Wireless Components

Application Note of ISDB-T Tuner with TUA 6034T

Version 1

Applications of IC TUA6034T :
Specially Suitable for Digital Broadcasting Standards
like DVB-T, DVB-C, ISDB-T, ATSC, etc.

Overview of the ISDB-T Tuner

Single Conversion Tuner
for ISDB-T application

With Infineon Components of

TUA 6034T Single Chip Mixer-Oscillator-PLL IC

BF 2030W self biasing MOSFET

BG 3130 Dual MOSFET

BB555, BB565, and BB659C Varactor Diodes

This very small sized single conversion tuner designed for ISDB-T front-end in the frequency range from 93 to 767 MHz can be used with minimum modifications for all digital broadcasting receptions. The tuner was developed as a real 3 band tuner concept, designed without switching diodes based on the Infineon 3 band tuner IC **TUA6034T** which has 3 mixer, 3 oscillators, separated SAW driver input, PLL, and balanced crystal oscillator for optimum digital front-end performance. The IC is particularly suitable for COFDM applications like DVB-T and ISDB-T that requires stringent close-in phase noise. The IC provides a balanced SAW filter driver output that is designed to drive a SAW filter directly.

The tuner is optimized for IF bandwidth = 6 MHz and IF center frequency = 57 MHz.
The frequency ranges of the tuner are as follows :

VHF I	:	93- 167 MHz
VHF II	:	173- 467 MHz
UHF	:	473- 767 MHz

All the passive and active components except air coils, 1 choke coil, are SMD components. The PCB is single-clad and the dimensions are 49.5 x 38.5 mm. The pin layout and the outline dimensions are designed according to the world standard tuner description, which is the current standard size of analog tuners in the market.

Semiconductors:

1 X TUA 6034T

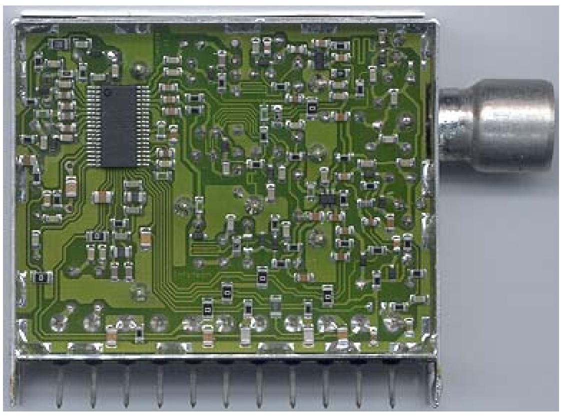
1 X BG3130

1 X BF 2030W

4 X BB 555

3 X BB 565

8 X BB 659C



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1. Tuner Design

1.1. Circuit Concept

The RF input signal is splitted by a simple high pass filter combined with IF & CB (Citizen Band) traps. Instead of band switching with PIN diodes a very simple triplexer circuit is used. With a high inductive coupling the antenna impedance is transformed to the tuned input circuits. The pre-selected signal is then amplified by the high gain self biased MOSFET **BF2030W** (UHF). One **BG3130 double-MOSFET** is used for both VHF bands. In the following tuned bandpass filter stage the channel is selected and unwanted signals like adjacent channels and image frequency are rejected. Tracking traps of prestages and capacitive image frequency compensations of band filters reject especially image frequencies.

The conversion to IF is done in the one chip tuner-PLL IC TUA 6034T. The **TUA6034T** is a real 3 band tuner IC which has all the active parts for the 3 mixers, 3 oscillators, an IF driver stage, the complete PLL functions including 4 PNP ports & 1 NPN port (ADC input) for the band switching, and a wideband AGC detector for internal tuner AGC. Combined with the optimized loop filter, 4 programmable charge pump currents, the balanced crystal oscillator, and the voltage controlled oscillators which have superb characteristics thanks to Infineon's B6HF technology, the tuner can achieve distinguished phase noise performance suitable for all digital applications. The balanced IF output signal of the **TUA6034T** is designed to drive directly a SAW filter in the following IF stage.

The tuner consumes less than 90 mA currents or 0.45 Watt power. This can be a big advantage for portable or handheld appliances.

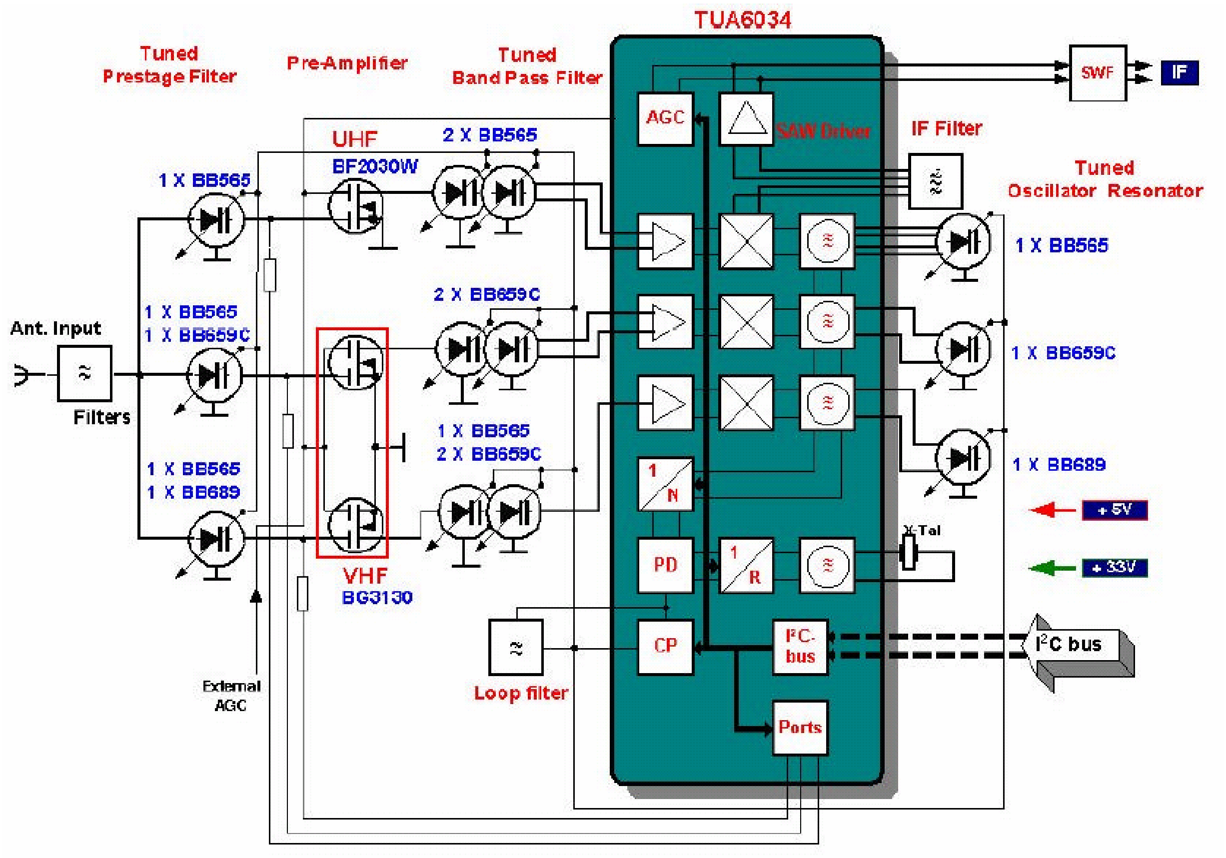


Fig. 1. Example of a circuit concept diagram of an ISDB-T tuner

1.2. UHF RF Block

With the wide range ultra linear varactor diode **BB555** it has become possible to design an UHF band without coupling diodes and without compensating coils for extending the frequency ratio in the tuned filters. To get a good tracking without a coupling diode between the input filter and the MOSFET the point of coupling is set between the tuning diode and the series capacitor, and not at the high end of the resonant circuit.

The bandpass stage is an inductive low end coupling filter, which concurrently provides the transformation from unbalanced to balanced. Also thanks to the matched image filters on both prestage and band pass filter stage, better than 80dB image rejection can be achieved over the whole UHF band. By means of simple gate 1 switching through PNP ports, pre-amplifiers are selected.

1.3. VHFH RF Block

For VHFH band, high quality ratio-extended varactor diode, **BB659C** is used. To compensate gain, one additional coupling diode, **BB565** is placed in the prestage of VHFH.

The RF bandpass filter is unbalanced on the primary side, and balanced on the secondary side just like UHF band pass filter. The coupling between filters is realized via a printed inductor. The mixer input circuit is optimized to protect the mixer from overloading. Image rejection filters work as those of UHF block.

1.4. VHFL RF Block

For the wide VHFL frequency range a tuning diode with an extended capacitance ratio is required. **BB659C** is a tuning diode, which was developed to cover the wide frequency range of Hyperband tuner and at the same time shows a low series resistance. 2 x **BB565** are used for coupling to achieve improved RF characteristics.

The RF band pass filter is unbalanced, and is also coupled asymmetrically to the high ohmic VHFL mixer, which has no negative effects due to the relatively low frequencies involved.

After the RF Block circuit design it is preferable to do block simulations to confirm its frequency dependent characteristics.

1.5. Phase noise

The oscillator tank circuits were carefully optimized for oscillator range, stability and phase noise. The layout is also optimized to prevent any kind of unwanted parasitic oscillations, capacitors of the resonators could be temperature-compensated if necessary. N750 type is recommended for this purpose.

Phase noise influences two important system performances: One is receiver selectivity by reciprocal mixing in Fig. 2, and the other is receiver sensitivity or SNR, which decides BER (Bit-Error-Rate) of the digital system combined with other noise sources like prestage noise figures, image noise, etc.

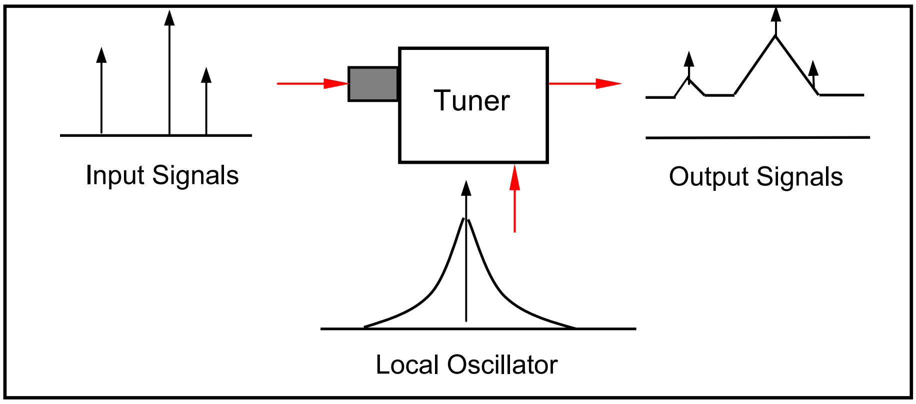


Fig. 2. Reciprocal Mixing Model

To design optimum resonators for the IC, the well-known Leeson's equation[1] should always be reflected. Even though there is an improved phase noise model[2] for better phase noise analysis and prediction, Leeson's equation is still a basis of all those new approaches.

$$L(fm) = 10\log\left[\frac{1}{2}\left[\left(\frac{fo}{2QLfm}\right)^2 + 1\right]\left(\frac{fc}{fm}+1\right)\left(\frac{FkT}{Ps}\right)\right]$$

L(fm) is the ratio of noise power in a 1-Hz bandwidth in units of dBc/Hz. fo is the frequency of oscillation. fc is the flicker noise corner. F is the noise figure of the oscillator. Ps is the carrier power. K is the Boltzmann's constant, 1.38×10^{-23} J/K. T is the Kelvin temperature. Q_L is the loaded Q factor.

Infineon Technologies B6HF bipolar process with a transit frequency (f_T) of 25 GHz to produce **TUA6034T** can satisfy a low intrinsic F requirement of oscillator. The external applications of the oscillator should be carefully designed not to degrade Q with regard to stable oscillation.

[1]. *G.Vendelin, A.Pavio, U.Rohde, Microwave Circuit Design using Linear & Nonlinear Techniques, John Wiley & Sons, New York,*
1992, pp.385-491.

[2]. *Hajimiri, A., & Lee, T.H., A genaral theory of phase noise in electrical oscillators, IEEE journal of solid-state circuits, Vol.33, No.2, pp.179-194.*

The critical role of loop filter is to remove the reference spurs produced by the phase detection process, which is fundamentally a sampled system in digital implementations. Since the control voltage directly modulates the frequency of the VCO, any AC components of tuning voltage results in a frequency modulation of the oscillator. If these components are periodic, they produce stationary side-bands like reference spurs. Because of the wide tuning range of the tuner, the tuning sensitivity of the tuner can go up to 35 MHz/V, so even a few millivolts of noise on the tuning lines will generate noticeable spectral interference.

The oscillator's output now has the benefits of phase locking such as improved stability and phase noise and this is another crucial function of PLL. By determining a proper loop bandwidth, optimum phase noise characteristics of the reference oscillator and the local oscillator can be utilized. For a given loop bandwidth, a higher order filter provides more attenuation of out-of-band spectral components. However, the higher the order, the more poles there are, and it means it gets harder to make the loop stable. The loop bandwidth and loop filter components should be carefully selected to achieve optimal phase noise and to reject reference spurs. 4 extended modes of charge pump currents also must be appropriately chosen and used for best phase noise performance of different frequency ranges. For this tuner design ISDB-T recommended f_{ref} = 142.857 kHz is used for all loop filter calculations and measurements.
A 3rd order passive loop filer is chosen for the tuner design. The following are simplified procedures to decide the loop filter components.

1. *Define the basic synthesizer requirements ; oscillator frequency ranges, f_{ref}, maximum frequency step, f_{BW} (Loop Bandwidth, Hz) with deep consideration of in-out band phase noise.*

2. *Identify K_{vco} (VCO sensitivity, Hz/V) and I_{cp} (charge pump current, A).*

3. *Calculate $F_{step} = f_{vco\_max} - f_{vco\_min}$, to optimize for f_{vco_max}*

4. *Calculate $N = f_{vco\_max} / f_{ref}$, to optimize for f_{vco_max}.*

5. *Calculate natural frequency, F_n ; ζ = damping factor*

$$Fn = \frac{2\times f_{BW}}{2\pi\times(\zeta+\frac{1}{4\times\zeta})} \quad \text{Hz} \qquad (2)$$

6. *Calculate C68 ;*

$$C68 = \frac{I_{cp}\times K_{vco}}{N\times(2\pi\times F_n)^2} \quad \text{Farad} \qquad (3)$$

7. *Calculate R39, and its phase noise contribution. This completes the main part of the loop filter.*

$$R39 = 2\times\zeta\times\sqrt{\frac{N}{I_{cp}\times K_{vco}\times C68}} \quad \text{Ohm} \qquad (4)$$

$$L_{\Phi}(fm) = 20\log\left(\frac{K_{vco}\sqrt{2k\times T\times R39}}{fm}\right) \quad \text{dBc/Hz} \qquad (5)^{3}$$

8. *Calculate C65, which is used to damp transients from the charge pump and should be at least 20 times smaller than C69, i.e.,*

$$C69 \le \frac{C68}{20}$$

[3]. *G.Vendelin, A.Pavio, U.Rohde, Microwave Circuit Design using Linear & Nonlinear Techniques, John Wiley & Sons, New York, 1992, pp.436.*

9. Calculate R40 & C24 within these limits and the phase noise contribution of R40 by Eq. (5).

$$\tau 1 = C68 \times R39, \tau 2 = C24 \times R40, \qquad 0.01 < \frac{\tau 2}{\tau 1} < 0.1$$

A bigger time constant results in somewhat better filtering action, but tends to be associated with lower stability.

10. In order to have the confidence in the stability of the loop, an open loop analysis is performed to estimate the gain and phase margin. By closed loop analysis we can obtain the frequency response & transient response of the loop. We use a mathmatic tool to analyse these parameters though a spreadsheet program is enogh for the above calculations.

Typically the crystal oscillator used for the reference has very good phase noise that then levels off near 10 kHz offset at around –150 dBc/Hz. The free running oscillator to be phase locked typically has much higher close in noise but continues down to around –120 dBc/Hz beyond 1 MHz. At some offset the reference noise multiplied up to the output frequency becomes higher than the oscillator's free running noise. This is the point where normally the loop bandwidth is set.

Inside the loop the oscillator noise is improved by the reference, yet outside the loop is not degraded by the reference. Because of the wide tuning range of the tuner oscillator the loop bandwidth should be very carefully chosen with deep consideration of these noise contribution mechanism.

The phase noise level within the loop bandwidth can be approximated by

$$Close\_in\_phase\_noise = (1Hz\_normalized\_phase\_noise\_floor) + 20\log N + 10\log f_{ref} \qquad (6)$$

There are other sources of phase noise that need to be considered when designing the tuner. One of the most common sources of noise is the power supply to the IC. This can be caused in many ways, but most commonly are due to supply ripple and electric or magnetic coupling to +5 V line. Correct PCB layout and good AC blocking are critical to ensure good noise performance. The highest level signal line in the tuner is the IF output line, and all those sensitive blocks like oscillator, loop filter and long DC lines should be well-protected from coupling by IF lines.

1.6. IF Block

The **TUA6034T** has separated mixer outputs and SAW driver inputs to realize an IF filter of band pass filter structure that helps much better adjacent channel rejection. Especially in simulcasting signal environment as in Fig.5, it is a big advantage combined with **internal AGC** of TUA6034T to efficiently suppress strong adjacent PAL signals. The tuner provides a balanced IF output to drive directly a **SAW** filter.

2. PCB

Single-clad, 1.5 mm thickness FR4 PCB is used for the tuner design. However, double-clad PCB will give more chances to achieve better performance.

3. TUA 6034T, One-Chip Multimedia Tuner IC

3.1 Highlights

Features

- **Suitable for DVB-C, DVB-T, ISDB-T and ATSC**
- Wideband AGC detector for internal tuner AGC
  - 5 programmable take-over points
  - 2 programmable time constants
- **Low Phase Noise**
- **Full ESD protection**
- **Mixer / Oscillator**
  - High impedance mixer input (common emitter) for LOW band
  - Low impedance mixer input (common base) for MID band
  - Low impedance mixer input (common base) for HIGH band
  - 2 pin oscillator for LOW band
  - 2 pin oscillator for MID band
  - 4 pin oscillator for HIGH band
- **IF-Amplifier**
  - IF preamplifier with symmetrical 75 Ω output impedance able to drive a SAW filter
- **PLL**
  - 4 independent I^2C addresses
  - I^2C bus protocol compatible with 3.3 V and 5 V micro-controllers up to 400 kHz
  - Short lock-in time
  - High voltage VCO tuning output
  - 4 PNP ports, 1 NPN port / ADC input
  - Internal LOW / MID / HIGH band switch
  - Lock-in flag
  - 6 Programmable reference divider ratio (24, 28, 32, 64, 80, 128)
  - 4 Programmable charge pump currents (50, 125, 250, 650 uA)
- **TSSOP-38 and VQFN-40 package on demand**

3.2 Block diagram

In the block diagram the internal structure of the IC is shown in Fig. 3.

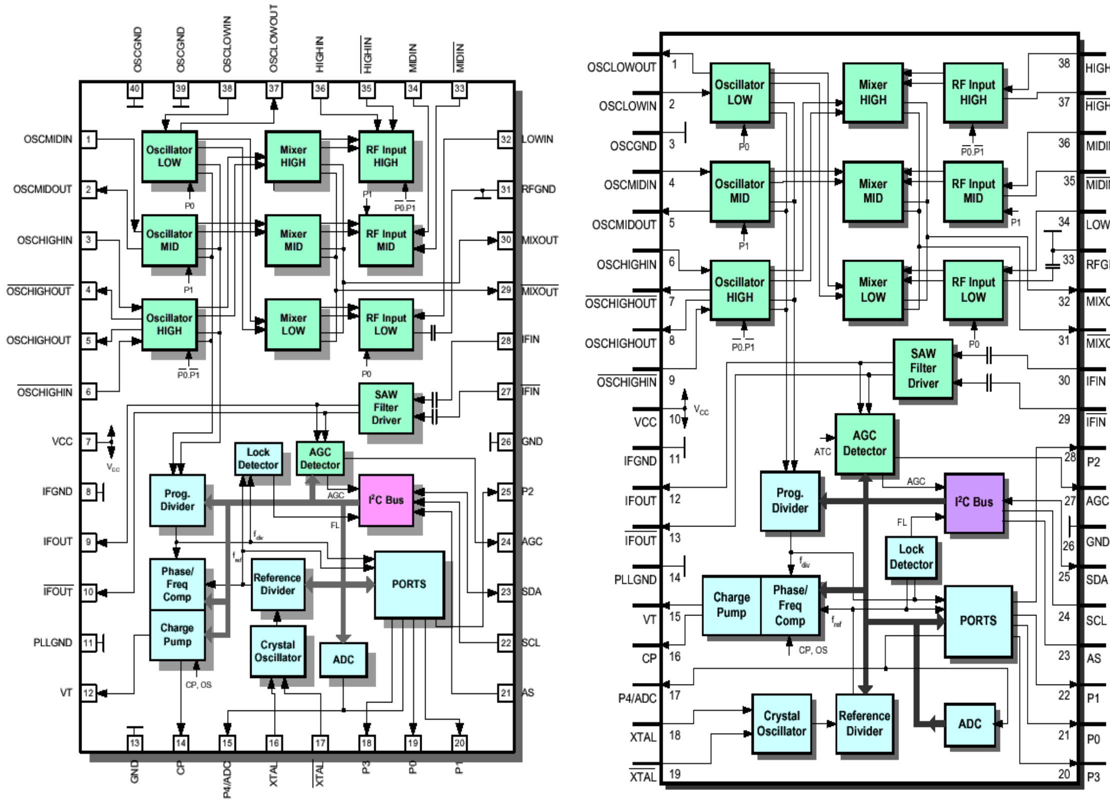


Fig. 3. Block Diagram of TUA6034T, VQFN-40 and TSSOP-38 package

TUA6034T combines a mixer-oscillator block with a digitally programmable phase locked loop (PLL) for use in broad-multimedia frontend applications. The mixer-oscillator block includes three balanced mixers (one mixer with an unbalanced high-impedance input and two mixers with a balanced low-impedance input), two 2-pin asymmetrical oscillators for the LOW and the MID band, one 4-pin symmetrical oscillator for the HIGH band, an IF amplifier, a reference voltage, and a band switch. Mixer outputs and IF amplifier inputs are separated to make it possible to realize a band pass IF filter to suppress adjacent channels efficiently.

The PLL block with four independently selectable chip addresses forms a digitally programmable phase locked loop. With a 4 MHz balanced reference quartz oscillator, the PLL permits precise setting of the frequency of the tuner oscillator up to 1024 MHz in increments, f_{ref} of 31.25, 50, 62.5, 125, 142.86 or 166.667 kHz. The tuning process is controlled by a microprocessor via I²C bus. The device has 5 output ports; one of them (P4) can also be used as ADC input port. A flag is set when the loop is locked. The lock flag can be read by the processor via the I²C bus. By means of 4 programmable charge pump currents, 50, 125, 250, and 650 uA tuner designers can choose an adequate charge pump current depending on their own loop filter design, frequency usage, and in-out band phase noise requirement.

4. Alignment

4.1 Alignment set-up

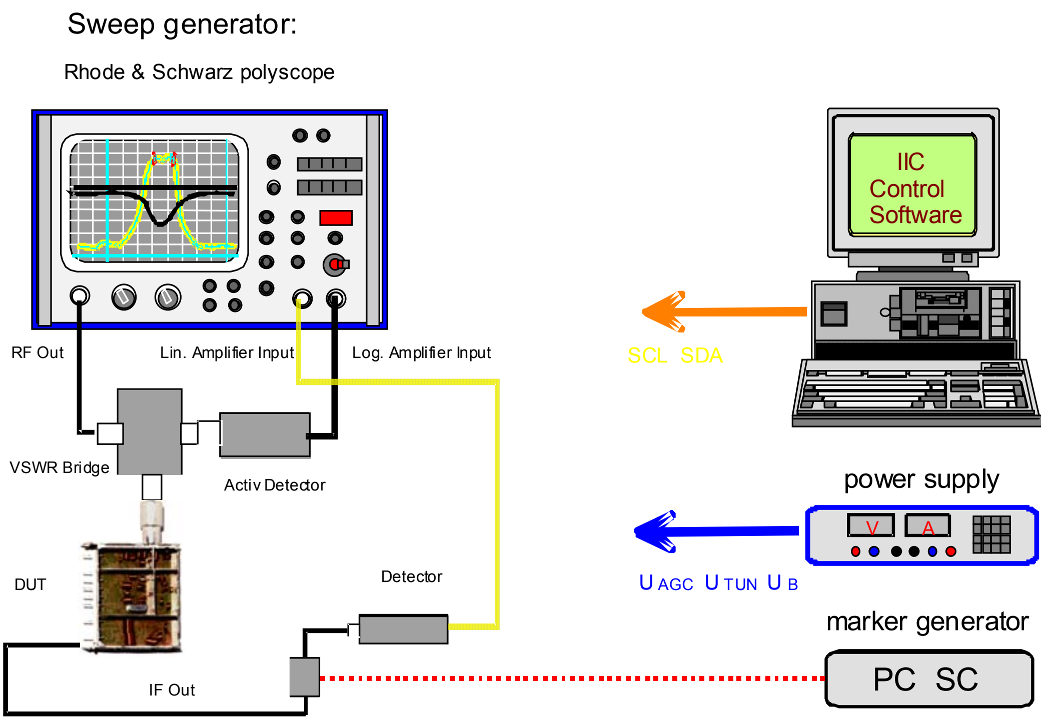
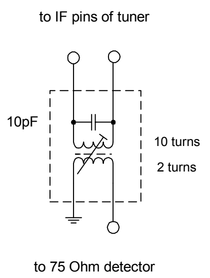


Fig. 4. Tuner Alignment Setup

This is an example of analog tuner alignment setup. The same setup can be used to align RF performance of ISDB-T tuner. IF center frequency of 57 MHz will be used for the overall alignment, and 3 points of IF frequencies, 54.0, 57.0 & 60.0 MHz should be monitored to align in-channel characteristics. Instead of a Polyscope we can use any type of network analyzer which has a conversion loss measurement function. With such a general-purpose network analyzer the system bandwidth and sampling points of the instrument should be adjusted for best resolution.

The sweep generator is connected via a return loss bridge to the antenna input of the tuner. Because of the balanced SAW driver output the 75 Ω detector has to be connected via a dummy balun simulating the SAW filter input impedance to the tuner output.

This dummy balun is also used for the measurements in the test set-up.



For digital tuner alignment only IF center frequency of 57 MHz can be used all through the alignment and measurement. The tuner is designed to cover IF bandwidth of 6 MHz between 54 MHz ~ 60 MHz.

The tuning voltage of each band should not fall below 1.0 V for lowest frequency and 28 V for highest frequency.

4.2 Alignment Procedures

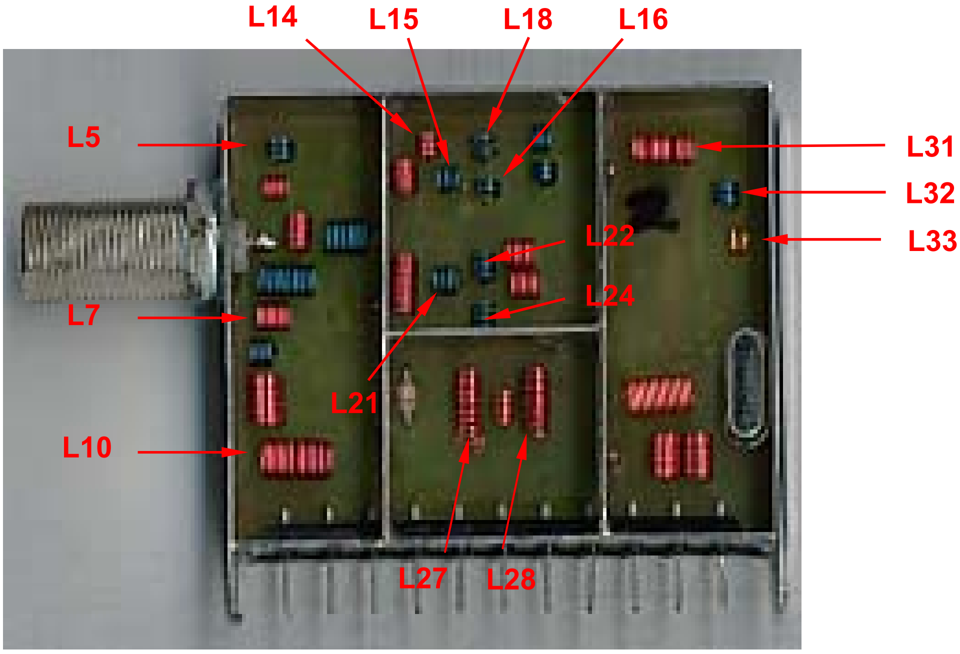


Fig. 5. Tuner module with coil marking

Presented on BOM, some coils should be pre-formed before starting alignment to align easily. Also all the coils must be checked whether they are in the right form, not distorted abruptly.

1. Current consumption & V_{tun} of the tuner must be monitored all through the alignment to check the proper operation of the IC. If the current consumption is over 100 mA, the IC must seem to be damaged. IF_{center} = 57 MHz.

2. UHF alignment :
   - Set the tuner to the highest channel of UHF band, frequency = 767.0 MHz and then adjust L33 to have $V_{tun} = 20.7 \pm 0.3$ V.
   - Adjust L5 for VSWR.
   - For RF curve & tilt adjust L15 first, and depending on the result, adjust L16 & L18. For highend fine-tuning, adjust L14 a little bit. If the pre-formation of L16, L18 is O.K., we need to touch only L15 & L14.
   - Sweep the whole band or selected channels, and do a fine tune once again if necessary.

3. VHFH alignment :
   - Set the tuner to the highest channel of VHFH band, frequency = 467.0 MHz and then adjust L32 to have $V_{tun} = 26.7 \pm 0.3$ V.
   - Adjust L7 for VSWR.
   - For RF curve & tilt adjust L21 first, and depending on the result, adjust L22 & L24 a little bit.
   - Sweep the whole band or selected channels, and do a fine tune once again if necessary.

4. VHFL alignment :
   - Set the tuner to the highest channel of VHFL band, frequency = 167.0 MHz and then adjust L31 to have V_{tun} = 16 ± 0.3 V.
   - Adjust L10 for VSWR.
   - For RF curve & tilt adjust L27 (main) & L28 a little bit.
   - Sweep the whole band or selected channels, and do a fine tune once again if necessary.

5. Measurement Results

5.1 Electrical characteristics of the Tuner

Unless otherwise specified all data were measured in conditions of supply voltage of +5 V ± 5%, AGC voltage of +4.5 V ± 5%, ambient temperature of +25 ºC ± 5%, f_{ref} of 142.857 kHz.

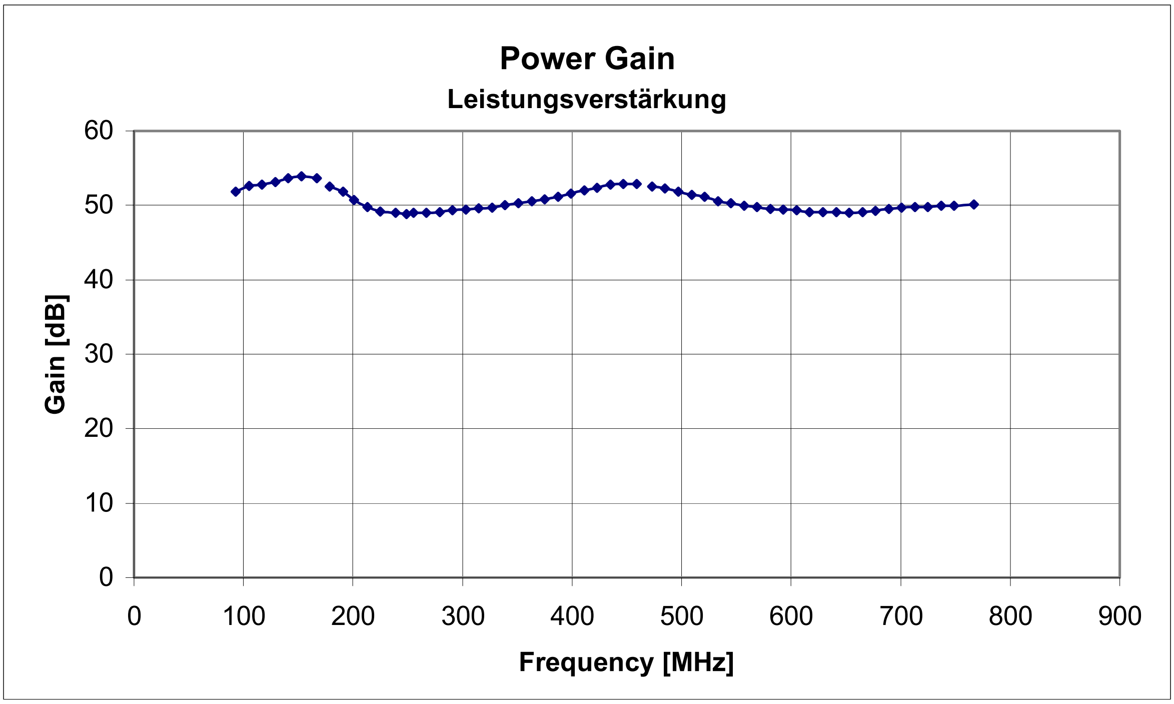
Parameter		min	typ.	max	Unit
Frequency range					
VHFL	93 ~ 167 MHz				
VHFH	173 ~ 467 MHz				
UHF	473 ~ 767 MHz				
IF center frequency			57		MHz
Frequency margin at low and high ends of each band		1.5			
Supply voltages and currents					
Supply voltage +5 V pin		4.5	5	5.5	V
Supply voltage VD pin (with PLL)		30	33	35	
Supply current +5 V pin				90	mA
Supply current VD pin (with PLL)				1.8	
Input connector: IEC					
RF Characteristics					
Input impedance			75		Ω
Output impedance with IF dummy			75		
VSWR at nominal gain and during AGC				5	
External AGC voltage for max gain		4.05	4.5	4.95	V
External AGC voltage for min gain		0.5			
Internal AGC voltage			3.8		
AGC range VHFL		60			dB
AGC range VHFH		60			
AGC range UHF		50			

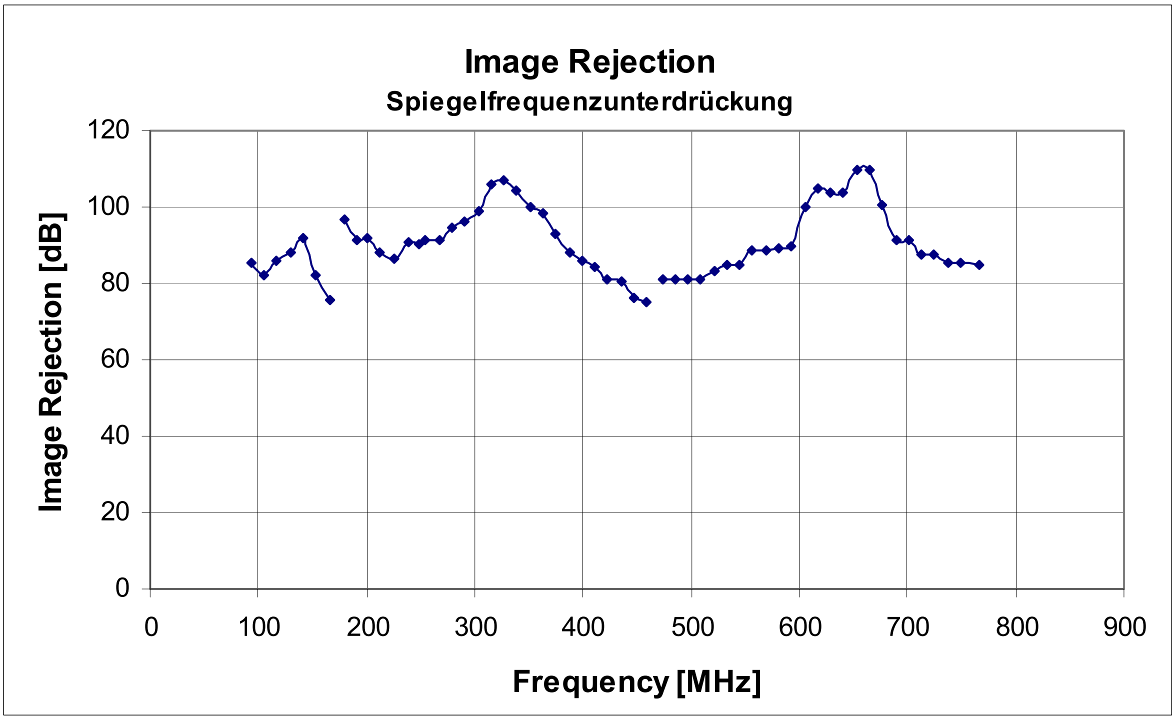
Tuning sensitivity VHFL Tuning sensitivity VHFH Tuning sensitivity UHF		6 12 16		MHz/V
Power gain measured with 10:2 IF dummy (dummy loss = 15 dB)		50		dB
Gain taper in each band			5	dB
Noise figure VHFL Noise figure VHFH Noise figure UHF		8 5 5	9 6 6	dB

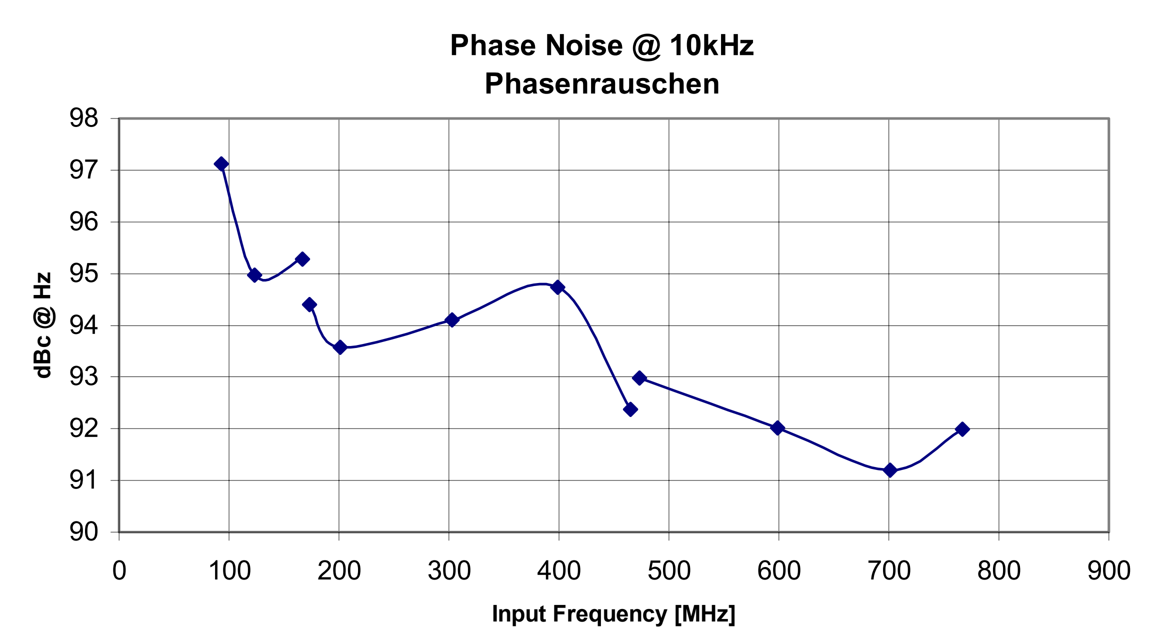
RF bandwidth (3 dB) VHFL RF bandwidth (3 dB) VHFH RF bandwidth (3 dB) UHF		8 8 8	15 15 15	MHz
Image rejection VHFL Image rejection VHFH Image rejection UHF	70 70 70	80 80 80		dB
IF rejection channel f = 93 MHz Other channels	60 80			dB
Input 1 dB compression Point	75			dBµV
Input IP3 (two tone)	70			
Input level producing 50 kHz of oscillator detuning (PLL open loop)	80			
Oscillator shift with supply voltage variation of ± 10 % (open loop)			± 250	kHz
Oscillator temperature drift 25...40 °C(open loop)			1	MHz
Antenna leakage up to 1 GHz			30	dBµV
Phase Noise 1 kHz offset 10 kHz offset 100 kHz offset	70 90 110			dBc/Hz
Cross modulation[4]				dBµV
N±1 Channel / disturbing voltage producing 1 % of Xmod	65			
N±2 Channel / disturbing voltage producing 1 % of Xmod	70			

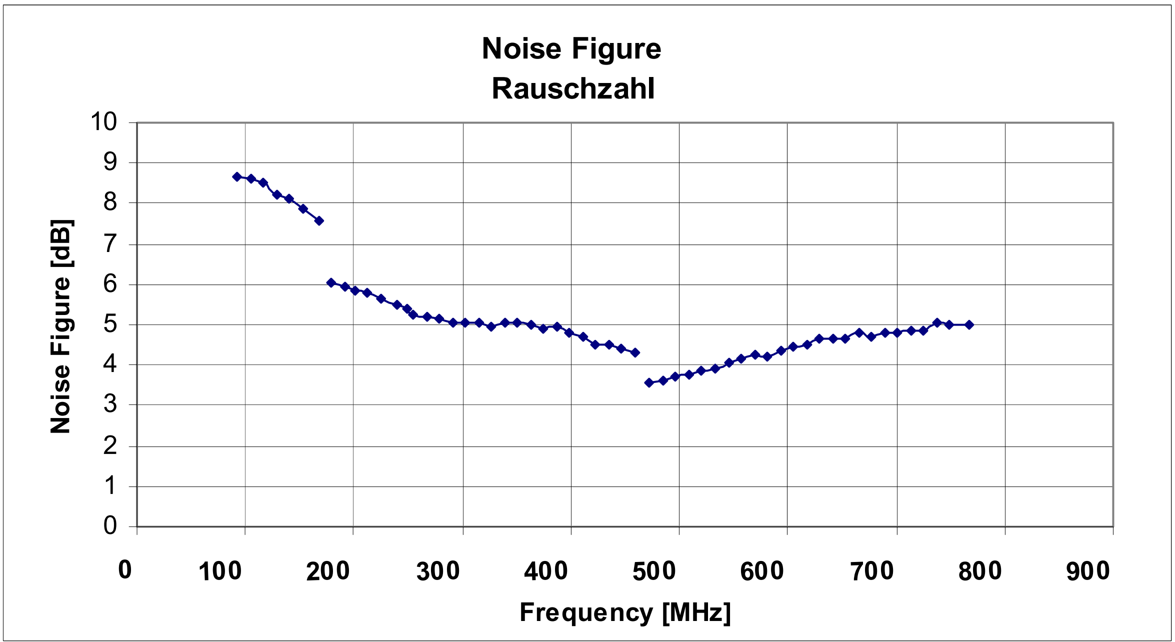
[4]. *Wanted signal 60 dBµV, unwanted signal 30% AM modulated with 2.5 kHz, AGC set to full of +4.5 V*

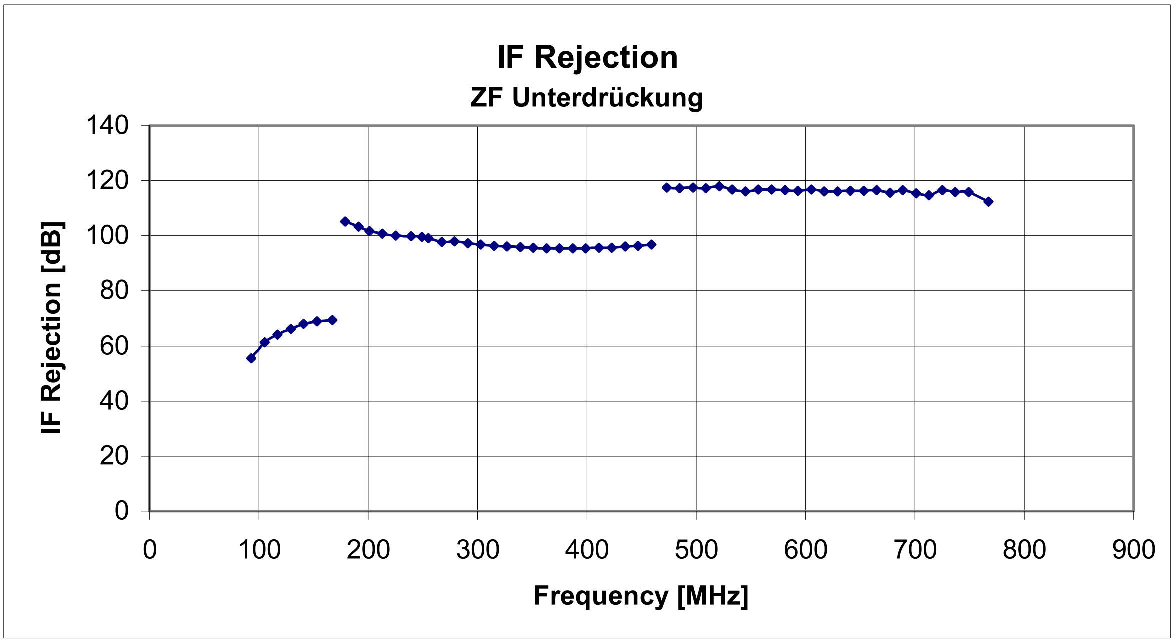
5.2 Measurement graphs:

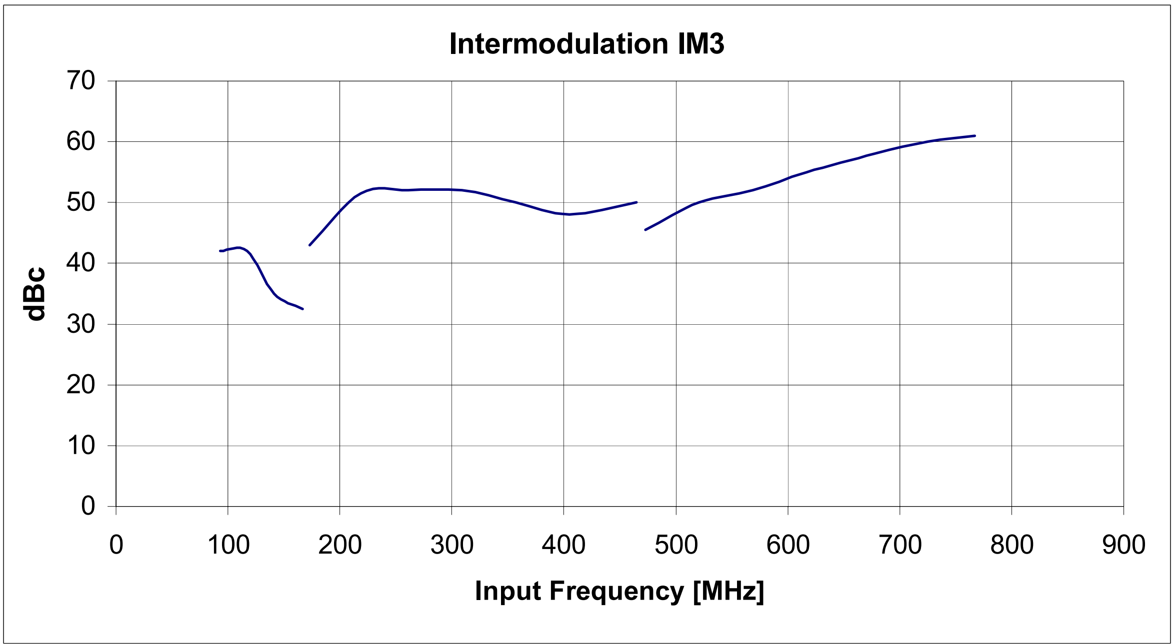


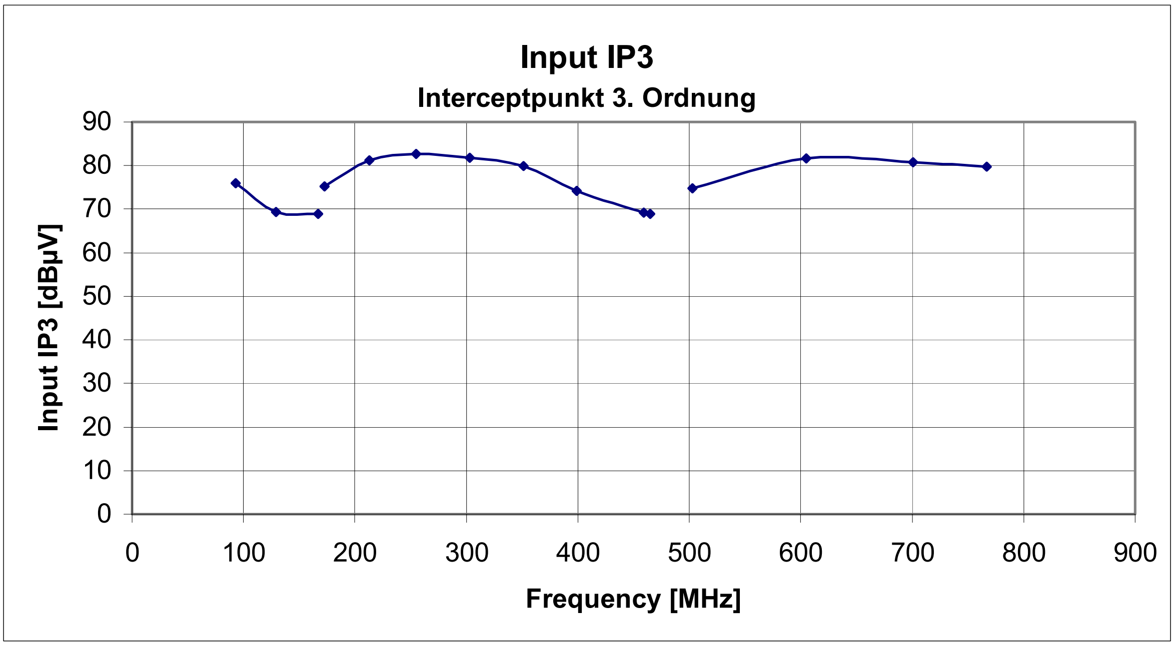


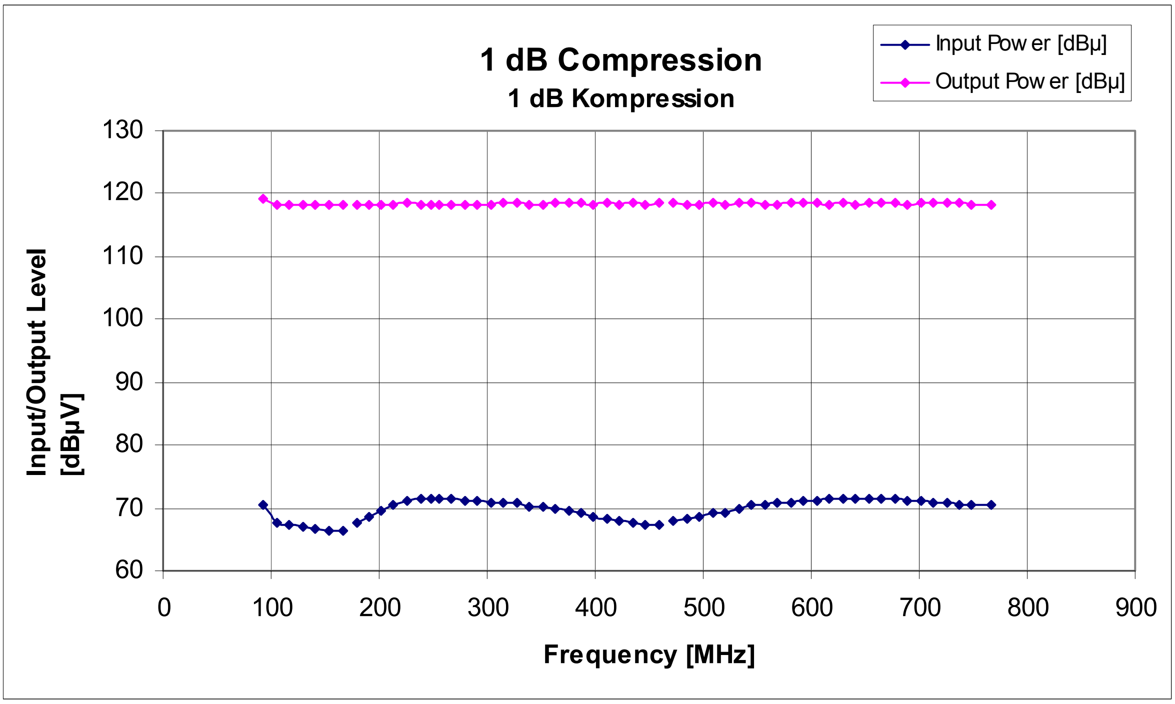

Phase Noise @ 10kHz
Phasenrauschen
dBc @ Hz
98
97
96
95
94
93
92
91
90
0
100
200
300
400
500
600
700
800
900
Input Frequency [MHz]

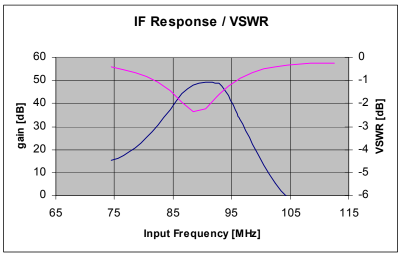

Noise Figure
Rauschzahl
Noise Figure [dB]
10
9
8
7
6
5
4
3
2
1
0
0
100
200
300
400
500
600
700
800
900
Frequency [MHz]

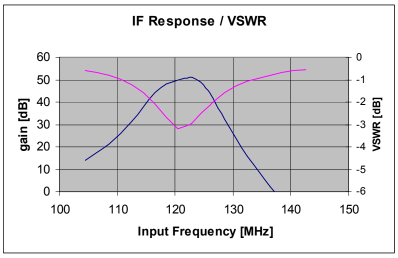

IF Rejection
ZF Unterdrückung
IF Rejection [dB]
140
120
100
80
60
40
20
0
0
100
200
300
400
500
600
700
800
900
Frequency [MHz]

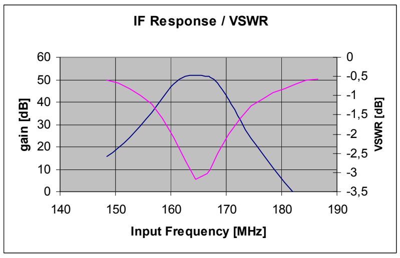

Intermodulation IM3
dBc
70
60
50
40
30
20
10
0
0
100
200
300
400
500
600
700
800
900
Input Frequency [MHz]

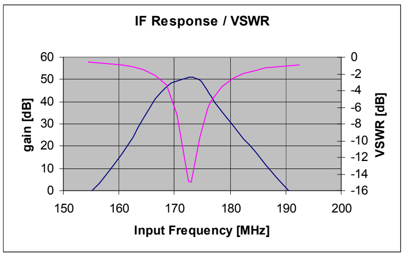

Input IP3
Interceptpunkt 3. Ordnung
Input IP3 [dBµV]
90
80
70
60
50
40
30
20
10
0
0
100
200
300
400
500
600
700
800
900
Frequency [MHz]

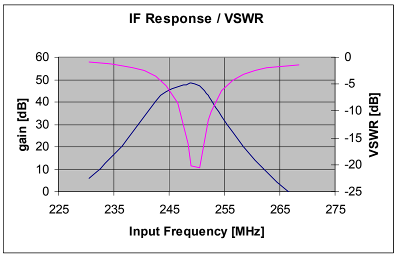

1 dB Compression
1 dB Kompression
Input Pow er [dBµ]
Output Pow er [dBµ]
Input/Output Level [dBµV]
130
120
110
100
90
80
70
60
0
100
200
300
400
500
600
700
800
900
Frequency [MHz]

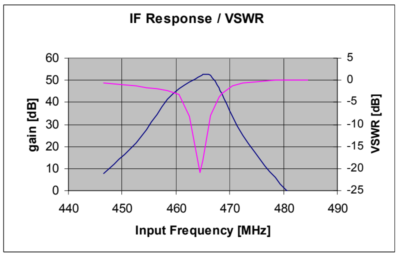

IF Response / VSWR
60
50
40
30
20
10
0
gain [dB]
0
-1
-2
-3
-4
-5
-6
VSWR [dB]
65
75
85
95
105
115
Input Frequency [MHz]

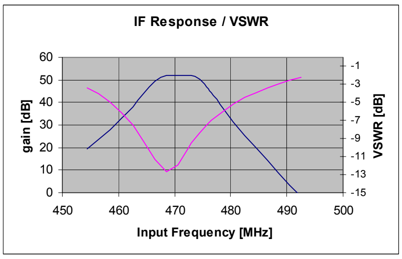

IF Response / VSWR
60
50
40
30
20
10
0
gain [dB]
0
-1
-2
-3
-4
-5
-6
VSWR [dB]
100
110
120
130
140
150
Input Frequency [MHz]

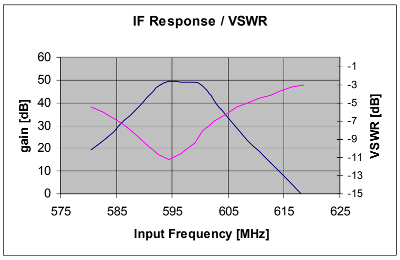

IF Response / VSWR
60
50
40
30
20
10
0
gain [dB]
0
-0,5
-1
-1,5
-2
-2,5
-3
-3,5
VSWR [dB]
140
150
160
170
180
190
Input Frequency [MHz]

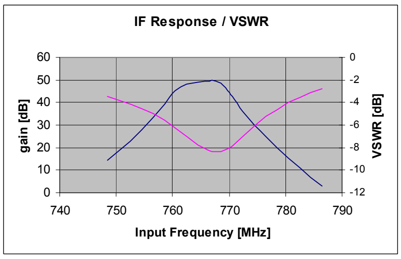

IF Response / VSWR
60
50
40
30
20
10
0
gain [dB]
0
-2
-4
-6
-8
-10
-12
-14
-16
VSWR [dB]
150
160
170
180
190
200
Input Frequency [MHz]

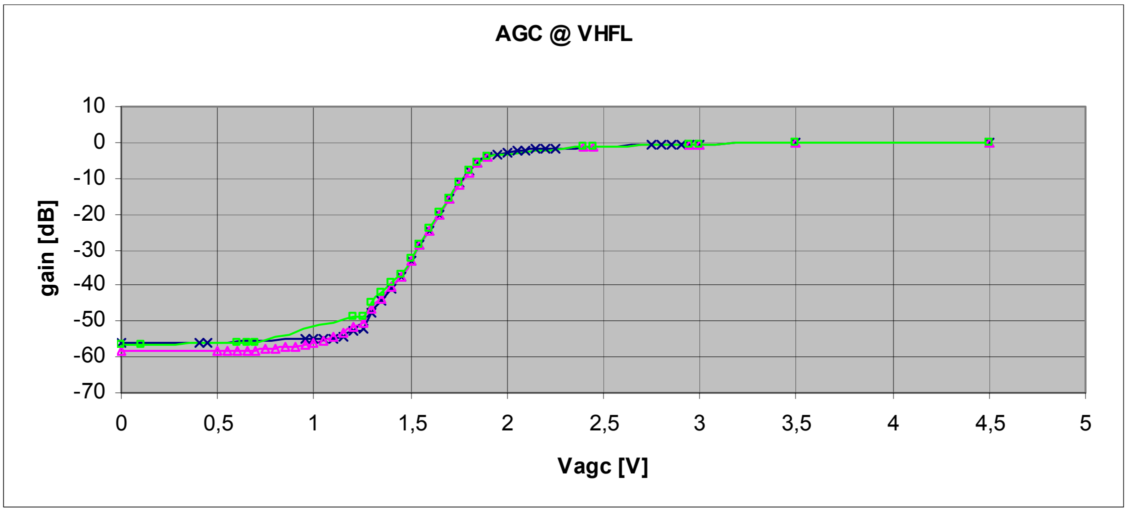

IF Response / VSWR
60
50
40
30
20
10
0
gain [dB]
0
-5
-10
-15
-20
-25
VSWR [dB]
225
235
245
255
265
275
Input Frequency [MHz]

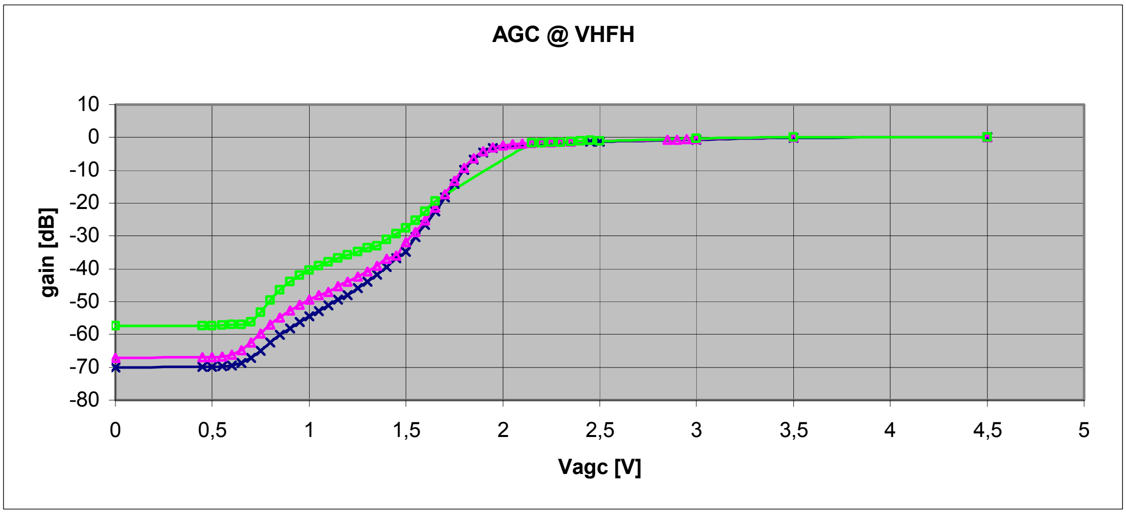

IF Response / VSWR
60
50
40
30
20
10
0
gain [dB]
5
0
-5
-10
-15
-20
-25
VSWR [dB]
440
450
460
470
480
490
Input Frequency [MHz]

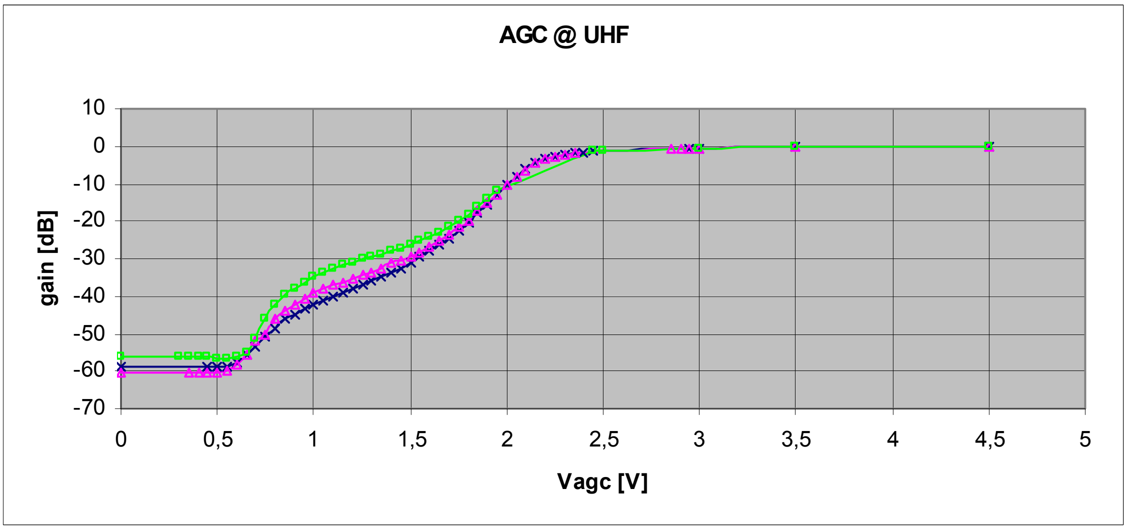

IF Response / VSWR
60
50
40
30
20
10
0
gain [dB]
-1
-3
-5
-7
-9
-11
-13
-15
VSWR [dB]
450
460
470
480
490
500
Input Frequency [MHz]


IF Response / VSWR
60
50
40
30
20
10
0
gain [dB]
-1
-3
-5
-7
-9
-11
-13
-15
VSWR [dB]
575
585
595
605
615
625
Input Frequency [MHz]


IF Response / VSWR
60
50
40
30
20
10
0
gain [dB]
0
-2
-4
-6
-8
-10
-12
VSWR [dB]
740
750
760
770
780
790
Input Frequency [MHz]

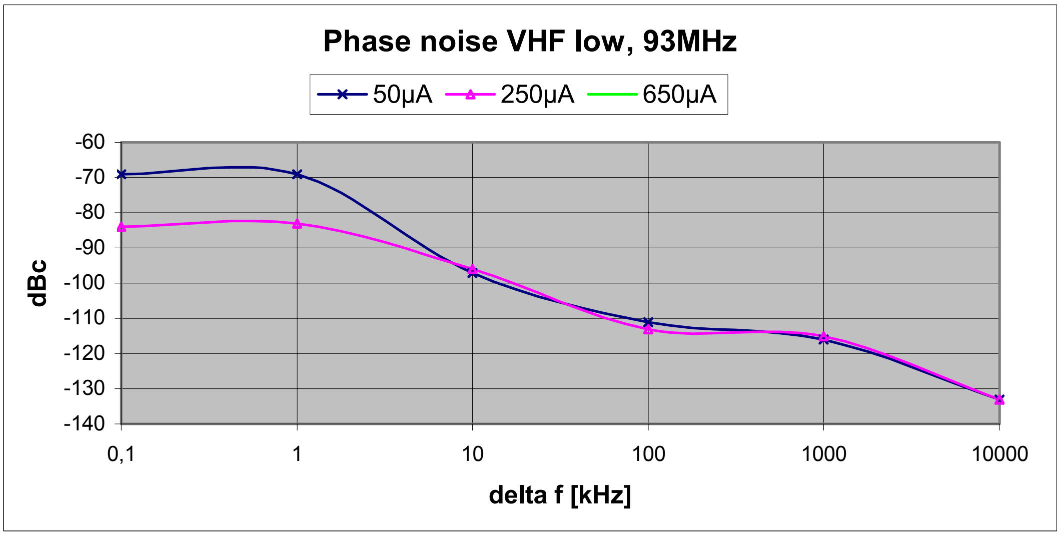

AGC @ VHFL
10
0
-10
-20
-30
-40
-50
-60
-70
gain [dB]
0
0,5
1
1,5
2
2,5
3
3,5
4
4,5
5
Vagc [V]

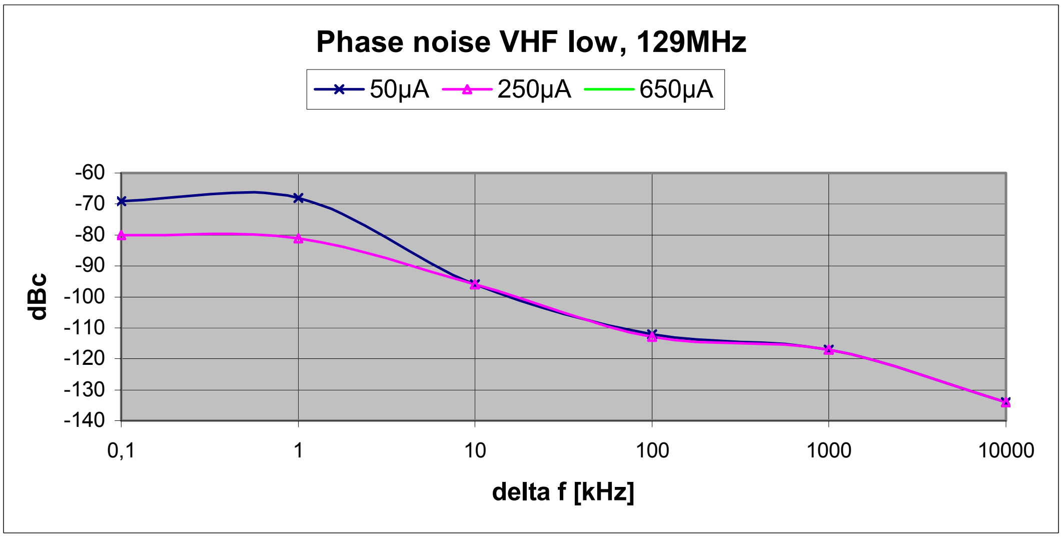

AGC @ VHFH
10
0
-10
-20
-30
-40
-50
-60
-70
-80
gain [dB]
0
0,5
1
1,5
2
2,5
3
3,5
4
4,5
5
Vagc [V]

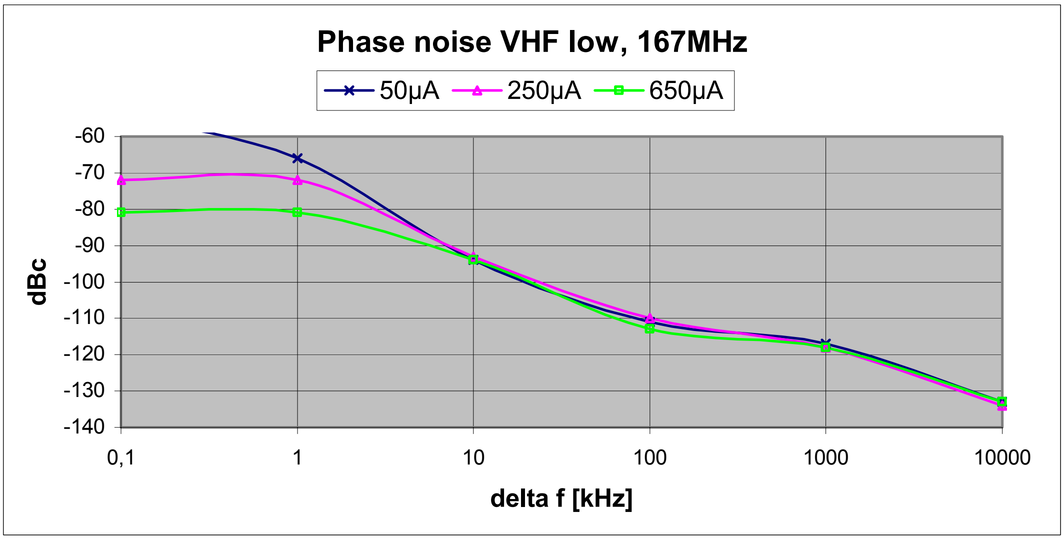

AGC @ UHF
10
0
-10
-20
-30
-40
-50
-60
-70
gain [dB]
0
0,5
1
1,5
2
2,5
3
3,5
4
4,5
5
Vagc [V]

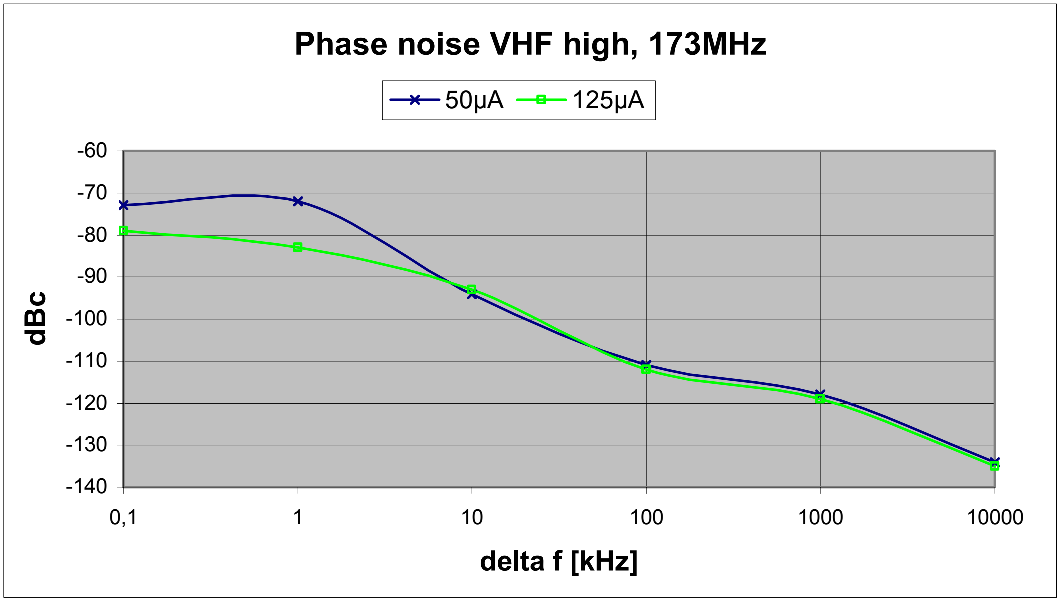
Phase noise measurement results:

Loopfilter parameter: C65=2n7; C68=56n; R39=22k; R40=1k; C24=22n

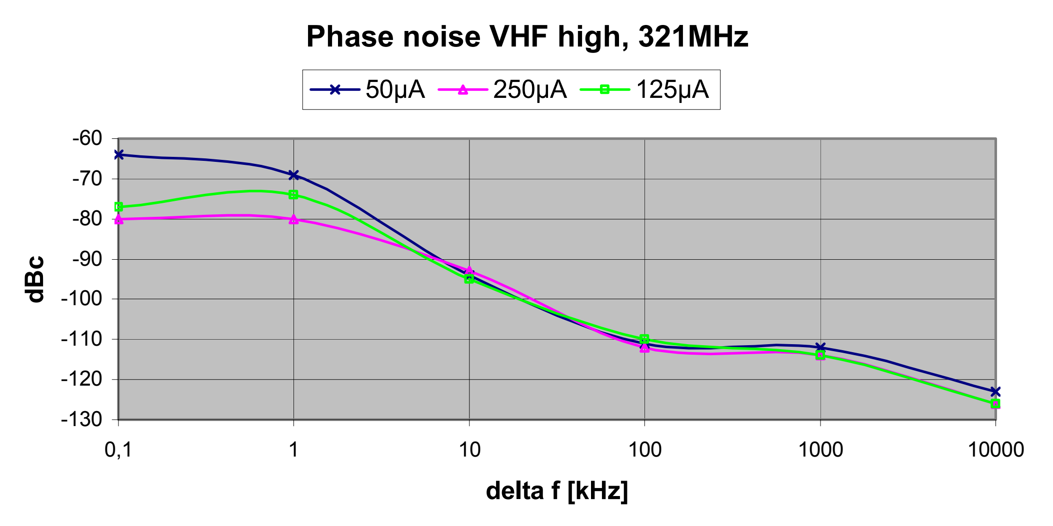




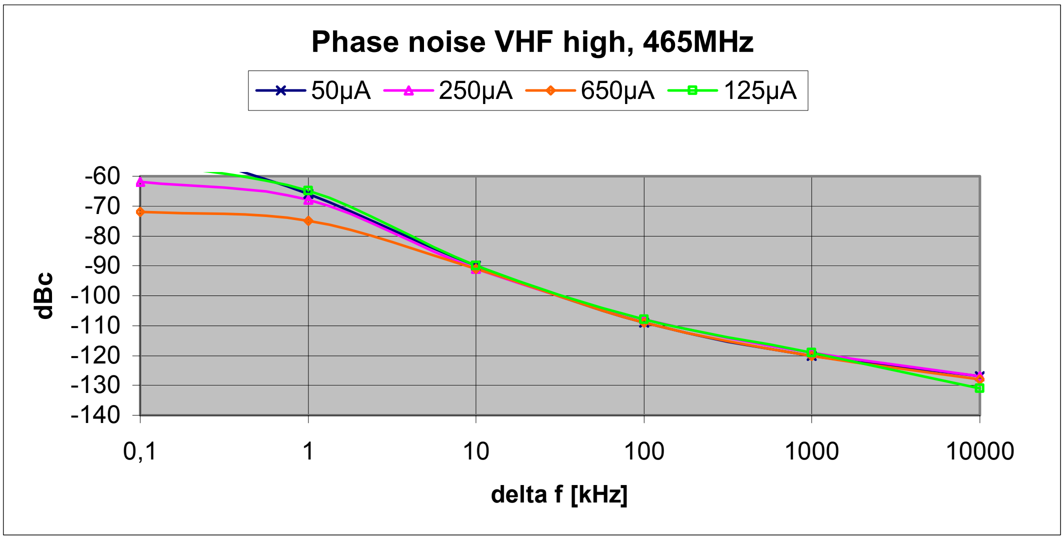




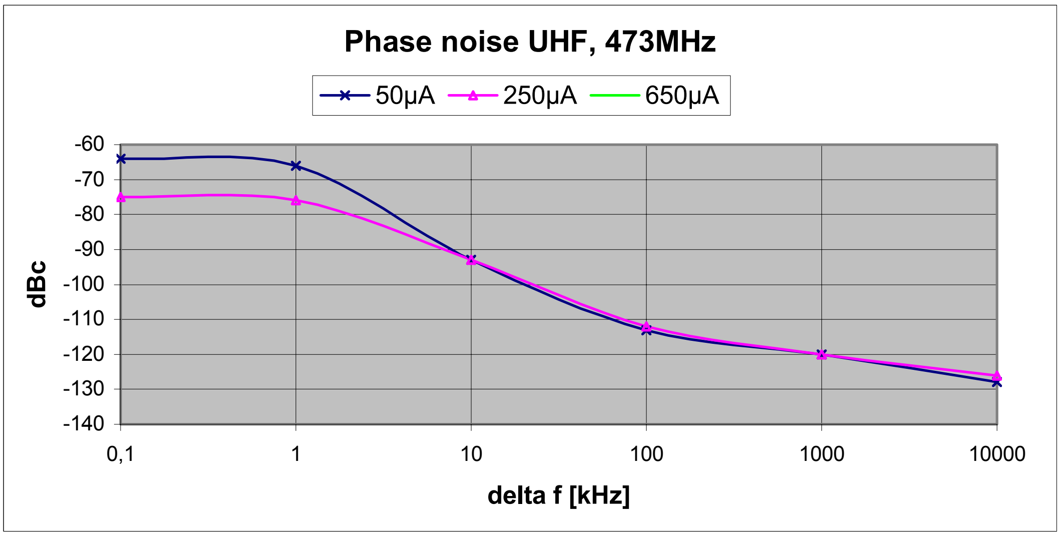
Phase noise VHF high, 173MHz
50µA
125µA
dBc
-60
-70
-80
-90
-100
-110
-120
-130
-140
0,1
1
10
100
1000
10000
delta f [kHz]

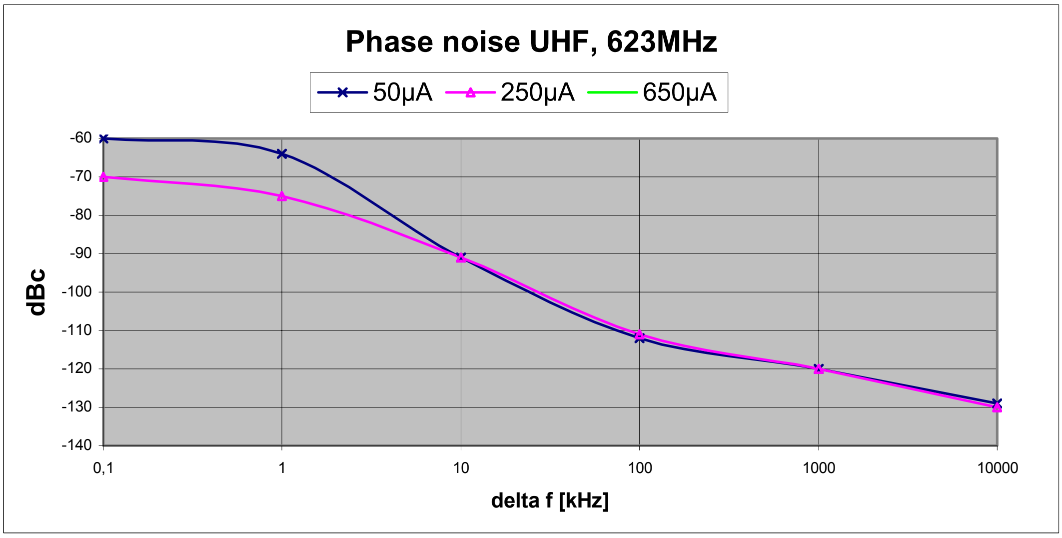


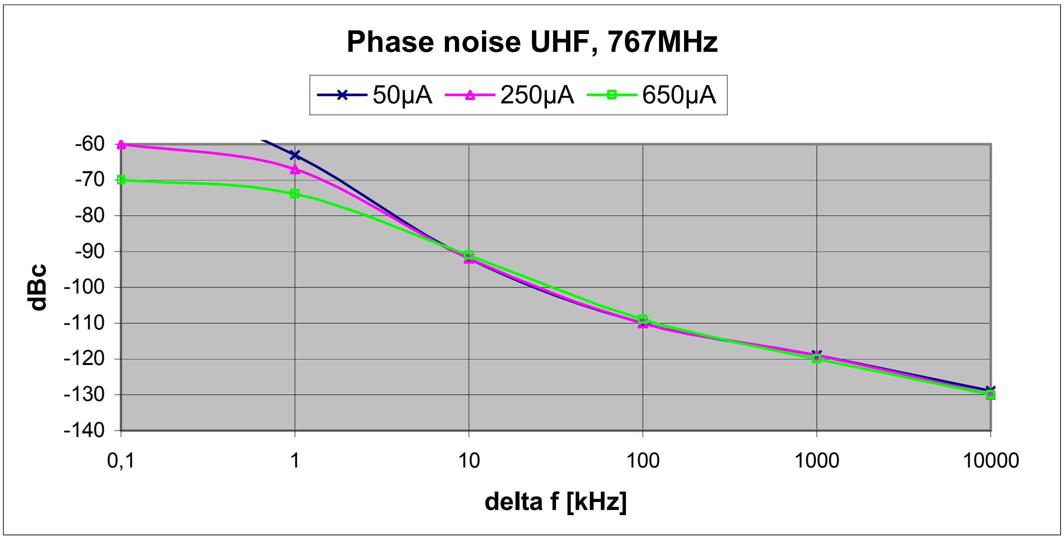
Phase noise VHF high, 321MHz
50µA
250µA
125µA
dBc
-60
-70
-80
-90
-100
-110
-120
-130
0,1
1
10
100
1000
10000
delta f [kHz]



Phase noise VHF high, 465MHz
50µA
250µA
650µA
125µA
dBc
-60
-70
-80
-90
-100
-110
-120
-130
-140
0,1
1
10
100
1000
10000
delta f [kHz]


Phase noise UHF, 473MHz
50µA
250µA
650µA
dBc
-60
-70
-80
-90
-100
-110
-120
-130
-140
0,1
1
10
100
1000
10000
delta f [kHz]


Phase noise UHF, 623MHz
50µA
250µA
650µA
dBc
-60
-70
-80
-90
-100
-110
-120
-130
-140
0,1
1
10
100
1000
10000
delta f [kHz]


Phase noise UHF, 767MHz
50µA
250µA
650µA
dBc
-60
-70
-80
-90
-100
-110
-120
-130
-140
0,1
1
10
100
1000
10000
delta f [kHz]

It is recommended to use the following charge pump currents:

VHF low: I_{PD} = 250 µA
VHF high: I_{PD} = 125 µA
UHF: I_{PD} = 250 µA

6. PLL Programming

Logic allocation of Write Data

	MSB	bit6	bit5	bit4	bit3	bit2	bit1	LSB	Ack
Address byte	1	1	0	0	0	MA1	MA0	0	A
Prog. divider byte 1	0	n14	n13	n12	n11	n10	n9	n8	A
Prog. divider byte 2	N7	n6	n5	n4	n3	n2	n1	n0	A
Control info byte 1	1	CP	T2	T1	T0	RSA	RSB	OS	A
Bandswitching byte	P7	P6	P5	P4	P4	P2	P1	P0	A
Auxiliary byte	ATC	AL2	AL1	AL0	0	0	0	0	A

Divider ratio:
N =16384 x n14 + 8192 x n13 + 4096 x n12 + 2046 x n11 + 1024 x n10 + 512 x n9 + 256 x n8 + 128 x n7 + x 64 x n6 + 32 x n5 + 16 x n4 + 8 x n3 + 4 x n2 + 2 x n1 + n0

Address selection (V_s = 5 V)

MA1	MA0	Voltage at CAS pin
0	0	(0 ~ 0.1) x V_s
0	1	Open
1	0	(0.4 ~ 0.6) x V_s
1	1	(0.9 ~ 1) x V_s

Band selection (via Bandswitching byte)

UHF	VHF2	VHF1
000 001 00	000 000 10	000 000 01

Charge pump current

I_{cp} (µA)	Mode	CP	T2	T1	T0
50	Nomal	0	0	0	X
250		1			X
50	Extended	0	1	1	0
125		0			1
250		1			0
650		1			1

Reference divider ratios

Reference divider ratio	f_{ref} (kHz)	Mode	T2	T1	RSA	RSB
80	50	Normal	0	0	0	0
128	31.25	Normal	0	0	0	1
24	166.67	X	X	X	1	0
64	62.5	X	X	X	1	1
32	125	Extended	1	1	0	0
28	142.86	Extended	1	1	0	1

The Tuner PLL control software, WinPLL is also available along with the evaluation board & the reference tuner.

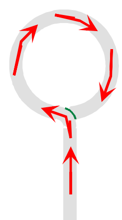
7. Component List & Ordering Information

(units: Farad, Ohm)

Part	Value	Size	Tolerance	Material	Part	Value	Size	Tolerance	Material
C1	330p	0603	10%	NP0	C51	22p	0603	5%	N750
C2	180p	0603	10%	NP0	C52	1p5	0603	5%	N750
C3	9p1	0603	5%	NP0	C53	1p2	0603	5%	N750
C4	1n	0603	10%	X7R	C54	68p	0603	5%	N750
C5	1p8	0603	5%	NP0	C55	1p2	0603	5%	N750
C6	open	0603	5%	NP0	C56	1p2	0603	5%	N750
C7	4n7	0603	10%	X7R	C57	1p2	0603	5%	N750
C8	0p5	0603	5%	NP0	C58	1p2	0603	5%	N750
C9	1n	0603	10%	X7R	C59	15p	0603	5%	N750
C10	4n7	0603	10%	X7R	C60	4n7	0603	10%	X7R
C11	10n	0805	10%	X7R	C61	4n7	0603	10%	X7R
C12	10n	0603	10%	X7R	C62	4n7	0603	10%	X7R
C13	120p	0603	5%	NP0	C63	4n7	0603	10%	X7R
C14	4n7	0603	10%	X7R	C64	4n7	0603	10%	X7R
C15	470p	0603	10%	X7R	C65	2n7	0603	5%	X7R
C16	4n7	0603	10%	X7R	C66	18p	0603	5%	NP0
C17	4n7	0603	10%	X7R	C67	open			
C18	4n7	0603	10%	X7R	C68	56n	0805	10%	X7R
C19	4n7	0603	10%	X7R	C69	100n	0805	10%	X7R
C20	4n7	0603	10%	X7R	C70	150n	0805	10%	X7R
C21	4n7	0603	10%	X7R	C71	4n7	0603	10%	X7R
C22	4n7	0603	10%	X7R	C72	4n7	0603	10%	X7R
C23	4n7	0603	10%	X7R	C75	39p	0603	5%	NP0
C24	22n	0603	10%	X7R	C76 / 77	12p	0603	5%	NP0
C25	4n7	0603	10%	X7R	R1	33k	0603	5%	
C26	4n7	0805	10%	X7R	R2	33k	0603	5%	
C27	1p2	0603	5%	NP0	R3	33k	0603	5%	
C28	100p	0603	5%	NP0	R4	22	0603	5%	
C29	13p	0603	5%	NP0	R5	33k	0603	5%	
C30	18p	0603	5%	NP0	R6	33k	0603	5%	
C31	27p	0603	10%	X7R	R7	10k	0603	5%	
C32	27p	0603	10%	X7R	R8	10k	0603	5%	
C33	1p8	0603	5%	NP0	R9	10k	0805	5%	
C34	120p	0603	5%	NP0	R10	33k	0603	5%	
C35	120p	0603	5%	NP0	R11	5Ω6	0805	5%	
C36	470p	0603	10%	X7R	R12	22	0603	5%	
C37	470p	0603	10%	X7R	R13	22	0603	5%	
C38	120p	0603	5%	NP0	R14	33k	0603	5%	
C39	470p	0603	10%	X7R	R16	100k	0603	5%	
C40	82p	0603	5%	NP0	R18	150k	0603	5%	
C41	82p	0603	5%	NP0	R19	150k	0603	5%	
C42	4n7	0603	10%	X7R	R20	33k	0603	5%	
C43	4n7	0603	10%	X7R	R21	33k	0603	5%	
C44	4n7	0805	10%	X7R	R22	33k	0603	5%	
C45	100p	0805	5%	NP0	R23	33k	0603	5%	
C46	100p	0805	5%	NP0	R24	open	0603		

C47	4n7	0805	10%	X7R	**R25**	2Ω7	0603	5%	
C48	560p	0603	10%	X7R	**R26**	0	0603		
C49	2p7	0603	5%	N750	**R27**	open	0603	5%	
C50	2p2	0603	5%	N750	**R28**	33k	0603	5%	
Part	**Value**	**Size**	**Tolerance**	**Part**	**Turns**	**D.of Wire**	**D. of Coil**	**Direction**	**Pre-form.**
R29	330	0603	5%	**L1**	12	0,4	2,2	CW	
R30	330	0603	5%	**L2**	9	0,4	2,5	CW	
R31	12	0603	5%	**L3**	9	0,3	2	CW	
R32	2k2	0805	5%	**L4**	6	0,4	1,8	CCW	
R33	8Ω2	0603	5%	**L5**	3	0,4	2,4	CW	
R34	2k7	0603	5%	**L6**	printed				
R35	5Ω6	0603	5%	**L7**	9	0,3	2	CCW	
R36	1k8	0603	5%	**L8**	5	0,4	1,9	CW	
R37	1k8	0603	5%	**L9**	12	0,3	3	CW	
R38	open			**L10**	16	0,3	2,5	CW	
R39	22k	0603	5%	**L11**	7	0,3	2	CW	
R40	1k	0805	5%	**L12**	15	0,3	1,9	CW	
R42	1k2	0603	5%	**L13**	choke coil L = 3.9uH				
R41	15	0603	5%	**L14**	5	0,3	1,7	CCW	
R15	10k	0603	5%	**L15**	3	0,4	1,9	CCW	0,5mm
R17	15	0603	5%	**L16**	2	0,5	1,6	CW	1,0mm
J1	0	0603		**L17**	printed				
J2	0	0805		**L18**	2	0,5	1,6	CCW	
J3	0	0805		**L19**	4	0,4	1,9	CW	
J4	0	0805		**L20**	4	0,4	1,9	CW	
J5	0	0603		**L21**	4	0,4	1,9	CW	
J6	0	0603		**L22**	4	0,4	1,5	CW	
J7	0	0805		**L23**	printed				
J8	0	0805		**L24**	4	0,4	1,6	CCW	
J9	0	0805		**L25**	8	0,3	2	CCW	
J10	0	0805		**L26**	8	0,3	2	CW	
J12	0	0603		**L27**	13	0,3	2,2	CW	
L36 / 37	150nH	0805	LQG21NR	**L28**	13	0,3	2,2	CW	
			15K10	**L29**	7	0,3	2	CCW	
			Murata	**L31**	9	0,3	2,2	CW	
				L32	2,5	0,5	2,4	CW	0,5mm
				L33	1,5	0,4	1,9	CW	
				L34	11	0,3	2,3	CW	
				L35	11	0,3	2,3	CW	

full-turn, CCW:



Note1) All the coils are full-turn types. The unit of the diameter of coil & wire is 'mm'.
Note2) J1 & C70 are only for internal tuner AGC.
Note3) Pre-form. value is the distance between each turn of the coils. The pre-formation of coils should be done before alignment by a coil manufacturer or by line workers.

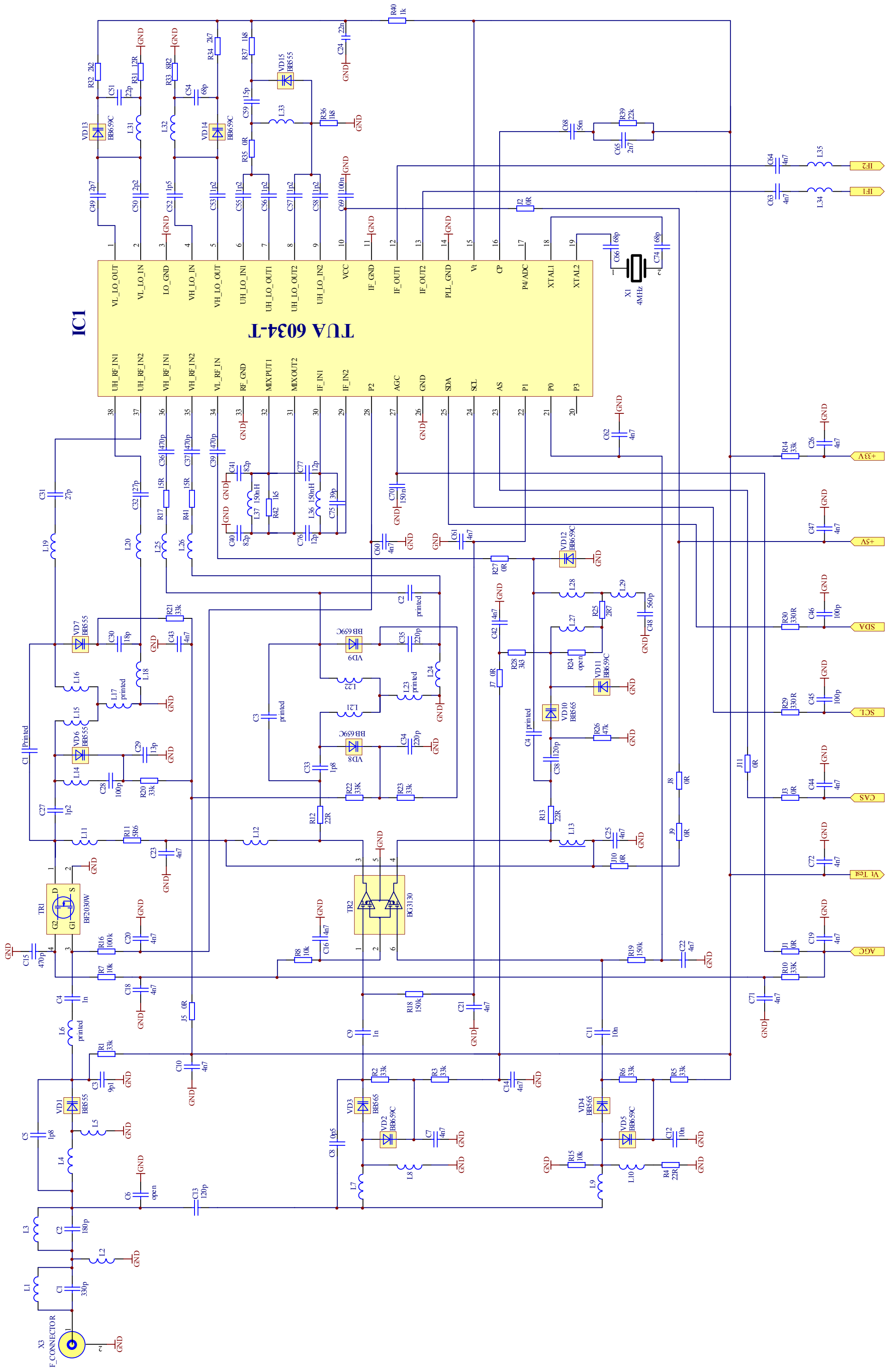
Part	Semiconductor	Package		Company	Ordering Code
IC1	TUA6034T	*TSSOP-38*		*Infineon Technologies AG*	Q67034-H0006
TR1	BF2030W	*SOT343*		*Infineon Technologies AG*	Q62702-F1774
TR2	BG3130	*SOT363*		*Infineon Technologies AG*	Q62702-Fxxx
VD1	BB555	*SCD80*	*SC79*	*Infineon Technologies AG*	Q62702-B853
VD2	BB659C	*SCD-80*	*SC79*	*Infineon Technologies AG*	Q62702-B884
VD3	BB565	*SCD-80*	*SC79*	*Infineon Technologies AG*	Q62702-B873
VD4	BB565	*SCD-80*	*SC79*	*Infineon Technologies AG*	Q62702-B873
VD5	BB659C	*SOD-80*	*SC79*	*Infineon Technologies AG*	Q62702-B884
VD6	BB555	*SCD-80*	*SC79*	*Infineon Technologies AG*	Q62702-B853
VD7	BB555	*SCD-80*	*SC79*	*Infineon Technologies AG*	Q62702-B853
VD8	BB659C	*SCD-80*	*SC79*	*Infineon Technologies AG*	Q62702-B884
VD9	BB659C	*SCD-80*	*SC79*	*Infineon Technologies AG*	Q62702-B884
VD10	BB565	*SCD-80*	*SC79*	*Infineon Technologies AG*	Q62702-B873
VD11	BB659C	*SOD-80*	*SC79*	*Infineon Technologies AG*	Q62702-B884
VD12	BB659C	*SCD-80*	*SC79*	*Infineon Technologies AG*	Q62702-B884
VD13	BB659C	*SOD-80*	*SC79*	*Infineon Technologies AG*	Q62702-B884
VD14	BB659C	*SOD-80*	*SC79*	*Infineon Technologies AG*	Q62702-B884
VD15	BB555	*SCD-80*	*SC79*	*Infineon Technologies AG*	Q62702-B853

Q1	**4MHz**
PCB	FR4 / 1.5mm
Jack	75 Ω IEC female
Pin-Head	Standard Pin

Products	Ordering Code	Price
Reference Tuner	Q67034-H000x	250Euro
Evaluation Board	Q67034-H000x	75Euro

8. Circuit and Layout

8.1 Circuit diagram



8.2 Layouts

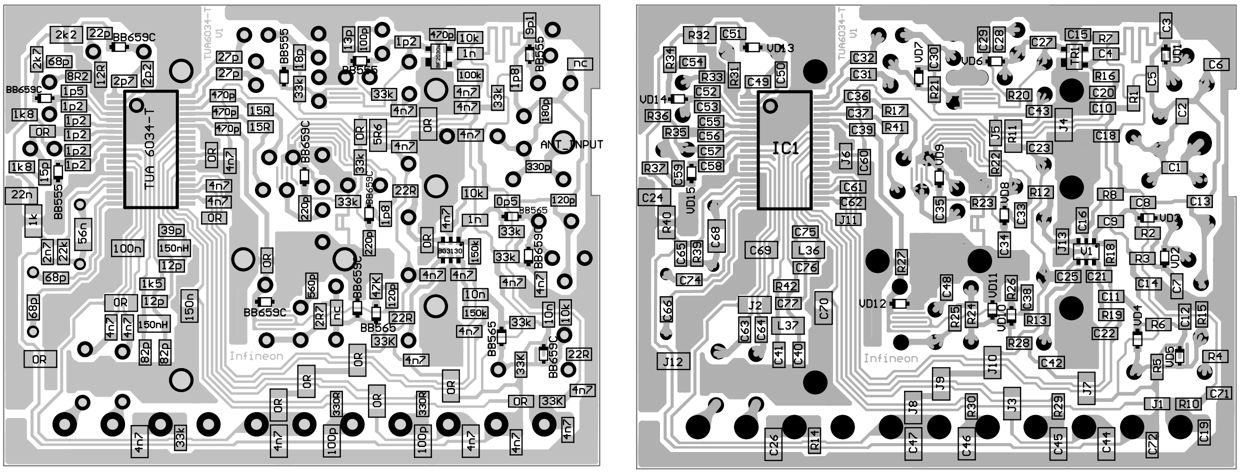


Figure 6. SMD parts with value and partnumber

8.3 Pin Layout & Outline Dimensions

To give an impression of the real sized tuner, a photo of the tuner module with the pin-out is given in figure 7.

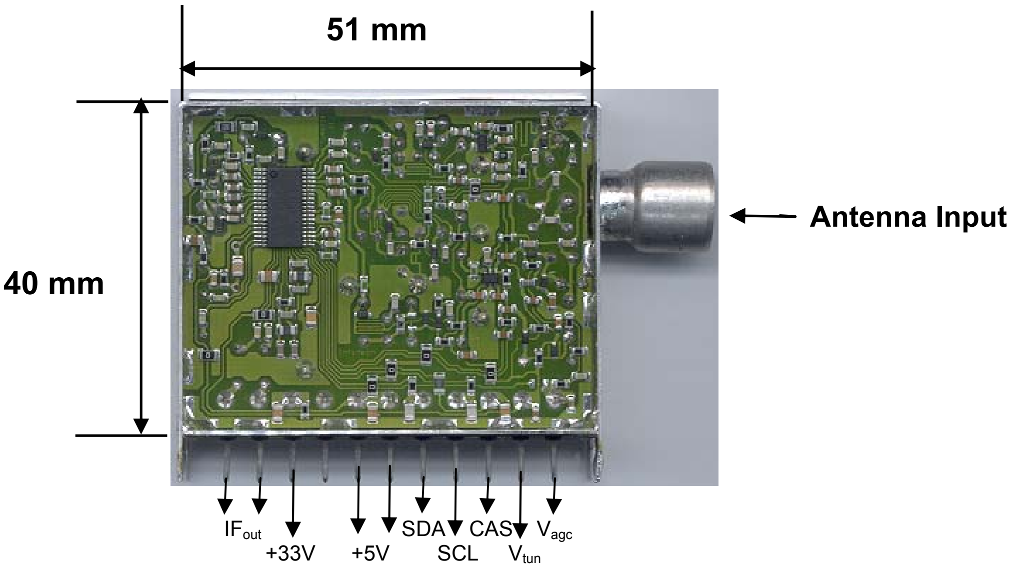


Figure 7. Tuner module without cover

9. Automatic Tuner Test Set-up

This automatic tuner set-up consists of the following RF measurement equipment:

Hewlett-Packard 8970B noise meter

Hewlett-Packard 5305A frequency counter

Hewlett-Packard 8561E spectrum analyzer

Rhode&Schwarz FMA modulation analyzer

Rhode&Schwarz NGPS voltage supply(2x)

Rhode&Schwarz URV5 millivolt meter

Marconi Instruments 2031 signal generator (2x)

Marconi Instruments 2024 signal generator (2x)

All these instruments are controlled via the IEEE bus by a tuner test software from a PC.
Test data will be attached to every sample tuner that is available on request.

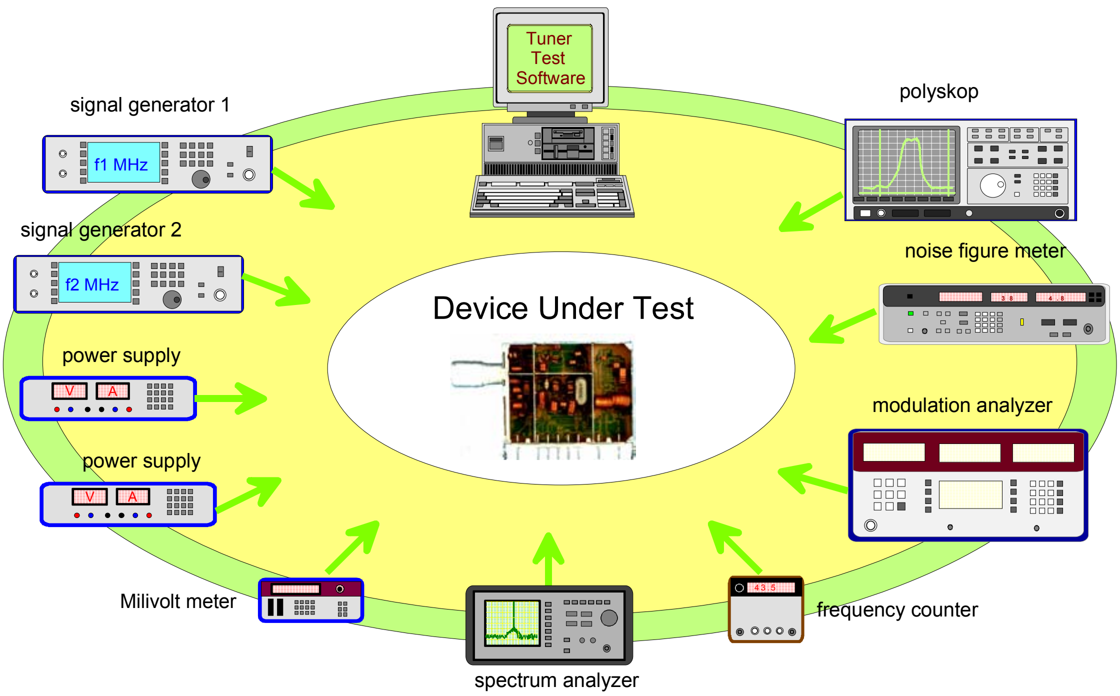


Figure 8. Tuner test set-up

10. Ordering & Contact Information

1. Ordering on the Web

   http://www.infineon.com/business/techlit/ordering/index.htm

2. For more information please contact our local sales colleagues in your region.

   http://www.infineon.com/business/offices/index1.htm

Information on the Web

1. Infineon Homepage

   http://www.infineon.com/

2. Ordering Info

   http://www.infineon.com/business/techlit/ordering/index.htm

3. Analog & Digital Tuner ICs Info

   http://www.infineon.com/cgi/ecrm.dll/ecrm/scripts/prod_cat.jsp?oid=-8036

4. Tuner MOSFETs & Varicap Diodes Info

   http://www.infineon.com/cgi/ecrm.dll/ecrm/scripts/prod_ov.jsp?oid=26213&cat_oid=-8960
   http://www.infineon.com/cgi/ecrm.dll/ecrm/scripts/prod_ov.jsp?oid=26227&cat_oid=-8960
   http://www.infineon.com/cgi/ecrm.dll/ecrm/scripts/prod_ov.jsp?oid=26231&cat_oid=-8960
   http://www.infineon.com/cgi/ecrm.dll/ecrm/scripts/prod_ov.jsp?oid=13798&cat_oid=-8148

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