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# DVB-T Mini Half NIM:TUA6039-2

## 3 Band Digital/Hybrid Tuner IC with IF AGC Amplifier

Application of TUA6039-2:

Specially Suitable for Digital Standard:

DVB-T, DVB-C, ATSC, ISDB-T, etc



Communication Solutions

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# Overview of the DVB-T Half NIM

**Single Conversion Half NIM**
**For European DVB-T application**

**With Infineon Components of**

| | |
|---|---|
| **TUA 6039-2** | **Single Chip Mixer-Oscillator-PLL IC** |
| **BF 5030W** | **Semi-biasing MOSFET** |
| **BG5120K** | **Semi-biasing Dual MOSFET** |
| **BB565, BB659C and BB 689** | **Varactor Diodes** |
| **BC847CW** | **High Gain AF Transistor** |
| **BAS70-04W** | **Dual Switching Diode** |

This mini sized single conversion Half NIM designed for DVB-T(COFDM) front-end in the frequency range from 51 to 858 MHz can be used with minimum modification for all digital broadcasting reception. The Half NIM was developed with a real 3 band tuner concept, designed without switching diodes based on the Infineon's 3 band tuner IC, **TUA6039-2** which has 3 mixers, 3 oscillators, separated SAW driver input, PLL and crystal oscillator buffer for optimum digital front-end performance. The IC is particularly suitable for COFDM applications like DVB-T and ISDB-T that require stringent close-in phase noise. The IC provides a balanced SAW filter driver output that is designed to drive a SAW filter (included in the Half NIM) directly. The DC-DC converter to generate +30VDC for tuning voltage is included in the Half NIM.

The Half NIM is optimized for IF bandwidth of 8MHz and IF center frequency = 36MHz.
The frequency ranges of the Half NIM are as follows:

| | | | | |
|---|---|---|---|---|
| **VHF I** | **:** | **51** | **-** | **157MHz** |
| **VHF II** | **:** | **164** | **-** | **442 MHz** |
| **UHF** | **:** | **450** | **-** | **858 MHz** |

All the passive and active components except air coils, 2 choke coils are SMD components. The PCB is double-sided and the dimensions are 49.5mm x 30 mm. The thickness of the Half NIM is around 9mm.

## Semiconductors:

| | |
|---|---|
| **TUA6039-2** | **X1** |
| **BF5030W** | **X1** |
| **BG5120K** | **X1** |
| **BB565** | **X7** |
| **BB659C** | **X4** |
| **BB689** | **X4** |
| **BC847CW** | **X1** |
| **BAS70-04W** | **X1** |

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# 1. Half NIM Design

## 1.1. Circuit Concept

The RF input signal is split by a simple high pass filter combined with IF & CB (Citizen Band) traps. Instead of band switching with PIN diodes a very simple tri-plexer 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 Semi-biased MOSFET BF5030W. One BG5120K, Dual-MOSFET can be used for both VHF bands. In the following tuned band-pass filter stage, the channel is selected and unwanted signals like adjacent channels and image frequency are rejected. Tracking traps of pre-stages and capacitive image frequency compensation of band filters reject especially image frequencies.

The conversion to IF is done in the one-chip tuner-PLL IC, TUA6039-2. TUA6039-2 is a real 3 band tuner IC which has all the active parts for the 3 mixers, 3 oscillators, an SAW driver and IF amplifier, the complete PLL functions including 4 PNP ports & 1 NPN port 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 attributes to Infineon's Bipolar technologies, the Half NIM can achieve distinguished phase noise performance suitable for all digital applications. The balanced IF output signal of the TUA6039-2 is designed to directly drive a SAW filter in the following IF stage. The signal from the SAW is further amplified by the Gain-Controlled on-chip amplifier and its output signal can be used directly by the demodulator IC in the following stage.

The Half NIM consumes less than 130mA current or 0.65 Watt power with +5V supply voltage (or 130mA current or 430mW with +3.3V). This can be a big advantage for portable or handheld appliances.

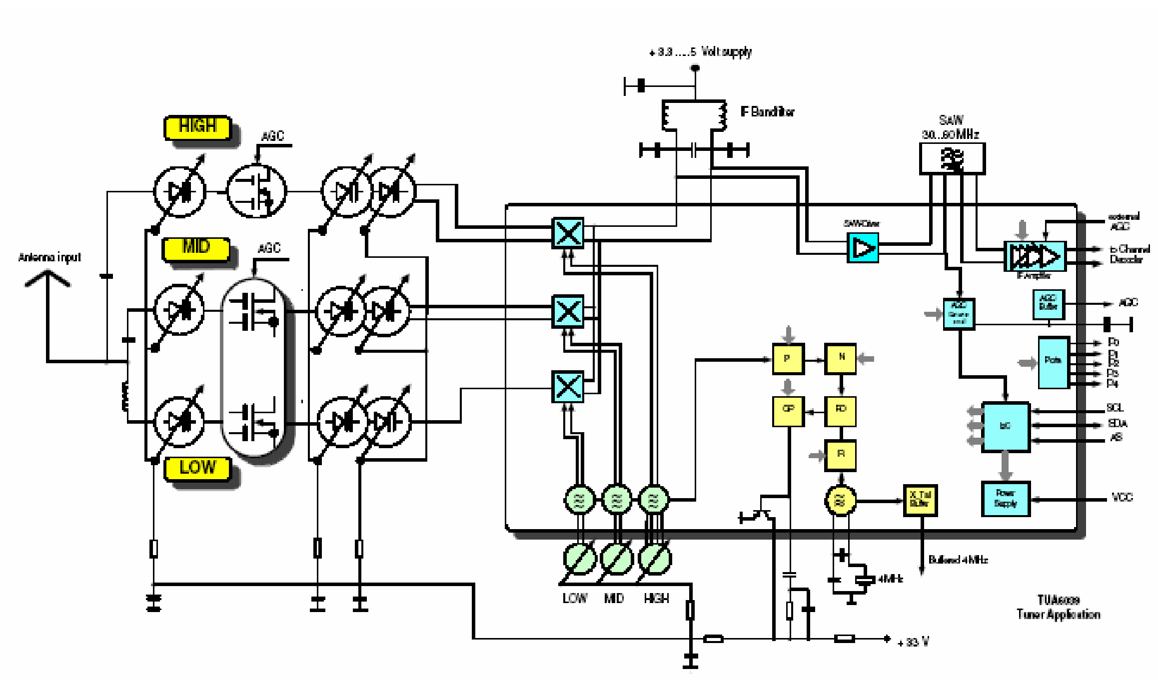



**Fig. 1 Circuit Block Diagram of DVB-T Half NIM**

For the detailed circuit description please refer to Section 8.

## 1.2. UHF RF Block

With the wide range ultra linear varactor diode BB565 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 band-pass stage is an inductive low end coupling filter, which concurrently provides the transformation from unbalance to balance. Also due to the matched image filters on both pre-stage and band-pass filter stage, better than 50dB 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. VHF High RF Block

For VHF High band, high quality ratio-extended varactor diode, BB659C is used. To compensate gain, one additional coupling diode, BB565 is placed on the pre-stage of VHF High.

The RF band-pass 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. VHF Low RF Block

For the wide VHF Low frequency range a tuning diode with an extended capacitance ratio is required. BB689 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 impedance VHF Low 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. Fig.2 is one of such simulation results.

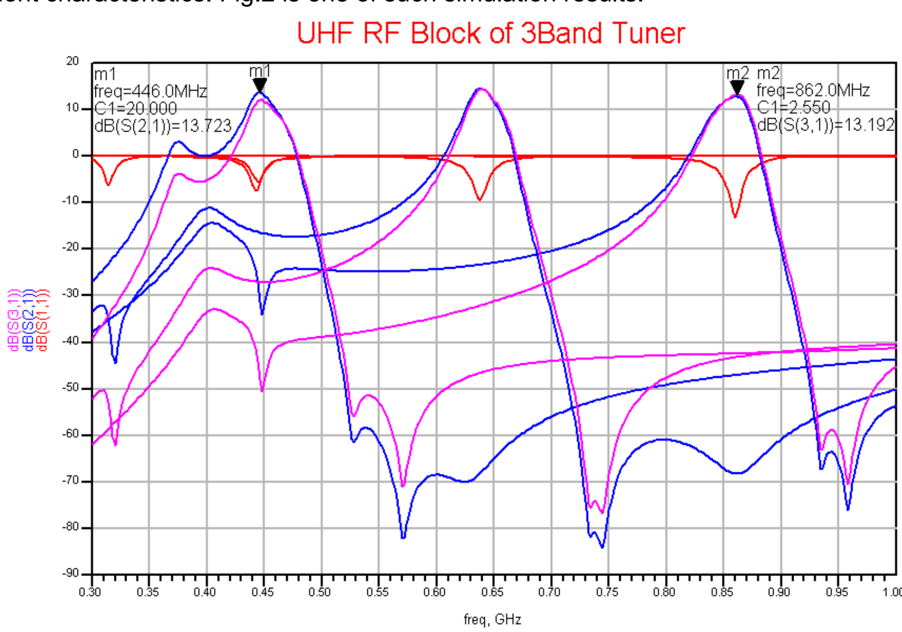
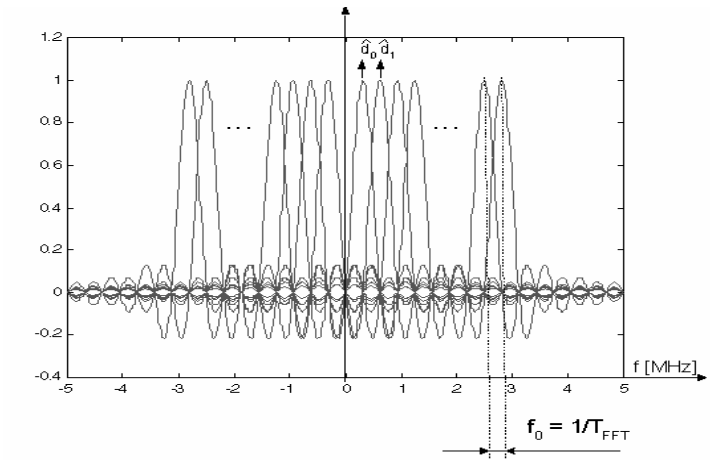



**Fig. 2 One of the Simulation Results of DVB-T Half NIM RF Blocks**

## 1.5. Oscillator Resonator, PLL Loop Filter and 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 oscillation. Capacitors of the resonators could be temperature-compensated if necessary. N750 type is recommended for this purpose.

One of the most important considerations to design a good DVB-T tuner is how to down-convert input RF signals to IF frequency with minimum phase noise. The DVB-T standards provides for two modes of operation, a 2K mode with 1705 sub-carriers, and an 8K mode with 6817 sub-carriers for OFDM(Orthogonal Frequency Division Multiplexing) transmission[1]. An OFDM signal as in Fig.3 contains multiple sub-carriers, each of which is a smaller percentage of the total frequency bandwidth than in a single carrier system. As a result, phase noise is a smaller percentage of the bandwidth in a single-carrier system. For this reason, phase noise degrades the performance of an OFDM system more than in a single carrier system.




Phase noise influences two important system performances: One is receiver selectivity by reciprocal mixing in Fig.4, and the other is receiver sensitivity or SNR[2], which decides BER (Bit-Error-Rate) of the digital system combined with other noise sources like pre-stage noise figures, image noise, etc.

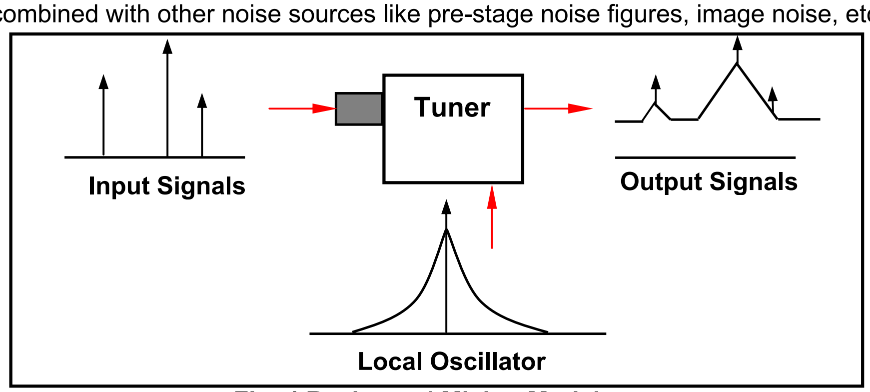



**Fig. 4 Reciprocal Mixing Model**

To design optimum resonators for the IC, the well-known Leeson's equation[3] should always be considered. Even though there is an improved phase noise model[4] for better phase noise analysis and prediction, Leeson's equation is still a basis of all those new approaches.

*1. ETSI EN 300 744 V1.2.1*

*2. Muschallik, C., Influence of RF oscillators on an OFDM signal, IEEE Transactions on Consumer Electronics, vol.41,No.3, pp.602-603*

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

*L(fm) is 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 oscillator. Ps is the carrier power. K is Boltzmann's constant, 1.38x10$^{-23}$ J/K. T is Kelvin temperature. $Q_L$is loaded Q factor.*

Infineon Technologies' bipolar process with a transit frequency ($f_T$) of 25 GHz to produce TUA6039-2 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.

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 fixed side-bands like reference spurs. Because of the wide tuning range of the Half NIM, the tuning sensitivity can go up to 35MHz/V, so even a few milli-volts of noise on the tuning lines might 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, making it more difficult to maintain the stability of the loop. The loop bandwidth and loop filter components should be carefully selected to achieve optimal phase noise and to reject reference spurs. Four 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 DVB-T recommended Fref=166.667kHz is used for all loop filter calculations and measurements.

A 3$^{rd}$ order passive loop filer is chosen for the tuner design. The following are simplified procedures to determine 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 Kvco(VCO sensitivity, Hz/V) and Icp(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, $F_n$ ; $\zeta$ = damping factor*

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

6. *Calculate C68 ;* $$C68 = \frac{I_{cp}\times K_{vco}}{N\times(2\pi\times F_n)^2} \quad Farad \quad (3)$$

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

---

*[3]. G.Vendelin, A.Pavio, U.Rohde, Microwave Circuit Design using Linear & Nonlinear Techniques, John Wiley & Sons, New York, 1992, pp.385-491.*
*[4]. 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.*

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

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

8. *Calculate C65, which is used to damp transients from the charge pump and should be at least 20 times smaller than C68, i.e.,* $C65 \le \frac{C68}{20}$
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 they levels off near 10kHz offset at around -150dBc/Hz. The free running oscillator to be phase locked typically has much higher close-in noise but continues down to around -120dBc/Hz beyond 1MHz. 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 oscillator, the loop bandwidth should be very carefully chosen with deep consideration of the 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 Half NIM. 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 Vcc line. Proper PCB layout and necessary AC blocking are critical to ensure decent noise performance. The signal line with highest level in the Half NIM is the IF output line, and all those sensitive blocks like oscillator, loop filter and long DC lines should be well-protected from coupling from IF lines.

## 1.6. IF Block

TUA6039-2 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 simul-casting signal environment as in Fig.5, it is a big advantage combined with internal AGC of TUA6039-2 to efficiently suppress strong adjacent PAL signals. The tuner provides a balanced IF output to drive directly a SAW filter. The AGC Controlled amplifier on-chip feeds out the IF signal directly to the demodulator IC.

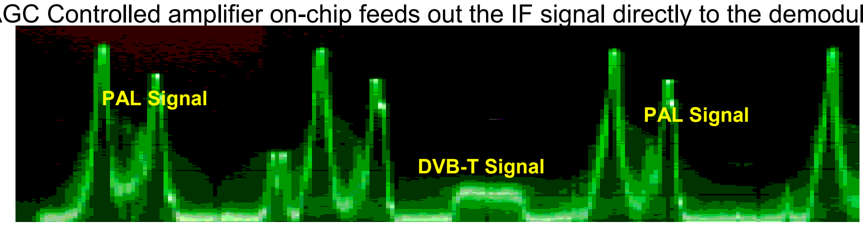



**Fig. 5 Spectrum of a DVB-T signal between strong analog PAL signals**

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

## 2. PCB

Double-sided, 1.0 mm thickness FR4 PCB is used for the half NIM design.

## 3. TUA 6039-2, One-Chip Multimedia Tuner IC with IF Amplifier

### 3.1 Highlights

The core of the half NIM is the one-chip MOPLL IC TUA 6039-2, which works from 3.3V~5V.

The following are some of the outstanding features:

**Features**

General

- Supply voltage 3 to 5.5 Volt
- Suitable for PAL, NTSC, SECAM, DVB-C, DVB-T, T-DMB, DAB, ATSC and Open Cable
- Narrowband RF AGC detector for internal tuner with
  - 5 programmable take over points
  - 2 programmable time constants
  - RF AGC buffer output
- Low phase noise
- Full ESD protection
- Qualified according to JEDEC for consumer applications

Mixer/Oscillator

- Three band tuner
- Unbalanced highohmic LOW input
- Balanced lowohmic MID input
- Balanced lowohmic HIGH input
- Two pin oscillators for LOW/MID band
- Four pin oscillator for HIGH band

SAW filter driver and IF-Amplifier

- 4 IF pins to connect a 2 pole bandpass
- Symmetrical SAW filter driver
- Fully balanced IF AGC amplifier

PLL

- $I^2C$ bus
- 4 pin-programmable $I^2C$ addresses
- High voltage VCO tuning output
- 4 PNP ports, 1 NPN port/ADC input
- Internal LOW/MID/HIGH band switch
- X_TAL 4 MHz, X_TAL buffer output
- 6 reference divider ratios
- 4 charge pump currents

Power management

- Bus controlled power down mode

Application

- The IC is suitable for PAL, NTSC, SECAM, DVB-C, DVB-T, T-DMB, DAB, ISDB-T, Open Cable and ATSC tuners.

Advancement and New Features of TUA6039-2:

- Loop-Thru Function Simplifies Alignment and Production Process
  There would be no longer external damping resistors which is necessary to disable the IF filter so as to test the RF filter performance and characteristics
- RF AGC Switch Simplifies the Adoption of External RF AGC Voltage
  There would be no longer Jumpers to select internal or external RF AGC. Simply select via IIC
- Crystal Buffer Allows Direct Connection to a Baseband with 4MHz Xtal Input
  RF AGC Buffer Reduces Impact from MOSFET to Tuner IC
  With RF AGC Buffer, RF AGC voltage can be measured without disturbing the RF AGC performance of the Tuner
- NPN port P4 can also be used as ADC input

## 3.2 Block diagram

In the block diagram the internal structure of the IC is shown in Fig.6.

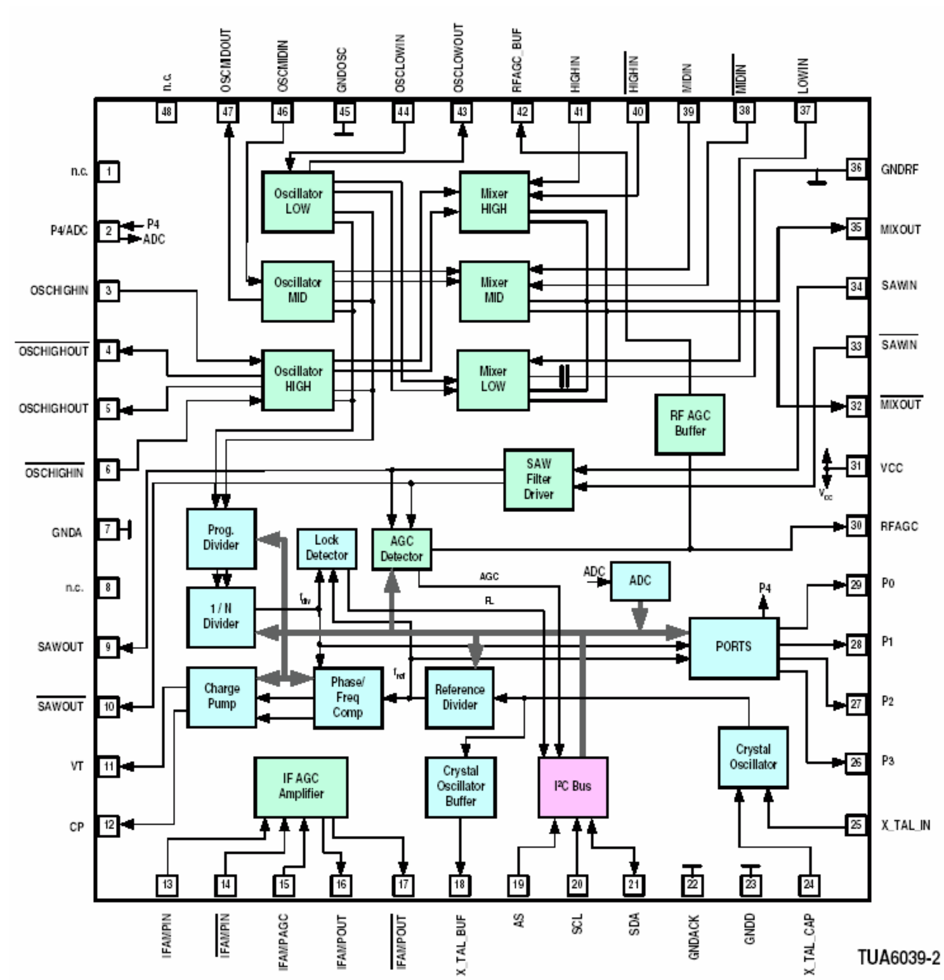



**Fig. 6 Block Diagram of TUA6039-2 (VQFN48)**

TUA6039-2 combines a mixer-oscillator block with a digitally programmable phase locked loop (PLL) for use in broad band multimedia front-end applications. The mixer-oscillator block includes three 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 source, 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 current, 50, 125, 250, 650uA 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 Setup

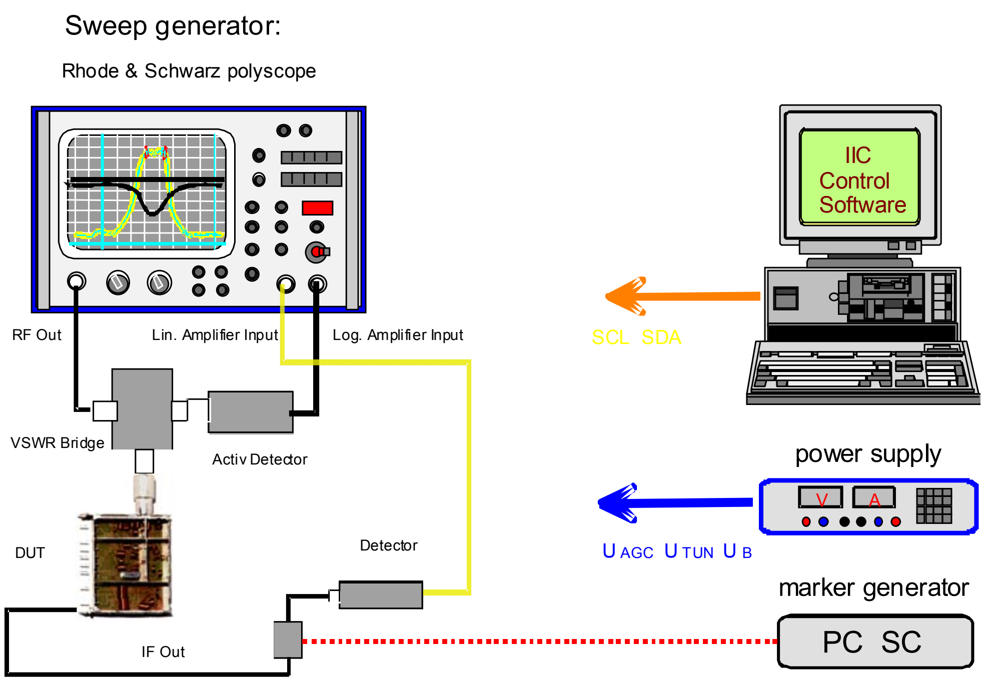
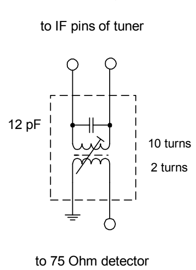



**Fig. 7 Half NIM Alignment Setup**

This is an example of analog tuner alignment setup. The same setup can be used to align RF performance of DVB-T Half NIM. IF center frequency of 36MHz will be used for the overall alignment, and 3 points of IF frequencies, 32, 36 & 40MHz 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.



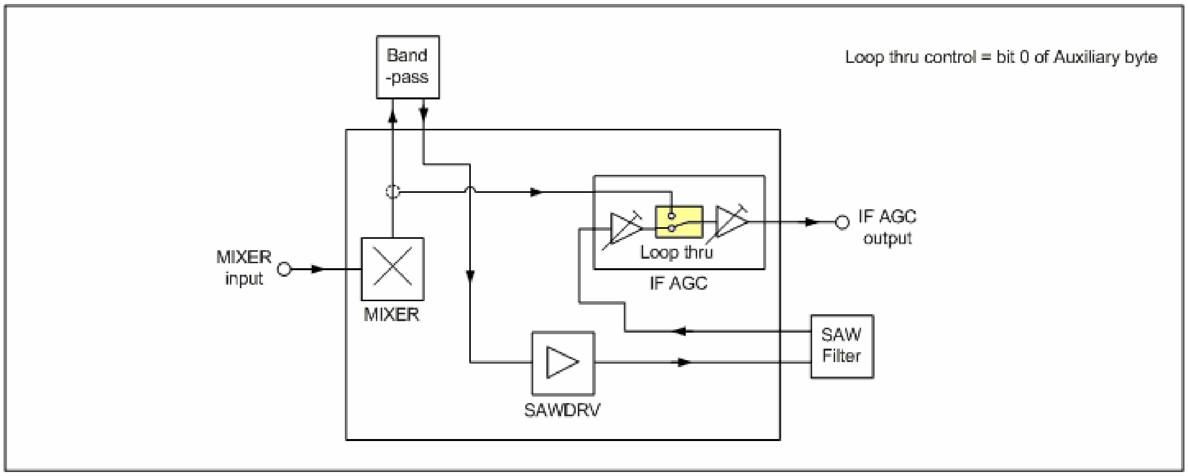

For digital Half NIM alignment only IF center frequency of 36 MHz can be used all through the alignment and measurement. The tuner is designed to cover IF bandwidth of 8MHz between 32MHz ~ 40MHz.

The tuning voltage of each band should not fall below 0.7 V for lowest frequency and 25.5 V for highest frequency.

There are two methods to connect the tuner/half NIM output when doing alignment for the tuner or half NIM with TUA6039, which are described as follows:

1. Traditional method connects the output at the SAW_OUT of the TUA6039 so that the RF characteristic of the tuner can be measured. This will need the testing probe to be connected to the internal test pin of the tuner/half NIM while damping resistor to be added to the IF filter to show the real RF curve;

2. Due to the new Loop_Through function of TUA6039, tuner/half NIM alignment can also be done without implementation of the internal test pin or requirement of the damping resistor at the IF filter. The measurement equipment, i.e. Spectrum analyzer or network analyzer can be directly connected to the tuner/half NIM IF output via a BALUN to perform the measurement and alignment. In order to monitor the RF characteristic, the Loop_Through is to be set to “enable” via IIC. The internal diagram to illustrate the operation of Loop_Through function is shown as follows:




When the Loop_Through function is enabled, the Signal at the MIXER_OUT will be brought directly to the IF output via IF Amplifier. It would bypass the IF filter, SAW_Driver and the SAW filter so that the real RF characteristic/curve can be shown at the IF output. This would simplify the alignment procedure and the design of a testing jig for alignment.

## 4.2 Alignment Procedures

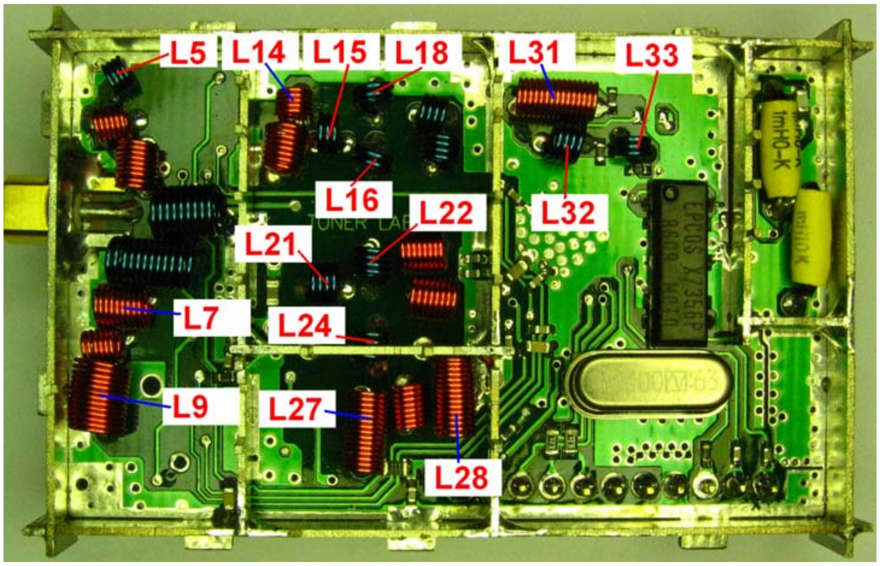



**Fig. 8 Picture of Half NIM after Alignment**

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 and Tuning Voltage of the tuner must be monitored all through the alignment to check the proper operation of the IC. If the current consumption is over 200mA, either IC, MOSFET might seem to be damaged or there might be short circuit in the hardware. $IF_{center}$ shall be set at 36MHz.
2. UHF alignment :
   - Set the tuner to the highest channel of UHF band, frequency = 858MHz and then adjust L33 to have Vt = 22.5 ± 0.3V.
   - Adjust L5 for VSWR.
   - For RF curve & tilt adjust L15 first, and depending on the result, adjust L16 & L18. For high-end 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. VHF High alignment :
   - Set the tuner to the highest channel of VHF High band, frequency = 442MHz and then adjust L32 to have Vt = 22.5 ± 0.3V.
   - 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. VHF Low alignment :
   - Set the tuner to the highest channel of VHF Low band, frequency = 157MHz and then adjust L31 to have Vt = 25.2 ± 0.3V.
   - Adjust L9 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. Half NIM Electrical Characteristics:

Unless otherwise specified, all data are measured in conditions of supply voltage of 3.3 V ± 5%, AGC voltage of 3.0 V ± 5%, ambient temperature of 25 ° C ± 5%, $f_{ref}$ of 166.667KHz.

| Parameter | | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| **Frequency range** | | | | | |
| VHFL | **51 ~ 157 MHz** | | | | |
| VHFH | **164 ~ 442 MHz** | | | | |
| UHF | **450 ~ 858 MHz** | | | | |
| | | | | | |
| IF center frequency | | | 36 | | MHz |
| | | | | | |
| Frequency margin at low and high ends of each band | | 1.5 | | | |
| | | | | | |
| **Supply voltages and currents** | | | | | |
| Supply voltage +Vcc Pin ※ | | 3.0 | 3.3 | 5.5 | V |
| | | | | | |
| Supply current +Vcc Pin | | | | 160 | mA |
| | | | | | |
| Input connector: MMCX | | | | | |
| | | | | | |
| **RF Characteristics** | | | | | |
| | | | | | |
| Input impedance<br>Output impedance with IF dummy | | | 75<br>75 | | Ω |
| | | | | | |
| VSWR at nominal gain and during AGC | | | | 5 | |
| | | | | | |
| External AGC voltage for max RF gain<br>External AGC voltage for min RF gain<br>Internal AGC voltage | | 2.7<br>0.5 | 3.0<br><br>3.0 | Vcc | V |
| | | | | | |
| AGC range VHFL<br>AGC range VHFH<br>AGC range UHF | | 50<br>45<br>45 | | | dB |
| | | | | | |
| Tuning sensitivity VHFL<br>Tuning sensitivity VHFH<br>Tuning sensitivity UHF | | 1<br>5<br>3 | | 10<br>23<br>36 | MHz/V |
| | | | | | |
| Power gain<br>(Tuner Part Only) | | 38 | 43 | | dB |
| | | | | | |
| Gain taper in each band (Tuner Part Only) | | | | 5 | dB |
| | | | | | |
| Noise figure VHFL (Tuner Part Only)<br>Noise figure VHFH (Tuner Part Only)<br>Noise figure UHF (Tuner Part Only) | | | 6.5<br>5.5<br>4.5 | 8<br>8<br>8 | dB |

| Parameter | Min | Typ | Max | Unit |
|---|---|---|---|---|
| | | | | |
| | | | | |
| RF bandwidth (3 dB) VHFL<br>RF bandwidth (3 dB) VHFH<br>RF bandwidth (3 dB) UHF | | 10<br>10<br>10 | 20<br>20<br>20 | MHz |
| | | | | |
| Image rejection VHFL<br>Image rejection VHFH<br>Image rejection UHF | 65<br>60<br>55 | 70<br>65<br>60 | | dB |
| | | | | |
| IF rejection channel E2(frequency = 51MHz)<br>Other channels | 75<br>80 | | | dB |
| | | | | |
| Input 1 dB compression Point | 70 | | | dBuV |
| | | | | |
| Input IP3 (two tone 1MHz apart) | 85 | | | |
| | | | | |
| 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 1GHz | | | 30 | dBuV |
| | | | | |
| Phase Noise 1KHz offset<br>10KH offset ***wide loop bandwidth***[6]<br>100KHz offset | 75<br>75<br>105 | | | dBc/Hz |
| Phase Noise, 1KHz offset<br>10KH offset ***narrow loop bandwidth***[7]<br>100KHz offset | 75<br>90<br>110 | | | |
| | | | | |
| DC-DC Converter Spurious Rejection | 52 | 55 | | dBc |
| | | | | |
| Cross modulation[8] | | | | dBµV |
| In_Channel / disturbing voltage producing 1% of Xmod | 65 | | | |
| N±1 Channel / disturbing voltage producing 1 % of Xmod | 70 | | | |
| N±2 Channel / disturbing voltage producing 1 % of Xmod | 75 | | | |

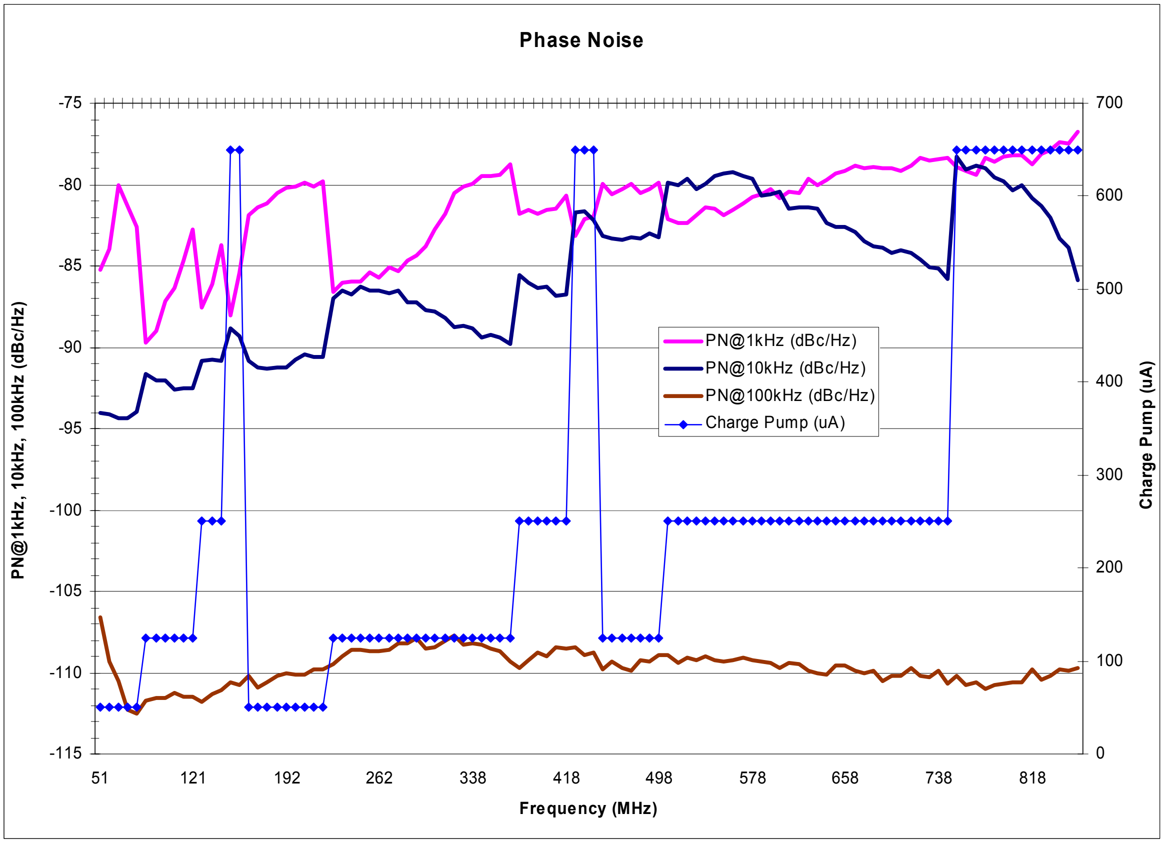
**All Measurement data in the following pages are based on 3.3V operation voltage and TUA6039-2 C1 typical sample.**

※ **To use Vcc at 3.3V, set R48 to 0 Ohm; To use Vcc at 5.0V, set R48 to 150 Ohms**

6. *Loop filter components for wide loop bandwidth; C68=6.8nF, C65=33pF, R39=150Kohm. This would be suitable for 166.67kHz Reference Frequency*

7. *Loop filter components for narrow loop bandwidth; C68=47nF, C65=470pF, R39=100Kohm. This would be suitable for Hybrid Application to cover both 62.5kHz and 166.67kHz Reference Frequency*

8. *Wanted signal 60 dBµV, unwanted signal 80% AM modulated with 1 kHz, AGC set to full RF Gain*




**Charge Pump Setting:**

**VHF Low**

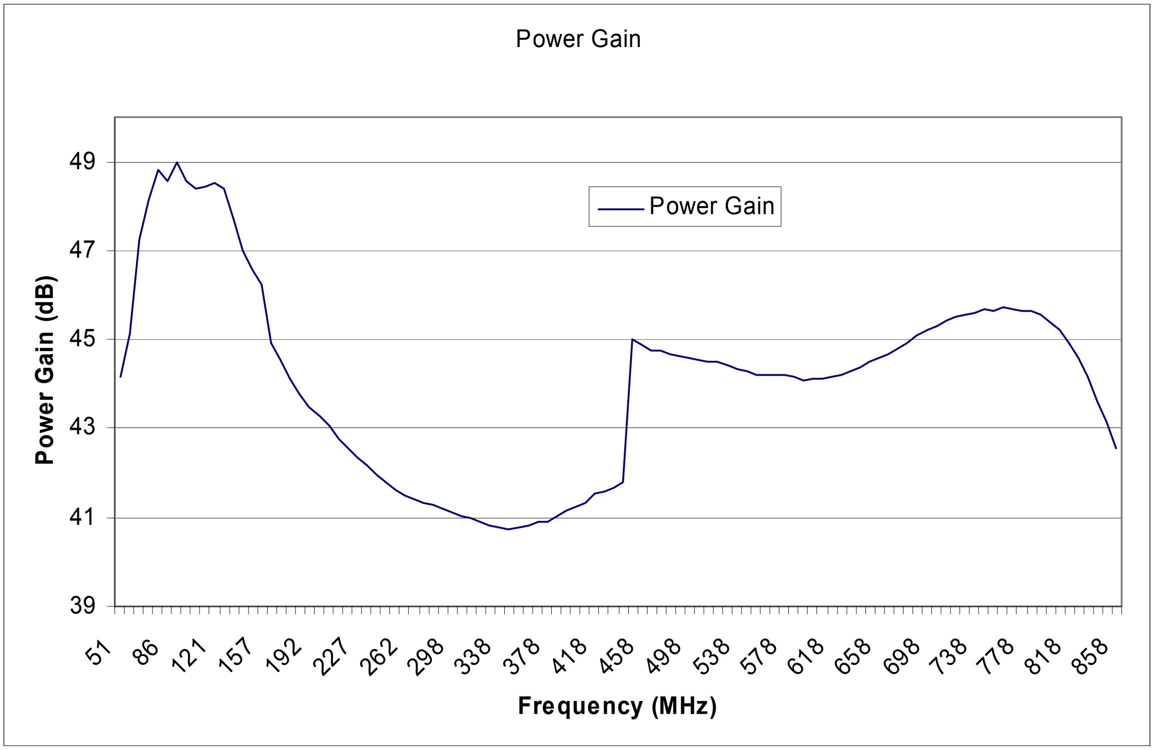
| | | | |
|---|---|---|---|
| **51MHz~ 79MHz** | **50uA** | **86MHz~121MHz** | **125uA** |
| **128MHz~142MHz** | **250uA** | **149MHz~157MHz** | **650uA** |

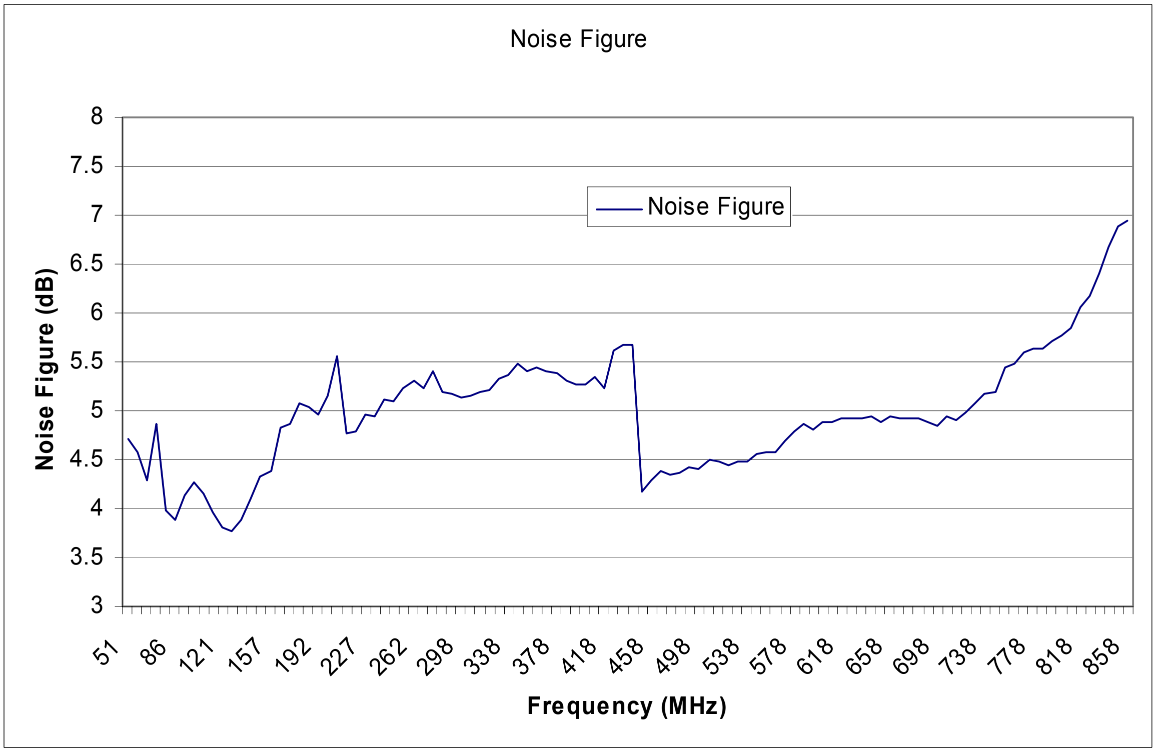
**VHF High**

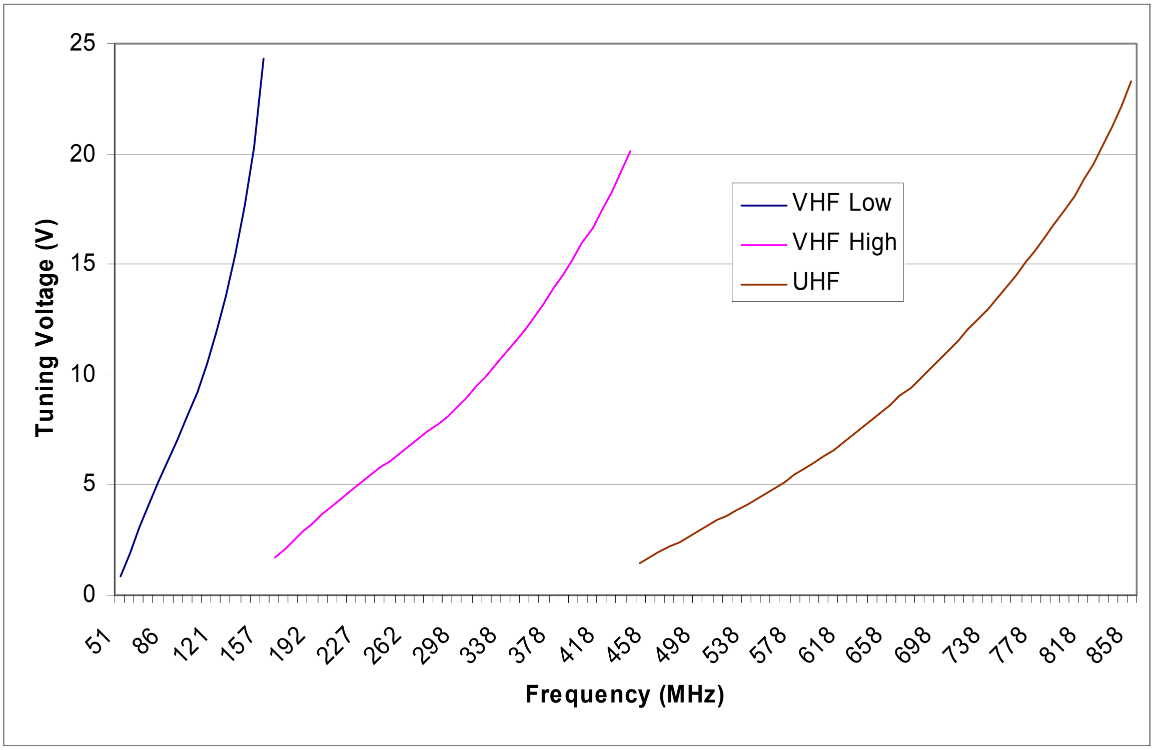
| | | | |
|---|---|---|---|
| **164MHz~220MHz** | **50uA** | **227MHz~370MHz** | **125uA** |
| **378MHz~418MHz** | **250uA** | **426MHz~442MHz** | **650uA** |

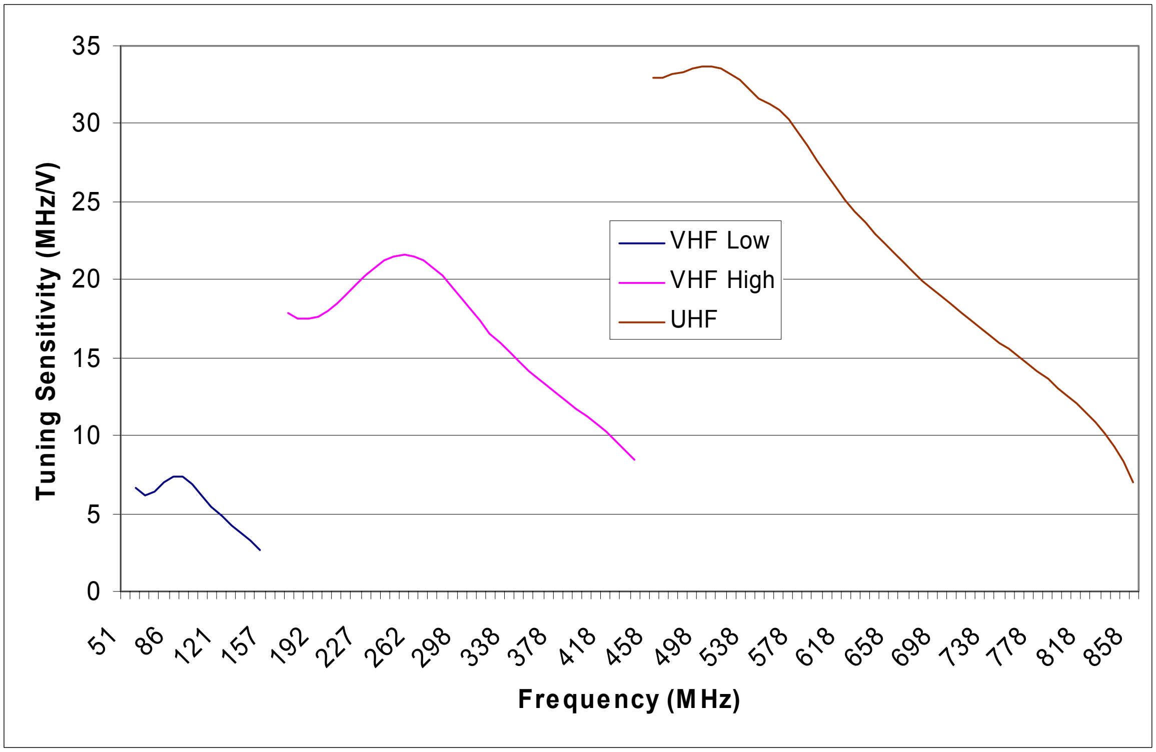
**UHF**

| | | | |
|---|---|---|---|
| **450MHz~498MHz** | **125uA** | **506MHz~746MHz** | **250uA** |
| **754MHz~858MHz** | **650uA** | | |


Power Gain
Power Gain
49
47
45
43
41
39
Power Gain (dB)
51
86
121
157
192
227
262
298
338
378
418
458
498
538
578
618
658
698
738
778
818
858
Frequency (MHz)


Noise Figure
Noise Figure
8
7.5
7
6.5
6
5.5
5
4.5
4
3.5
3
Noise Figure (dB)
51
86
121
157
192
227
262
298
338
378
418
458
498
538
578
618
658
698
738
778
818
858
Frequency (MHz)


Tuning Voltage (V)
25
20
15
10
5
0
VHF Low
VHF High
UHF
51 86 121 157 192 227 262 298 338 378 418 458 498 538 578 618 658 698 738 778 818 858
Frequency (MHz)


Tuning Sensitivity (MHz/V)
35
30
25
20
15
10
5
0
VHF Low
VHF High
UHF
51 86 121 157 192 227 262 298 338 378 418 458 498 538 578 618 658 698 738 778 818 858
Frequency (MHz)

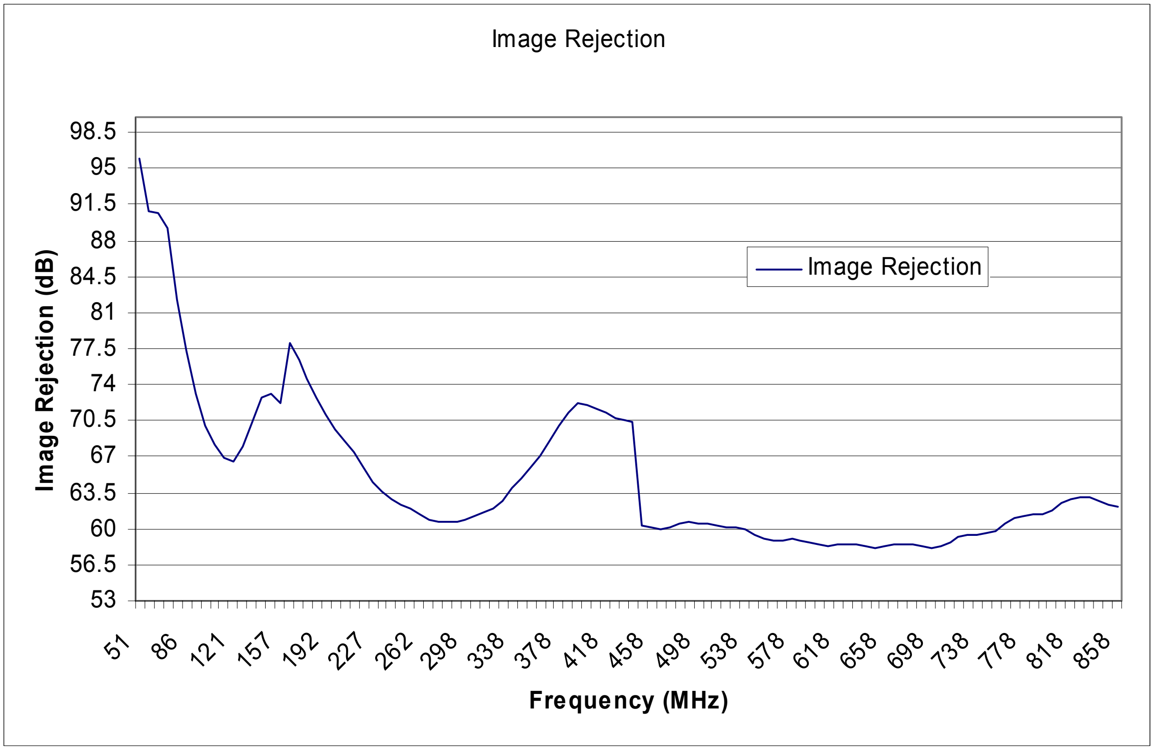
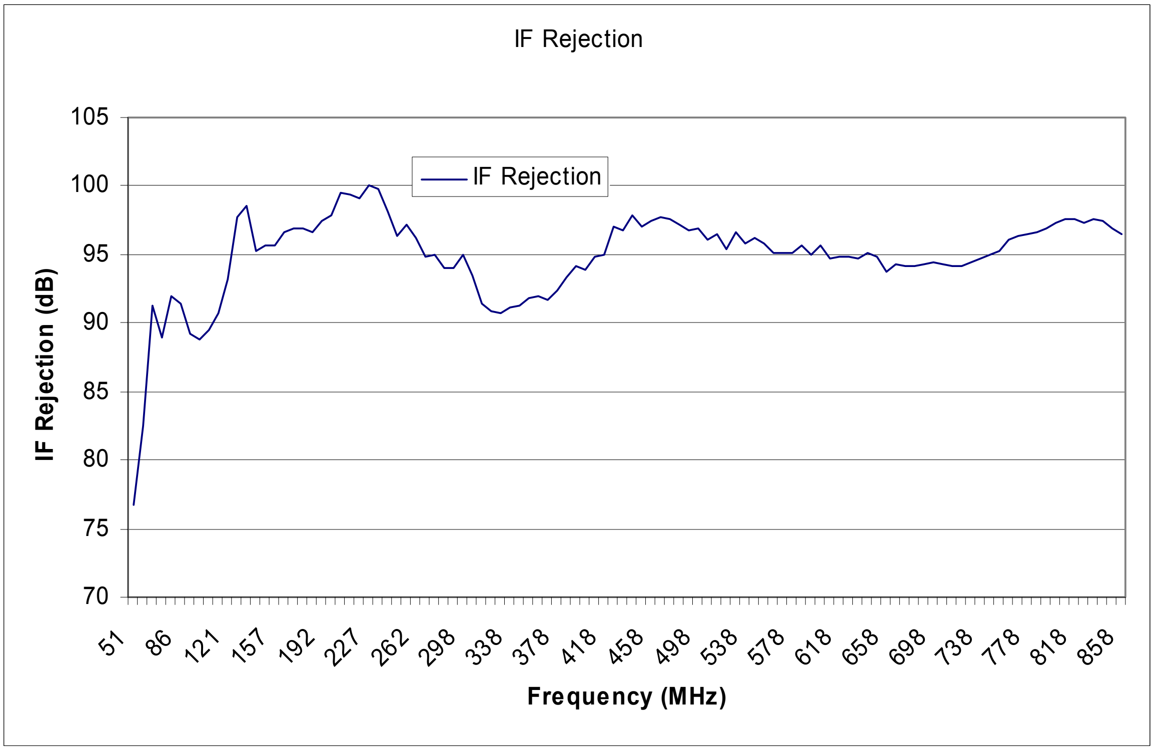
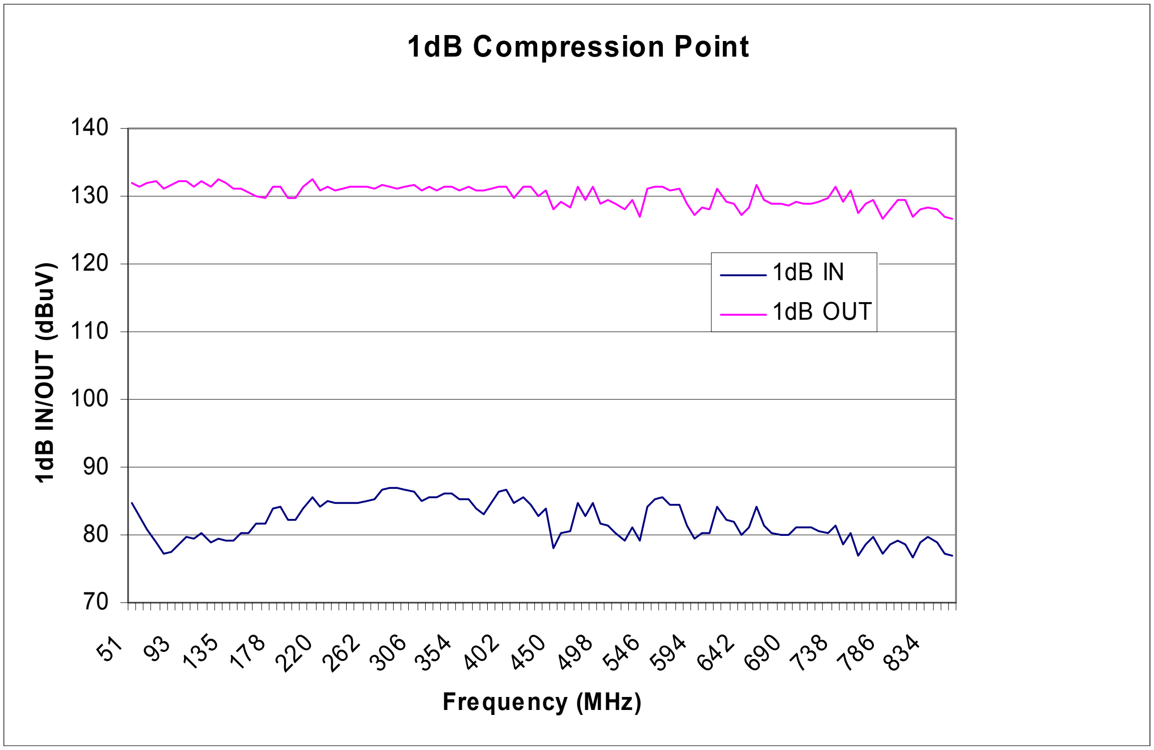
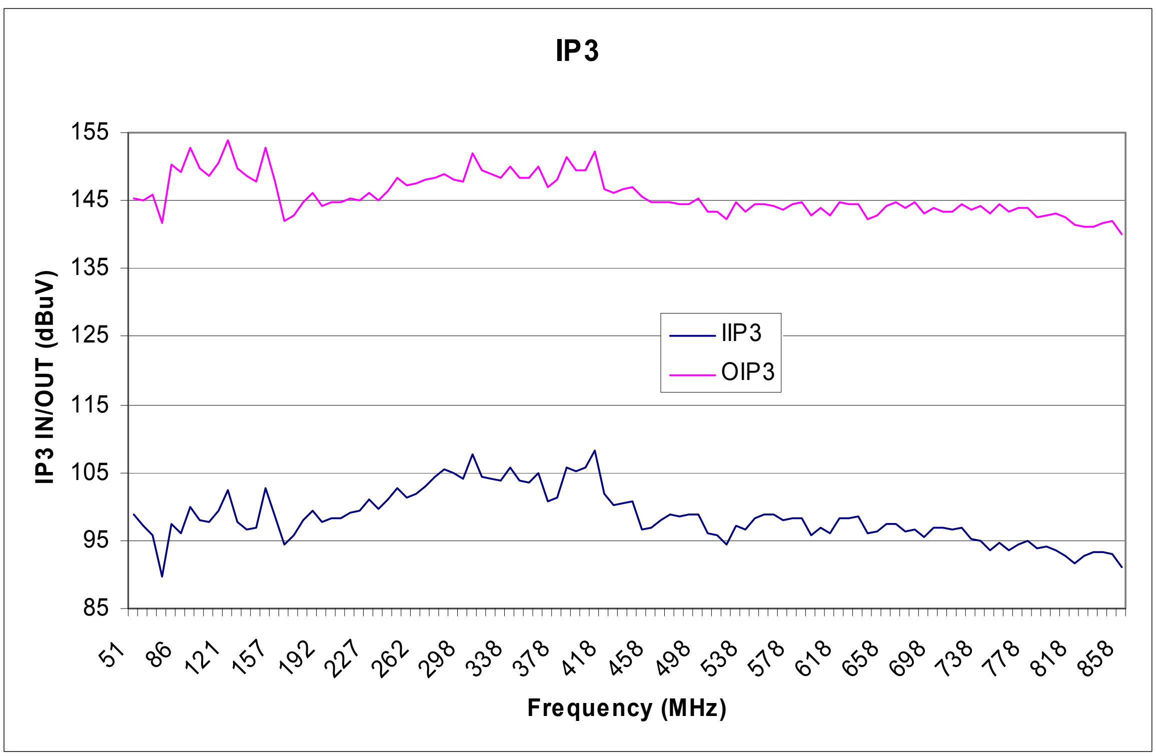


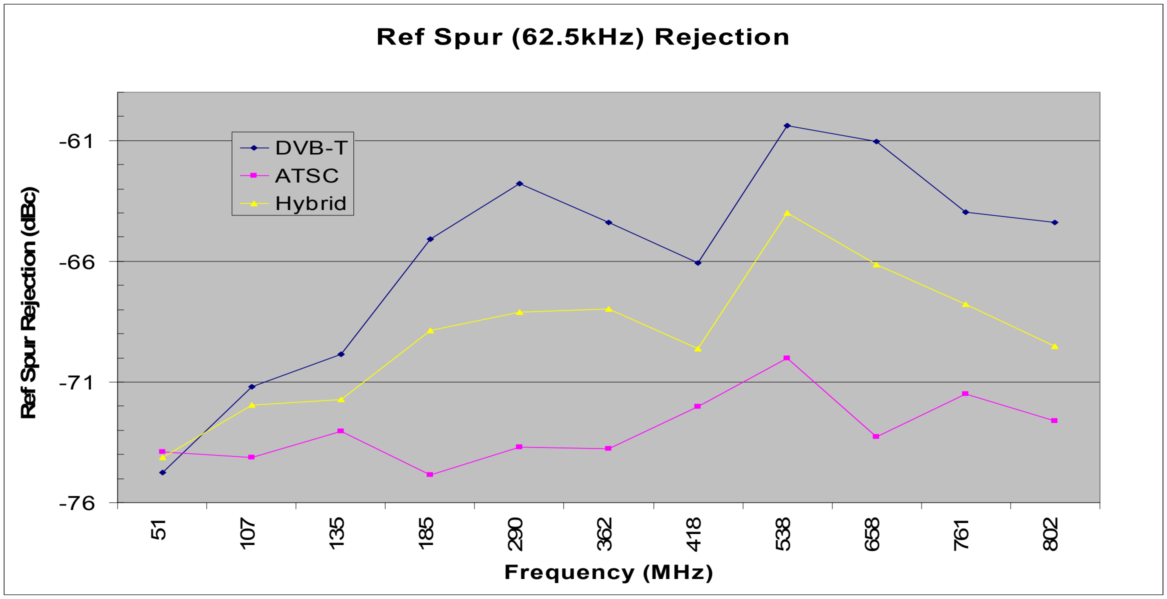
Image Rejection
Image Rejection (dB)
98.5
95
91.5
88
84.5
81
77.5
74
70.5
67
63.5
60
56.5
53
Image Rejection
51
86
121
157
192
227
262
298
338
378
418
458
498
538
578
618
658
698
738
778
818
858
Frequency (MHz)


IF Rejection
IF Rejection (dB)
105
100
95
90
85
80
75
70
IF Rejection
51
86
121
157
192
227
262
298
338
378
418
458
498
538
578
618
658
698
738
778
818
858
Frequency (MHz)


1dB Compression Point
1dB IN/OUT (dBuV)
140
130
120
110
100
90
80
70
1dB IN
1dB OUT
51
93
135
178
220
262
306
354
402
450
498
546
594
642
690
738
786
834
Frequency (MHz)


IP3
IP3 IN/OUT (dBuV)
155
145
135
125
115
105
95
85
IIP3
OIP3
51
86
121
157
192
227
262
298
338
378
418
458
498
538
578
618
658
698
738
778
818
858
Frequency (MHz)

The following graph shows the 62.5kHz reference frequency rejection ratio based on different loop filter and its post filter configuration. The measurement result is based on TUA6039-2 C1 typical sample




Referring to the schematic diagram of the reference mini half nim with TUA6039-2, the loop filter and its post filter is configured according to following component values:

DVB-T:

| | |
|---|---|
| Main Loop Filter Config: | C68 = 6.8nF |
| | C65 = 33pF |
| | R39 = 150kOhm |
| Post Filter Config: | R40 = 33kOhm |
| | R45 = 2.2kOhm |
| | C41 = 3.3nF |
| | C24 = 15nF |

ATSC:

| | |
|---|---|
| Main Loop Filter Config: | C68 = 47nF |
| | C65 = 470pF |
| | R39 = 100kOhm |
| Post Filter Config: | R40 = 330kOhm |
| | R45 = 15kOhm |
| | C41 = 6.8nF |
| | C24 = 22nF |

Hybrid:

| | |
|---|---|
| Main Loop Filter Config: | C68 = 6.8nF |
| | C65 = 33pF |
| | R39 = 100kOhm |
| Post Filter Config: | R40 = 150kOhm |
| | R45 = 2.2kOhm |
| | C41 = 3.3nF |
| | C24 = 15nF |

**The above test result shows that the rejection ratio for reference frequency of 62.5kHz is dependant of the loop filter and post filter configuration. This application note covers only DVB-T reception with reference frequency of 166.67kHz. Although Loop filter can be modified to cover both 166.67kHz and 62.5kHz for hybrid purposes, there is always compromise among Phase Noise, Reference Frequency Rejection and PLL Lock-in Time. It is strongly recommended that designers decide the reference frequency first (62.5kHz or 166.67kHz or both) before adopting the relevant loop filter and post filter configuration.**

# 6. PLL Programming[9]

**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 | XTB | NA | NA | P4 | P3 | P2 | P1 | P0 | A |
| Auxiliary byte | ATC | AL2 | AL1 | AL0 | 0 | 0 | 0 | LP | 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: (Vs = 5 V)**

| MA1 | MA0 | voltage at CAS pin |
|---|---|---|
| 0 | 0 | (0 ~ 0.1) x Vs |
| 0 | 1 | Open |
| 1 | 0 | (0.4 ~ 0.6) x Vs |
| 1 | 1 | (0.9 ~ 1) x Vs |

**Band selection** (via BandSwitching byte)

| UHF | VHF2 | VHF1 |
|---|---|---|
| 100 001 00 | 100 000 10 | 100 000 01 |

**Charge Pump Current**

| Icp(uA) | Mode | CP | T2 | T1 | T0 |
|---|---|---|---|---|---|
| 50 | Normal | 0 | 0 | 0 | X |
| 250 | | 1 | | | X |
| 50 | Extended | 0 | 1 | 1 | 0 |
| 125 | | 0 | | | 1 |
| 250 | | 1 | | | 0 |
| 650 | | 1 | | | 1 |

**Reference Divider Rations**

| Reference Divider Ratio | $f_{ref}$(KHz)[10] | 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 |

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

[9]. *Please refer to chapter 5.2 of TUA6039-2 data sheets for more details of IIC programming*
[10]. *with 4MHz Quartz*

## 7. Component List and Ordering Information

(units : Farad, Ohm, Henry)

| Designators | Footprint | Value | Tolerance | Remarks | Manufacturer |
|---|---|---|---|---|---|
| | | | | | |
| Passive Devices | | | | | |
| General Devices | | | | | |
| C1 | 0402 | 330p | 5% | GRM15/18 | Murata |
| C2 | 0402 | 220p | 5% | GRM15/18 | Murata |
| C3 | 0402 | 12p | 5% | GRM15/18 | Murata |
| C4 | 0402 | 1n | 10% | GRM15/18 | Murata |
| C5 | 0402 | 2p2 | 5% | GRM15/18 | Murata |
| C6 | 0402 | OPEN | 5% | GRM15/18 | Murata |
| C7 | 0402 | 4n7 | 10% | GRM15/18 | Murata |
| C8 | 0402 | 0p5 | 5% | GRM15/18 | Murata |
| C9 | 0402 | 1n | 10% | GRM15/18 | Murata |
| C10 | 0402 | 4n7 | 10% | GRM15/18 | Murata |
| C11 | 0402 | 4n7 | 10% | GRM15/18 | Murata |
| C12 | 0402 | 4n7 | 10% | GRM15/18 | Murata |
| C13 | 0402 | 120p | 5% | GRM15/18 | Murata |
| C14 | 0402 | 4n7 | 10% | GRM15/18 | Murata |
| C15 | 0402 | 470p | 10% | GRM15/18 | Murata |
| C16 | 0402 | 4n7 | 10% | GRM15/18 | Murata |
| C18 | 0402 | 4n7 | 10% | GRM15/18 | Murata |
| C19 | 0402 | 100n | 10% | GRM15/18 | Murata |
| C20 | 0402 | 4n7 | 10% | GRM15/18 | Murata |
| C21 | 0603 | 4n7 | 10% | GRM15/18 | Murata |
| C22 | 0402 | 4n7 | 10% | GRM15/18 | Murata |
| C23 | 0402 | 4n7 | 10% | GRM15/18 | Murata |
| C24 | 0603 | 15n | 10% | GRM15/18 | Murata |
| C25 | 0603 | 4n7 | 10% | GRM15/18 | Murata |
| C26 | 0402 | 270p | 5% | GRM15/18 | Murata |
| C27 | 0402 | 1p2 | 5% | GRM15/18 | Murata |
| C28 | 0402 | 100p | 5% | GRM15/18 | Murata |
| C29 | 0402 | 12p | 5% | GRM15/18 | Murata |
| C30 | 0402 | 22p | 5% | GRM15/18 | Murata |
| C31 | 0402 | 27p | 5% | GRM15/18 | Murata |
| C32 | 0402 | 27p | 5% | GRM15/18 | Murata |
| C33 | 0402 | 1p8 | 5% | GRM15/18 | Murata |
| C34 | 0402 | 220p | 5% | GRM15/18 | Murata |
| C35 | 0402 | 220p | 5% | GRM15/18 | Murata |

| Designators | Footprint | Value | Tolerance | Remarks | Manufacturer |
|---|---|---|---|---|---|
| C36 | 0402 | 470p | 10% | GRM15/18 | Murata |
| C37 | 0402 | 470p | 10% | GRM15/18 | Murata |
| C38 | 0402 | 22p | 5% | GRM15/18 | Murata |
| C39 | 0402 | 470p | 10% | GRM15/18 | Murata |
| C41 | 0402 | 3n3 | 10% | GRM15/18 | Murata |
| C42 | 0402 | 4n7 | 10% | GRM15/18 | Murata |
| C43 | 0603 | 4n7 | 10% | GRM15/18 | Murata |
| C44 | 0603 | 4n7 | 10% | GRM15/18 | Murata |
| C45 | 0603 | 100p | 5% | GRM15/18 | Murata |
| C46 | 0603 | 100p | 5% | GRM15/18 | Murata |
| C47 | 0402 | 4n7 | 10% | GRM15/18 | Murata |
| C48 | 0402 | 3n3 | 5% | GRM15/18 | Murata |
| C49 | 0402 | 2p7 | 5% | GRM15/18 | Murata |
| C50 | 0402 | 2p2 | 5% | GRM15/18 | Murata |
| C51 | 0603 | 39p | 5% | GRM15/18 | Murata |
| C52 | 0402 | 1p5 | 5% | GRM15/18 | Murata |
| C53 | 0402 | 1p2 | 5% | GRM15/18 | Murata |
| C54 | 0402 | 82p | 5% | GRM15/18 | Murata |
| C55 | 0402 | 1p2 | 5% | GRM15/18 | Murata |
| C56 | 0402 | 1p2 | 5% | GRM15/18 | Murata |
| C57 | 0402 | 1p2 | 5% | GRM15/18 | Murata |
| C58 | 0402 | 1p2 | 5% | GRM15/18 | Murata |
| C59 | 0402 | 22p | 5% | GRM15/18 | Murata |
| C60 | 0402 | 4n7 | 10% | GRM15/18 | Murata |
| C61 | 0402 | 4n7 | 10% | GRM15/18 | Murata |
| C62 | 0603 | 4n7 | 10% | GRM15/18 | Murata |
| C63 | 0402 | 4n7 | 10% | GRM15/18 | Murata |
| C64 | 0402 | 4n7 | 10% | GRM15/18 | Murata |
| C65 | 0402 | 33p | 5% | GRM15/18 | Murata |
| C66 | 0402 | 33p | 5% | GRM15/18 | Murata |
| C67 | 0402 | 2p | 5% | GRM15/18 | Murata |
| C68 | 0603 | 6n8 | 10% | GRM15/18 | Murata |
| C69 | 0402 | 100n | 10% | GRM15/18 | Murata |
| C70 | 0603 | 150n | 10% | GRM15/18 | Murata |
| C71 | 0603 | 4n7 | 10% | GRM15/18 | Murata |
| C72 | 0603 | 4n7 | 10% | GRM15/18 | Murata |
| C74 | 0402 | 33p | 5% | GRM15/18 | Murata |
| C75 | 0402 | 51p | 5% | GRM15/18 | Murata |
| C76 | 0402 | 22p | 5% | GRM15/18 | Murata |

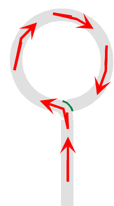
| Designators | Footprint | Value | Tolerance | Remarks | Manufacturer |
|---|---|---|---|---|---|
| C77 | 0402 | 22p | 5% | GRM15/18 | Murata |
| C79 | 0402 | 2p2 | 10% | GRM15/18 | Murata |
| C80 | 0402 | 5p6 | 5% | GRM15/18 | Murata |
| C81 | 0402 | 10n | 10% | GRM15/18 | Murata |
| C82 | 0603 | 10n | 10% | GRM15/18 | Murata |
| C83 | 0603 | 220p | 5% | GRM15/18 | Murata |
| C84 | 0402 | 4n7 | 10% | GRM15/18 | Murata |
| C85 | 0603 | 47n | 10% | GRM15/18 | Murata |
| C87 | 0402 | 22n | 10% | GRM15/18 | Murata |
| C88 | 0402 | 47n | 10% | GRM15/18 | Murata |
| C89 | 0402 | 18p | 5% | GRM15/18 | Murata |
| C90 | 0402 | 18p | 5% | GRM15/18 | Murata |
| C91 | 0402 | 4n7 | 10% | GRM15/18 | Murata |
| C92 | 0402 | 4n7 | 10% | GRM15/18 | Murata |
| C93 | 0402 | 0p5 | 5% | GRM15/18 | Murata |
| C94 | 0402 | 0p5 | 5% | GRM15/18 | Murata |
| C100 | 0603 | 0p5 | 5% | GRM15/18 | Murata |
| All Capacitors have a voltage rating of 50V or above | | | | | |
| | | | | | |
| J1 | 0402 | OPEN | | | General Brand |
| J2 | 0402 | OPEN | | | General Brand |
| | | | | | |
| R1 | 0402 | 33K | 5% | | General Brand |
| R2 | 0402 | 33K | 5% | | General Brand |
| R3 | 0402 | 33K | 5% | | General Brand |
| R4 | 0402 | 10K | 5% | | General Brand |
| R5 | 0603 | 33K | 5% | | General Brand |
| R6 | 0402 | 33K | 5% | | General Brand |
| R7 | 0402 | 10K | 5% | | General Brand |
| R8 | 0402 | 10K | 5% | | General Brand |
| R10 | 0603 | 33K | 5% | | General Brand |
| R11 | 0603 | 5R6 | 5% | | General Brand |
| R12 | 0603 | 22 | 5% | | General Brand |
| R13 | 0402 | 22 | 5% | | General Brand |
| R14 | 0402 | 33K | 5% | | General Brand |

| Designators | Footprint | Value | Tolerance | Remarks | Manufacturer |
|---|---|---|---|---|---|
| R15 | 0402 | 10K | 5% | | General Brand |
| R16 | 0402 | 100K | 5% | | General Brand |
| R17 | 0402 | 15 | 5% | | General Brand |
| R18 | 0603 | 150K | 5% | | General Brand |
| R19 | 0402 | 150K | 5% | | General Brand |
| R20 | 0603 | 33K | 5% | | General Brand |
| R21 | 0603 | 33K | 5% | | General Brand |
| R22 | 0603 | 33K | 5% | | General Brand |
| R23 | 0603 | 33K | 5% | | General Brand |
| R25 | 0603 | 0 | 5% | | General Brand |
| R26 | 0402 | 47K | 5% | | General Brand |
| R27 | 0603 | 0R | 5% | | General Brand |
| R28 | 0402 | 33K | 5% | | General Brand |
| R29 | 0603 | 330 | 5% | | General Brand |
| R30 | 0603 | 330 | 5% | | General Brand |
| R31 | 0402 | 12 | 5% | | General Brand |
| R32 | 0603 | 2k7 | 5% | | General Brand |
| R33 | 0402 | 10 | 5% | | General Brand |
| R34 | 0402 | 2K7 | 5% | | General Brand |
| R36 | 0402 | 2K2 | 5% | | General Brand |
| R37 | 0402 | 2K2 | 5% | | General Brand |
| R39 | 0402 | 100K | 5% | | General Brand |
| R40 | 0603 | 150K | 5% | | General Brand |
| R41 | 0402 | 15 | 5% | | General Brand |
| R42 | 0402 | 1K2 | 5% | | General Brand |
| R44 | 0402 | 10K | 5% | | General Brand |
| R45 | 0402 | 2K2 | 5% | | General Brand |
| R46 | 0402 | 100K | 5% | | General Brand |
| R48 | 0805 | 150/0 | 5% | | General Brand |
| | | | | | |
| Special Devices | | | | | |
| F1 | SMT | X7356P | | | EPCOS |
| | | | | | |
| Q1 | Height 3.5mm | 4MHz 16~20pF | AT-41(SP) | | NDK |
| | | | | | |
| Customized Devices | | | | | |
| L1 | | 12,0.4,2.2 CW | | | Customized |

| Designators | Footprint | Value | Tolerance | Remarks | Manufacturer |
|---|---|---|---|---|---|
| L2 | | 9,0.4,2.5 CW | | | Customized |
| L3 | | 9,0.3,2 CW | | | Customized |
| L4 | | 6,0.3,1.6 CCW | | | Customized |
| L5 | | 3.5,0.315,1.6 CW | | | Customized |
| L7 | | 9,0.3,2 CCW | | | Customized |
| L8 | | 6,0.3,1.6 CCW | | | Customized |
| L9 | | 13,0.3,3 CW | | | Customized |
| L10 | 0805 | 390nH | | LQW2BH | Murata |
| L11 | | 8,0.3,2 CW | | | Customized |
| L12 | | 15,0.3,1.9 CW | | | Customized |
| L13 | 0805 | 3.9uH | | | General Brand |
| L14 | | 5,0.3,1.7 CCW | | | Customized |
| L15 | | 3,0.4,1.9 CCW | | | Customized |
| L16 | | 2,0.5,1.6 CW | | | Customized |
| L18 | | 2,0.5,1.6 CCW | | | Customized |
| L19 | | 4,0.4,1.7 CW | | | Customized |
| L20 | | 4,0.4,1.7 CW | | | Customized |
| L21 | | 4,0.4,2 CW | | | Customized |
| L22 | | 4,0.4,1.6 CW | | | Customized |
| L24 | | 4,0.4,1.6 CCW | | | Customized |
| L25 | | 8,0.3,2 CCW | | | Customized |
| L26 | | 8,0.3,2,CW | | | Customized |
| L27 | | 15,0.3,2 CW | | | Customized |
| L28 | | 15,0.3,2 CW | | | Customized |
| L29 | | 8,0.3,1.6 CCW | | | Customized |
| L30 | 0603 | 470nH | | LQW18A | Murata |
| L31 | | 15,0.3,1.9 CW | | | Customized |
| L32 | | 4,0.4,1.9 CW | | | Customized |
| L33 | | 2.5,0.4,1.5CW | | | Customized |
| L34 | 0805 | 1.2uH | | LQM21F | Murata |
| L35 | | 1mH | | | General Brand |
| L36 | 0603 | 470nH | | LQW18A | Murata |
| L37 | | 100uH | | | General Brand |
| L38 | 0805 | 1.2uH | | LQM21F | Murata |
| L39 | 0603 | 390nH | | LQW18A | Murata |
| | | | | | |

| Designators | Footprint | Value | Tolerance | Remarks | Manufacturer |
|---|---|---|---|---|---|
| Active Devices | | | | | |
| Integrated Chips | | | | | |
| IC | VQFN-48 | TUA6039-2 | | | INFINEON |
| | | | | | |
| Transistors/Diodes | | | | | |
| TR1 | SOT343 | BF5030W | | | INFINEON |
| TR2 | SOT363 | BG5120K | | | INFINEON |
| TR3 | SOT323 | BC847CW | | | INFINEON |
| TR4 | SOT323 | BAS70-04W | | | INFINEON |
| DZ | SOD323 | BZX384-C33 | | | PHILIPS |
| Varactor Diodes | | | | | |
| VD1 | SCD-80 | BB565 | | | INFINEON |
| VD2 | SCD-80 | BB659C | | | INFINEON |
| VD3 | SCD-80 | BB565 | | | INFINEON |
| VD4 | SCD-80 | BB565 | | | INFINEON |
| VD5 | SCD-80 | BB689 | | | INFINEON |
| VD6 | SCD-80 | BB565 | | | INFINEON |
| VD7 | SCD-80 | BB565 | | | INFINEON |
| VD8 | SCD-80 | BB659C | | | INFINEON |
| VD9 | SCD-80 | BB659C | | | INFINEON |
| VD10 | SCD-80 | BB565 | | | INFINEON |
| VD11 | SCD-80 | BB689 | | | INFINEON |
| VD12 | SCD-80 | BB689 | | | INFINEON |
| VD13 | SCD-80 | BB689 | | | INFINEON |
| VD14 | SCD-80 | BB659C | | | INFINEON |
| VD15 | SCD-80 | BB565 | | | INFINEON |
| Mechanincal Devices | | | | | |
| RF Input Connector | | | | | |
| C1 | SMT Female | 82 MMCX-S50-0-2/111KE | | | HUBER&SUHNER |
| Interface Pin | | | | | |
| C2 | | 11-Pin Pitch 2mm | | | General Brand |
| RECOMMENDED TESTING ADAPTOR | | | | | |
| MMCX male to BNC female | | 33 MMCX-BNC-50-1/111 UE | | | HUBER&SUHNER |

**1) All the coils are full-turn or half-turn types. The Unit of the Diameter of Coil & Wire is 'mm';**



**Full-Turn, CCW**

**2) The SMD component list above is made with reference to the tuner with 1 x MOSFET and 1 x Dual MOSFET;**

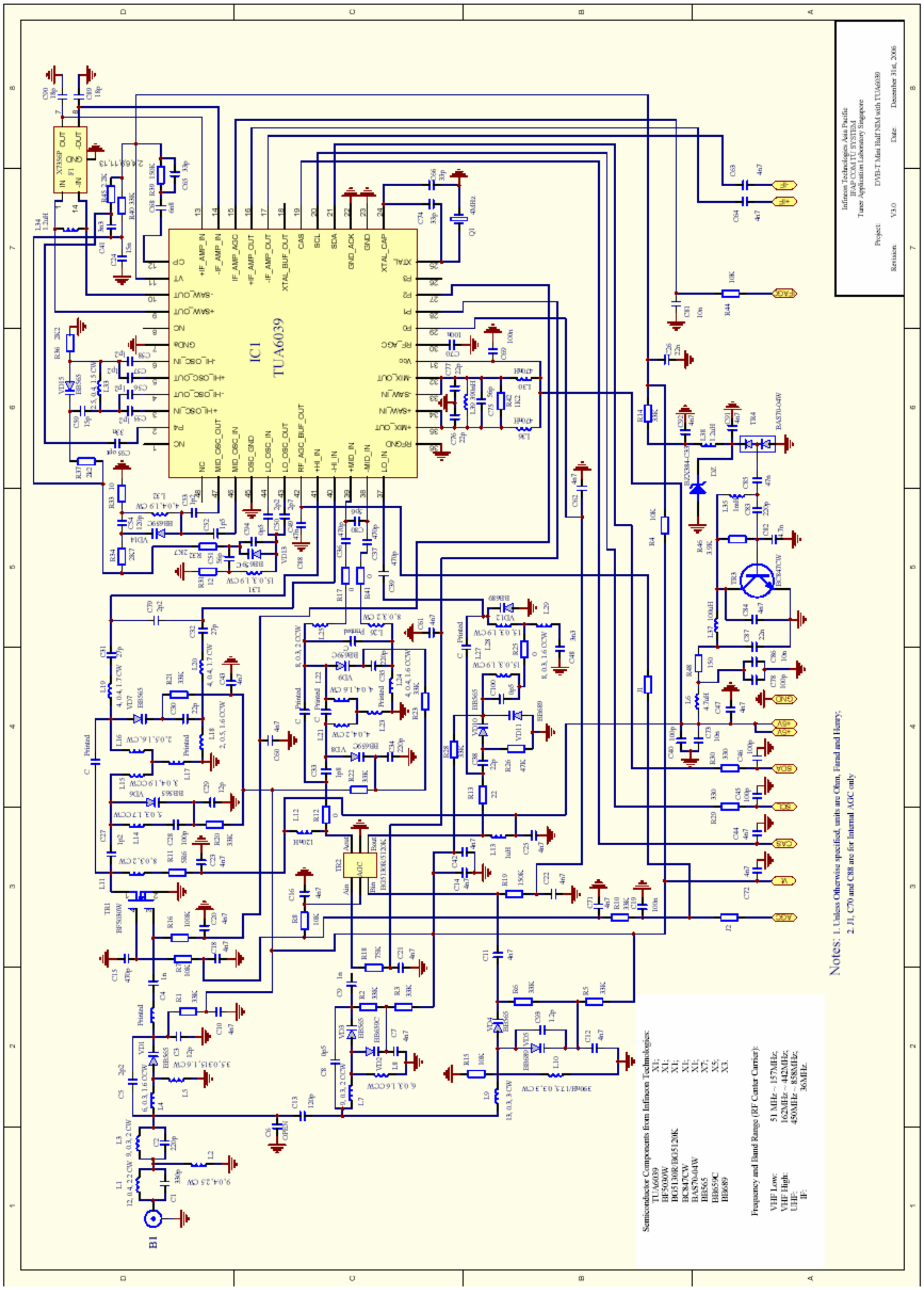
**3) To download the product from Infineon Technologies, please browse to the website www.infineon.com;**

**4) For more information regarding third-party components such as RF connectors, SAW filters, and Crystal, please browse to the relevant websites listed below:**

**www.hubersuhner.com**
**www.epcos.com**
**www.ndk.com**
**www.murata.com**
**www.philips.com**

# 8. Circuit and Layout[11]

## 8.1 Circuit diagram



8.2 Layout

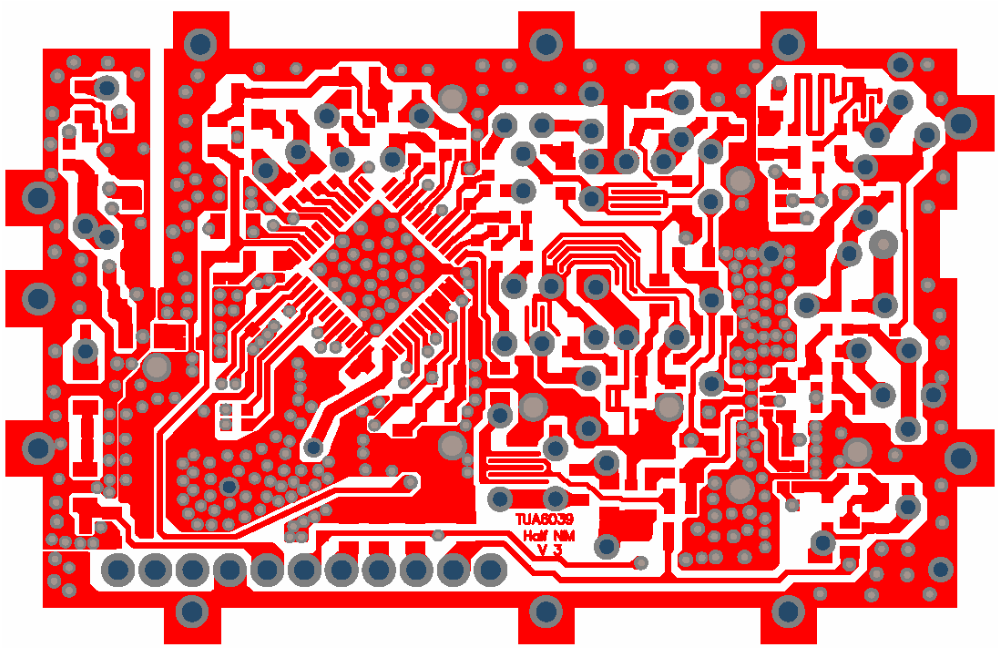



Fig. 9 Component Side View

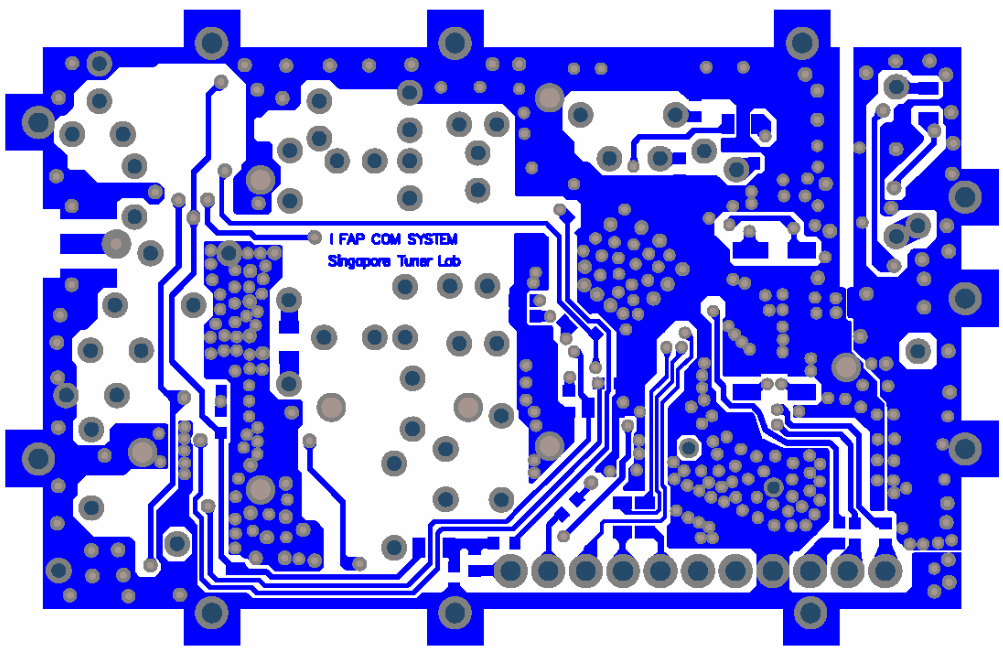



Fig. 10 Air Coils Side View

## 8.3 Pin Layout and Outline Dimension

To give an impression of the real sized tuner, a layout of the tuner PCB is given in Fig. 11. The pin layout of the Mini Tuner is described as followings:

1. Tuner AGC Output;
2. Tuning Voltage Output;
3. Chip Address Selection;
4. Serial Clock Input;
5. Serial Data Input/Output;
6. Vcca;
7. Vccd;
8. Ground;
9. IF AGC Input;
10. +IF Output;
11. –IF Output;

Pin #1 is at the right side and Pin #11 is at the left side.

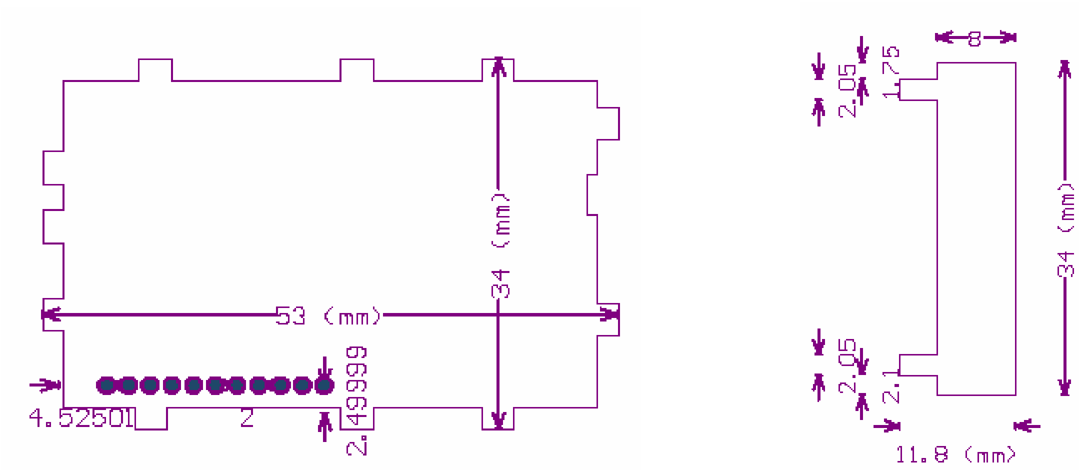



**Fig. 11 Layout of the Half NIM PCB**

[11]. ***Important:*** *Infineon Technologies reserves all rights to change, modify and update the specifications, schematic diagram, PCB layout and Component list without prior notice to the customers. For the latest design—Schematic, PCB and BOM which is suitable for pilot production, please refer to Infineon's Local Sales Offices, Authorized Distributors and other Agents for the update.*

# 9. Automatic Tuner Test Setup of the Team

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

Hewlett-Packard 8970B noise meter

Hewlett-Packard 53131A frequency counter

Rohde&Schwarz FSEA30 spectrum analyzer

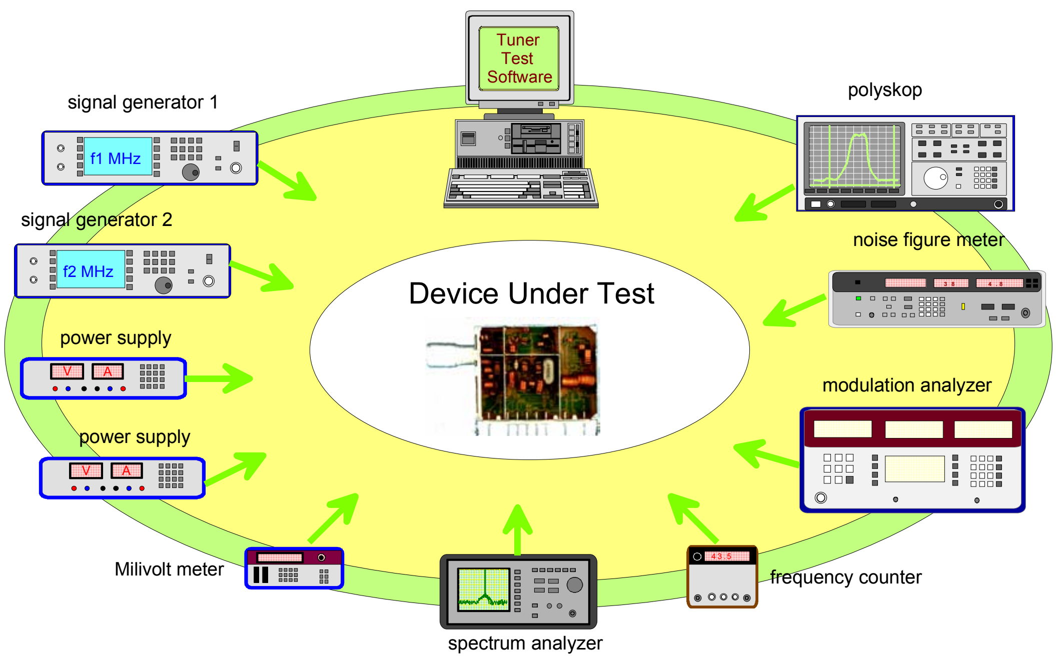
Rohde&Schwarz FMA modulation analyzer

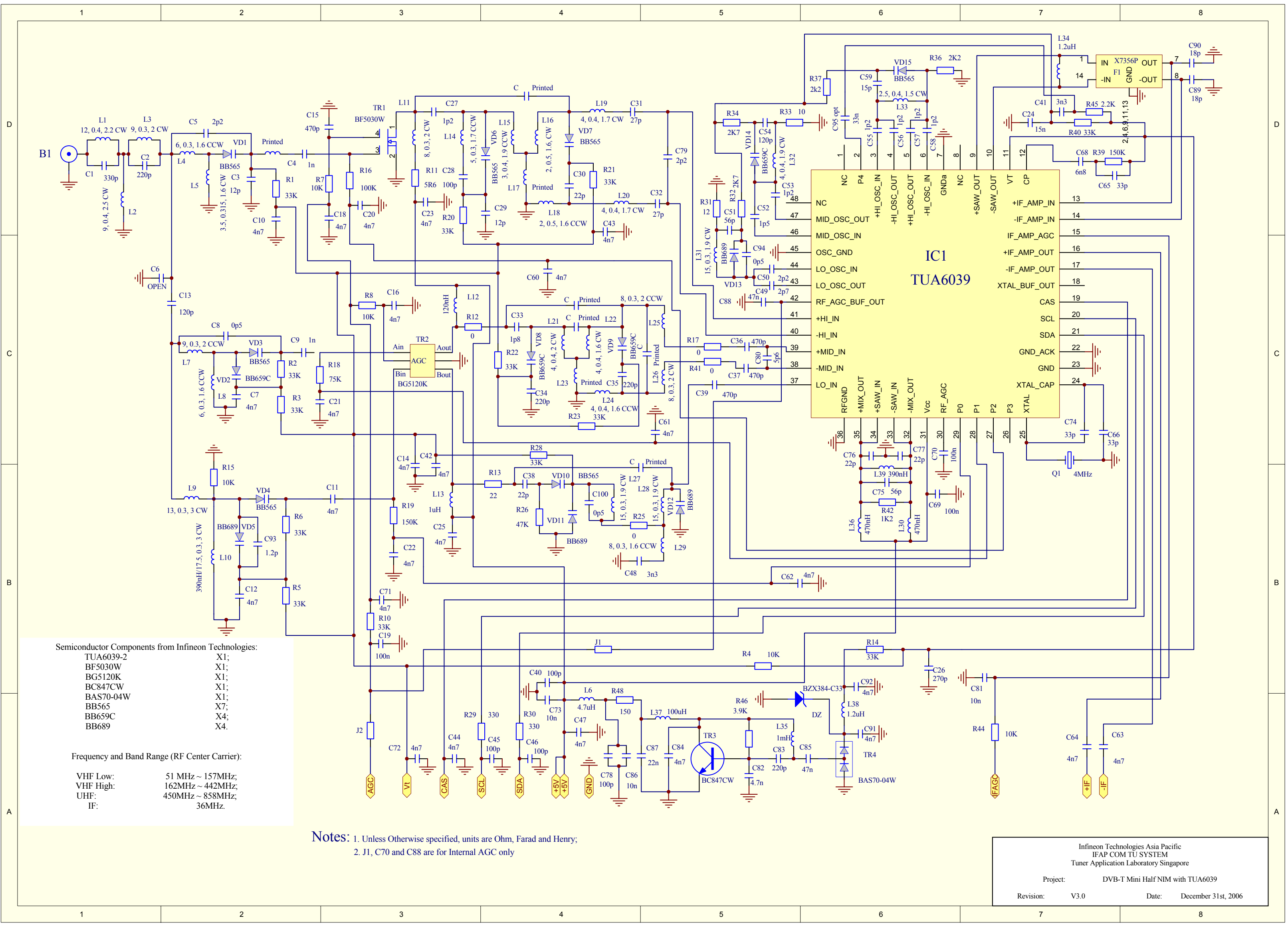
HP E3631A and E3632A voltage supply

Rohde&Schwarz ZWOB6 Scalar Polyskop

Marconi Instruments 2031 signal generator (2x)

All instruments are controlled via the GPIB bus by the tuner test and measurement software from PC. Test data will be attached (upon request) to tuner which is available for order through ISAR system. Please contact Infineon's local sales offices, authorized distributors and other agents for the detailed information regarding the reference mini Half NIM.






Semiconductor Components from Infineon Technologies:

| | |
|---|---|
| TUA6039-2 | X1; |
| BF5030W | X1; |
| BG5120K | X1; |
| BC847CW | X1; |
| BAS70-04W | X1; |
| BB565 | X7; |
| BB659C | X4; |
| BB689 | X4. |

Frequency and Band Range (RF Center Carrier):

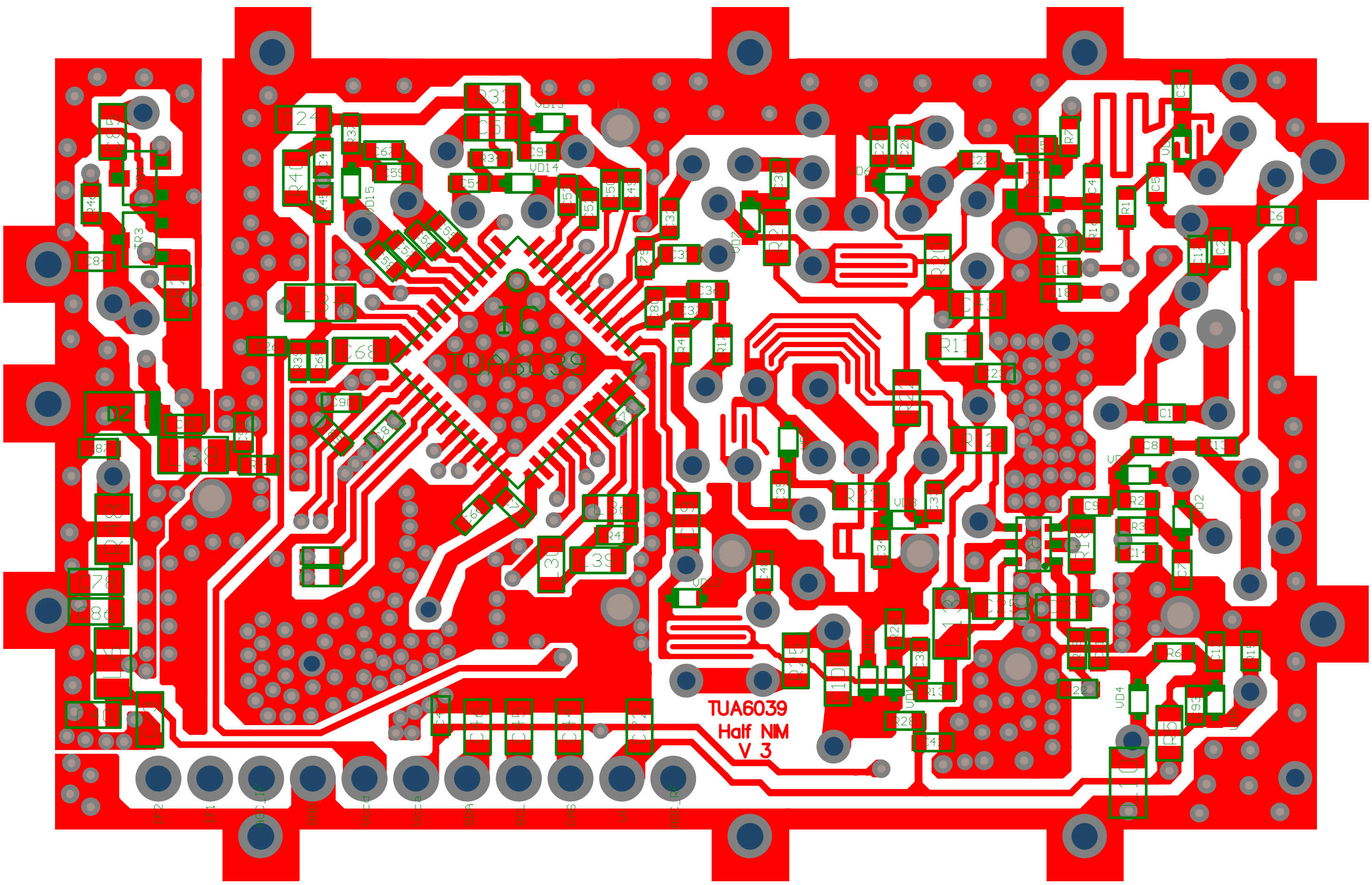
| | |
|---|---|
| VHF Low: | 51 MHz ~ 157MHz; |
| VHF High: | 162MHz ~ 442MHz; |
| UHF: | 450MHz ~ 858MHz; |
| IF: | 36MHz. |

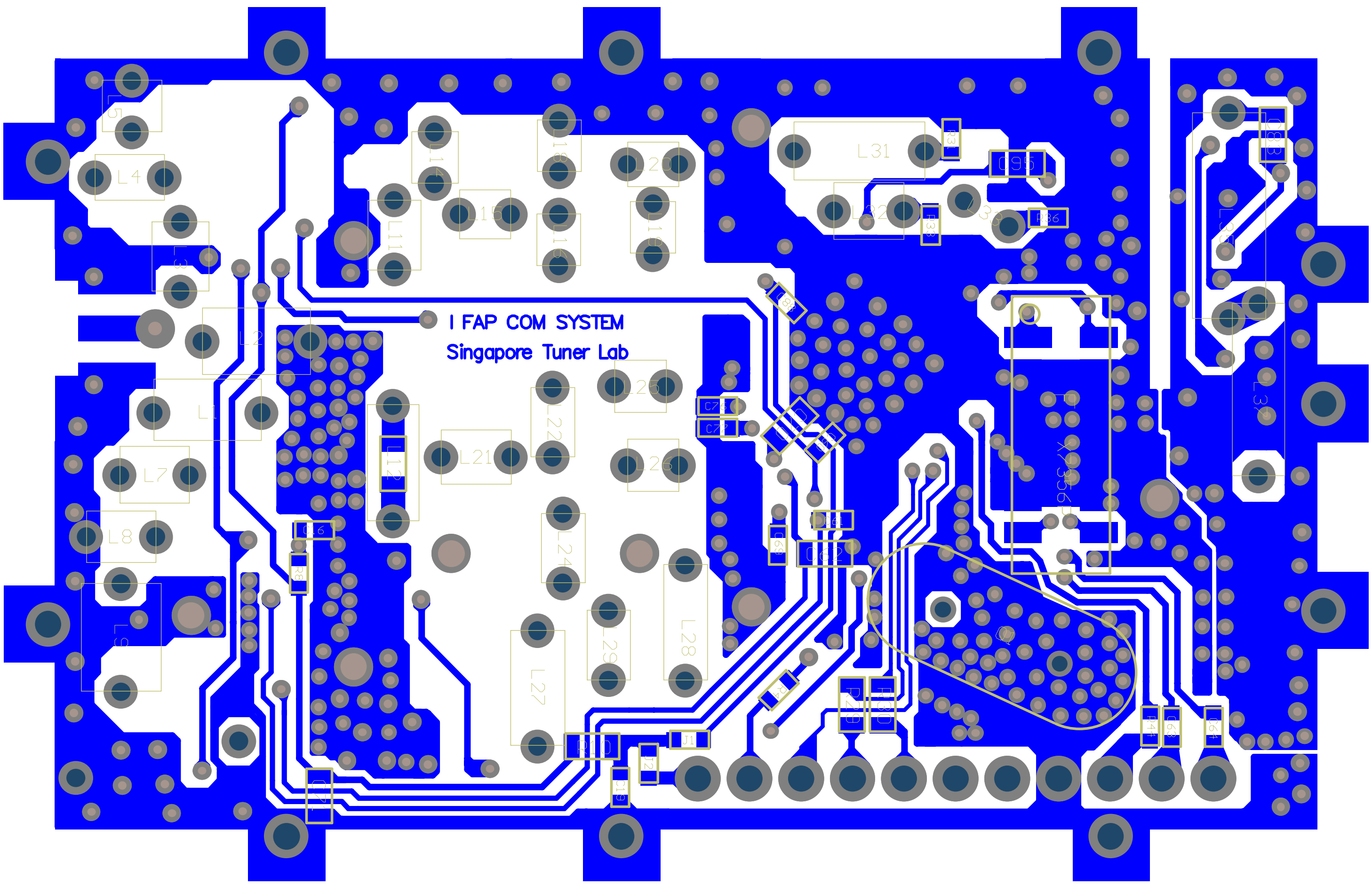
Notes: 1. Unless Otherwise specified, units are Ohm, Farad and Henry;
2. J1, C70 and C88 are for Internal AGC only

Infineon Technologies Asia Pacific
IFAP COM TU SYSTEM
Tuner Application Laboratory Singapore

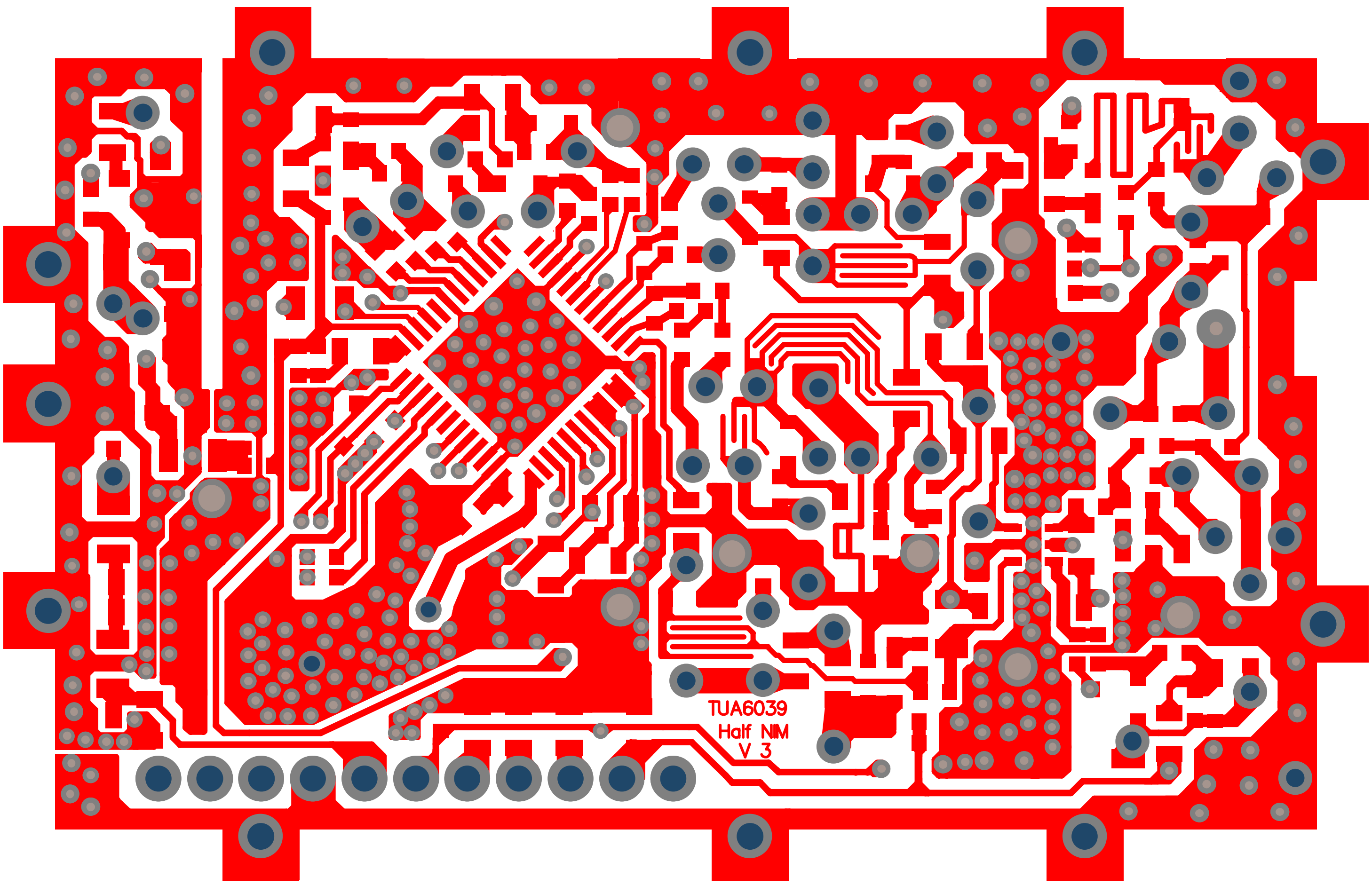
Project: DVB-T Mini Half NIM with TUA6039

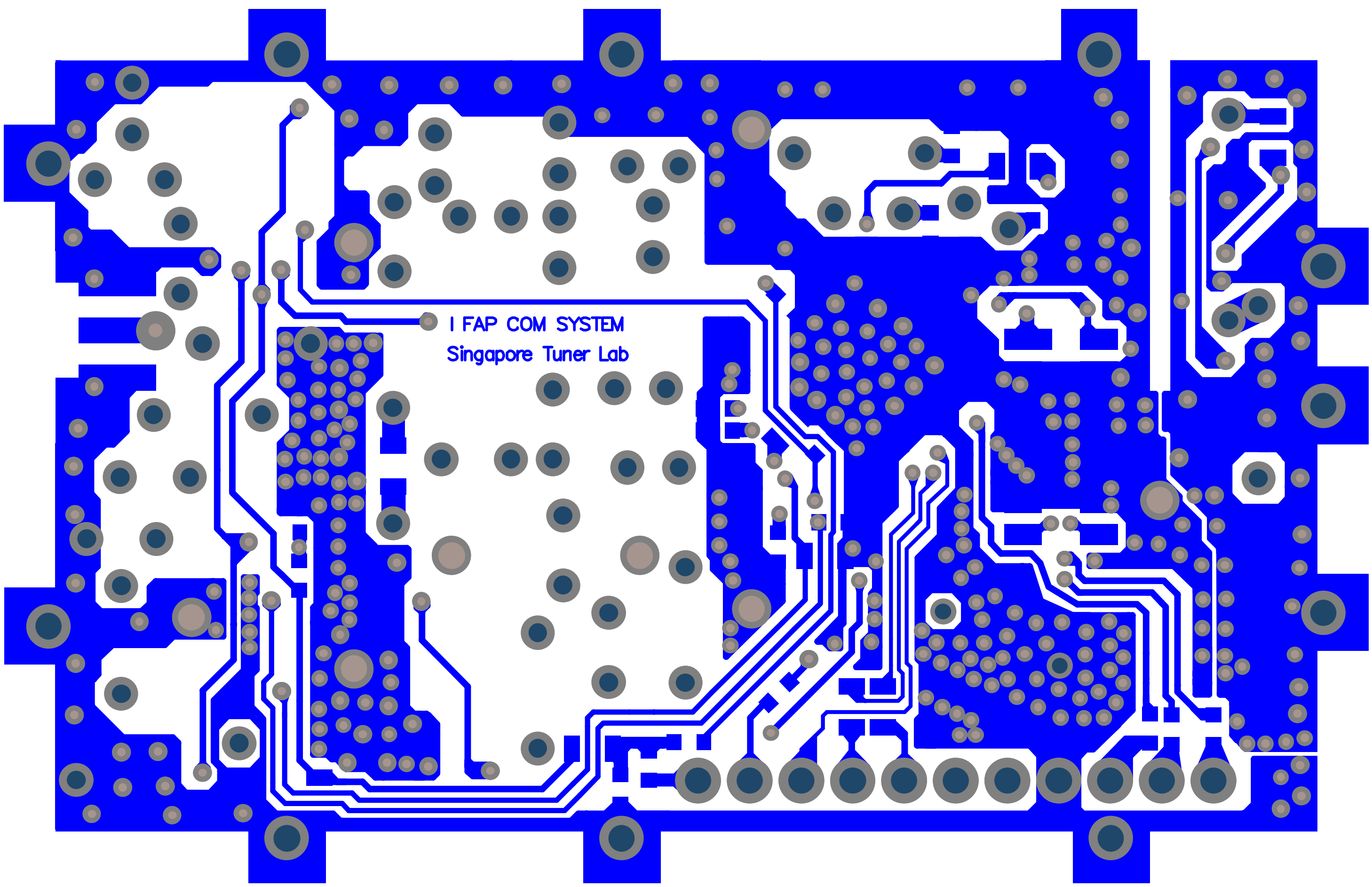
Revision: V3.0 Date: December 31st, 2006

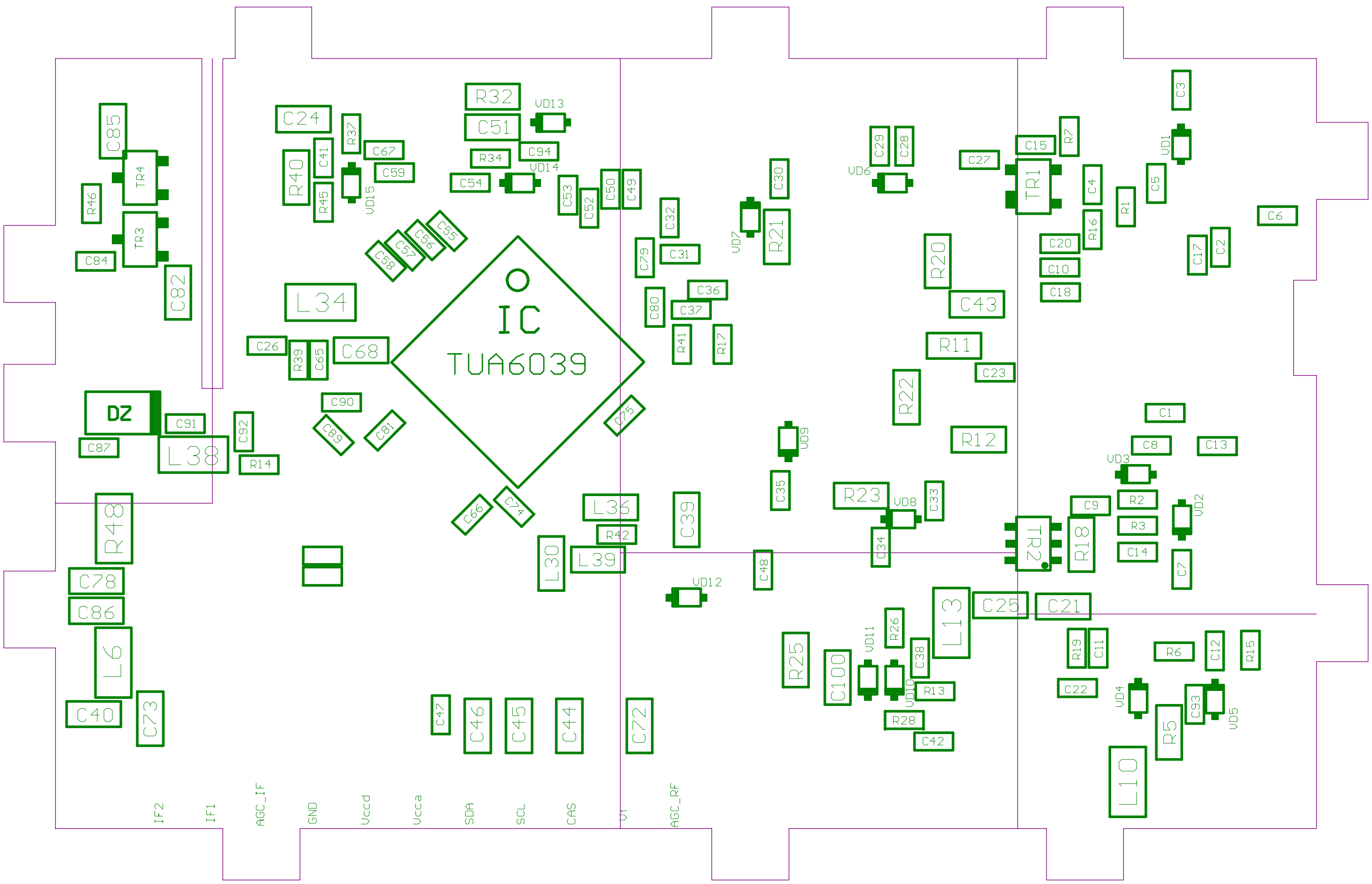

TUA6039
Half NIM
V 3

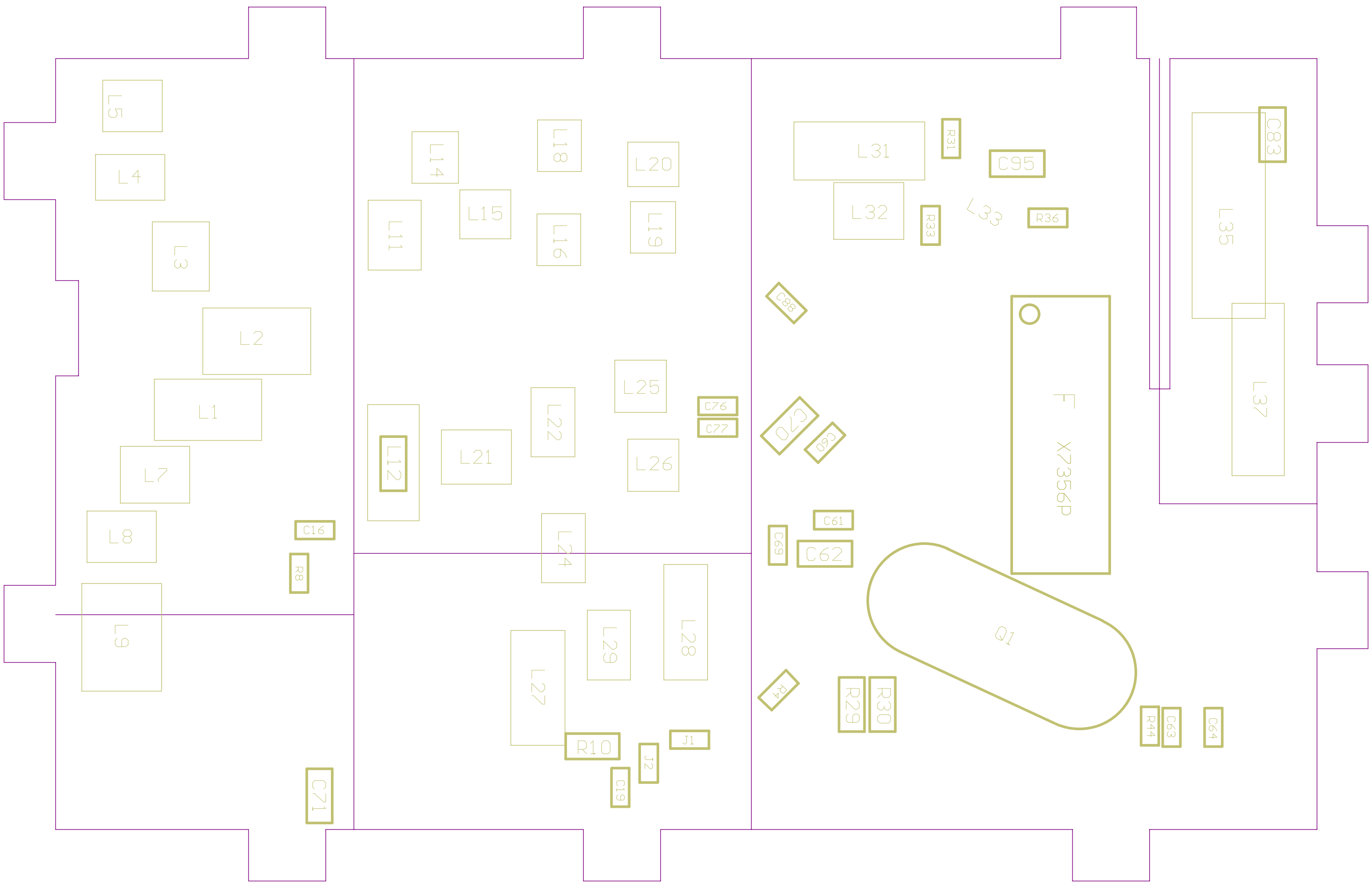


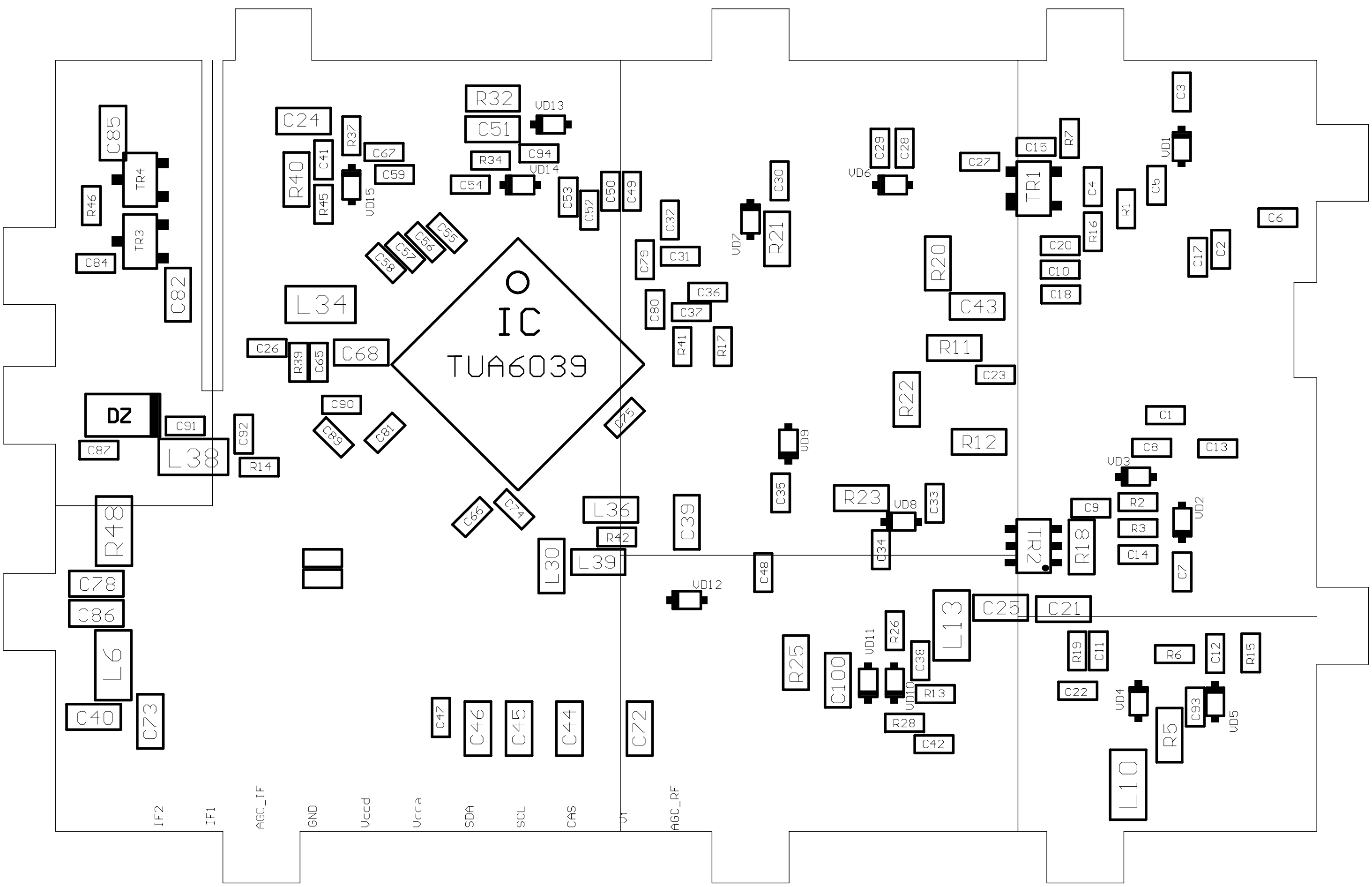
I FAP COM SYSTEM
Singapore Tuner Lab

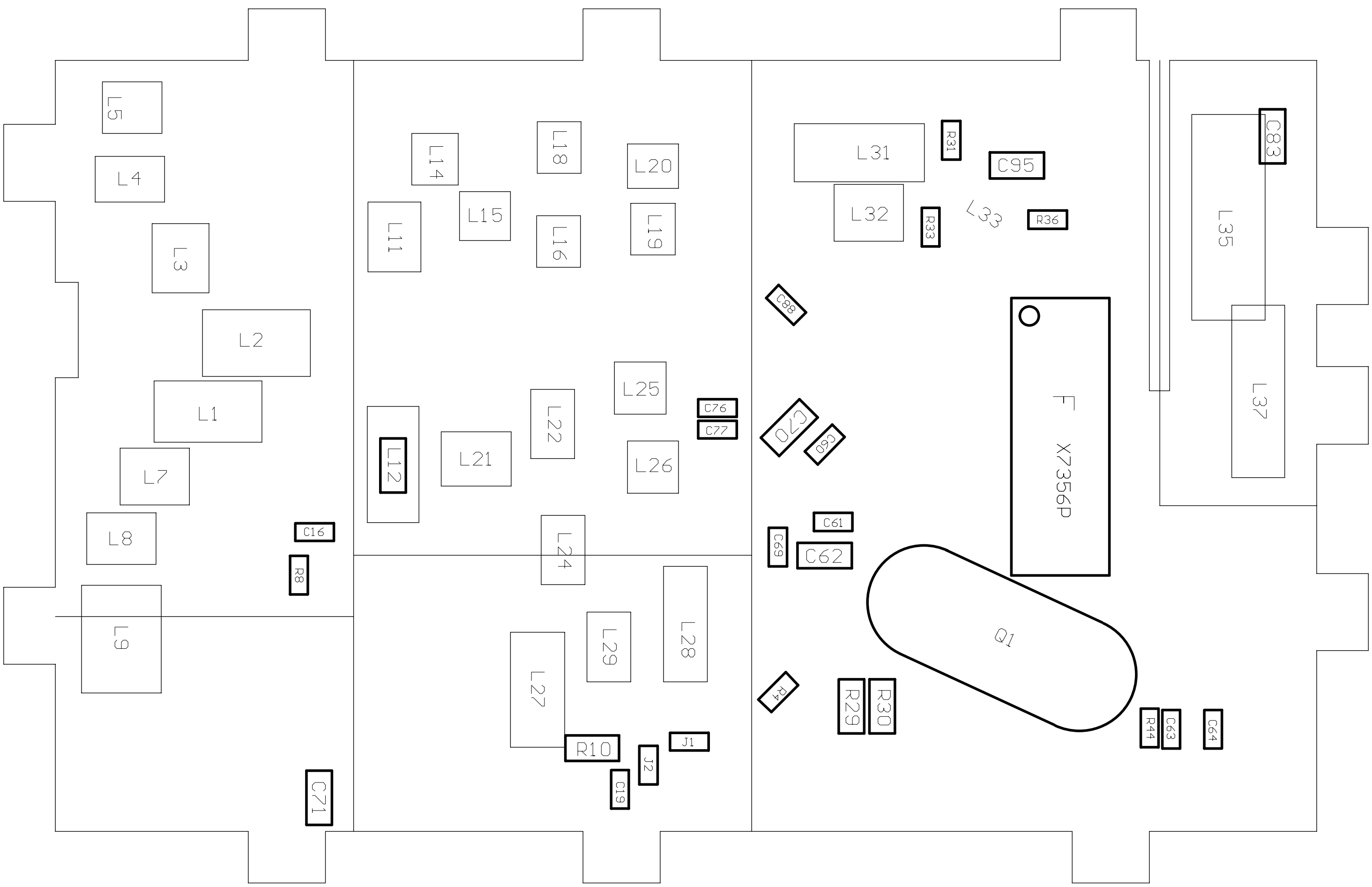

TUA6039
Half NIM
V 3


I FAP COM SYSTEM
Singapore Tuner Lab


IC
TUA6039
DZ
IF2
IF1
AGC_IF
GND
Vccd
Vcca
SDA
SCL
CAS
Vt
AGC_RF


L5
L4
L3
L2
L1
L7
L8
L9
C16
R8
C71
L14
L18
L20
L11
L15
L16
L19
L25
L12
L21
L22
L26
L24
L29
L28
L27
R10
J2
J1
C19
C76
C77
C70
C60
C68
L31
R31
C95
L32
R33
L33
R36
C83
L35
L37
X7356P
C61
C69
C62
Q1
R29
R30
R44
C63
C64


IC
TUA6039
DZ
TR1
TR2
TR3
TR4
L6 L10 L13 L30 L34 L36 L38 L39
R1 R2 R3 R5 R6 R7 R11 R12 R13 R14 R15 R16 R17 R18 R19 R20 R21 R22 R23 R25 R26 R28 R32 R34 R37 R39 R40 R41 R42 R45 R46 R48
C1 C2 C3 C4 C5 C6 C7 C8 C9 C10 C11 C12 C13 C14 C15 C17 C18 C20 C21 C22 C23 C24 C25 C26 C27 C28 C29 C30 C31 C32 C33 C34 C35 C36 C37 C38 C39 C40 C41 C42 C43 C44 C45 C46 C47 C48 C49 C50 C51 C52 C53 C54 C55 C56 C57 C58 C59 C65 C66 C67 C68 C72 C73 C74 C75 C78 C79 C80 C81 C82 C84 C85 C86 C87 C89 C90 C91 C92 C93 C94 C100
VD1 VD2 VD3 VD4 VD5 VD6 VD7 VD8 VD9 VD10 VD11 VD12 VD13 VD14 VD15
IF2
IF1
AGC_IF
GND
Vccd
Vcca
SDA
SCL
CAS
Ut
AGC_RF


L5
L4
L3
L2
L1
L7
L8
L9
C16
R8
C71
L14
L18
L20
L11
L15
L16
L19
L25
C76
C77
L22
L21
L12
L26
L24
L29
L28
L27
R10
J1
J2
C19
L31
R31
C95
L32
R33
L33
R36
L35
C83
L37
C88
C70
C60
F
X7356P
C61
C69
C62
Q1
R4
R29
R30
R44
C63
C64