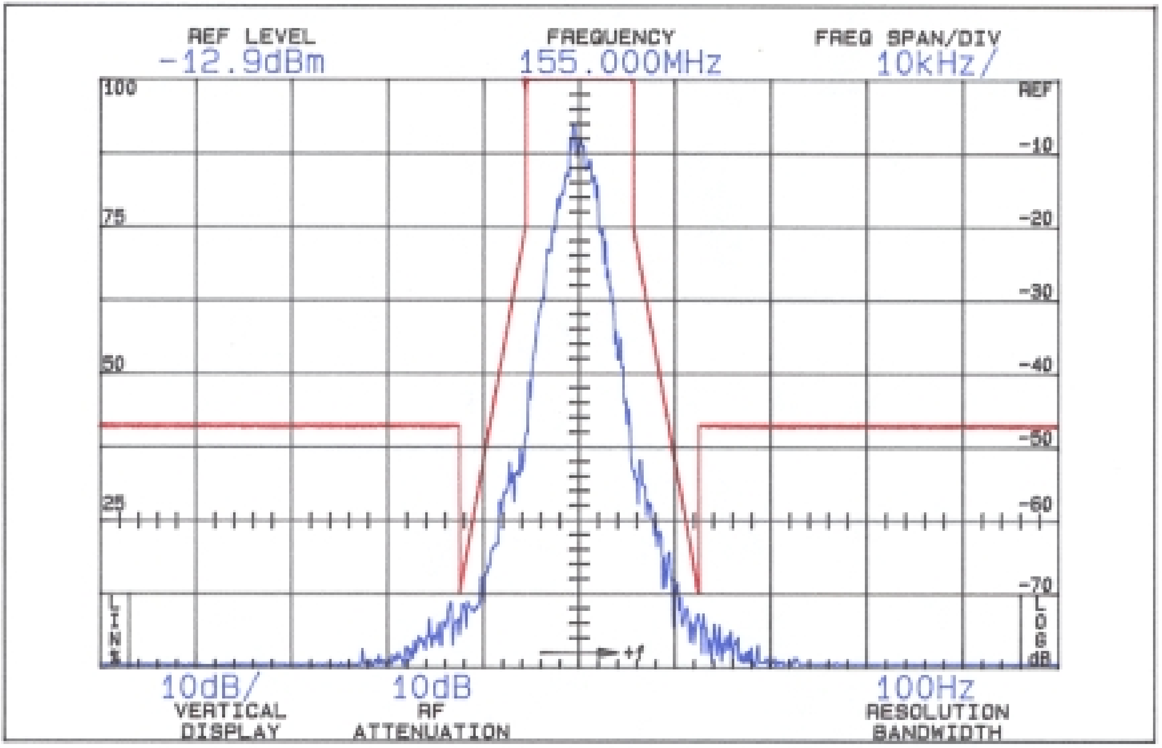


	ATTENUATION IN dB Required
(1) On any frequency from the center of the authorized bandwidth f_o to 5.625 kHz removed from f_o: Zero dB	0
(2) On any displacement frequency of more than 5.625 kHz but no more than 12.5 kHz: At least 7.27(f_d – 2.88 kHz) dB.	70
(3) On any displacement frequency of more than 12.5 kHz: At least 50 + 10 log (P) dB or 70 dB, whichever is the lesser attenuation.	50+10 LogP = 60 (P = 9.8W)

FIGURE 2b

OCCUPIED BANDWIDTH

12.5 kHz, 0.5 watt



	ATTENUATION IN dB Required
(1) On any frequency from the center of the authorized bandwidth f_o to 5.625 kHz removed from f_o: Zero dB.	0
(2) On any displacement frequency of more than 5.625 kHz but no more than 12.5 kHz: At least 7.27(f_d – 2.88 kHz) dB.	70
(3) On any displacement frequency of more than 12.5 kHz: At least 50 + 10 log (P) dB or 70 dB, whichever is the lesser attenuation.	43+10 LogP=47 (P=0.5W)

D. SPURIOUS EMISSIONS AT THE ANTENNA TERMINALS
(Paragraph 2.991 of the Rules)

The Tracs TDMA transmitter was tested for spurious emissions at the antenna terminals while the equipment was modulated with a 8 kb/s signal for 12.5 kHz channels which represents worst-case attenuation requirements.

Measurements were made with Advantest R3361A spectrum analyzer coupled to the transmitter output terminal through Narda 765-20 microwave power attenuator.

During the tests, the transmitter was terminated in the 50 ohm attenuator. Power was monitored on a Bird 43 Thru-Line wattmeter; dc supply was 13.8 volts throughout the tests.

A notch filter attenuated the carrier.

Spurious emissions were measured at 9.8/0.5 watts output throughout the RF spectrum from 8 (lowest frequency generated in the transmitter) to 1.6 GHz. Any emissions that were between the required attenuation and the noise floor of the spectrum analyzer were recorded. Data are shown in Table 1.

TABLE 1

TRANSMITTER CONDUCTED SPURIOUS
155.000 MHz, 9.8/0.5 W, 13.8 Vdc

Spurious Frequency MHz	dB Below Carrier Reference	
	0.5W	9.8W
310.000	97	96
465.000	103	94
620.000	104	105
775.000	105	105
930.000	104	104
1085.000	103	104
1240.000	105	103
1395.000	106	104
1550.000	103	104
Required: 50+10Log(P)	47	60

All other emissions from 8 MHz to 1.6 GHz were 20 dB or more below FCC limit.

E. DESCRIPTION OF MEASUREMENT FACILITIES

A description of the Hyak Laboratories' radiation test facility is a matter of record with the

FCC. The facility was accepted for radiation measurements from 30 to 1000 MHz on October 1, 1976, and is currently listed as an acceptable site.

F. FIELD STRENGTH MEASUREMENTS OF SPURIOUS RADIATION

Field intensity measurements of radiated spurious emissions from the Tracs TDMA were made with a Tektronix 494P spectrum analyzer using Singer DM-105A calibrated test antennae for the measurements to l GHz, Polarad CA-L for 1-2.4 GHz. The transmitter and dummy load were located in an open field 3 meters from the test antenna. Supply voltage was a power supply with a terminal voltage under load of 13.8 Vdc. Output power was 9.8 watts at the 155.000 MHz operating frequency. The transmitter and test antennae were arranged to maximize pickup. Both vertical and horizontal test antenna polarizations were employed.

Reference level for the spurious radiations was taken as an ideal dipole excited by 9.8 watts, the output power of the transmitter according to the following relationship:*

$$E = \frac{(49.2P_t)^{1/2}}{3}$$

where E = electric-field intensity in volts/meter

P_t = transmitter power in watts

R = distance in meters

for this case $$E = \frac{(49.2x9.8)^{1/2}}{3} = 7.3 \text{ V/m}$$

Since the spectrum analyzer is calibrated in decibels above one milliwatt (dBm), a conversion, for convenience, was made from dBu to dBm.

7.3 volts/meter = 7.3x106 uV/m

dBu/m = $20 \text{ Log}_{10}(7.3x10)^6$

= 137 dBu/m

Since 1 uV/m = -107 dBm, the reference becomes

137 - 107 = 30 dBm

*Reference Data for Radio Engineers, Fourth Edition, International Telephone and Telegraph Corp., p. 676.

F. FIELD STRENGTH MEASUREMENTS OF SPURIOUS RADIATION (Cont.)

The measurement system was capable of detecting signals 90 dB or more below the reference level. Measurements were made from the lowest frequency generated within the unit (8 MHz), to 10 times operating frequency, 1.6 GHz. Data after application of antenna factors and line loss corrections are shown in Table 2.

TABLE 2

TRANSMITTER CABINET RADIATED SPURIOUS
155.000 MHz, 13.8 Vdc, 9.8 Watts

Frequency MHz	dB Below Carrier Reference[1]
913.070	98H
1369.602	97H
1826.136	81H
2282.670	93V
2739.204	89H
3195.736	91H
3652.288	96V
4108.802	97V
4565.360	94H
Required: 50+10LogP(9.8) =	60

[1]Worst-case polarization, H-Horizontal, V-Vertical.

*Reference data only, more than 20 dB below FCC limit.
**Measuring system noise floor.

All other spurious from 8 MHz to 1.6 GHz were 20 dB or more below FCC limit.

G. FREQUENCY STABILITY
(Paragraph 2.995(a)(2) and 90.213 of the Rules)

Measurement of frequency stability versus temperature was made at temperatures from -30°C to +50°C. At each temperature, the unit was exposed to test chamber ambient a minimum of 60 minutes after indicated chamber temperature ambient had stabilized to within ±20°C of the desired test temperature. Following the 1 hour soak at each temperature, the unit was turned on, keyed and frequency measured within 2 minutes. Test temperature was sequenced in the order shown in Table 3, starting with -30°C.

A Thermotron S1.2 temperature chamber was used. Temperature was monitored with a Keithley 871 digital temperature probe. The transmitter output stage was terminated in a dummy load. Primary supply was 13.8 volts. Frequency was measured with a HP 5385A digital frequency counter connected to the transmitter through a power attenuator. Measurements were made at 155.000 MHz. No transient keying effects were observed.

TABLE 3
155.000 MHz, 13.8 V Nominal

Temperature, °C	Output Frequency, MHz	p.p.m.
-29.4	155.000016	0.1
-19.7	155.000004	0.0
- 9.8	155.999948	-0.3
0.3	155.000004	0.0
10.2	155.000030	0.2
19.8	155.000022	0.1
30.6	155.999899	-0.7
38.3	155.999757	-1.6
50.2	155.999638	-2.3

Maximum frequency error: 154.999638
155.000000

\- .000362 MHz

FCC Rule 90.213(a) specifies .00025% or a maximum of ± .000388 MHz, which corresponds to:

High Limit	155.000388 MHz
Low Limit	154.999613MHz

H. FREQUENCY STABILITY AS A FUNCTION OF SUPPLY VOLTAGE
(Paragraph 2.995(d)(2) of the Rules)

Oscillator frequency as a function of power supply voltage was measured with a HP 5385A digital frequency counter as supply voltage provided by an HP 6264B variable dc power supply was varied from ±15% above the nominal 13.8 volt rating to below the battery end point. A Keithley 197 digital voltmeter was used to measure supply voltage at transmitter primary input terminals. Measurements were made at 20 °C ambient.

TABLE 4

155.534 MHz, 20°C, 13.8 V Nominal

%	Supply Voltage	Output Frequency, MHz	p.p.m.
115	15.87	155.000023	0.1
110	15.18	155.000023	0.1
105	14.49	155.000023	0.1
100	13.80	155.000022	0.1
95	13.11	155.000022	0.1
90	12.42	155.000022	0.1
85	11.73	155.000021	0.1

Maximum frequency error: 155.000023
155.000000

\+ .000023 MHz

FCC Rule 90.213(a) specifies .00025% or a maximum of ± .002283 MHz, corresponding to:

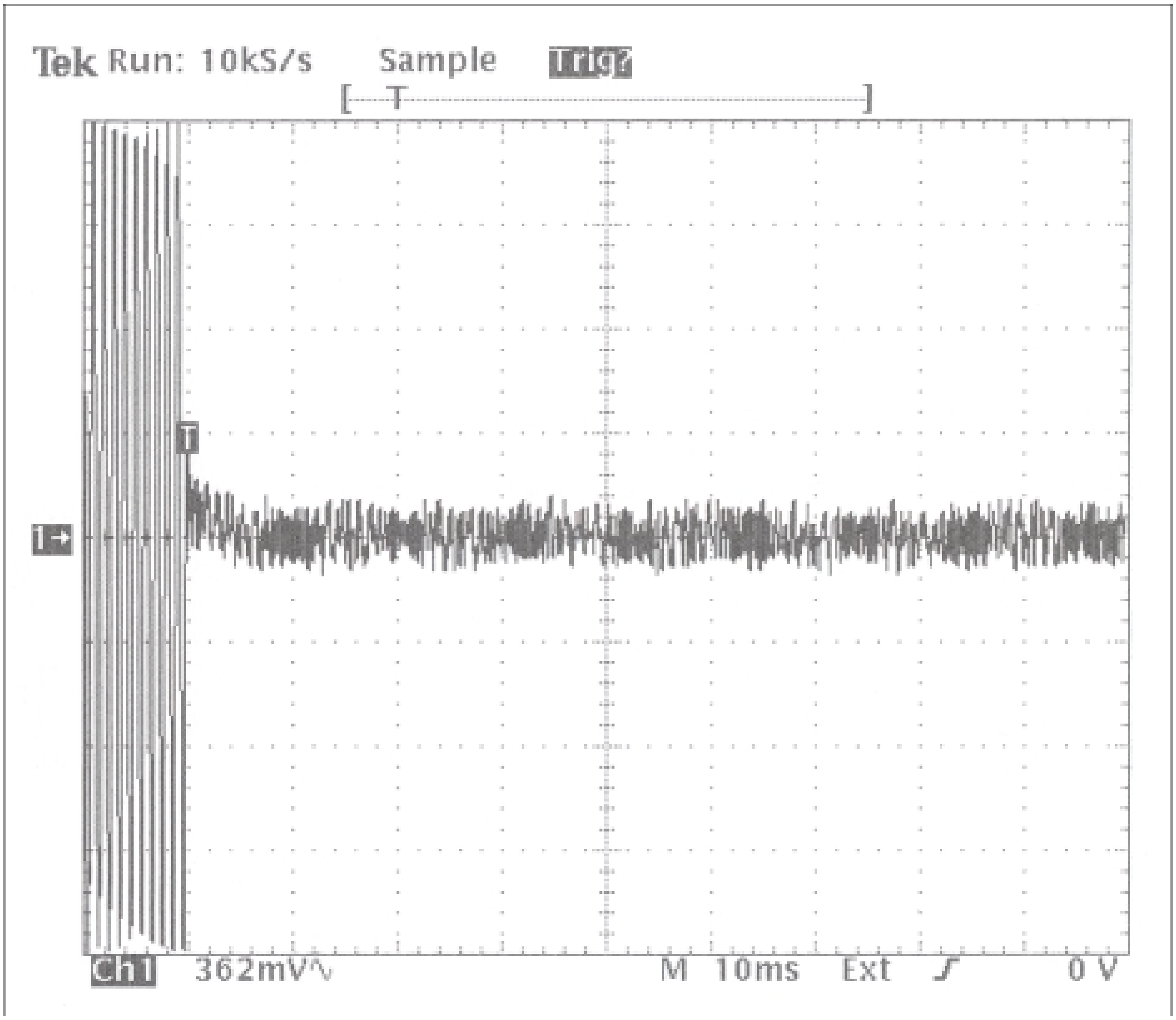
High Limit	155.000388 MH
Low Limit	155.999613 MHz

FUNCTION OF DEVICES
Tracs TDMA

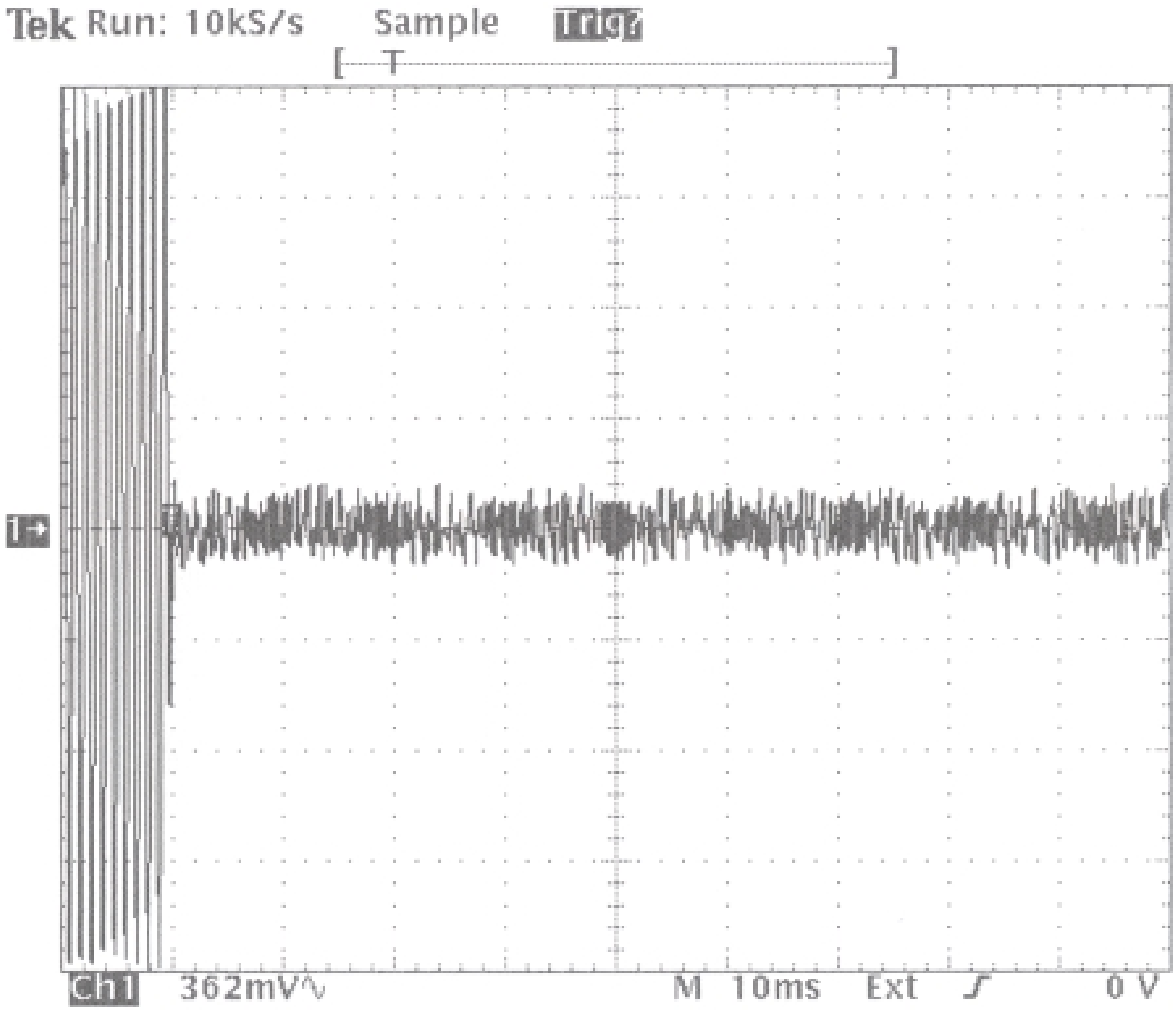
Reference	Function
TR1	RX RF Amplifier
TR2, TR3	First IF Amplification
TR4, TR5, TR8, And TR17	RX VCO
TR23, TR24	Reference Oscillator
TR6, TR7, TR9, TR10, And TR11	Synthesizer Error Amplifier
TR16, TR28, TR29, And TR30	TX VCO
TR32, TR37, TR38 And TR12	PA O/P Transistor
TR26, TR46, TR47, TR27 and TR36	TX RF Stage Bias/Power Control
IC2	Second Mixer and Second LO
IC3	Bandwidth Select
IC4, IC5-A, IC5-B	Second IF Amplification, Discriminator And Audio Out
IC6	First Mixer
IC10, IC12	Prescaler and Synthesizer

90.214

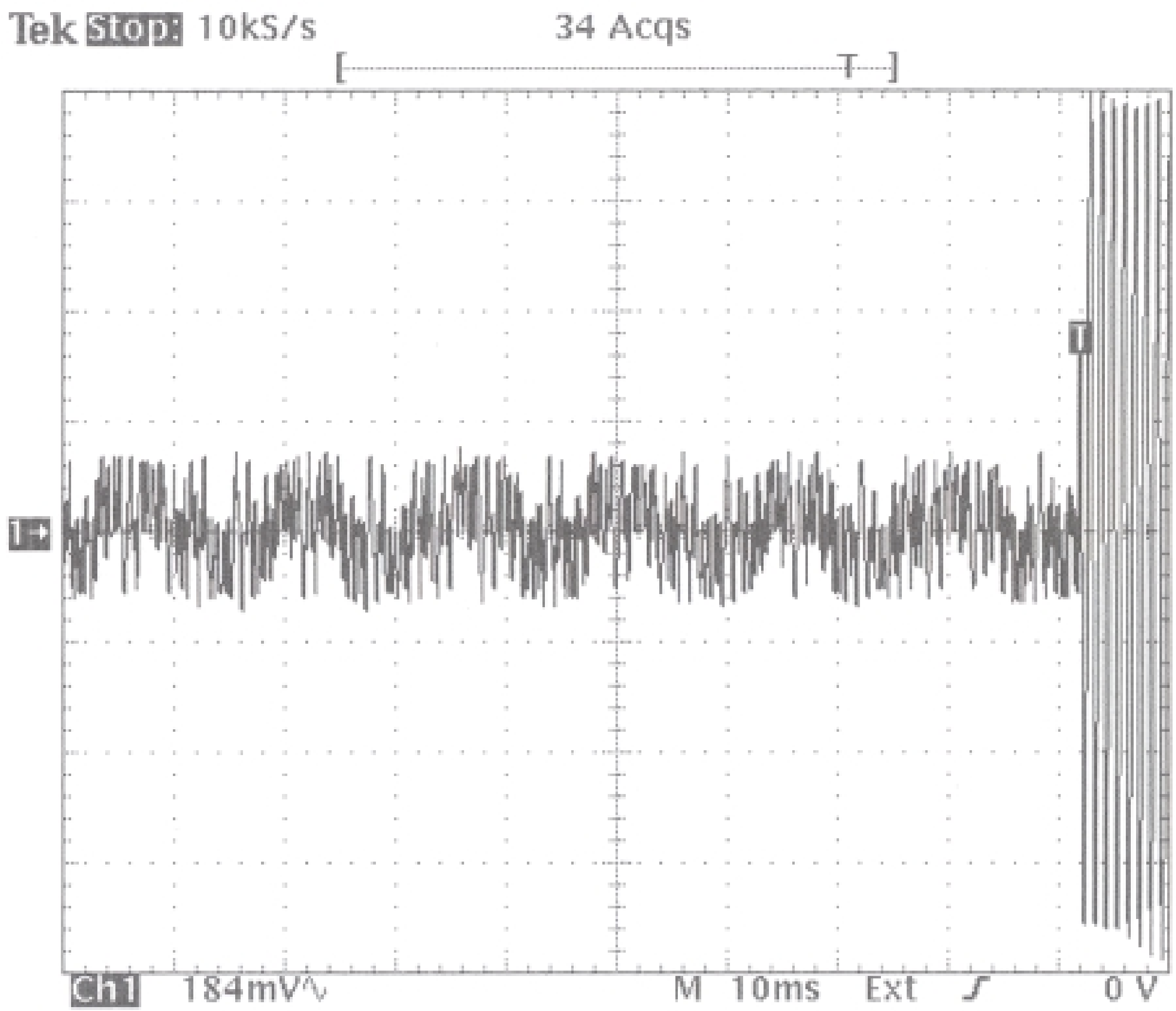
25 kHz Turn-On



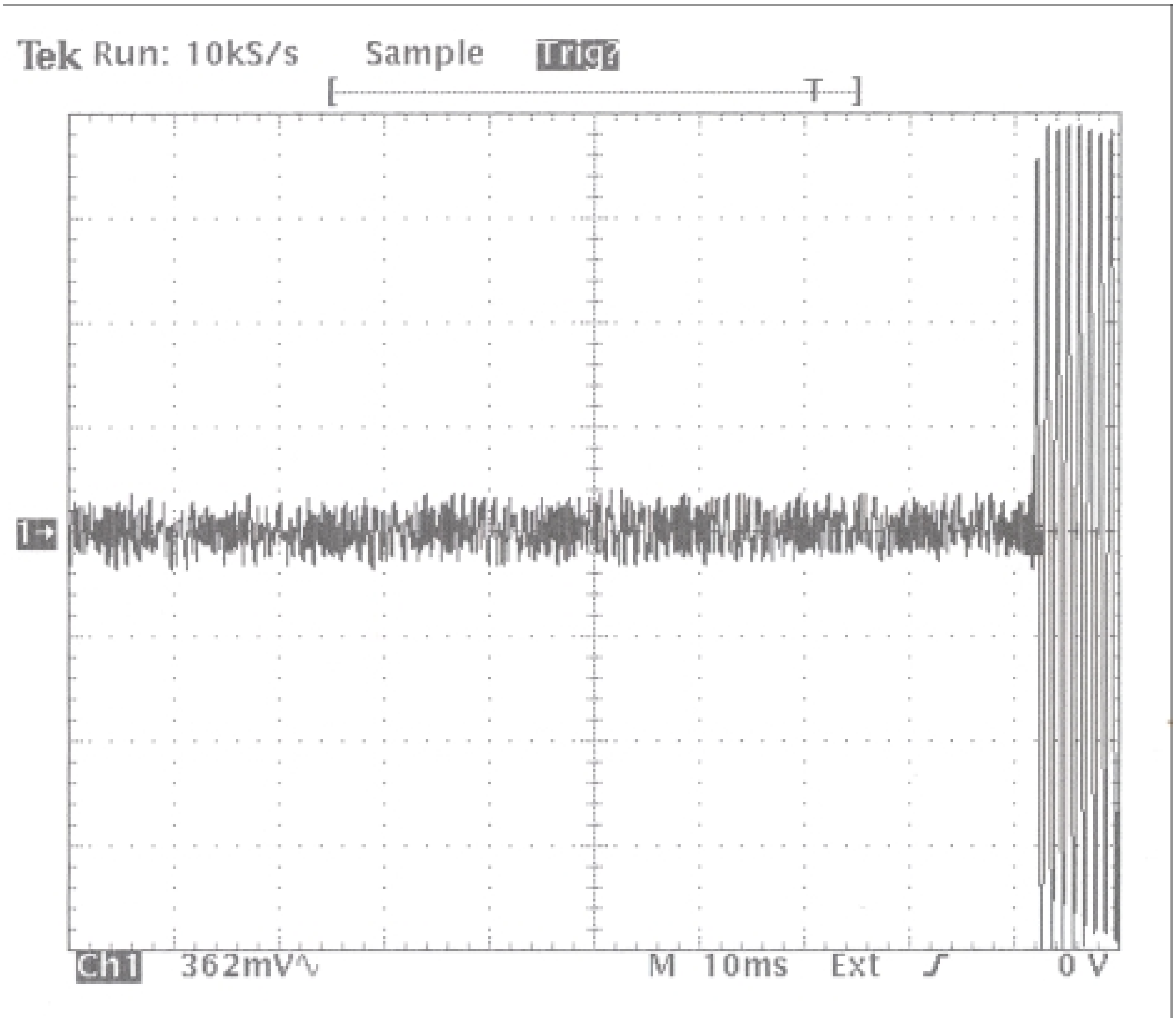
12.5 kHz Turn-On



12.5 kHz Turn-Off



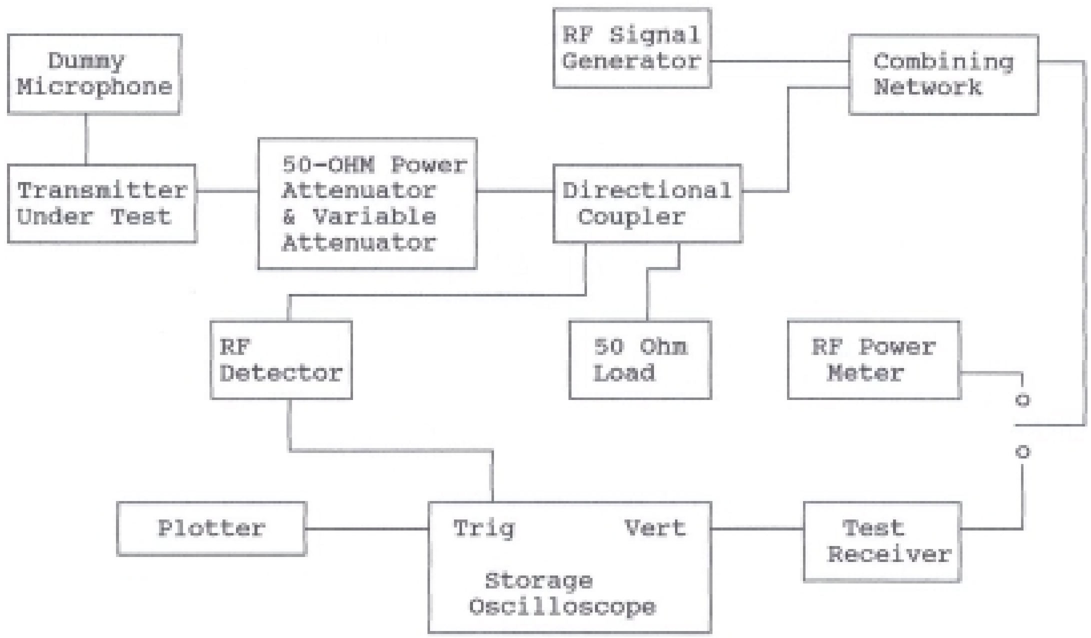
25 kHz Turn-Off



Tek Run: 10kS/s Sample Trig?
T
1→
Ch1 362mV∿ M 10ms Ext ∫ 0 V

Para. 2.995(a)(b)(d) <u>Frequency stability</u>

90.214 Transient Frequency Behavior
(continued)



90.214 TRANSIENT FREQUENCY BEHAVIOR

REQUIREMENTS: In the 136 – 174 MHz frequency band, transient frequencies must be within the maximum frequency difference limits during the time interval indicated below for 25 kHz channels:

Time Interval	Maximum Frequency	Radios 150 - 174 MHz
t_1	±25.0 kHz	5.0 ms
t_2	±12.5 kHz	20.0 ms
t_3	±25.0 kHz	5.0 ms

End of t_2 to beginning of t_3: 5 ppm.

TEST PROCEDURE: TIA/EIA TS603, PARA. 2.219, the levels were set as follows:

1. Using the variable attenuator, the transmitter level was set to 40 dB below the test receivers maximum input level, then the transmitter was turned off.
2. With the transmitter off, the signal generator was set 20 dB below the level of the transmitter in the above step (this level was maintained with the signal generator throughout the test.
3. Reduce the attenuation between the transmitter and the RF detector by 30 dB.
4. Measurements were made with the unit modulated at rated data with pseudo-random sequence.
5. With the levels set as above the transient frequency behavior was observed & recorded.

APPENDIX 3

CIRCUITS AND DEVICES TO STABILIZE FREQUENCY

Output Frequency Stabilization

The output frequency is synthesized from a reference oscillator comprising TR23, TR24 and crystal XTL2. Fine frequency control is by the voltage applied to varactor diodes D13 and D18. The temperature of XTL2 is monitored by thermistor R203.

As part of the calibration procedure, the radio is subjected to a slow temperature sweep covering the full operating temperature range. During the sweep, the fine frequency control voltage is adjusted to maintain the correct output frequency and the corresponding thermistor reading is noted. A table of fine frequency control voltage versus thermistor reading is derived and stored in flash memory IC351.

During operation, a background task run by the CPU IC353 checks the thermistor reading and from the table applies the appropriate fine frequency control voltage, thus maintaining the output frequency to a high degree of accuracy.

APPENDIX 4

CIRCUITS TO SUPPRESS SPURIOUS RADIATION AND

Suppression of Spurious Emissions

The RF output from the PA transistor TR12 is filtered by the low pass filter comprising L27, L31, L32 and associated capacitors. Additional filtering is achieved with the band pass filter comprising L34, L35, L33 and associated capacitors. This filter is also used in receive mode. These two filters in combination provide a high degree of filtering to the harmonic content of the RF output.

Correct deviation levels are established during calibration and stored in flash memory IC351. There are no user adjustments affecting deviation and thus there is no scope for incorrect or excess deviation.