

HF Front End for Car Radios and HiFi Receivers

Description

Technology: Bipolar

Features

- Completely integrated FM front end increases quality level and reliability
- High performance due to three AGC loops allow extreme large signal handling
- Fulfills FTZ rules
- Double-balanced high linear mixer with low-noise figure
- Oscillator with low phase noise and excellent frequency stability
- IF preamplifier with dB-linear gain control
- Low noise and high stability of the reference voltage circuit for internal and auxiliary functions

Block Diagram

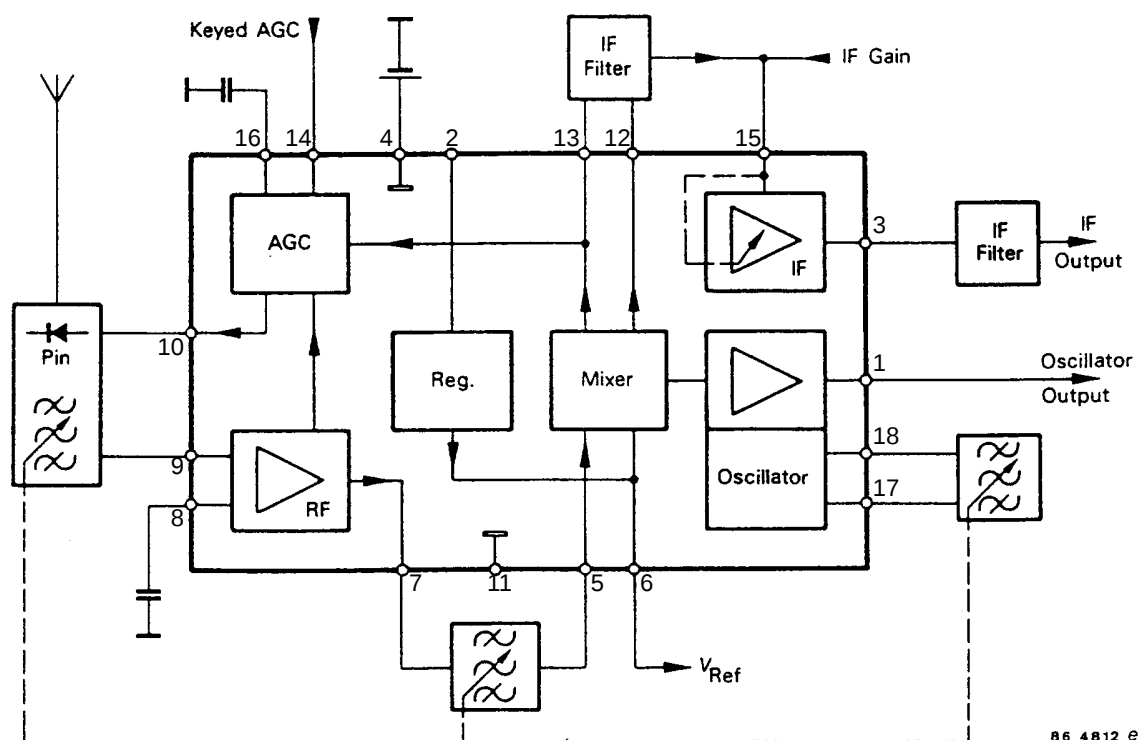


Figure 1. Block diagram

Ordering Information

Extended Type Number	Package	Remarks
U4062B-B	DIP18	

Pin Description

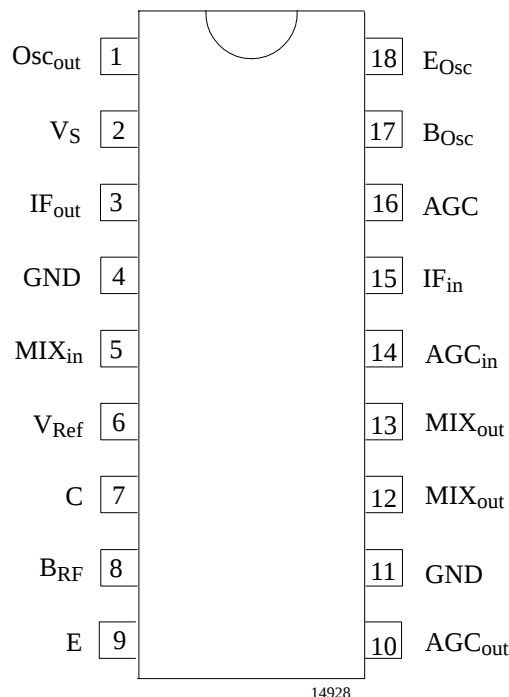


Figure 2. Pinning DIP18

Pin	Symbol	Function
1	Osc _{out}	Oscillator output
2	V _S	Supply voltage
3	IF _{out}	IF output
4	GND	Ground
5	MIX _{in}	Mixer input
6	V _{Ref}	Reference voltage output
7	C	Collector
8	B _{RF}	Base, RF preamplifier
9	E	Emitter
10	AGC _{out}	AGC output
11	GND	Ground
12	MIX _{out}	Mixer output
13	MIX _{out}	Mixer output
14	AGC _{in}	AGC input (IF strip)
15	IF _{in}	IF input / IF gain control
16	AGC	AGC time constant
17	B _{Osc}	Base oscillator
18	E _{Osc}	Emitter oscillator

Absolute Maximum Ratings

Reference point ground, Pins 4 and 11

Parameters	Symbol	Value	Unit
Supply voltage Pins 2, 12 and 13	V _S	18	V
Power dissipation T _{amb} = 85°C	P _{tot}	450	mW
Junction temperature	T _j	125	°C
Storage temperature range	T _{stg}	−50 to +125	°C
Ambient temperature range	T _{amb}	−25 to +85	°C

Thermal Resistance

Parameters	Symbol	Value	Unit
Junction ambient	R _{thJA}	90	K/W

Electrical Characteristics

$V_S = 10\text{ V}$, $f_{\text{IRF}} = 50.3\text{ MHz}$, $f_{\text{Osc}} \approx 100\text{ MHz}$, $f_{\text{IF}} = f_{\text{Osc}} - f_{\text{IRF}} \approx 49.7\text{ MHz}$, reference point Pins 4 and 11, $T_{\text{amb}} = +25^\circ\text{C}$, unless otherwise specified, see test circuit figure 4.

Parameters	Test Conditions / Pins	Symbol	Min.	Typ.	Max.	Unit
Supply voltage range		V_S	7		16	V
Supply currents						
Supply current	Pin 2	I_S		11.5		mA
Mixer	Pins 12 and 13	$I_{12} + I_{13}$		9		mA
RF stage	$R_4 = 470\ \Omega$ Pin 7	I_7		9		mA
RF preamplifier ($R_{g9} = 50\ \Omega$, $R_{L7} = 200\ \Omega$)						
DC voltage	Pin 7	V_7		5.7		V
	Pin 8	V_8		0.77		V
Power gain		G_{RF}		10.5		dB
Third order intercept		IP_3		12		dBm
Dynamic characteristics, $f = 100\text{ MHz}$						
Input impedance		Z_9			5	Ω
Forward current gain	$ i_7/i_9 $	h_{fb}		1		A/A
Parallel output resistance		R_7		3		k Ω
Parallel output capacitance		C_1		3.8		pF
Noise figure		NF_{RF}		2		dB
Oscillator ($f_{\text{Osc}} = 100\text{ MHz}$, unloaded $Q = 80$, resonance resistance $R_{g17} = 250\ \Omega$)						
DC voltage	Pin 17	V_{17}		3.2		V
	Pin 18	V_{18}		2.5		V
Oscillator voltage	Pin 17	$V_{\text{Osc}17}$	100	130		mV
Frequency drift	By supply voltage change d_{f_0}/dV_S	$\Delta f_{\text{Osc}}(V_S)$		1.3		kHz/V
	By temperature change d_{f_0}/dT_K	$\Delta f_{\text{Osc}}(T_j)$		2		kHz/K
FM noise equivalent deviation, (Ripple voltage < 0.5 mV)	Frequency band 300 Hz to 20 kHz, unweighted	Δf_{noise}		5		Hz
	Peak CCIR	Δf_{noise}		10.5		Hz
	Peak CCIR, weighted with 75 μs , deemphasis	Δf_{noise}		4.2		Hz
FM by AM signal at mixer input	$f_{\text{IRF}} = 90\text{ MHz}$, $m = 0.8$, $f_M = 1\text{ kHz}$, $V_{\text{IRF}} = 106\text{ dB}\mu\text{V}$	$\Delta f_{\text{Osc}}(V_{\text{IRF}})$		160		Hz
Oscillator output buffer ($R_{L1} = 520\ \Omega$)						
DC current load limitation	Pin 1	I_1			0.2	mA
DC voltage	Pin 1	V_1		1.7		V
Voltage gain	$V_{\text{Osc}17} \leq 200\text{ mV}$ $V_{\text{Osc}1}/V_{\text{Osc}17}$ Pin 1	G_{buffer}		0.86		
Harmonics				<-30		dBc
Output impedance	Pin 1	Z_1		80		Ω

Electrical Characteristics (continued)

$V_S = 10\text{ V}$, $f_{\text{IRF}} = 50.3\text{ MHz}$, $f_{\text{Osc}} \approx 100\text{ MHz}$, $f_{\text{IF}} = f_{\text{Osc}} - f_{\text{IRF}} \approx 49.7\text{ MHz}$, reference point Pins 4 and 11,
 $T_{\text{amb}} = 25^\circ\text{C}$, unless otherwise specified, see test circuit figure 4.

Parameters	Test Conditions / Pins	Symbol	Min.	Typ.	Max.	Unit
Mixer ($R_{g5} = 200\ \Omega$, $R_{L12-13} = 200\ \Omega$)						
Conversion power gain		G_C		7.5		dB
Third order intercept		IP_3		3.5		dBm
Parallel input resistance	$f = 100\text{ MHz}$ Pin 5	R_5		5		k Ω
Parallel input capacitance	$f = 100\text{ MHz}$ Pin 5	C_5		3		pF
Parallel output resistance	$f = 10.7\text{ MHz}$, Pins 12, 13 parallel connected	R_{12+13}		55		k Ω
Effective output capacitance between Pin 12 and 13	$f = 10.7\text{ MHz}$	C_{12-13}	2.9	3.1	3.3	pF
	$V_{12,13} = 10\text{ V}$	C_{12-13}	3.25	3.5	3.75	pF
	$V_{12,13} = 7\text{ V}$	C_{12-13}	2.5	2.7	2.9	pF
Conversion transconductance	$ i_{12}/u_5 $, $ i_{13}/u_5 $	g_c		5.8		m-mho
Maximum available conversion power gain	$f_{\text{IRF}} = 100\text{ MHz}$, $f_{\text{IF}} = 10.7\text{ MHz}$	MACG		43		dB
Noise figure ($f_{\text{IF}} = 10.7\text{ MHz}$) Single side band	$R_{g5}(f_{\text{IRF}}) = 450\ \Omega$, $f_{\text{IRF}} = f_{\text{Osc}} - f_{\text{IF}}$	NF_{CSSB}		5.6		dB
IF preamplifier ($f = 10.7\text{ MHz}$, $R_{L3} = R_{g15} = 200\ \Omega$)						
DC voltage	Pin 3	V_3		7.6		V
Power gain	Maximum control voltage of $V_{15} = 1.6\text{ V}$ is recom- mended $V_{15} = 1.6\text{ V}$ $V_{15} < 0.8\text{ V}$	G_{maxIF}		24		dB
		G_{minIF}		-4		dB
Gain control deviation by V_{15}		ΔG_{IF}		28		dB
External control current	at G_{maxIF}	$I_{15\text{max}}$		20		μA
	at G_{minIF} Pin 15	$I_{15\text{min}}$		0		μA
Gain control slope	dG_{IF}/dI_{15}	S_{I15}		1.3		dB/ μA
	dG_{IF}/dV_{15} Pin 15	S_{V15}		35		dB/V
Temperature coefficient of voltage gain	dG_{IF}/dT_j at $V_{15} = 1.6\text{ V}$ $V_{15} < 0.8\text{ V}$ $I_{15} = \text{constant}$	TCG		0		dB/K
				0.04		dB/K
				-0.02		dB/K
Parallel input resistance	Pin 15	R_{15}		2.4		k Ω
Parallel input capacitance	Pin 15	C_{15}		5.9		pF
Parallel output resistance	Pin 3	R_3		350		Ω
Parallel output capacitance	Pin 3	C_3		4.1		pF
Noise figure	$V_{15} = 1.6\text{ V}$	NF_{IF}		11		dB

Electrical Characteristics (continued)

$V_S = 10\text{ V}$, $f_{\text{IRF}} = 50.3\text{ MHz}$, $f_{\text{Osc}} \approx 100\text{ MHz}$, $f_{\text{IF}} = f_{\text{Osc}} - f_{\text{IRF}} \approx 49.7\text{ MHz}$, reference point Pins 4 and 11,
 $T_{\text{amb}} = 25^\circ\text{C}$, unless otherwise specified, see test circuit figure 4.

Parameters	Test Conditions / Pins		Symbol	Min.	Typ.	Max.	Unit
AGC circuit (no signal at Pins 5 and 9)							
DC voltage		Pin 16	V ₁₆		1.0		V
Saturation voltage		Pin 10	V _{10min}		0.08	0.2	V
Input current	V ₁₄ ≤ V ₆	Pin 14	−I ₁₄		0.01	0.1	μA
Maximum allowable current		Pin 14	± I ₁₄ _{max}			50	μA
Maximum control current for external PIN-diode	I ₁₀ = 0		I _{diode}			I ₇	
AGC threshold voltages (respecting V ₁₀ = 0.25 V)							
RF stage output		Pin 7	V _{RF7}		450		mV
Mixer-stage output	V ₁₄ = V ₆	Pin 13	V _{IF13}		300		mV
External AGC voltage	V _{IF13} = 1 V	Pin 14	V _{14min}		0.9		V
Internal AGC voltage		Pin 16	V _{16min}		1.4		V
Reference voltage source							
Output voltage, without load	I ₆ = 0	Pin 6	V ₆	1.6	1.7	1.8	V
Temperature dependence of V ₆	V ₆ T _{amb} = −25 to +85°C		ΔV ₆ (T)		20		mV
Internal differential resistance	dV ₆ /dI ₆ when I ₆ = 0 mA		r _{d6}		50		Ω
Ripple rejection	20 log (dV _S /dV ₆) when I ₆ = 0 mA		α ₆		65		dB
Noise voltage / √Hz	when I ₆ = 0 and f = 25 Hz f = 125 Hz f = 1 kHz f = 10 kHz				0.6 0.37 0.1 0.1		μV μV μV μV

Test Circuit

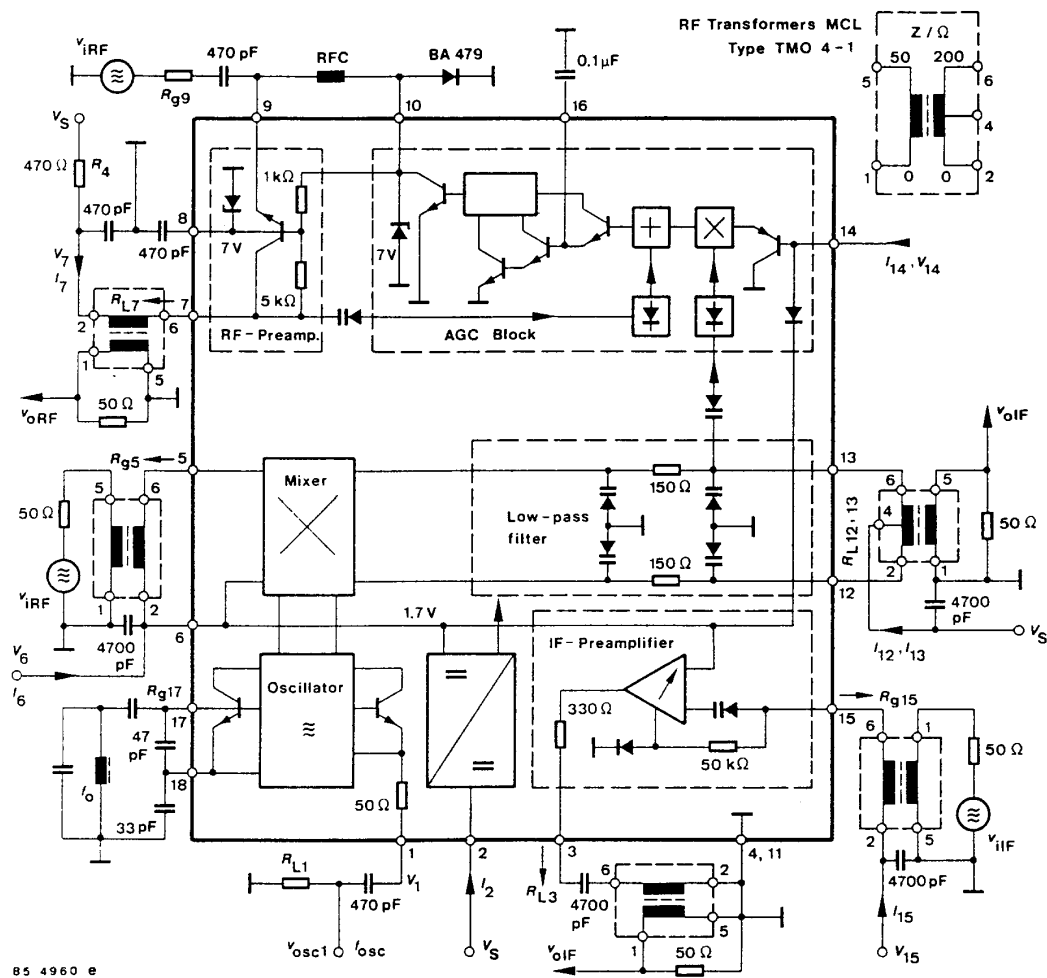


Figure 3. Test circuit

RF Preamplifier

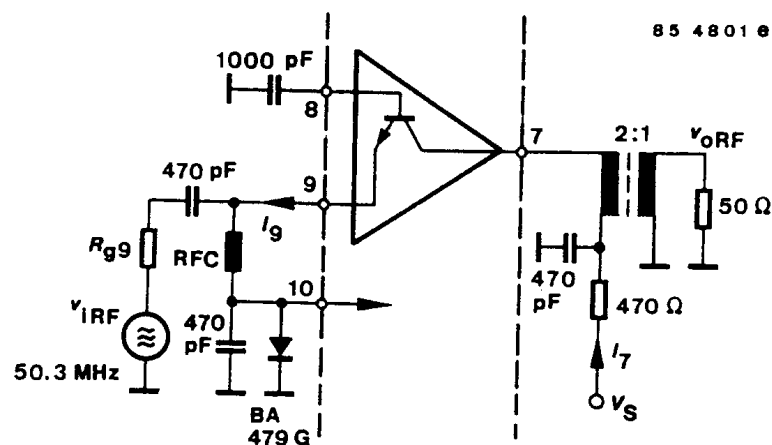


Figure 4. Test circuit

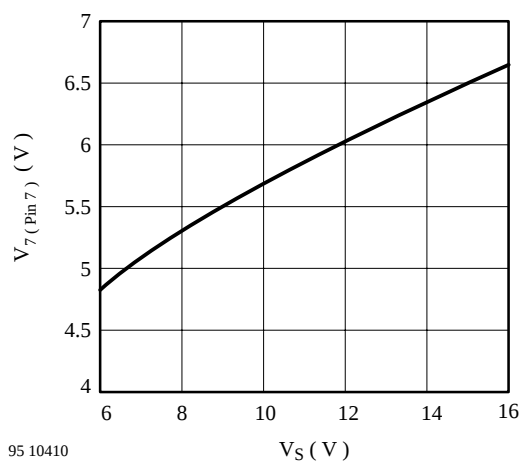


Figure 5. V_7 vs. V_S

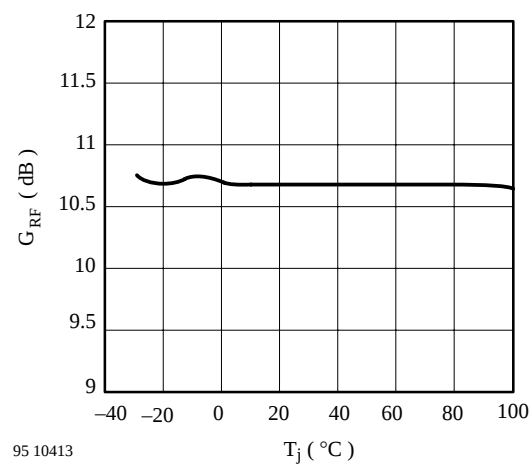


Figure 8. G_{RF} vs. T_j

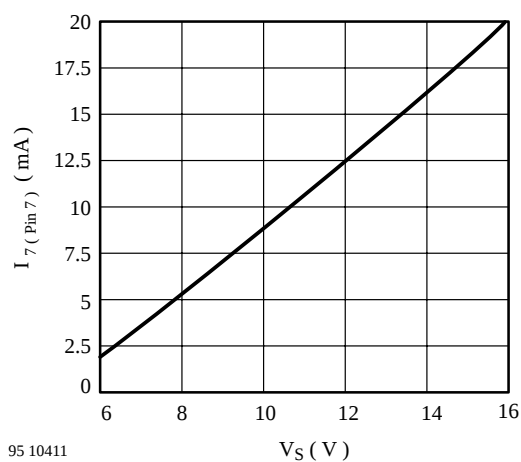


Figure 6. I_7 vs. V_S

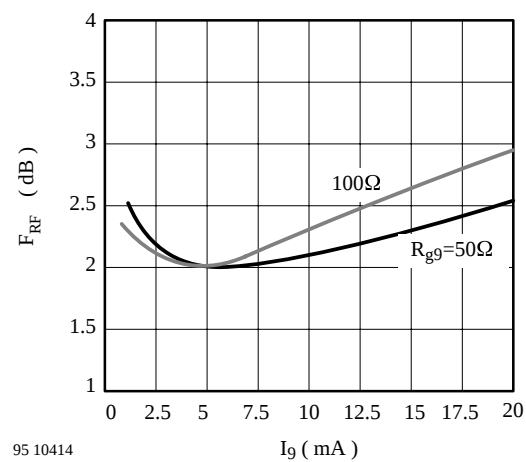


Figure 9. F_{RF} vs. I_g

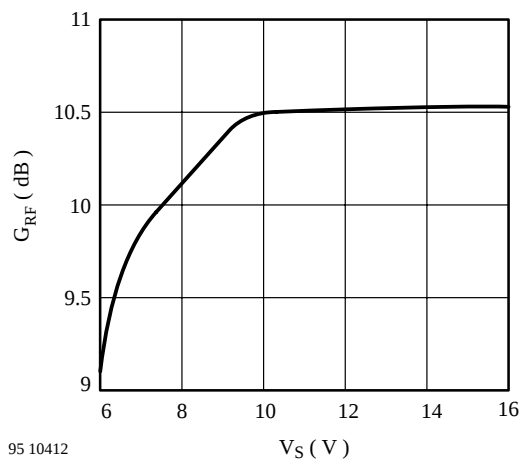


Figure 7. G_{RF} vs. V_S

[illegible]

Graph of frequency shift Δf_{osc} (kHz) versus supply voltage V_S (V) for $f_{osc} = 100 \text{ MHz}$. The curve shows a minimum shift of approximately -1 kHz at $V_S = 9.5 \text{ V}$.

V_S (V)	Δf_{osc} (kHz)
6.0	18.0
6.5	5.0
7.0	3.0
8.0	0.5
9.0	-1.0
9.5	-1.2
10.0	-0.8
11.0	0.5
12.0	2.0
13.0	3.5
14.0	4.5
15.0	5.5

V_S (V)	$V_{OSC} \text{ Pin 1}$ (dB μ)
6.0	100.8
6.5	102.2
8.0	102.4
10.0	102.6
12.0	102.8
14.0	103.0
16.0	103.1

Figure 1 is a plot showing the frequency shift Δf_{osc} (kHz) versus the junction temperature T_j (°C) for a 100 MHz oscillator. The plot displays a hysteresis loop, indicating bistable behavior. The y-axis ranges from -20 to 30 kHz, and the x-axis ranges from -40 to 100°C. The text $f_{\text{osc}}=100\text{MHz}$ is present in the upper right area of the plot.

T_j (°C)	$V_{OSC} Pin 1$ (dBμ)
-30	101.6
-20	102.0
0	102.3
25	102.4
40	102.3
60	102.1
80	101.9
100	101.7

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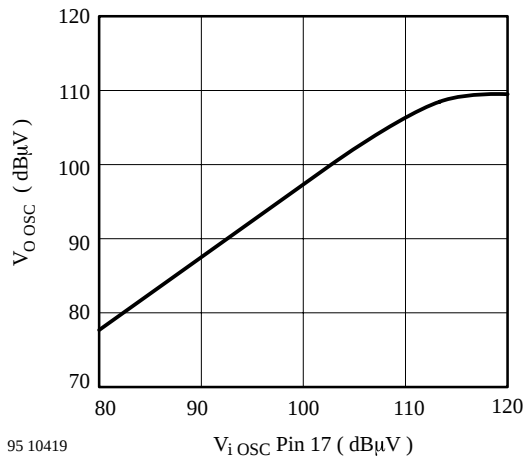


Figure 15. V_{Osc} vs. V_{i Osc}

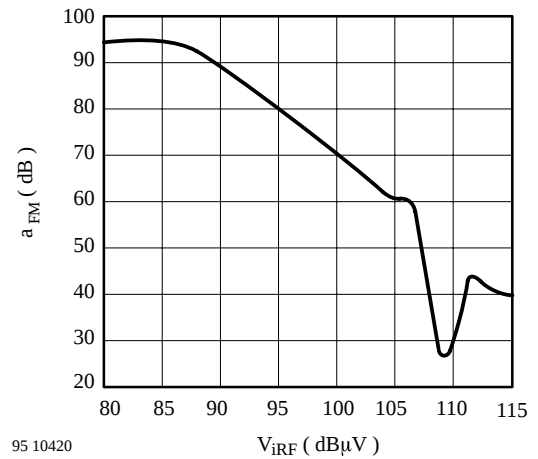
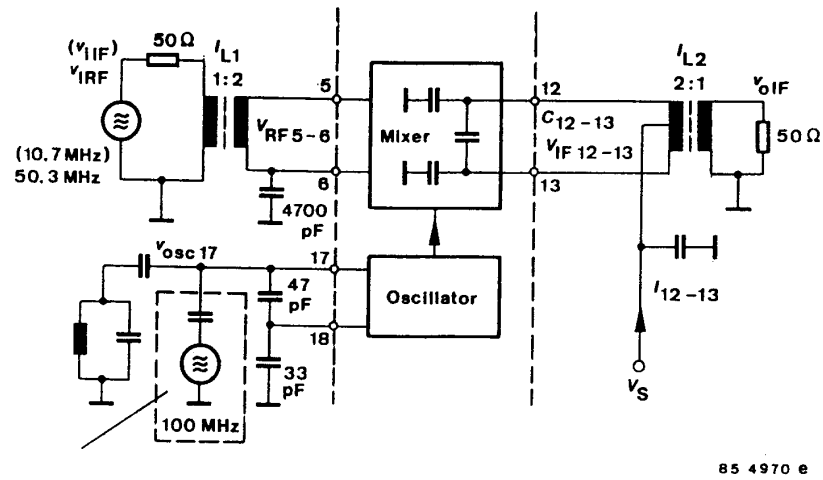


Figure 16. a_{FM} vs. V_{i RF}

Mixer



For test's versus v_{osc 17} only

Figure 17. Test circuit

I_{L1}, I_{L2} = Insertion loss of the RF transformers

Conversion power gain G_C = 20 log (2 V_{oIF}/V_{iRF}) + I_{L1} (dB) + I_{L2} (dB)

V_{RF5-6} (dBμV) = V_{iRF} (dBμV) - I_{L1} (dB) + 6

V_{IF12-13} (dBμV) = V_{oIF} (dBμV) - I_{L2} (dB) + 6

ΔG_C = G_C (V_{OSC17}) - G_C (nominal)

Input to output IF isolation

a_{IF} = 20 log (2 V_{oIF}/V_{iIF}) + I_{L1} (dB) + I_{L2} (dB) - G_C (nominal)

Characteristics α_{FM} versus v_{iRF}, see previous page

Oscillator frequency immunity against amplitude modulated signal at mixer input (Pin 5-6) related to FM standard modulation:

α_{FM} = 20 log [75 kHz/Δf_{OSC}(v_{iRF})] whereas

v_{iRF} = mixer input signal (f_{iRF} = 89.3 MHz, m = 0.8, f_M = 1 kHz)

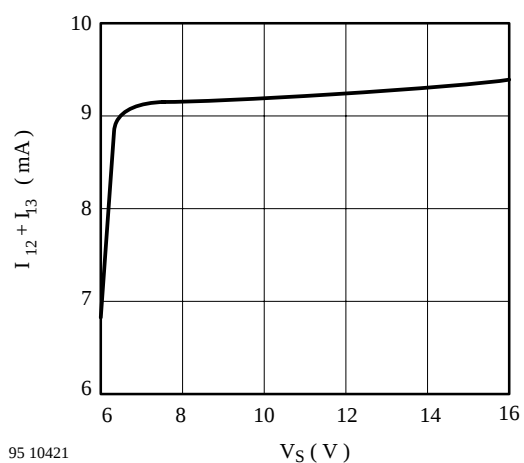


Figure 18. $I_{12} + I_{13}$ vs. V_S

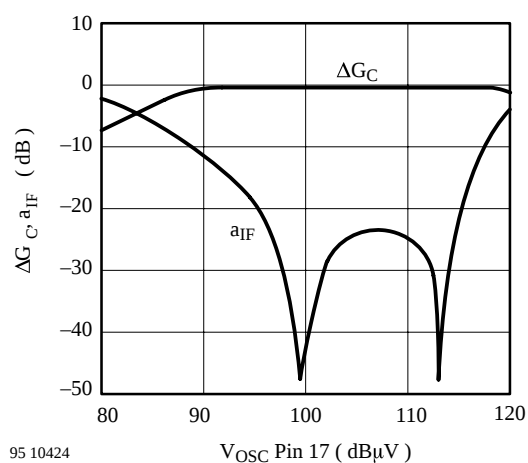


Figure 21. ΔG_C , a_{IF} vs. V_{OSC} Pin 17

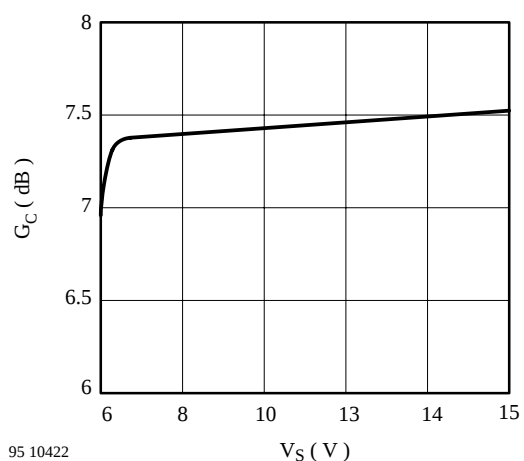


Figure 19. G_C vs. V_S

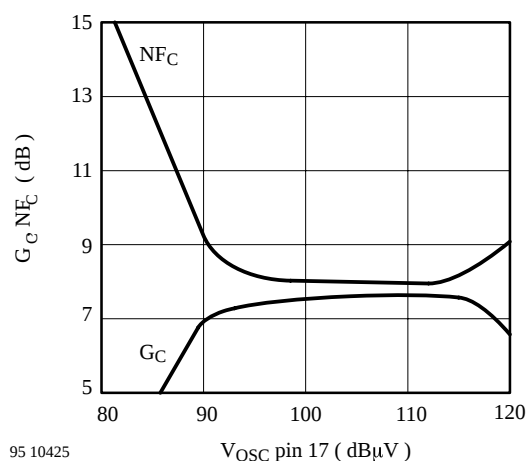


Figure 22. G_C N_{FC} vs. V_{OSC} Pin 17

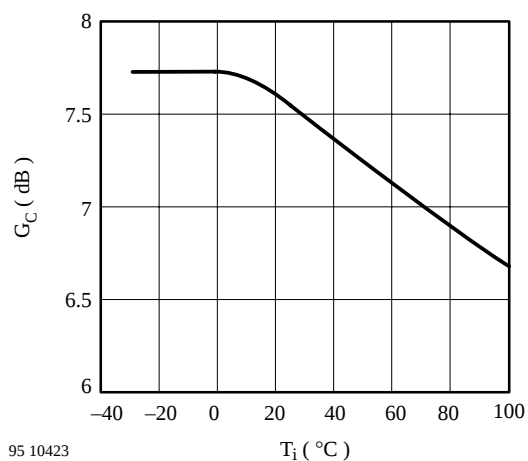


Figure 20. G_C vs. T_j

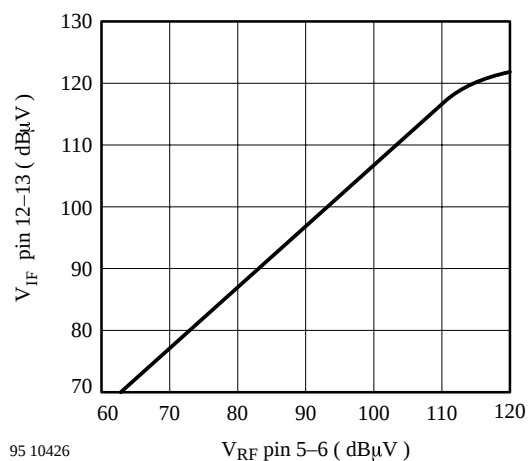


Figure 23. V_{IF} Pin 5-6 vs. V_{RF} Pin 5-6

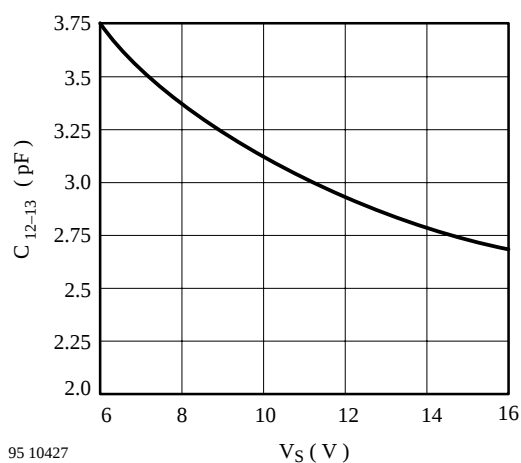


Figure 24. C_{12-13} vs. V_S

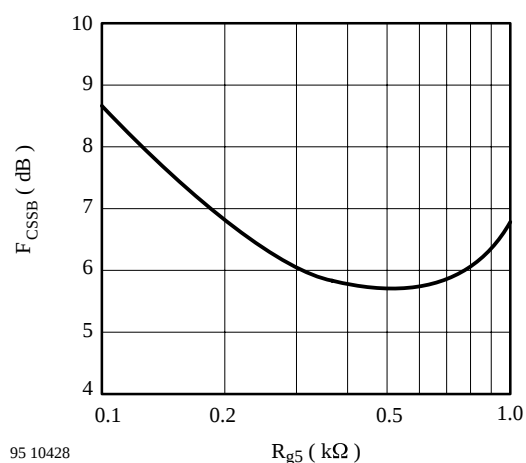


Figure 25.
 F_{CSSB} = Noise figure reading /dB- I_L /dB
 I_L = Insertion loss of the tuned transformer network

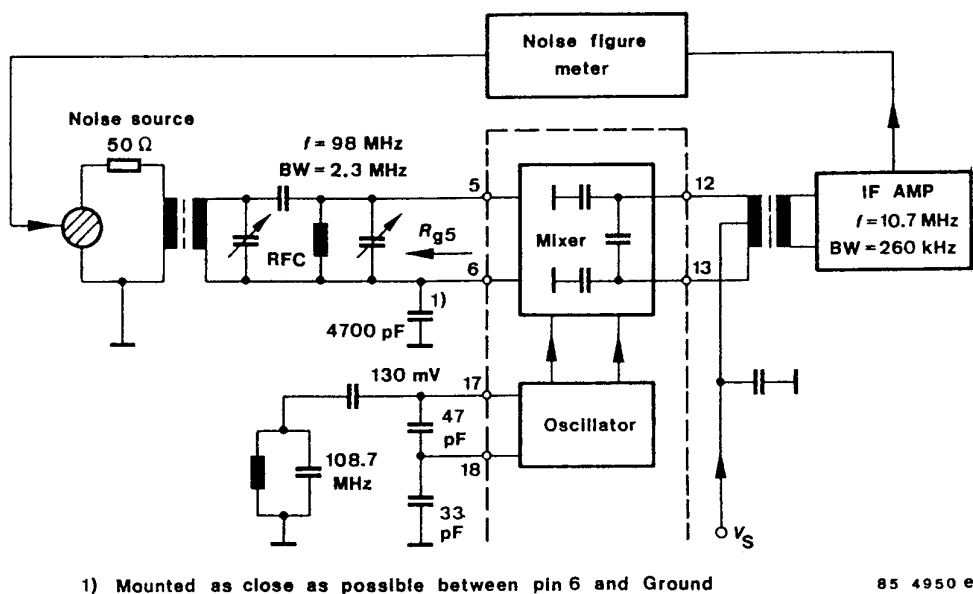


Figure 26. Test circuit for single sideband noise (F_{CSSB})

AGC Circuit

I_{L1}, I_{L2} = Insertion loss of the RF transformers,

$$V_{RF7} \text{ (dB}\mu\text{V)} = V_{IRF} \text{ (dB}\mu\text{V)} - I_{L1} \text{ (dB)} + 6$$

$$V_{IF13} \text{ (dB}\mu\text{V)} = V_{IIF} \text{ (dB}\mu\text{V)} - I_{L2} \text{ (dB)}$$

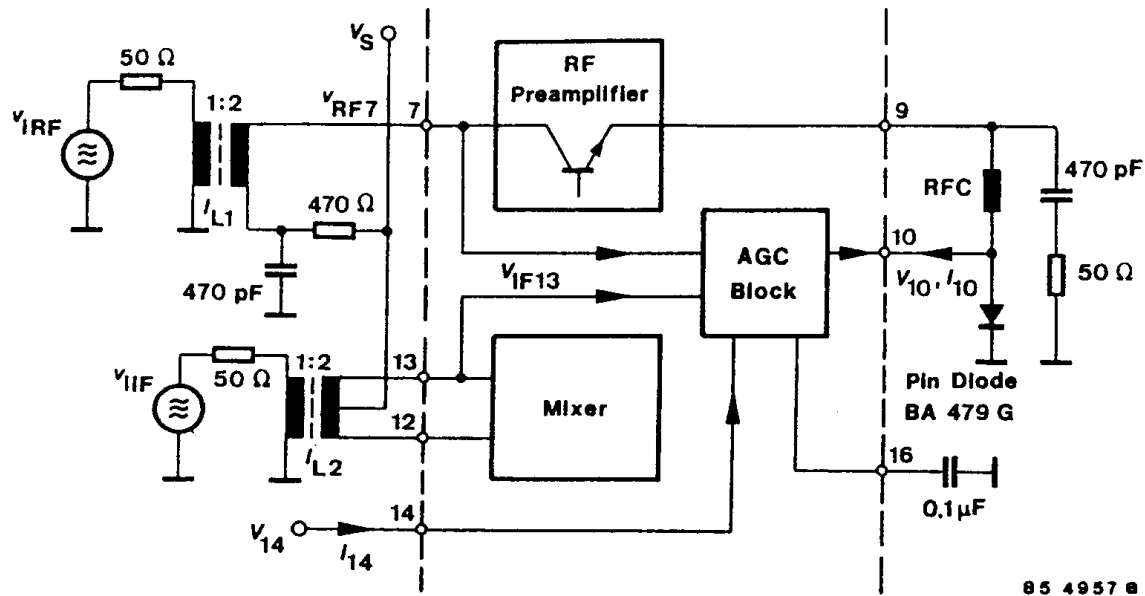


Figure 27. Test circuit

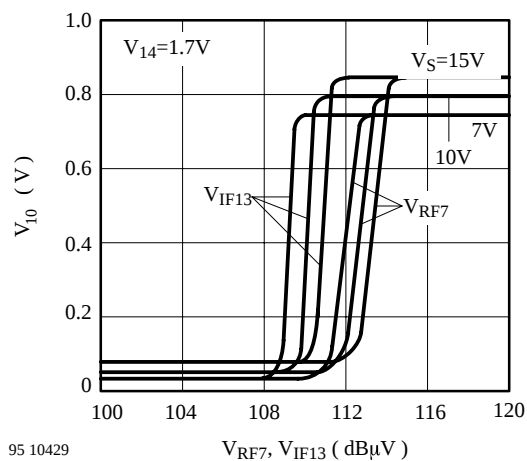


Figure 28. V_{10} vs. V_{RF7} , V_{IF13}

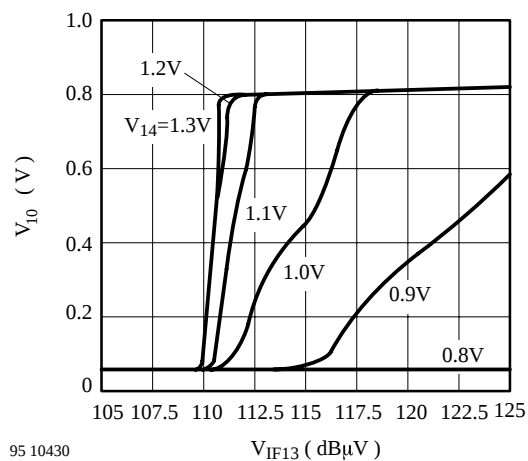


Figure 29. V_{10} vs. V_{IF13}

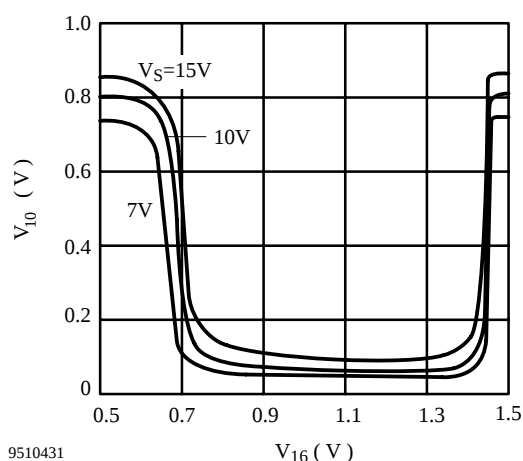


Figure 30. V_{10} vs. V_{16}

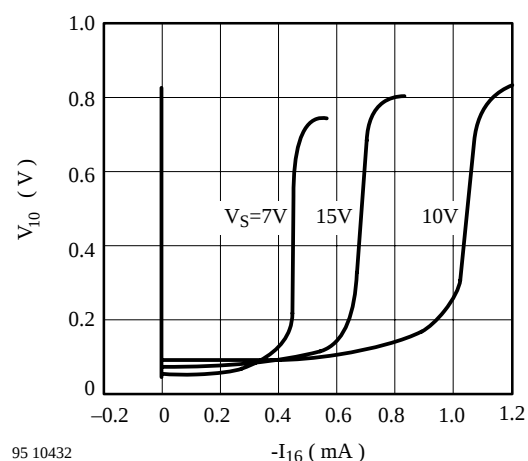


Figure 31. V_{10} vs. $-I_{16}$

IF Preamplifier

I_{L1}, I_{L2} = Insertion loss of the RF transformers

Power gain $G_F = 20 \log (2 V_{oIF}/V_{iRF}) + I_{L1} \text{ (dB)} + I_{L2} \text{ (dB)}$

$V_{iIF15} \text{ (dB}\mu\text{V)} = V_{iIF} \text{ (dB}\mu\text{V)} - I_{L1} \text{ (dB)} + 6$

$V_{oIF3} \text{ (dB}\mu\text{V)} = V_{oIF} \text{ (dB}\mu\text{V)} - I_{L2} \text{ (dB)} + 6$

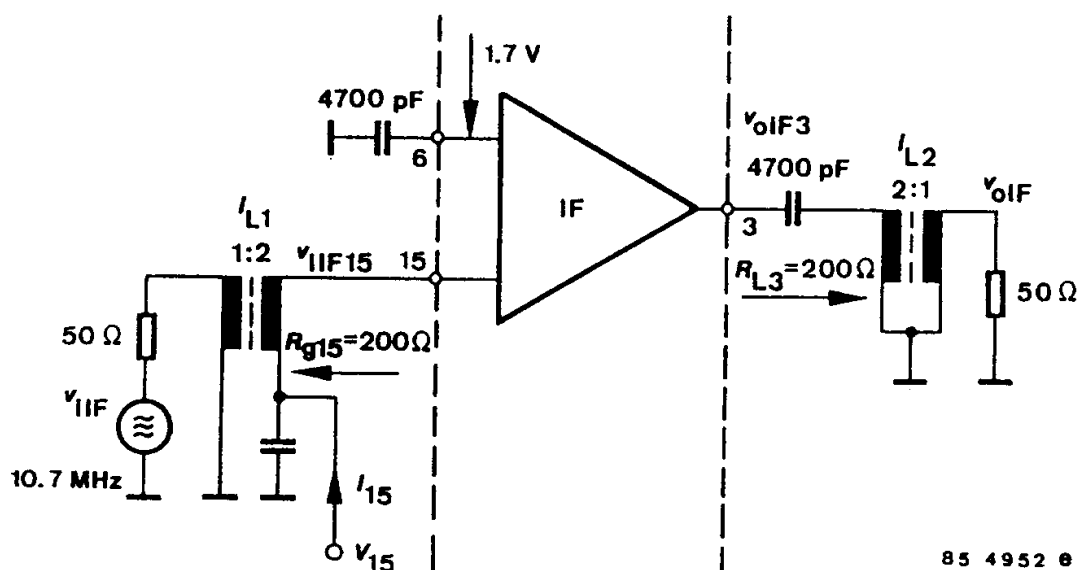


Figure 32. Test circuit

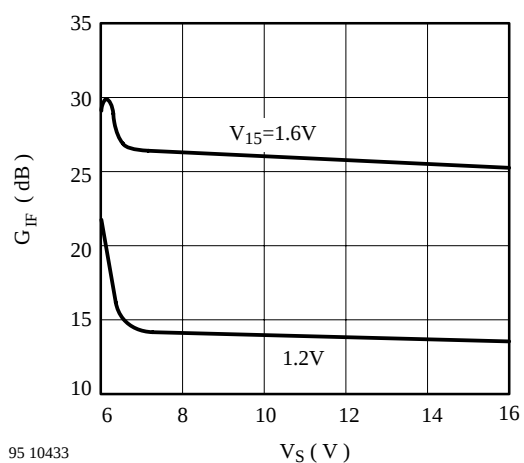


Figure 33. G_{IF} vs. V_S

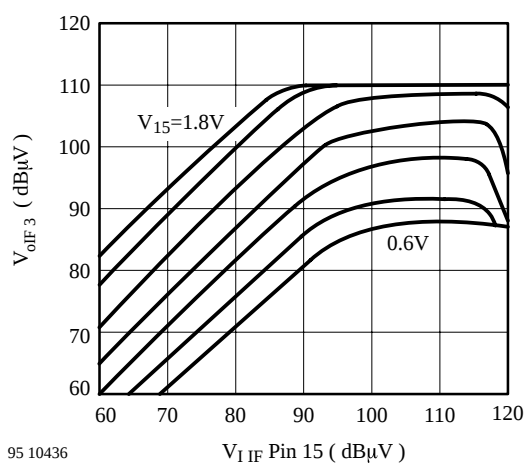


Figure 36. V_{OIF3} vs. V_{1IF} Pin 15

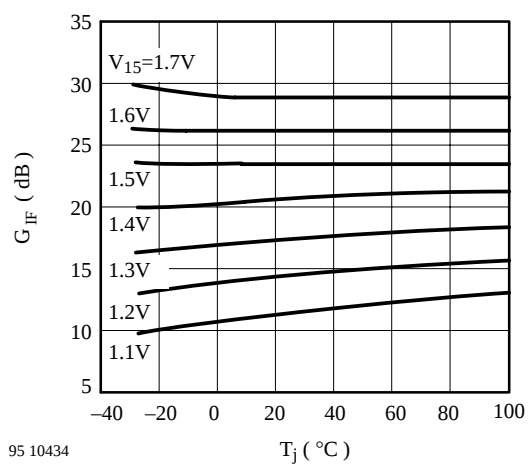


Figure 34. G_{IF} vs. T_j

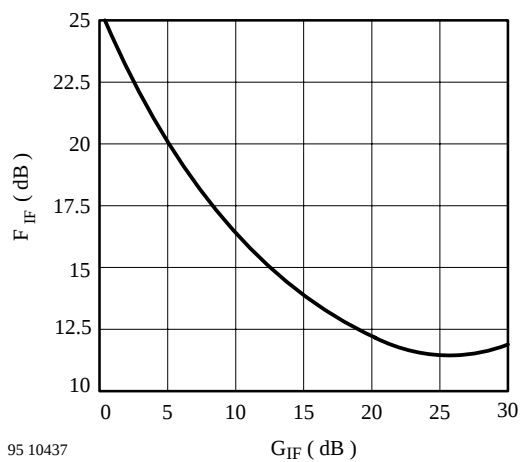


Figure 37. F_{IF} vs. G_{IF}

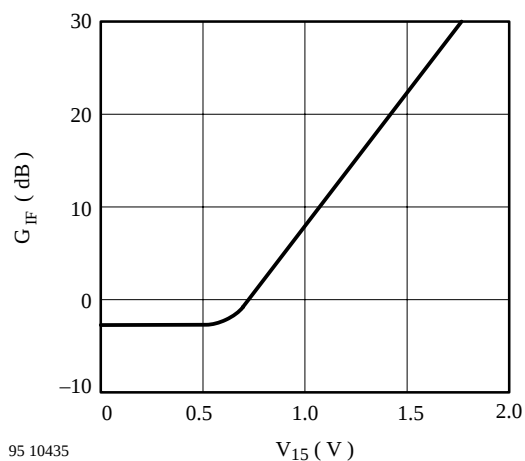


Figure 35. G_{IF} vs. V_{15}

Reference Voltage

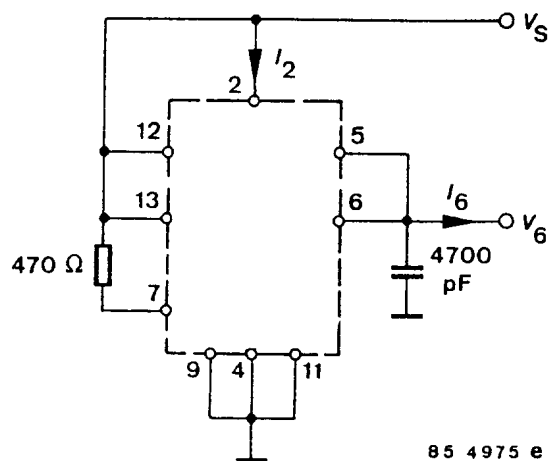


Figure 38. Test circuit

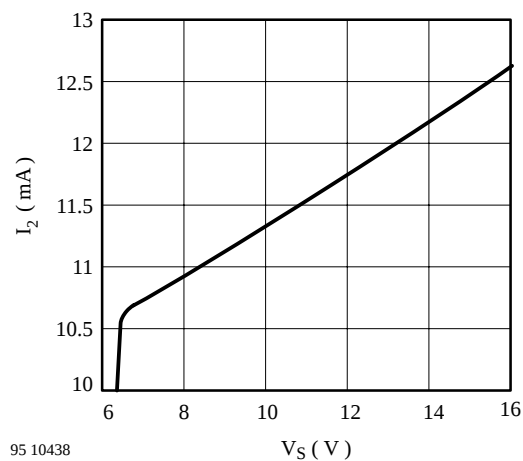


Figure 39. I_2 vs. V_S

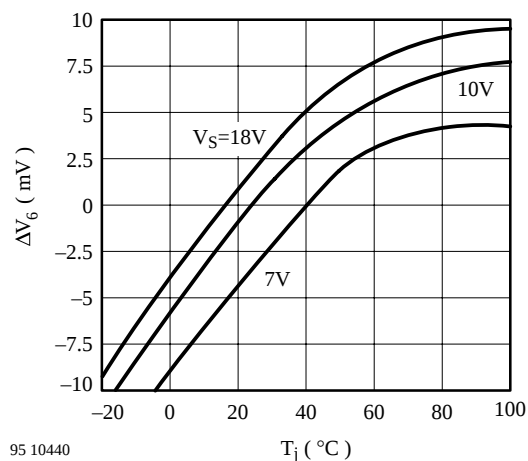


Figure 41. ΔV_6 vs. T_j

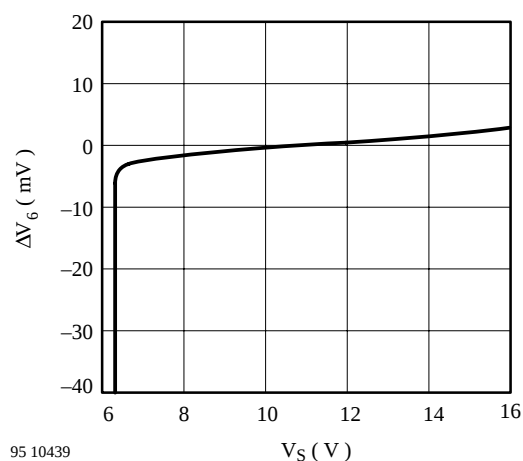


Figure 40. ΔV_6 vs. V_S

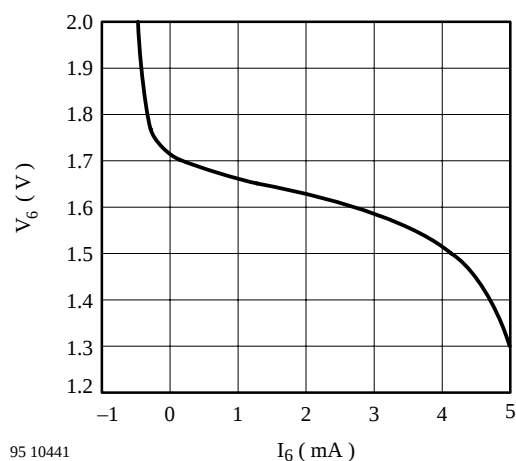
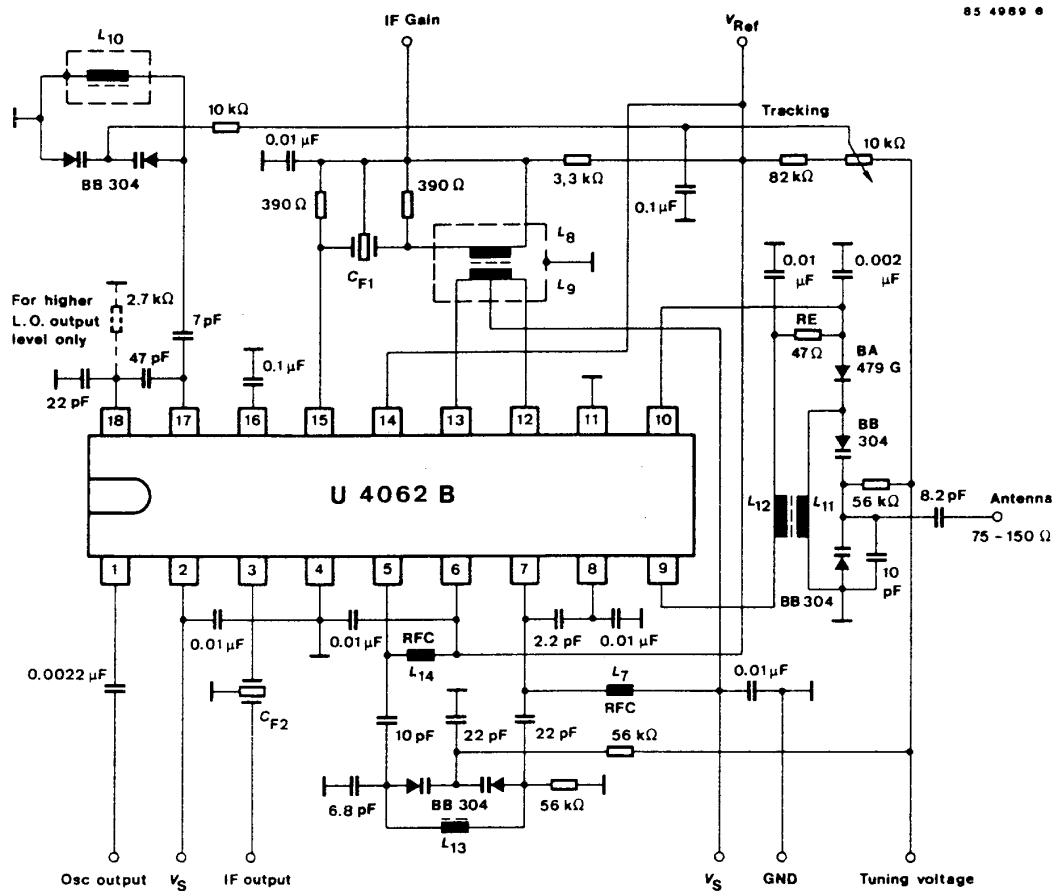


Figure 42. V_6 vs. I_6

Application Circuit



Circuit (section) from above diagram with keyed AGC

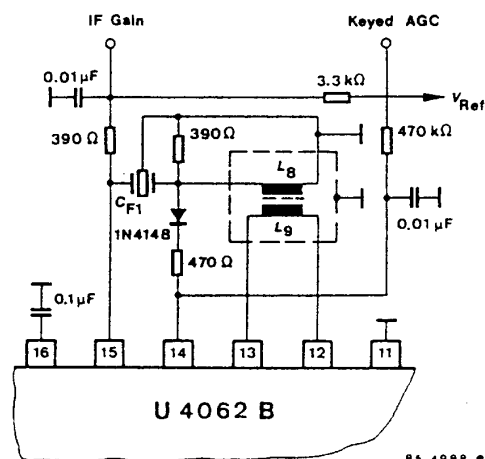


Figure 43. Typical Application circuit for high performance FM front end using non-repetitive alignment concept

Coils Specifications

L ₈ /L ₉	Toko 7 PL9/ (18 + 18) turns Nr. 218 ANS – 788 N
L ₁₀	Toko 7 K1 3 turns Nr. 291 ENS – 2054 IB or Toko MC 122 Nr. E528 SNAS – 100075
L ₁₁ /L ₁₂	Toko 7 K1 without case 4/8 turns Nr. 291 ENF – 2342 x
L ₁₃	Toko 7 K1 4 turns Nr. 291 ENS – 2341 IB or Toko MC 122 Nr. E528 SNAS – 100076
L ₁₄ /L ₁₇	Choke 1.5 µH Toko 348 LS – 1R5 or similar
CF1; CF2	Toko CFSK – 107M3 or similar
V _S = 8.5 V, T _{amb} = 25°C	

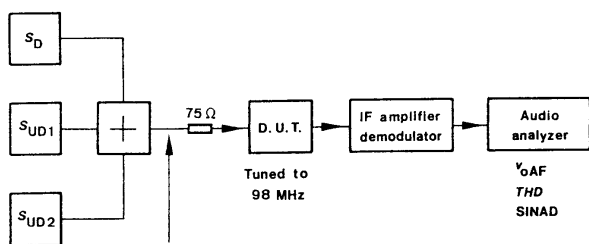
Electrical Connections	Pin DIP18	Voltage (DC) in V
LO output	1	1.73
V _S	2	8.5
IF output	3	6.1
Ground	4	0
Mixer input	5	1.7
Reference output voltage	6	1.7
RF preamplifier (collector)	7	8.5
RF preamplifier (base)	8	1.3
RF preamplifier (emitter)	9	0.53
AGC output	10	0.07
Ground	11	0
Mixer output	12	8.5
Mixer output	13	8.5
AGC input	14	1.7
IF input, IF gain control	15	1.54
AGC time constant	16	1.06
LO (base)	17	3.2
LO (emitter)	18	2.51

FM Front End Data Using Application Circuit

Antenna impedance 75 Ω, Z_{load} IF = 330 Ω, V_S = 8.5 V, T_{amb} = 25°C

Characteristics	Symbol	Min.	Typ.	Max.	Unit
Supply current	I _S		32		mA
Tuning range	f	88		108	MHz
Tuning voltage – at 88 MHz (equal IC's reference voltage) – at 108 MHz	V _{tune} V _{tune}		1.7 6.5		V V
Center IF	f		10.7*		MHz
IF output bandwidth at –3 dB	B _{IF}		130*		kHz
Power gain	G		46*		dB
Gain variation versus the band	ΔG		1		dB
Noise figure	NF		6		dB
Image rejection		57	70		dB
RF intermodulation			70		dB
1/2 IF rejection			90		dB
Spurious response, second osc. harmonic			90		dB
IF rejection		85			dB
Osc. output voltage at 520 Ω load	V _{OSC}		200		mV

* Depending on ceramic IF filters to be used



$V_{iD}(f_D)$ = Desired signal (EMF)
 $V_{iUD1}(f_{UD1})$
 $V_{iUD2}(f_{UD2})$ } = Undesired signals (EMF)

Figure 44. Block diagram of the test set up

Test conditions

- De-emphasis - 75μs
- AF bandwidth 30 to 20 kHz
- RMS, unweighted

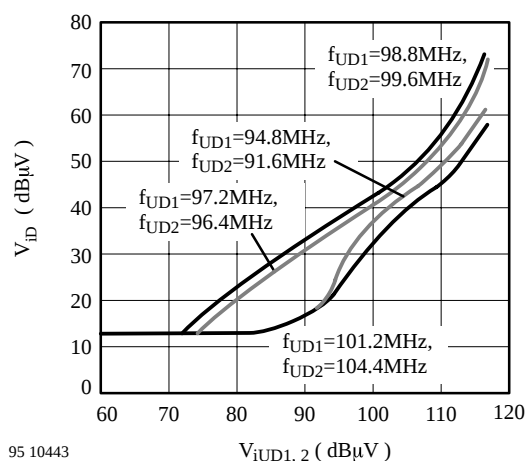
Setup for one signal measurement

- $f_D = 98 \text{ MHz}$

Note: V_{oAF} related to 75 kHz dev., 1 kHz, $V_{iD} = 66 \text{ dB } \mu\text{V}$

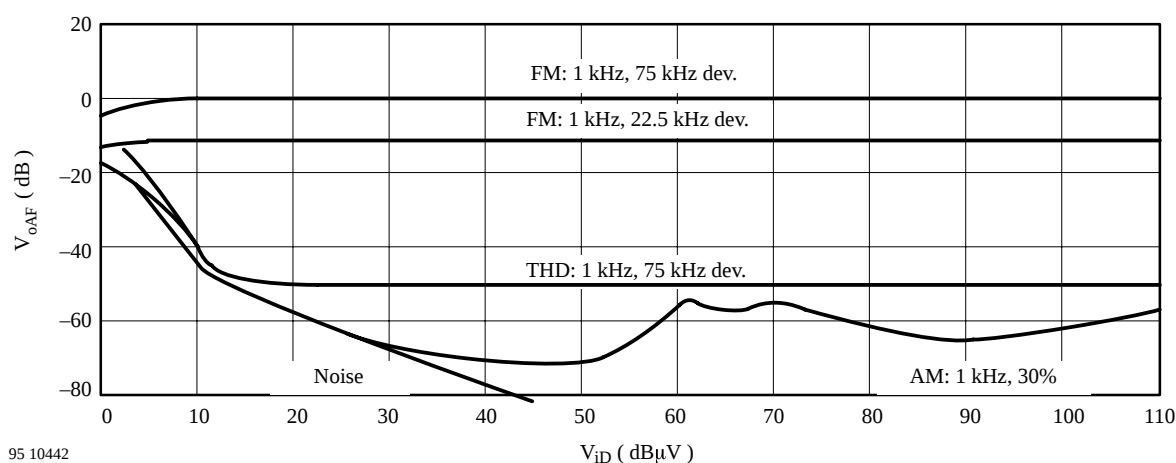
Setup for three signals intermodulation measurement

- S_D : $f_D = 98 \text{ MHz}$, FM: 1 kHz, 22.5 kHz dev.
- S_{UD1} : FM: 0.15 kHz, 22.5 kHz dev.
- S_{UD2} : Unmodulated
- V_{iD} : for 35 dB SINAD



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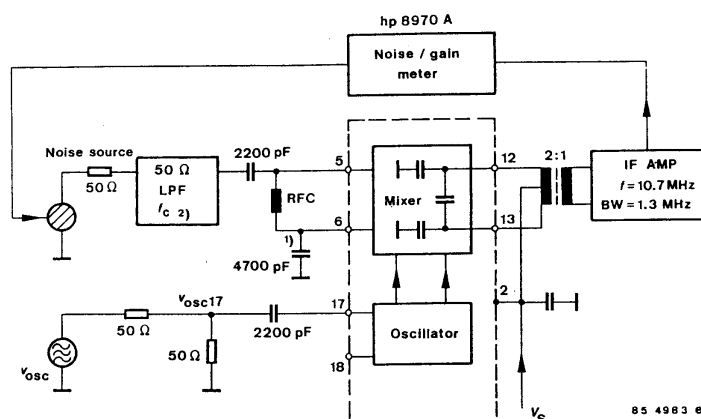
Figure 45. V_{iD} vs. $V_{iUD1,2}$
 V_{iD} = input desired, V_{iUD} = input undesired



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Figure 46. V_{oAF} vs. V_{iD}

VHF/UHF-Application



- 1) Mounted as close as possible between Pin 6 and Ground
 2) Cut off frequency, f_c adjustment: $(f_{osc} + f_{IF}) < f_c < (2 f_{osc} - f_{IF})$

Figure 47. Test circuit for conversion gain and noise measurement

Mixer, VHF Characteristics

Test conditions: $R_{g5} = 50 \Omega$, $R_{L12-13} = 200 \Omega$, $V_S = 10 V$
 $f_{IF} = 10.7 \text{ MHz}$, $f_{IRF} = 200 \text{ MHz}$, $f_{OSC} = f_{IRF} + f_{IF}$, $V_{OSC17} = 140 \text{ mV}$

Parameter	Symbol	Typ.	Unit
Conversion power gain, $f_{IF} = 10.7 \text{ MHz}$	G_C	2.5	dB
$f_{IF} = 70 \text{ MHz}$	G_C	2.3	dB
Double side band noise figure $f_{OSC} = 200 \text{ MHz}$	NF_{DSB}	8.2	dB
3rd order intercept input signal level	IP_3	5.5	dBm
Parallel input resistance, Pin 5, $f = 200 \text{ MHz}$	R_{p5}	1500	Ω
Parallel input capacitance, Pin 5, $f = 200 \text{ MHz}$	C_{p5}	3.3	pF
Parallel input resistance, Pin 17, $f = 200 \text{ MHz}$	R_{p17}	4000	Ω
Parallel input capacitance, Pin 17, $f = 200 \text{ MHz}$	C_{p17}	2.7	pF
Conversion transconductance	G_C	6.4	m-mho

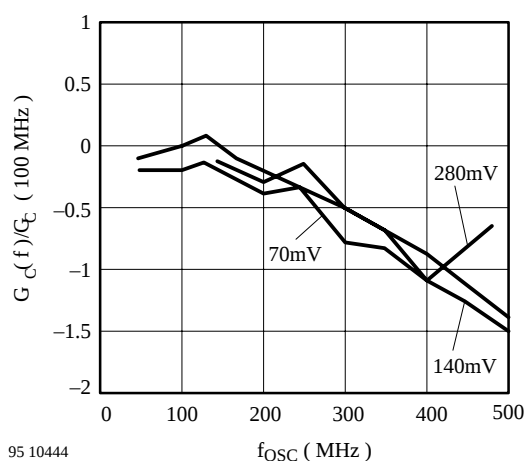


Figure 48. G_C vs. f_{OSC}

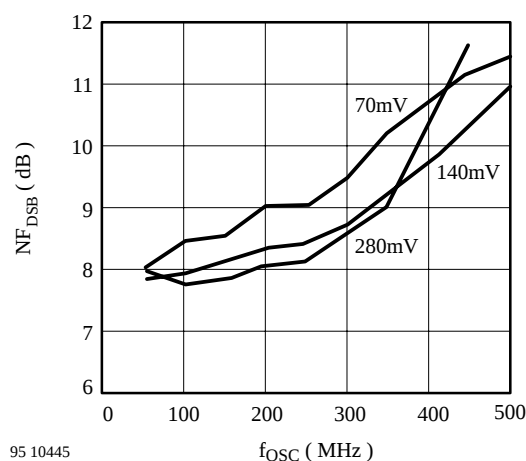
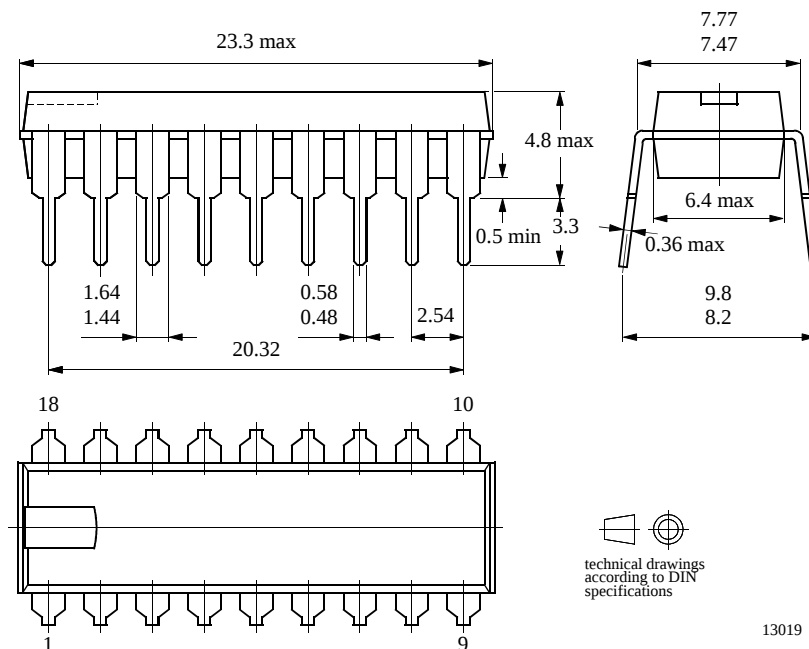


Figure 49. NF_{DSB} vs. f_{OSC}

Package Information

Package DIP18

Dimensions in mm



Ozone Depleting Substances Policy Statement

It is the policy of **TEMIC Semiconductor GmbH** to

1. Meet all present and future national and international statutory requirements.
2. Regularly and continuously improve the performance of our products, processes, distribution and operating systems with respect to their impact on the health and safety of our employees and the public, as well as their impact on the environment.

It is particular concern to control or eliminate releases of those substances into the atmosphere which are known as ozone depleting substances (ODSs).

The Montreal Protocol (1987) and its London Amendments (1990) intend to severely restrict the use of ODSs and forbid their use within the next ten years. Various national and international initiatives are pressing for an earlier ban on these substances.

TEMIC Semiconductor GmbH has been able to use its policy of continuous improvements to eliminate the use of ODSs listed in the following documents.

1. Annex A, B and list of transitional substances of the Montreal Protocol and the London Amendments respectively
2. Class I and II ozone depleting substances in the Clean Air Act Amendments of 1990 by the Environmental Protection Agency (EPA) in the USA
3. Council Decision 88/540/EEC and 91/690/EEC Annex A, B and C (transitional substances) respectively.

TEMIC Semiconductor GmbH can certify that our semiconductors are not manufactured with ozone depleting substances and do not contain such substances.

We reserve the right to make changes to improve technical design and may do so without further notice.

Parameters can vary in different applications. All operating parameters must be validated for each customer application by the customer. Should the buyer use TEMIC Semiconductors products for any unintended or unauthorized application, the buyer shall indemnify TEMIC Semiconductors against all claims, costs, damages, and expenses, arising out of, directly or indirectly, any claim of personal damage, injury or death associated with such unintended or unauthorized use.

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