AM/FM RADIO RECEIVER CIRCUIT

GENERAL DESCRIPTION

The TEA5591 is an integrated radio circuit which is designed for use in portable receivers and clock radios. The IC is also applicable to mains-fed AM and AM/FM receivers and car radio-receivers. The main advantage of this IC is its ability to operate over a wide range of supply voltages without loss of performance. The AM circuit incorporates a balanced mixer and a 'one-pin' oscillator, which operates in the 0.6 MHz to 30 MHz frequency range, with amplitude control. The circuit also includes an IF amplifier, a detector and an AGC circuit which controls the IF amplifier and the mixer. The FM circuit incorporates an RF amplifier, a balanced mixer and a 'one-pin' oscillator together with two AC coupled IF amplifiers (with distributed selectivity), a quadrature demodulator for the ceramic filter and internal AFC.

Features

- DC AM/FM switch facility
- Three internal separate stabilizers to enable operation over a wide range of supply voltages (1.8 to 15 V)
- All pins (except pin 9) are ESD protected

QUICK REFERENCE DATA

parameter	conditions	symbol	min.	typ.	max.	unit
Supply voltage (pin 8)		V_P	1.8	3.0	15	V
Supply current						
AM part		$I_{P(AM)}$	–	14	19	mA
FM part		$I_{P(FM)}$	–	17	23	mA
Operating ambient temperature range		T_{amb}	−15	–	+60	°C
AM performance (pin 13)	m = 0.3					
RF sensitivity						
RF input voltage	V_o = 10 mV	V_i	–	3.5	–	μV
RF input voltage	(S+N)/N = 26 dB	V_i	–	17	–	μV
Signal plus noise-to-noise ratio	V_i = 1 mV	(S+N)/N	–	48	–	dB
AF output voltage		V_o	–	50	–	mV
Total harmonic distortion		THD	–	0.7	–	%
FM performance (pin 1)	Δf = 22.5 kHz					
RF sensitivity						
RF input voltage						
−3 dB before limiting		V_i	–	2.3	4.0	μV
Signal plus noise-to-noise ratio for:						
RF input signal voltage (V_i)	V_i = 3.0 μV	(S+N)/N	23	26	–	dB
	V_i = 1 mV	(S+N)/N	–	60	–	dB
AF output voltage	V_i = 100 μV	V_o	75	90	–	mV
Total harmonic distortion		THD	–	0.8	–	%

PACKAGE OUTLINE

20-lead DIL; plastic (SOT146).

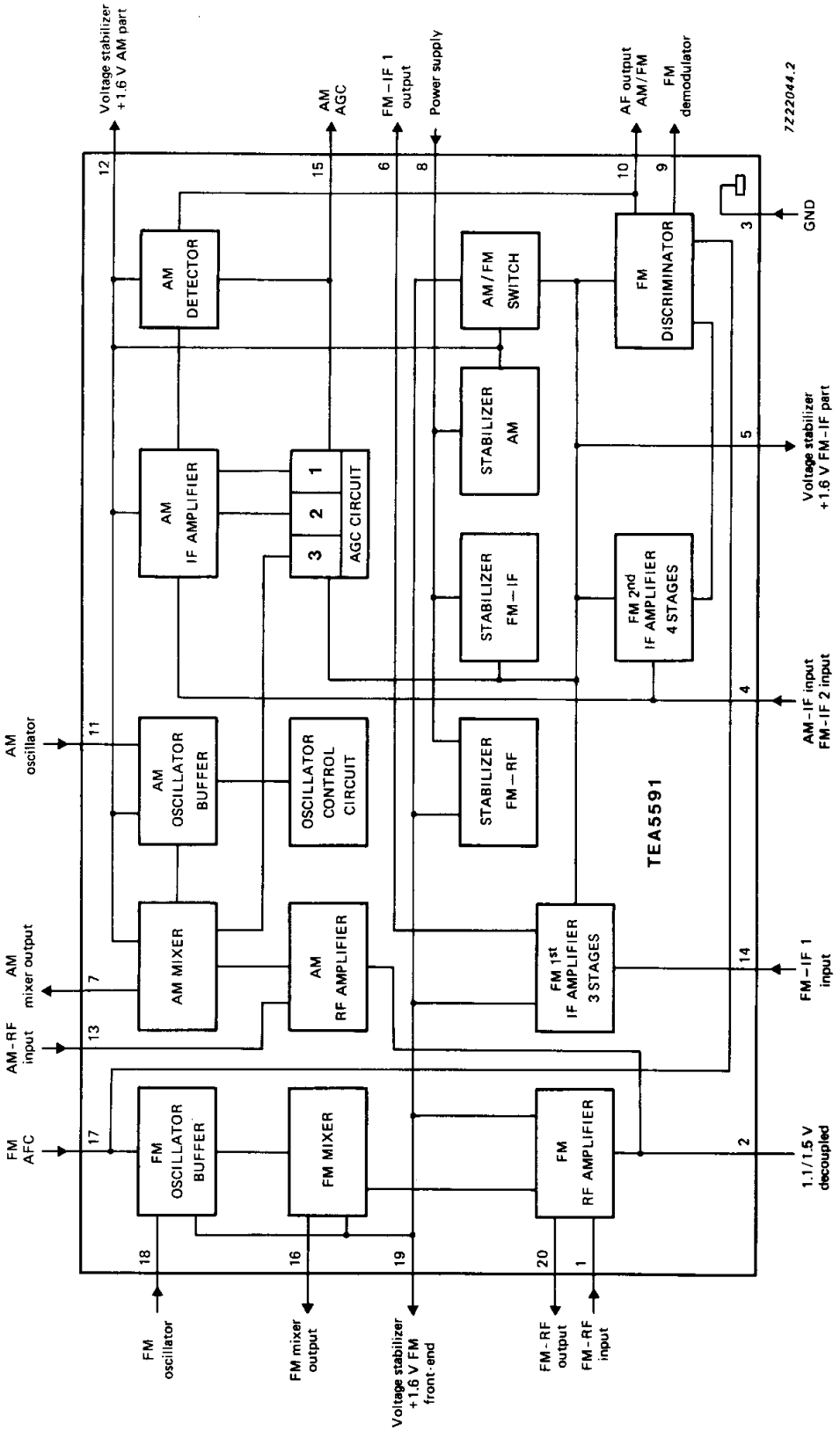


Fig.1 Block diagram.

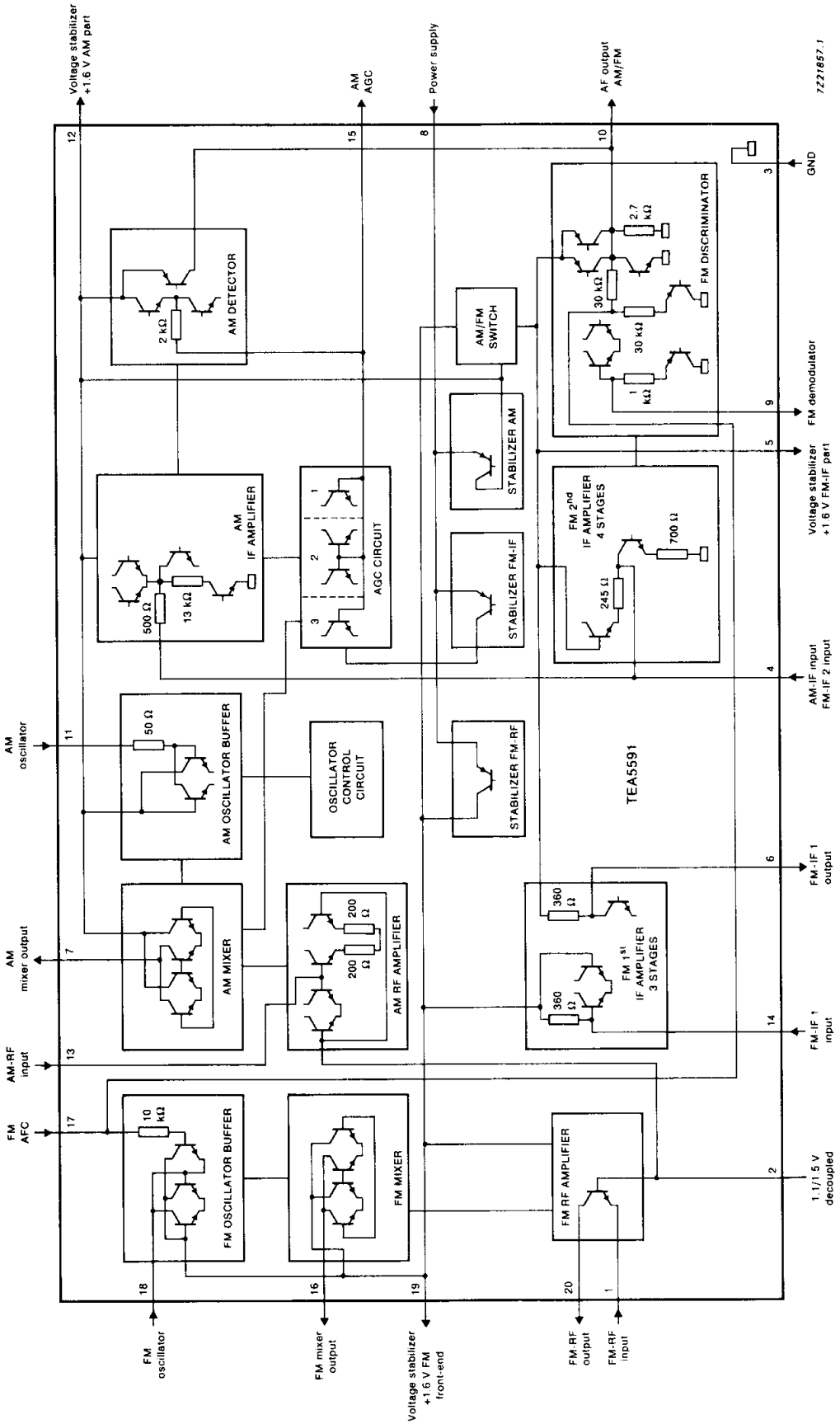


Fig.2 Equivalent circuit diagram.

PINNING

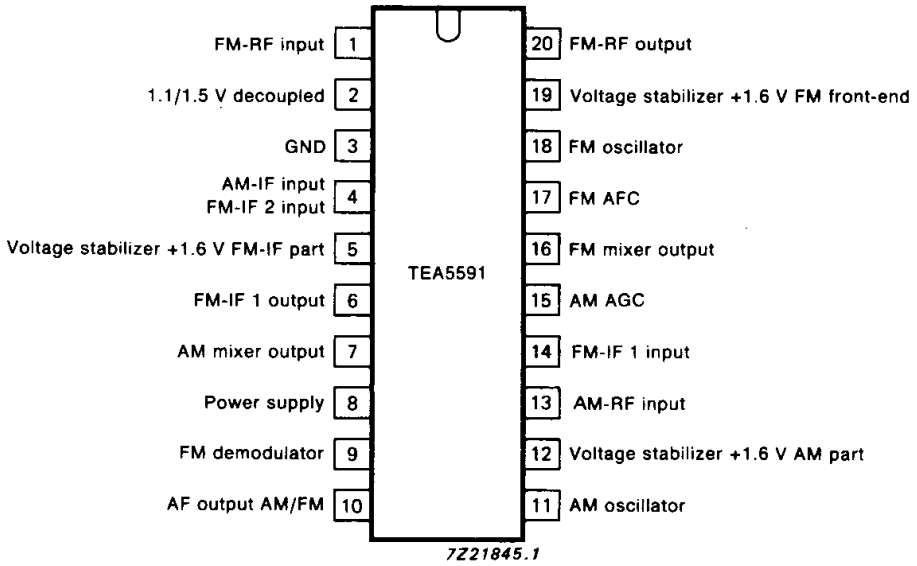


Fig.3 Pinning diagram.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

parameter	conditions	symbol	min.	max.	unit
Supply voltage (pin 8)		V_P	–	18	V
Storage temperature range		T_{stg}	−65	+ 150	°C
Operating ambient temperature range		T_{amb}	−15	+ 60	°C
Total power dissipation		P_{tot}	see Fig.4		

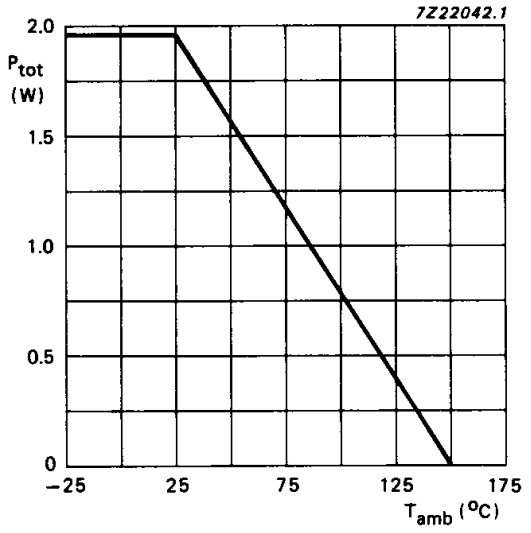


Fig.4 Power derating curve.

DC CHARACTERISTICS

All voltages are referenced to pin 3; all input currents are positive; all parameters are measured in Fig.5 at nominal supply voltage V_P = 3 V; T_{amb} = 25 °C unless otherwise specified

parameter	conditions	symbol	min.	typ.	max.	unit
Supply voltage		V_P	1.8	3.0	15	V
Voltages (FM)						
pin 1		V_1	–	0.90	–	V
pin 2		V_2	–	1.60	–	V
pin 4		V_4	–	0.85	–	V
pin 5		V_5	1.5	1.60	1.75	V
pin 6		V_6	–	1.48	–	V
pin 9		V_9	–	1.05	–	V
pin 14		V_{14}	–	1.63	–	V
pin 17		V_{17}	–	0.60	–	V
pin 19		V_{19}	–	1.60	–	V
Voltages (AM)						
pin 2		V_2	–	1.10	–	V
pin 12		V_{12}	–	1.60	–	V
pin 15		V_{15}	–	1.54	–	V
Supply current						
AM part		$I_{P(AM)}$	–	14	19	mA
FM part		$I_{P(FM)}$	–	17	23	mA

AC CHARACTERISTICS

V_P = 3 V; T_{amb} = 25 °C unless otherwise specified

parameter	conditions	symbol	min.	typ.	max.	unit
AM PART						
Input conductance pin 4	f = 0.5 MHz	g_{ie}	–	1.7	–	ms
Input capacitance pin 4	f = 0.5 MHz	C_{ie}	–	5	–	pF
Input conductance pin 13	f = 1.0 MHz	g_{ie}	–	230	–	μs
Input capacitance pin 13	f = 1.0 MHz	C_{ie}	–	13	–	pF
Output conductance pin 7	f = 0.5 MHz	g_{oe}	–	4	–	μs
Output capacitance pin 7	f = 0.5 MHz	C_{oe}	–	4.7	–	pF
Conductance pin 11	f = 1.5 MHz	g_e	–	−6.8	–	ms
Capacitance pin 11	f = 1.5 MHz	C_e	–	25	–	pF
FM PART						
Input conductance pin 4	f = 10.7 MHz	g_{ie}	–	2.7	–	ms
Input capacitance pin 4	f = 10.7 MHz	C_{ie}	–	6	–	pF
Input conductance pin 14	f = 10.7 MHz	g_{ie}	–	2.8	–	ms
Input capacitance pin 14	f = 10.7 MHz	C_{ie}	–	2.5	–	pF
Output conductance pin 6	f = 10.7 MHz	g_{oe}	–	2.8	–	ms
Output capacitance pin 6	f = 10.7 MHz	C_{oe}	–	3.0	–	pF
Output conductance pin 16	f = 10.7 MHz	g_{oe}	–	1.6	–	μs
Output capacitance pin 16	f = 10.7 MHz	C_{oe}	–	4.5	–	pF
Conductance pin 9	f = 10.7 MHz	g_e	–	880	–	μs
Capacitance pin 9	f = 10.7 MHz	C_e	–	3.6	–	pF
Conductance pin 18	f = 100 MHz	g_e	–	−4	–	ms
Capacitance pin 18	f = 100 MHz	C_e	–	10	–	pF

AC CHARACTERISTICS

All parameters are measured in Fig.5 at nominal supply voltage V_P = 3 V; T_{amb} = 25 °C unless otherwise specified.
RF conditions: Input frequency 1 MHz; 30% modulation where f_{mod} = 1 kHz; unless otherwise specified

parameter	conditions	symbol	min.	typ.	max.	unit
AM PERFORMANCE						
RF sensitivity						
AF output voltage for: V_i = 7.5 μV	no AGC	V_o	16	30	40	mV
Noise						
Signal plus noise-to-noise ratio for:						
RF input signal voltage of V_i = 17 μV		(S + N)/N	23	26	–	dB
V_i = 1 mV		(S + N)/N	–	48	–	dB
Optimum source impedance		Z_S	–	1.8	–	kΩ
Noise factor	optimum noise impedance	NF	–	4	–	dB
AGC						
Change in RF input voltage for 10 dB change in output voltage	V_{i1} = 100 mV	V_{i1}/V_{i2}	80	86	–	dB
AF output voltage	V_i = 100 μV	V_o	40	50	60	mV
Total harmonic distortion	V_i = 100 μV to 10 mV	THD	–	0.7	1.5	%
	V_i = 100 μV to 10 mV; m = 0.8	THD	–	3	5	%
	V_i = 80 mV; m = 0.8	THD	–	–	8	%

Transimpedance (Z_{tr}) = v_4/i_7 = 900Ω.

parameter	conditions	symbol	min.	typ.	max.	unit
IF suppression (note 1)	V_o = 30 mV	α	–	20	–	dB
Oscillator (pin 11)						
Input voltage	f_{osc} = 1.5 MHz	V_{osc}	–	150	190	mV
	f_{osc} = 30.5 MHz	V_{osc}	–	150	–	mV
	V_P = 1.5 V	V_{osc}	100	–	–	mV
Temperature behaviour	−15 to + 60 °C (only the IC)					
Sensitivity		ΔV_i	–	−2	–	dB
Output voltage	V_i = 1 mV	ΔV_o	–	1	–	dB
Oscillator frequency						
LW		Δf_{osc}	–	500	–	Hz
MW		Δf_{osc}	–	300	–	Hz
SW		Δf_{osc}	–	100	–	kHz
Supply voltage behaviour	V_P = 1.8 to 15 V					
Sensitivity		ΔV_i	–	0	–	dB
Output voltage	V_i = 1 mV	ΔV_o	–	0.5	–	dB
Oscillator frequency						
LW		Δf_{osc}	–	6	–	kHz
MW		Δf_{osc}	–	0.1	–	kHz
SW		Δf_{osc}	–	30	–	kHz

AC CHARACTERISTICS

All parameters are measured in Fig.5 at nominal supply voltage V_P = 3 V; T_{amb} = 25 °C unless otherwise specified

RF conditions: Input frequency 100 MHz; frequency deviation f = ± 22,5 kHz and f_{mod} = 1 kHz

parameter	conditions	symbol	min.	typ.	max.	unit
FM PERFORMANCE						
RF sensitivity						
RF input voltage	−3 dB before limiting	V_{iFM}	–	2.3	4.0	μV
Noise						
Signal plus noise-to-noise ratio for:						
RF input signal voltage (V_i)						
V_i = 3.0 μV		(S + N)/N	23	26	–	dB
V_i = 1 mV		(S + N)/N	–	60	–	dB
Optimum source impedance		Z_{source}	–	50	–	Ω
Noise factor	optimum source impedance	NF	–	6	–	dB
AF output voltage	V_i = 100 μV	V_o	75	90	–	mV
Total harmonic distortion	V_i = 30 μV to 50 mV	THD	–	0.8	–	%
	V_i = 1 mV; Δf = 75 kHz	THD	–	3	–	%
	V_i = 100 mV; Δf = 75 kHz	THD	–	3	–	%
AM suppression	note 2					
RF input signal	V_i = 100 μV to 10 mV	AMS	–	50	–	dB
Oscillator voltage (pin 18)	f_{osc} = 100 MHz	V_{osc}	–	220	–	mV
	V_P = 1.5 V	V_{osc}	100	–	–	mV
IF rejection ratio		IF_{rr}	–	60	–	dB
AFC	f_{osc} = 111.2 MHz					
	V_{17} = 1.4 V	Δf	–	−620	–	kHz
	V_{17} = 0.2 V	Δf	–	+420	–	kHz

parameter	conditions	symbol	min.	typ.	max.	unit
Temperature behaviour	−15 to + 60 °C (only the IC)					
RF sensitivity	−3 dB limiting	ΔV_i	–	−6	–	dB
Output voltage	V_i = 100 μV	ΔV_o	–	−2	–	dB
Oscillator frequency		Δf_{osc}	–	−0.3	–	%
Supply voltage behaviour	V_P = 1.8 to 15 V					
RF sensitivity	−3 dB limiting	ΔV_i	–	6	–	dB
Output voltage	V_i = 100 μV	ΔV_o	–	0.5	–	dB
Oscillator frequency		Δf_{osc}	–	100	–	kHz
Oscillator voltage		ΔV_{osc}	–	1.0	–	dB

Notes to the AC characteristics

1. $\alpha = \frac{V_i \text{ at } f_i = 455 \text{ kHz}}{V_i \text{ at } f_i = 1 \text{ MHz}}$.
2. AM suppression is measured at f_{mod} = 400 Hz, m = 0.3 for AM; f_{mod} = 1 kHz, Δf = 75 kHz for FM.

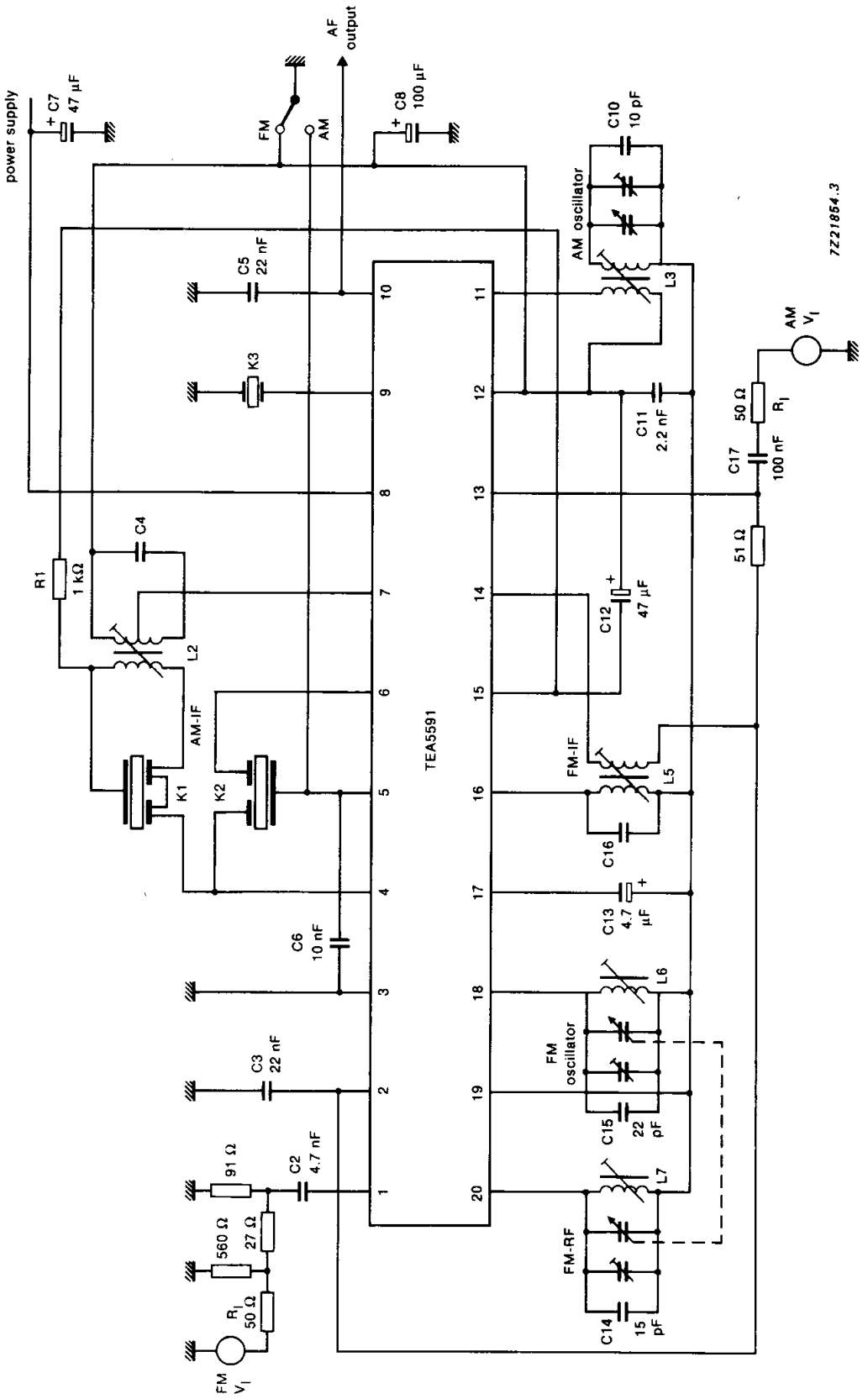


Fig.5 Test circuit.

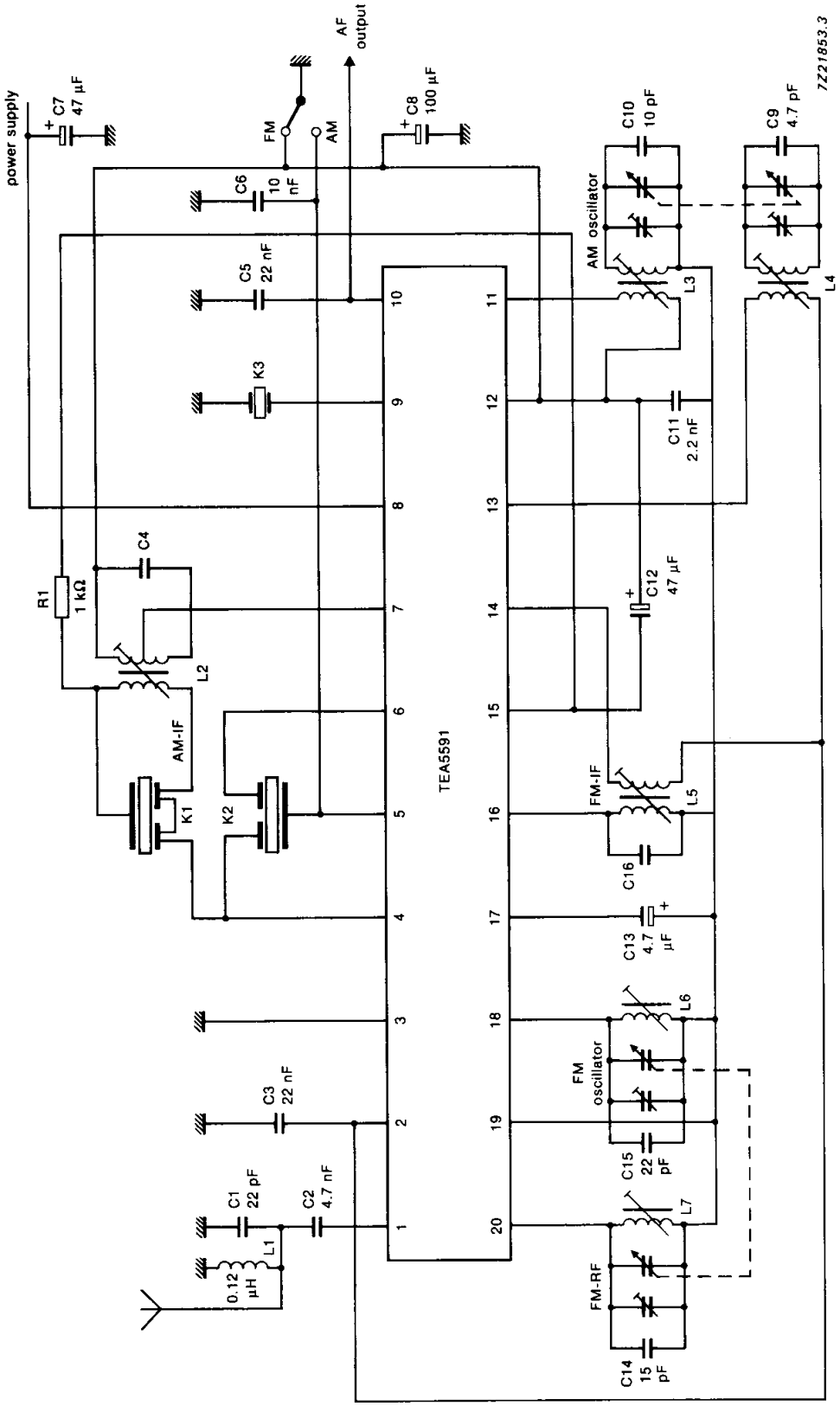
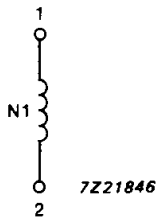


Fig.6 Application diagram.

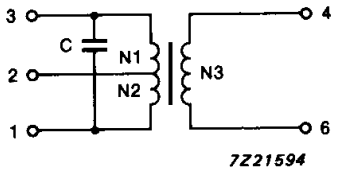
APPLICATION INFORMATION

Component data



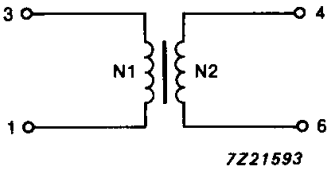
N1 = 4.5
L = 0.12 μH
Wire = 0.8 mm diameter
diameter = 4.5 mm

Fig.7 FM BFP coil (L1).



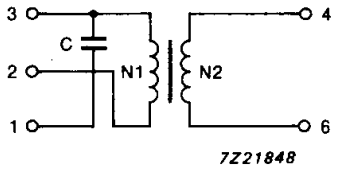
N1 = 132
N2 = 14
N3 = 9
C = 180 pF (internal)
Lprim = 660 μH
fo = 468 kHz
Wire = 0.07 mm diameter
Coil type 7P-TOKO
Material 7MCS

Fig.8 AM IF coil (L2). TOKO sample no. 7MCS-7P.



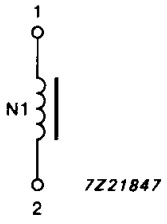
N1 = 86
N2 = 11
Lprim = 270 μH
Wire = 0.07 mm diameter
Coil type 7P-TOKO
Material 7BRS

Fig.9 Oscillator coil (L3). TOKO sample no. 7BRS-7P.



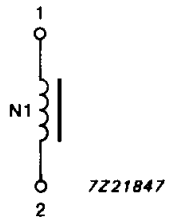
N1 = 11
N2 = 2
C = 85 pF (internal)
fo = 10.7 MHz

Fig.10 FM IF coil (L5). TOKO equivalent no. 119ACS-30120M.



N1 = 1.5
L = 0.03 μH

Fig.11 Oscillator coil (L6). TOKO equivalent no. 301SN-0100.



N1 = 2.5
L = 0.05 μH

Fig. 12 FM RF coil (L7). TOKO equivalent no. 301SN-0200.

Ferroceptor coil

L4: N1 = 105; N2 = 10; L = 625 μH

Ceramic Filters

AM IF (K1). SFZ468 HL.
FM IF (K2). SFE10 . 7 MS2.
FM detector (K3). CDA10 . 7 MC1.

Tuning capacitors

AM 140/82 pF
FM 2 x 20 pF

APPLICATION INFORMATION (continued)

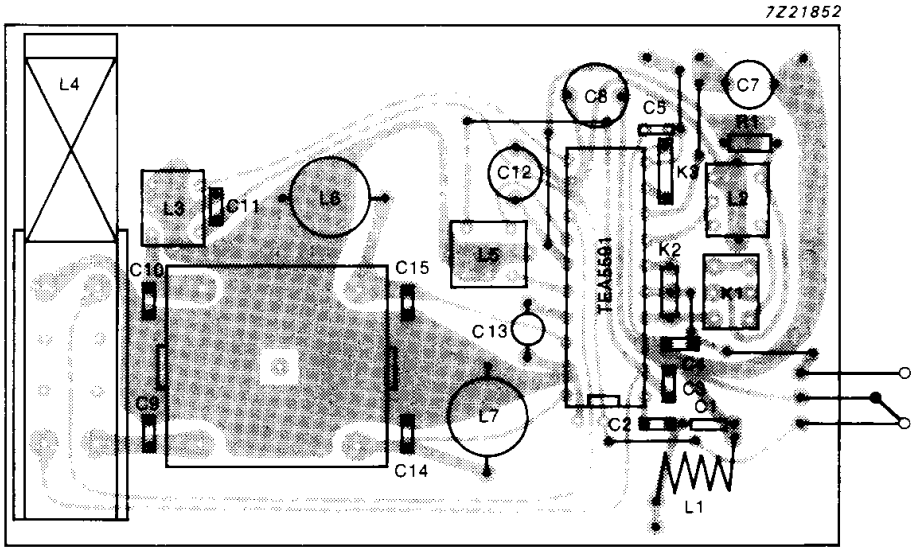


Fig.13 Printed-circuit board component side, showing component layout. For circuit diagram see Fig.6.

Physical dimensions of the printed circuit board = 5.0 x 8.1 cm.

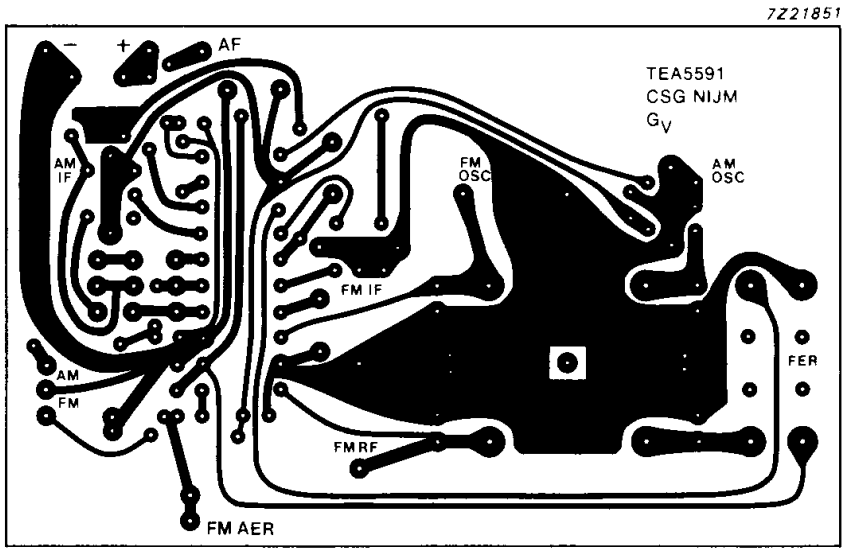


Fig.14 Printed-circuit board showing track side.

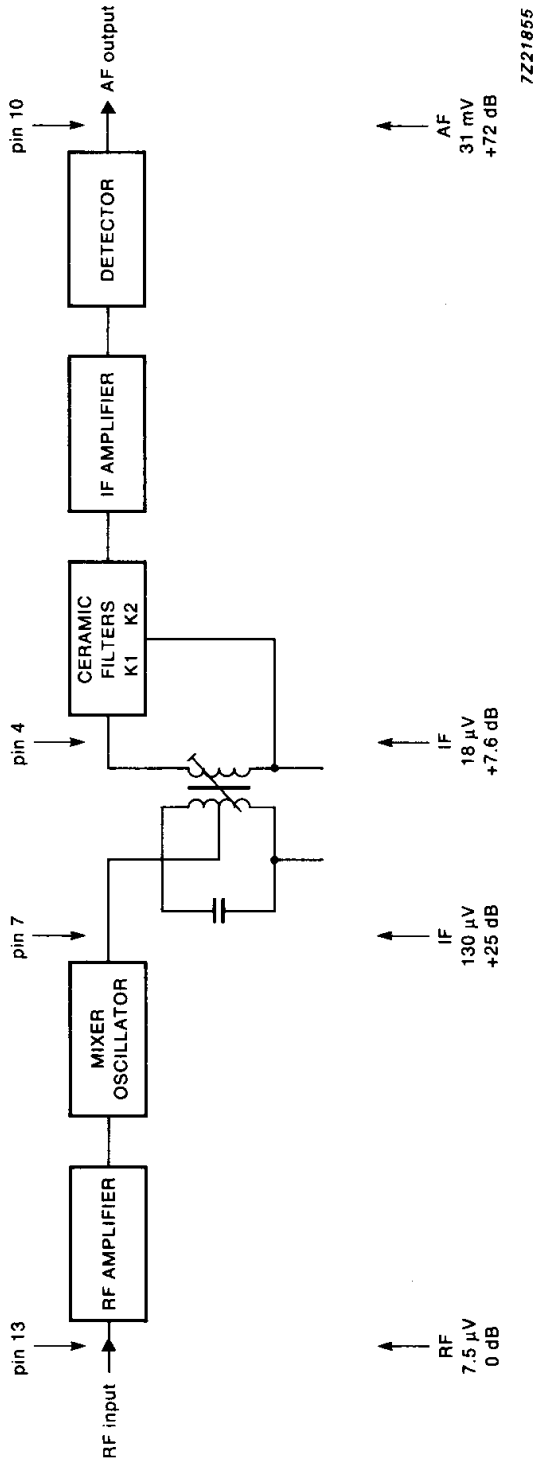


Fig.15 AM signal levels.

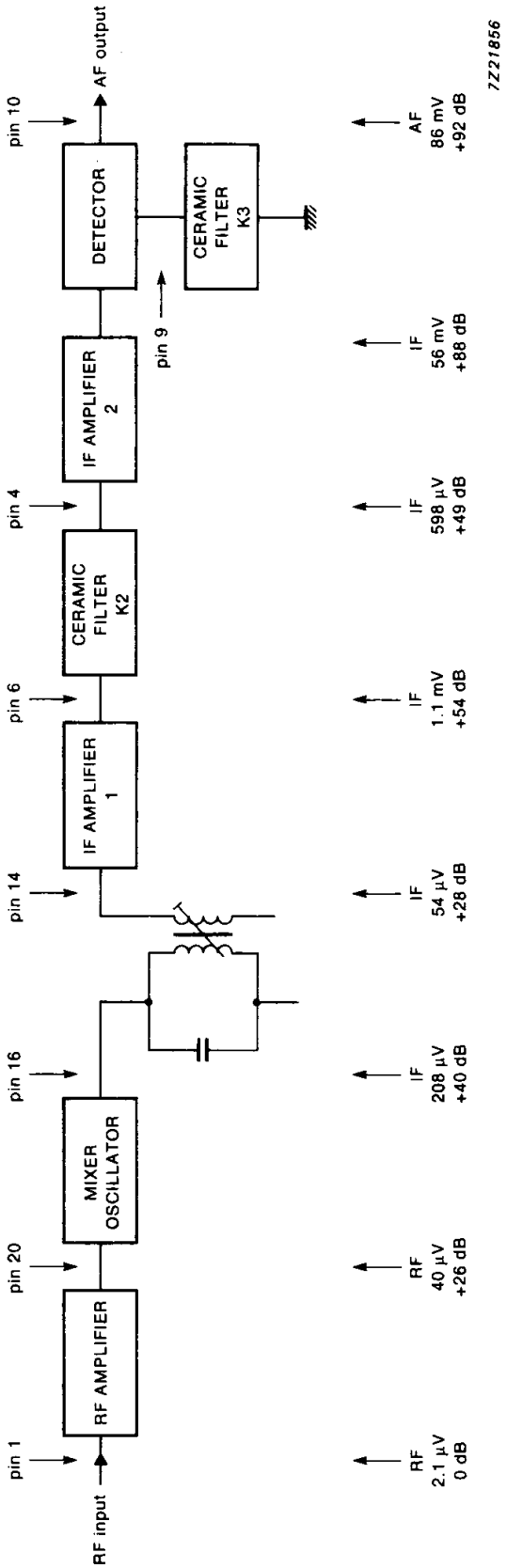


Fig.16 FM signal levels.

APPLICATION INFORMATION (continued)

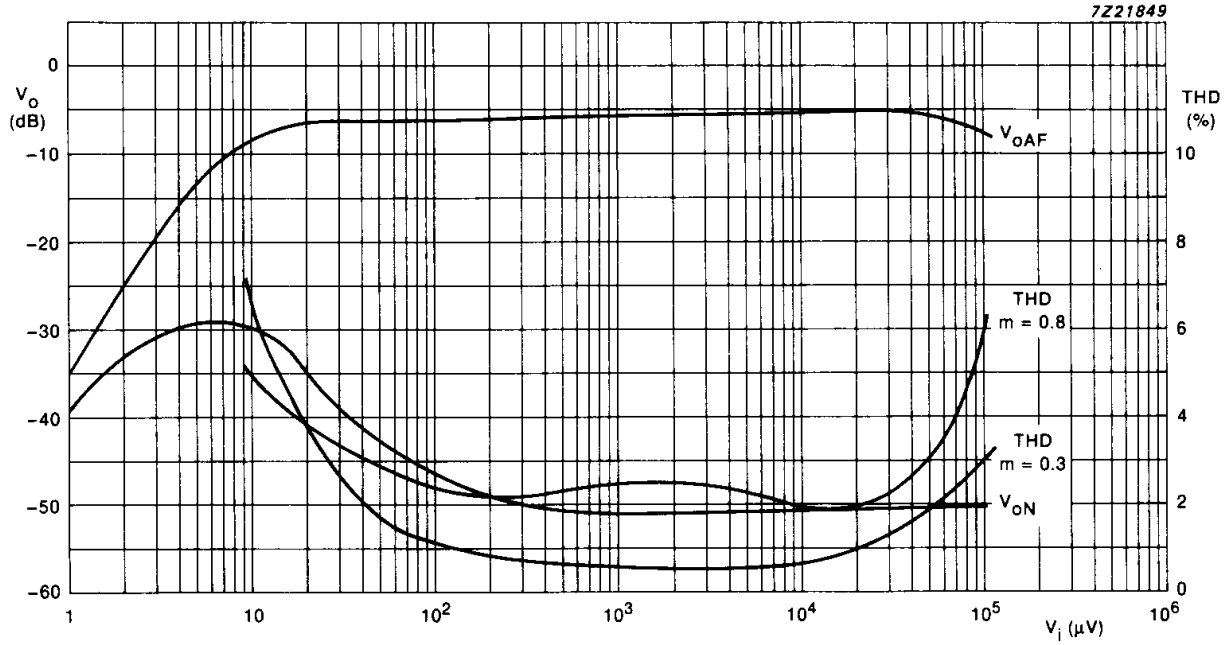


Fig.17 Signal and noise (V_{oAF}), noise (V_{oN}); reference level 0 dB = 100 mV, and total harmonic distortion (THD) as a function of input voltage (V_i) at pin 13. Measured in test circuit Fig.5. AM AGC is measured at f_i = 1 MHz; f_{mod} = 1 kHz; m = 0.3. AM distortion is measured at f_i = 1 MHz; f_{mod} = 1 kHz.

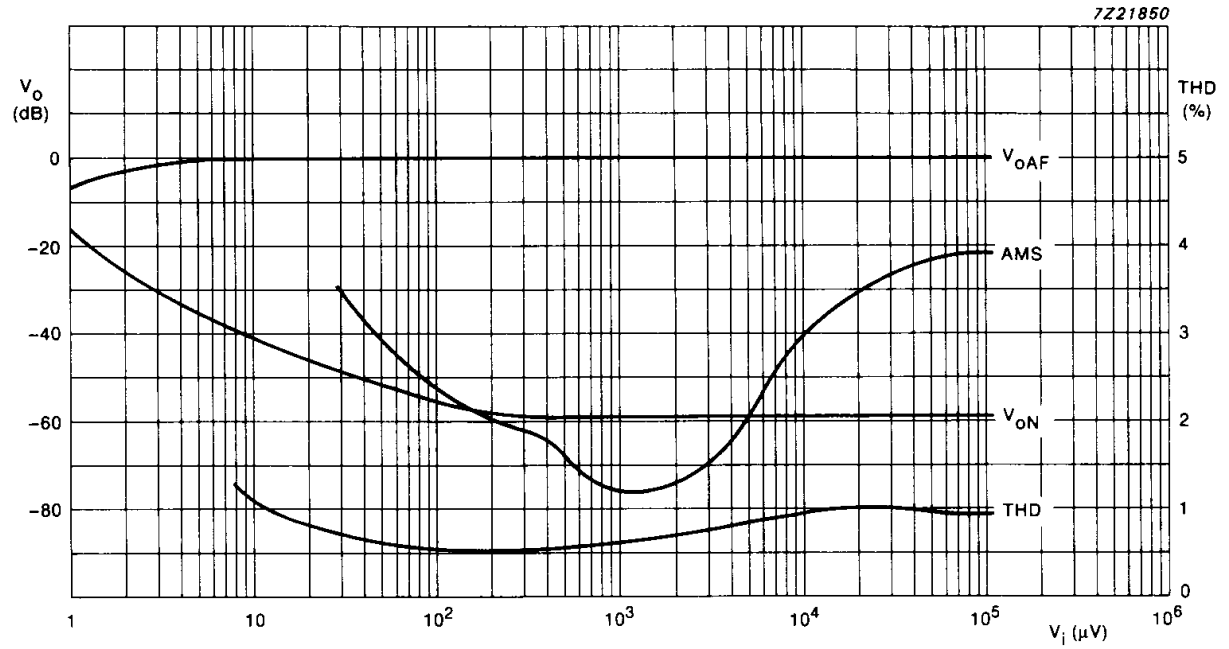


Fig.18 Signal and noise (V_{oAF}), noise (V_{oN}); reference level 0 dB = 100 mV; AM suppression (AMS) and total harmonic distortion (THD) as a function of input voltage (V) at pin 1. Measured in test circuit Fig.5 at f_i = 98 MHz; f_{mod} = 1 kHz; Δf 22.5 kHz. AM suppression is measured at f_{mod} = 400 Hz, m = 0.3 for AM; f_{mod} = 1 kHz, Δf = 75 kHz for FM.