APPLICATION NOTE

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TEA6848H

A NICE RADIO
with
CIRCUMSTANTIAL
CONTROLLED
SELECTIVITY.

Version 1.2

Abstract

*The IC **TEA 6848H is** for small dimensioned Electronic Tuned AM/FM Car Radio receiver, with advantage in application-area's where the FM band is crowded.*

They carry the following functions:
** AM receiver for long-, medium- and short- wave (up to 49 m) with*
  . reduced desensitization by cascode AGC
  . noise-blanking and weak signal control.
** FM receiver with*
  . image cancelling on chip;
  . dynamically controlled IF selectivity on chip
  . keyed AGC;
  . VCO for global application, with low side injection for Japan and Eastern Europe
  . weather band included.
** A fast tuning Synthesizer with on chip control for inaudible RDS-AF updating.*
** Digital Automatic Alignment for FM- RF circuit and for RF-fieldstrength indication.*

AM and FM operate with worldwide application flexibility, given by peripheral components and by software control via I^{2}C-Bus.

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TEA 6848H

A NICE RADIO

with

Circumstantial Controlled Selectivity

Version 1.2

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TEA 6848H A NICE RADIO APPLICATION NOTE

Summary

The **TEA 6848H** in an LQFP80 package is a complete, highly-reliable/small dimensioned, **AM/FM Car Radio** Receiver for global application.

It carries the following functions:

*** AM receiver for LW/MW and SW (31 to 49m)**,
with double conversion, including

- linear AGC with high dynamic range, using cascode AGC and the AM pindiode BAQ806; .
- fast level-detection;
- IF-output matched for AM stereo decoding;
- Noise Blanking Circuit at IF;

*** FM receiver** for broadcast frequencies 65 to 108MHz,
with double conversion, including

- image rejection on chip;
- controlled IF$_2$ selectivity (detecting adjacent channels / modulation index / frequency offset)
- digital auto alignment for the RF-tuned circuit;
- large AGC range with keyed agc feature;
- inaudible RDS updating feature

*** Weather-band application** 162.4 to 162.55MHz.

*** Tuning Synthesizer**, using

- fast tuning VCO with low phase noise
- a VCO, designed for global application, with low side injection for Japan and Eastern Europe
- a reference from a x-tal oscillator, designed for low interference.

*** Interface**, matched to Audio Signal Processors **TEA6880H (CASP) and SAA7706/7709(CDSP)**

*** Bus Transceiver (I^2C)**, operating at 3.3 and 5 Volt,

- for tuning (PLL) and RF auto-alignment;
- programmable starting point / slope for AM/FM fieldstrength detection;
- for AM & FM wide band AGC-start;
- for alignment of: IF$_2$ filter-centre frequency, filter gain and frequency offset.

AM and FM double mixing goes via 10.7MHz to 450kHz.
The PLL Synthesizer has a fast tuning (for RDS AF-updating): < 1ms for a maximum step.
Special care has been taken for interference immunity, having the synthesizer on chip with the RF.

Excellent sensitivity figures can be achieved:
at AM, 30% modulation, typ. 43µV (from 15/60pF source) and
at FM, Δf=±22.5kHz, typ. 1.4µV (at 75 Ohm source).
Large signal figures S/N: typ 60dB at AM (m=30%) and about 63dB at FM (Δf= ±22.5kHz).
High intercept points: At AM is IP3=130dBµV$_{rms}$ and at FM 117 dBµV$_{rms}$ for "ín-band signals".

The peripheral components are limited,

- using just one x-tal as reference:
  . for 2nd conversion,
  . for Synthesizer reference,
  . for Audio Signal Processor reference,
  . for sequential RDS-updating circuitry and
  . for IF-counter window.
- having wideband AM input (no RF- tuning or -switching);
- no LNA in FM front-end; only one single tuned circuit;
- only 2 standard ceramic filters and no demodulator coil or resonator.

With Circumstantial control for **P**recision **A**daptive **C**hannel **S**uppression (**PACS**), IF$_2$ gives performance matching to local requirements. Performance setting by software gives matching to regional requirements.
The AM/FM receiver module for **N**ew **I**n **C**ar **E**ntertainment (**NICE**) can be realised with small PCB dimensions.

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TEA 6848H A NICE RADIO APPLICATION NOTE

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TEA 6848H A NICE RADIO APPLICATION NOTE

1. INTRODUCTION

The **TEA 6848H** in an LQFP80 package is a complete, small dimensioned, **AM/FM Car Radio** Receiver for global application. It carries the following functions:

* **AM receiver for LW/MW and SW (31 to 49m)**, with double conversion, including
  - linear AGC high dynamic range, using cascode AGC and the AM pindiode BAQ 806;
  - fast level-detection and a signal- ‘low distortion’ detector;
  - IF-output matched for AM stereo decoding;
  - Noise Blanking Circuit at IF;
* **FM receiver** for broadcast frequencies 65 to 108MHz, with double conversion, including
  - image rejection on chip for both frequency conversions;
  - IF_2 selectivity on chip, controlled via detection of adjacent channels/ modulation index / and frequency offset;
  - digital auto alignment for the RF-tuned circuit;
  - large AGC range with keyed agc feature;
  - inaudible RDS updating feature.
* **Weather-band application** 162.4 to 162.55MHz, with
  - Image rejection and IF_2 channel-selectivity on chip;
  - output current for front-end switching;
  - audio gain compensation for standard output level.
* **Tuning Synthesizer**, using
  - fast tuning VCO with low phase noise;
  - a VCO, designed for global application, with low side injection for Japan and Eastern Europe;
  - a reference from a x-tal oscillator, designed for low interference.
* **Interface**, matched to Audio Signal Processors **TEA6880H (CASP) and SAA7706/7709(CDSP).**
* **Bus Transceiver (I^2C)**, operating at 3.3 and 5 Volt,
  - for tuning (PLL) and RF auto-alignment;
  - programmable starting point / slope for AM/FM fieldstrength detection and AM AGC start;
  - for setting IF_2 filter-centre frequency, filter gain and frequency offset.

AM and FM double mixing goes via 10.7MHz to 450kHz, see Fig. 1

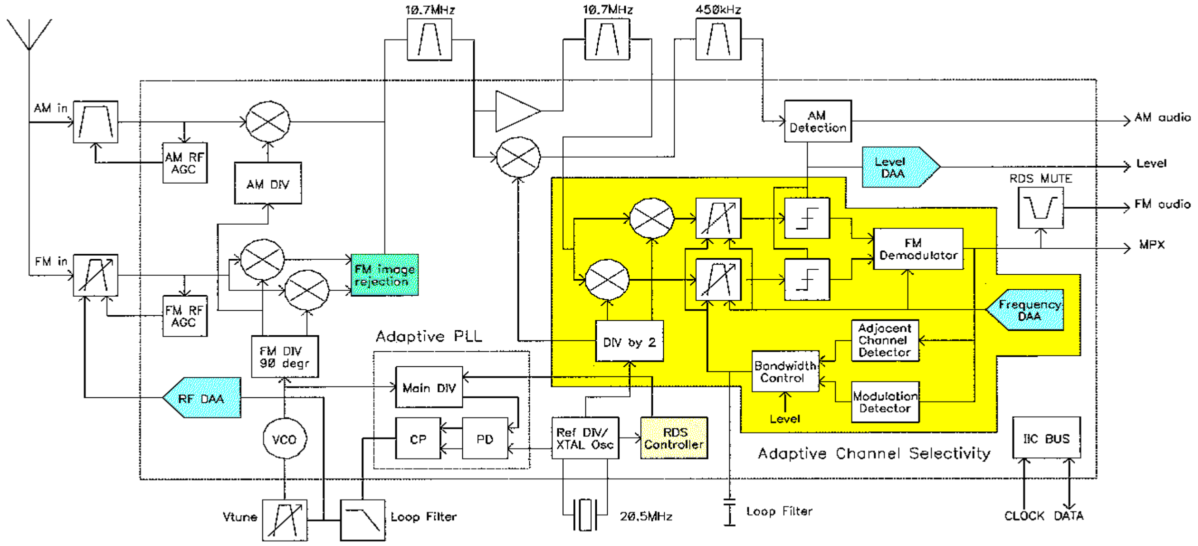

Fig. 1 Simplified Block Diagram of the TEA6848H Receiver Architecture.

Circumstantial control of the **P**recision **A**daptive **C**hannel **S**electivity (**PACS**), IF_2, gives performance matching to local requirements. Performance setting by software gives matching to regional requirements.

This report describes the standard application FM and AM/MW based on TEA6848H.

2. FUNCTIONAL DESCRIPTION

The strong growth in the number of FM transmitters, stimulated by various services such as R(B)DS and DARC, has increased the demand on the channel selectivity of the receivers. As a consequence, the number of IF ceramic filters in a standard tuner application, in particular in Car Radio, has grown from 2 to 3 and sometimes 4 and with narrower bandwidths than ever before. This increases costs (more components that have to be matched) and reduces performance (higher THD and poorer data reception). This trend is likely to continue into the next decennium.

A solution could be switching to a narrow ceramic filter. However, drawbacks are that the extra narrow band filter will have to be carefully selected to match with the rest of the channel (filters and the PLL crystal reference). In the narrow state, THD is high and data on ultrasonic sub-carriers is lost, moreover actions of switching back and forth between the 2 states of selectivity causes audible disturbances.

The IC described contains an integrated time-continuous adaptive FM-IF filter, whose instantaneous bandwidth is determined by all relevant system parameters. The combination of the filter structure and its bandwidth control algorithm deliver higher dynamic selectivity, improved sensitivity and low THD at high frequency deviation without any audible artefacts. The automatic alignment of the filter centre frequency eliminates IF channel tolerances and makes it suitable for global applications. Next to this dynamic controlled IF-selectivity on chip, a reliable high performance concept with minimum system price has been obtained, with special attention on interference reduction. To that end image rejection is obtained by conversion to a high IF at AM and on-chip image-rejection at FM.

The AM Section is a double conversion receiver. The first IF is 10.7MHz, which allows a wide band RF input stage without tracking requirements. The RF input has a wide dynamic range with a linear AGC, using a cascode AGC at the RF-amplifier and the AM pin-diode BAQ806. The start of AGC setting is Bus programmable by the set maker. The cost of IF filtering is kept low by a second conversion to 450kHz. The AM IF stage provides soft mute, AM stereo compatibility and a fast stop-level detection. Different antennas (capacitive / ohmic) are possible. AM noise detection with blanking at IF is included.

The FM section has also double conversion architecture with the same IF frequencies as the AM channel for maximum component sharing. The first conversion stage utilises a quadrature-input stage combined with a wide band quadrature phase shift circuit for 30dB internal image rejection at 10.7MHz. The RF input filtering requirements are therefore reduced and can be met with a single tuned stage. The RF Digital Automatic Alignment (DAA) block achieves the tracking of this tuned circuit. The linear FM AGC has programmable start points and offers an optional Keyed AGC function. The input quadrature mixers are designed for low noise and large signal handling so that no FET Low Noise Amplifier (LNA) is required.

Only two relatively wide ceramic filters are required for the first IF selectivity. The second frequency conversion provides quadrature signals at 450kHz, obtaining integrated IF2 image rejection. The rest of the IF selectivity is then carried out by the integrated adaptive filter section, which has adjustable centre frequency and bandwidth. The centre frequency is aligned by Bus, but the bandwidth is dynamically controlled. The integrated resonator of the demodulator circuit is matched to and aligned with the filter. The bandwidth control circuit determines the instantaneous bandwidth of the filter for dynamic conditions. Combined with an Adjacent Channel Detector the IF bandwidth control takes care for **P**recision **A**djacent **C**hannel **S**uppression (**PACS**).

The FM channel is prepared for Weather Band application. In the Weather band (WX) mode, the

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integrated filter is automatically switched to its narrowest bandwidth to give adequate WX channel selectivity.
Both AM and FM level outputs are aligned by Bus for start and slope. The alignment coefficients for FM RF tracking and AM/FM level can be stored in a memory (e.g. EEPROM) for each individual receiver.

The VCO has been defined such that all AM/FM-reception bands can be accessed without band switching or any changes to the application. The wide band up-conversion AM input combined with the programmable VCO AM dividers reduce the tuning range such that LW, MW and SW become a continuous band without mechanical switching. The VCO FM dividers bring the required FM frequency ranges for tuning in Western Europe, Eastern Europe, Japan, USA and Weather Band, taking into account a low-side oscillator injection for Japan and Eastern Europe bands. Therefore one VCO tunes to all bands in the same tuning voltage range.

The Adaptive PLL Tuning System combines low phase-noise and low reference spurious breakthrough with a fast tuning response. During FM frequency jumps two charge pumps are active enabling stability and fast tuning to be achieved. After the fast frequency jump only one pump is active, resulting in a small loop bandwidth and low noise operation of the tuning system The crystal oscillator operates in a linear-current mode to avoid interferences to the sensitive RF parts. This oscillator generates all the necessary reference signals for the tuning operation and frequency conversions.

The Mute circuitry. To provide a better reception, or other information, quality control of other signal channels is used, for example in Radio Data System (R(B)DS) alternative frequency checking. This usually causes audible breaks in the main channel, as the audio signal has to be muted while the receiver is tuning to other frequencies. **Muting actions** are detected in two ways. Gaps in the audio signal may be perceived if the muting time is not short enough. The other mechanism is the distortion of the power spectrum, which is independent of the muting time. In practice, with actual audio signals, muting times below 7ms with gentle slopes of 1ms are inaudible. To achieve FM signal quality checks of 5ms, the tuning times have to be reduced to below 1ms, and the frequency jumps have to be made independent of the slow Bus communication times. The first requirement has to be accomplished by the tuning system, whereas the latter was solved by inclusion of 'local intelligence' in the form of **a sequential circuit** that controls tuning operations during quality checks.

The I2C Bus makes different regional requirements programmable. It has specific building blocks in order to perform inaudible frequency jumps: the sequential circuit, a shaped mute and the adaptive PLL tuning system.
The IF2 filter-frequency alignment circuit centres the integrated filter for maximum RF level, thereby eliminating both IC process and the PLL crystal reference tolerances.
The IF2 filter-gain alignment provides constant gain when the bandwidth is varied.
The frequency offset detector , which detects the offset between the momentary demodulator output and the nominal output, is aligned to the nominal demodulator output.
The IC employs **Digital Automatic Alignment** of RF tuned circuit and level signals to avoid mechanical alignments, using pre-aligned coils.
This, and the integration of FM-IF filtering, the FM image rejection, the tuning system and the AM double conversion topology makes the application of TEA6848H simple.

3. FEATURES.

1. **Global Tuner** concept to match on geographical requirements, including Weather Band
2. **Modular**, small dimensioned design; one chip receiver having few external components
3. **Compatibility** with both analogue and digital audio processors
4. **Digital alignment**
5. **High performance** with synthesizer on chip for high immunity and fast tuning
6. **Fast Station detection and quality checking**
7. **Low interferences** with FM image rejection/ AM IF Noise blanking and a linear Xtal-oscillator
8. **Smooth operation** with a.o. inaudible RDS updating
9. **Circumstantial controlled FM-selectivity**, to reduce the adjacent channel interferences
10. **Flexibility** by programmable settings, AM-stereo IF-output etc
11. **High sensitivity** even at very large signal conditions: high dynamic range (AM RF cascode AGC)
12. **Innovative design towards low price** with
    . one X-tal oscillator for all reference frequencies
    . standard IF-filters
    . analogue AM-agc with pin-diode.

4. CIRCUIT DESCRIPTION

See Fig. 44 for Total Circuit Diagram.
Note: In the description some application info is given in *italic writing.*

The main supply is 8.5 Volt; a 5 Volt supply is used for digital parts and some analogue functions. The external voltages are stabilised, with ripple rejection of >50dB at 800Hz ripple, creating internal reference voltages and currents.

4.1 AM-signal channel.

Main features:
*__AM-RF input is voltage driven :__ Antenna to be capacitive or ohmic (active aerial);
*__Linear RF-AGC__ (plop free), using an AM Pin-diode BAQ806 and a FET-amplifier with an optional cascode transistor. Flexibility is realized by Bus-controlled setting of agc threshold.
*__AM noise blanking__ with a noise detector at 1st mixer output and blanking at mixer 2.
*Fast station-level detection.
*AM-stereo compatibility

To avoid RF-selective circuitry for image rejection, or, to permit wideband RF-input, the input frequencies are mixed to a 1st IF_Frequency of 10.7MHz. By doing so the main image frequencies (image 1 in Fig.2) are 21.54 to 23.11 MHz, which is so far from the receiving band, that they can be easily suppressed by a Low Pass Filter in front of the 1st Mixer.

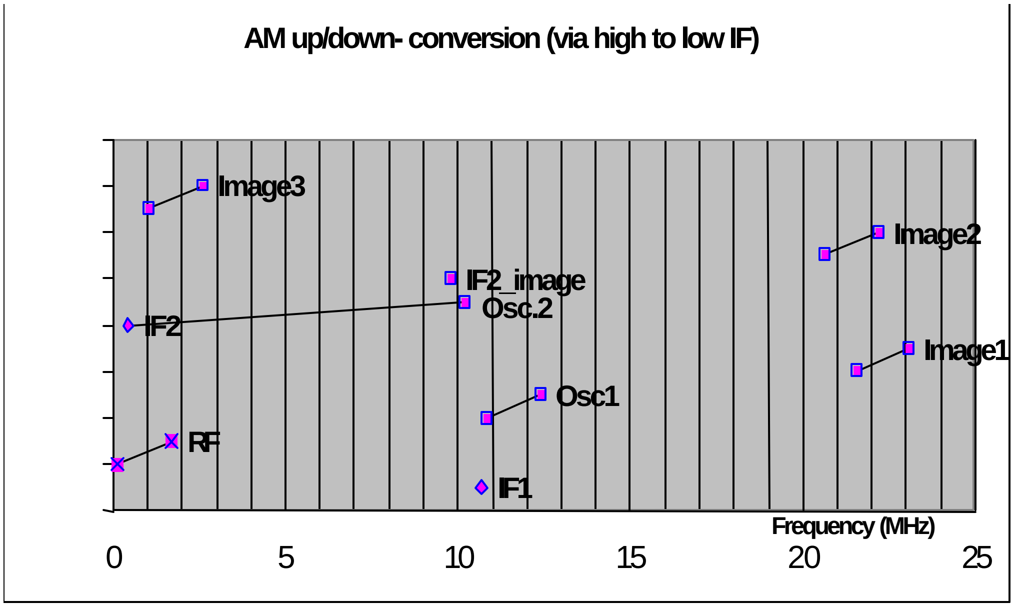


Fig. 2 AM MW/LW conversion via 10.7 MHz to 450 kHz

The 1st IF-freq. (filtered with ceramic filter of 10.7MHz, common used with FM-IF) is mixed down to 450kHz, a standard frequency where a low priced filter takes care for channel selectivity before detection takes place. The image frequencies 2 and 3 are caused by this 2nd mixing, as the VCO has transferred these image frequencies to 9.8MHz (here called IF2_image). This 9.8 MHz will be mixed to 450kHz by the 2nd mixer and therefor 9.8 MHz has to be suppressed in the 10.7MHz 1st IF filter. *Suppression at 9.8MHz in a first IF selectivity acc. to Fig. 8 is about 65dB.*

4.1.1 RF Input Amplifier

The Aerial input (wideband-) amplifier, shown in Fig. 3, consists of:

- * an input LC to separate AM from FM,
- * the RF-amplifier with FET BF862 and a BC848C in cascode,
- * an RF-AGC amplifier with pindiode BAQ806;
- * surge-protection double diode BAV99;
- * an output AM-bandpass-filter before entering the first mixer.

The aerial is capacitive loaded by about 90 pF, being the sum of

- . the input capacitance of the FET BF862 (10pF, but dynamically about 60pF *));
- . the zero capacitance of the pin-diode (about 5pF);
- . the capacitive input of the FM-RF part (about 15pF) and
- . the parasitic capacitance of aerial-connector and PCB (about 9pF).

With a capacitive (telescope) antenna, acting at 1MHz as a 15 to 60pF divider, the total gain loss from dummy aerial input to FET-gate is about 20dB.

**) Note: In cascode-input application this input capacitance is just 12.5pF (10+2.5pF).*

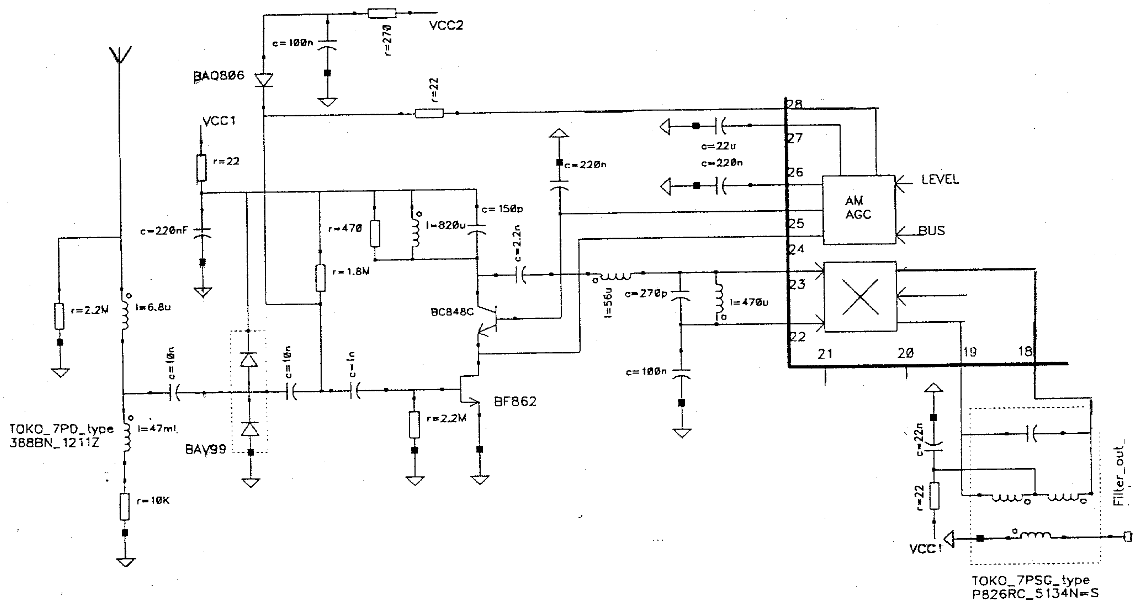


Fig. 3 AM-RF Input Amplifier for LW/MW.

a. The AM-pin-diode BAQ 806

With the BAQ806 (see Fig. 4), special designed on high linearity, with slow operation for AM frequencies, the RF-signal can be attenuated over a range of about 50dB.

The pin diode acts like a variable resistor for RF signals. Its linearity results in excellent large signal capabilities. *(In the given application IP2 and IP3 values are 140 and 130dBµV respectively.)*

However, by its virtue of behaviour as a resistor, it's a source of noise. As this would result in loss of sensitivity (desensitization) at the start of pin-diode control, its control will be delayed, using gain control in the cascode RF amplifier first.

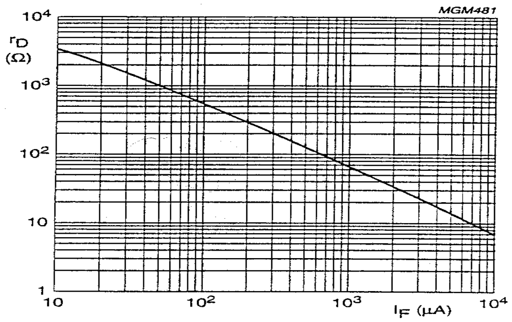


Fig.4 AM Pin Diode Characteristic: BAQ806

b. AM RF Amplifier:

The FET BF862 has a low noise of 0.8nV/√Hz. With its high trans- conductance the gain is Gm*Rload= 25dB. Gain control at the gate is linear: without agc-plops and with large signal handling.

The concept matches to different antenna characteristics.

With this FET in the application of Fig.44, the overall AM sensitivity is typ V_a= 43mV for S/N= 26dB (at m=0.3), defined with a 15/60pF dummy antenna.

A S/N of 10 dB is reached at an input signal of V_a= 7mV from a dummy antenna, see Fig. 34.

c. The RF-AGC

In the TEA6848H IC, the RF-signal at the mixer1 input (pins 22/23) is detected, to build up a RF-AGC voltage available at pins 26 and 27. The gain control starts at RF-amplifier, the bipolar transistor 'on top' of the FET, controlled by the AGC-signal delivered from pin 25, followed by additional gain control with the pin-diode, to which end pin 28 sinks a current up to 15mA.

The cascode-control lowers the drain voltage of the FET, in turn decreasing the FET transconductance when the drain-source voltage has brought the FET in its linear region. The gain control range of the cascode stage has to be limited to about 10dB to avoid overloading the FET, special to avoid third-order/ cross-modulation at higher signals.

The BF862 maximum gate voltage related to cross-modulation performance is about $100mV_{rms}$ (IP3 is 127dBμV).

A practical limitation is the drain-source voltage: not too low for reason of spread.

In the given application the gain control of the cascode stage is 10 dB (where the drain-source voltage ranges 4.1 to 0.26 Volt).

Notes:

a. If a different type of bipolar transistor (with higher Ft) is used in the cascode stage, it is possible that under certain conditions the stage is showing a spurious oscillation. This can be avoided by ensuring that the decoupling line at the base is as short as possible.

b. If, for cost reasons, the cascode AGC is not applied, the PIN-diode AGC will take over at the original start of AGC.

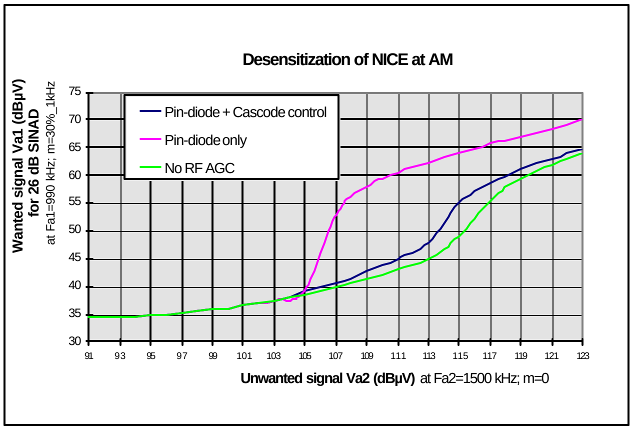


Fig.5 AM desensitization: SINAD influenced by an unwanted

As an example desensitization by a 1500kHz signal at 990kHz tuning has been given in Fig. 5 for ‘pin-diode control only’ and for ‘delayed pin-diode control’, using cascode stage control as well. The last one behaves close to the situation of no RF-agc.

To avoid harmonic distortion at large in-band signals an additional IF2-detector can start the RF-agc earlier (e.g. at V23=30mV) then in case of large 'out-of band signals', such to keep the sensitivity for weak signals as high as possible in the last mentioned situation.
The wide-band agc starting point is programmable via the I^2C-Bus (2-Bits).
For 80% modulated out of band large signals the RF-agc starts in TEA 6848H application (Fig.44) at signals of 90/120/150/180mV , dependent on Bus setting.
With C= 22µF at pin 27 and C= 220nF at pin 26 the overall attack time of this AGC is 25ms; decay in 250ms, switching from 0.05mV to 0.5 Volt at AM 990kHz.

d. Input Filter:
The input filter takes care for attenuation of undesired frequencies.

e. The AM-Bandpass filter at the FET-output

The output signal of the RF-FET has to pass a fixed band pass filter that suppresses the image band before the signal is converted to 10.7MHz in the first mixer.
In the standard LW/MW-application the low pass filter has a cut-off frequency of 2MHz, which 4th order filter, see Fig.7, gives >60dB suppression for images 1 and 2.

For reception of the 49m-SW-band a filter with cut-off frequency of 6MHz has to be chosen

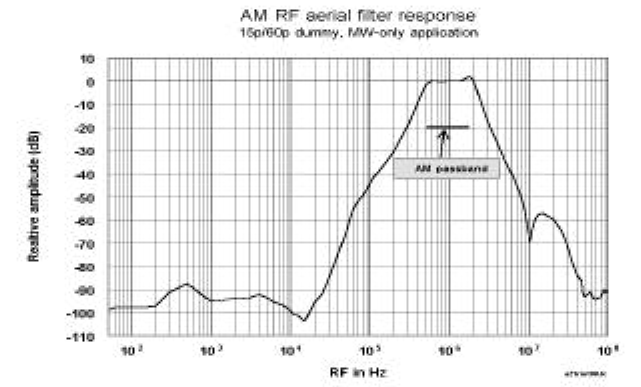


Fig. 6 AM RF aerial filter response

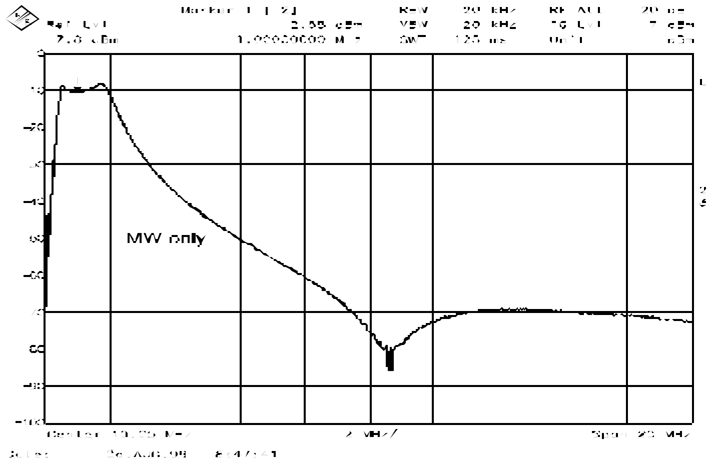


Fig. 7 AM RF Band pass filter response

f. The Surge protection.

The high -speed double diode BAV99 protects against static charging at the aerial.
The matching of the two diodes set them each at half the supply voltage to minimize distortion by non-linear effects (note that capacitive coupling takes care for a stable dc-midpoint).

4.1.2 AM Mixers

* **The 1st Mixer,** entered at pins 23/22, input resistance about 20 kOhm. The mixer transconductance is 2.5mA/V.

To receive MW 530 to 1710 kHz an oscillator- frequency of 11.23 to 12.41MHz is required at the 1st Mixer, to mix up to the 1st IF of10.7 MHz.

Important for the mixer is a low noise voltage, being 6nV/√Hz, and low intermodulation (IP3 is about 138dBµV at 2.8kOhm ac-load at mixer output). The mixer operates at a current of 2x6mA, having a large signal handling (-1dB compression) of > 500mV$_{rms}$.

* **The VCO** (pins 49/50), delivers the required frequencies via **an Oscillator-Freq.-Divider,** dividing the VCO-frequency by 20 at MW/LW operation; therefor the VCO operates at 216.88 to 248.2MHz. For SW the division ratio is 10.

It is done in this way to have one VCO for both AM and FM.

- The **1st IF-filter,** symmetrical at the mixer-output, pins 18/19, is a tuned LC circuit with a ceramic 10.7MHz filter, common used with FM, having behaviour as shown in Fig.8.

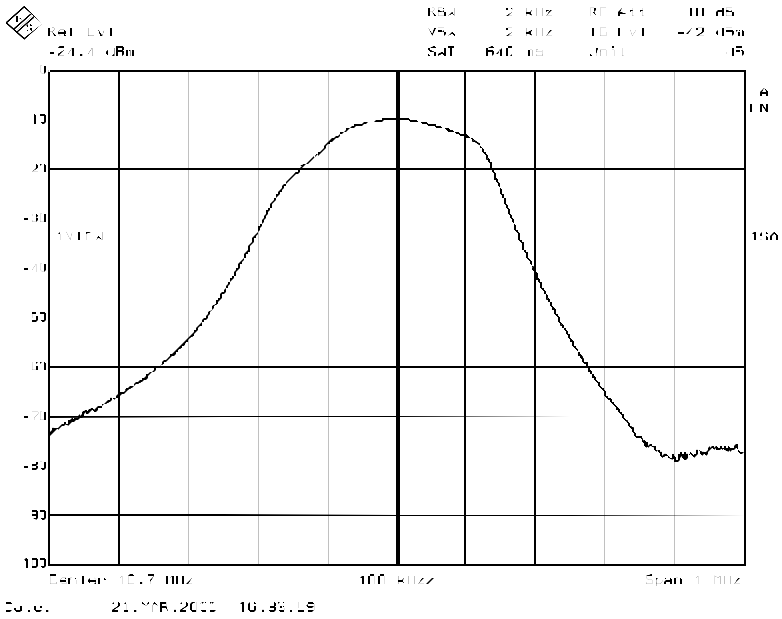


Fig.8 AM 1st IF selectivity

An LC circuit with C= 150pF and Q_0= 55 is loaded, giving a mixer output impedance of 2.8kOhm. With the 330 Ohm ceramic filter via a coil turn ratio 8 to 2, the gain of given mixer1 is 17dB, resulting in about 1.5dB from mixer1 input to mixer2 input. The choice of turn-ratio is weighted by AM-sensitivity and third order intermodulation, related to the noise and IP3 contribution of the 2nd mixer and detector. (The larger the mixer gain, the better the sensitivity, but at the cost of IP3). Moreover care has to been taken to 9.8MHz suppression for image rejection.

After this 1st IF selectivity, the signal enters the **2nd Mixer** at pins 14/15.

* The **2nd Mixer** mixes the 1st IF of 10.7MHz down to 450kHz with an oscillator signal at 10.25MHz, obtained from **a X-tal Oscillator**. The mixer2 transconductance is 1.6mA/V; the input resistance is 330 Ohm.

At 330 Ohm source its noise voltage is about 15nV/√Hz; biased for 2x4.5 mA current.

The mixer has a large signal handling (-1dB compression) of > 1.1V$_{peak}$. IP3 is about 137dBµV at 1.5kOhm mixer output load, measured with signals at 50kHz distance.

4.1.3 IF and detection

The Mixer output (pins 77/78) passes a 450kHz narrow band IF-filter (LC plus a 6_pole ceramic filter, see Fig.9) and enters **the IF section** (at pins 6/3; pin 66 is AM-IF2 ground).

Including the losses in the 450 kHz filter, the gain from mixer2 input to IF2 amplifier input is 5dB, which makes the gain from input-dummy to IF2 input 11dB.

Note: In the given application a CFWS450H filter (6th order) is used, to obtain highest performance as far as selectivity and stopband-attenuation is concerned.

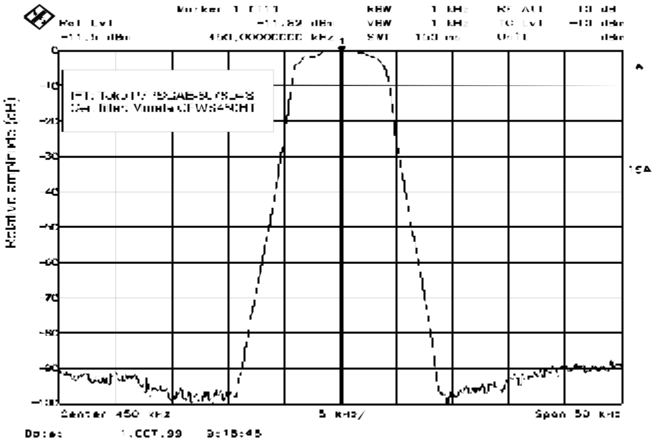


Fig. 9 AM 2nd IF ceramic filter

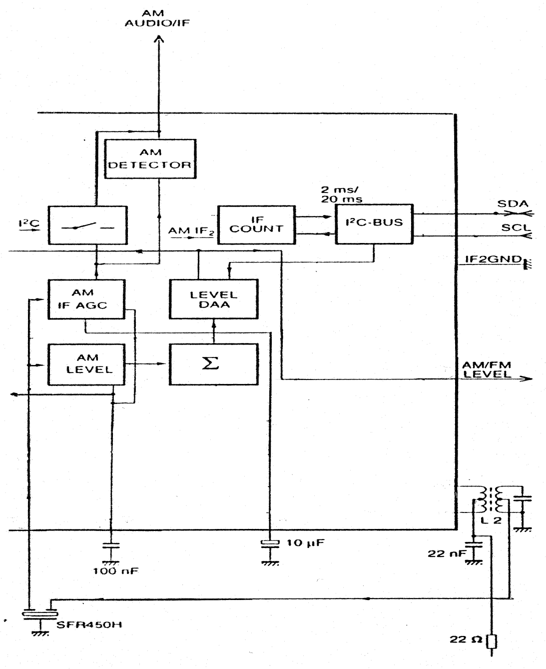


Fig. 10 AM IF and detection

The **AM-I.F. System** (see Fig. 10), takes care for:

. amplification with automatic gain control

. field strength level information

. a gain-controlled IF signal for AM-stereo application

. AM-signal detection over a large dynamic signal range, such with

. fast level detection

. smooth behaviour at small signal level using soft mute.

* **The AGC**.

The IF-amplifier has a 3-stage gain control with careful take-over behaviour to keep distortion low. The input impedance of this IF2 amp. (2kOhm) has been matched to ceramic filter applications. The equivalent noise voltage is below 18nV/√Hz at 2kOhm source. It can handle min. 1.0V_{peak} with low distortion. The 89dB agc-range starts at 20µV IF2 input signal (peak level). The time constant (pin 79; commonly used with the time constant of the FM frequency offset detector) in this AGC influences both settling time and low-frequent modulation distortion. A 10µF capacitor gives

550 ms settling time with acceptable distortion of 0.3% for 400Hz/80% modulation (1.5% at 100Hz). By Bus the settling time can be changed to 10 times faster (in test-mode).

This IF system is sensitive: V_{6-3}= 45µV for S/N=26dB at 30 % modulation.

At large signal a max S/N of 60dB is reached (30% modulation).

* **The detector**

The envelope detector is with an on-chip 100 kHz low-pass filter to remove IF-frequency components from the detected signal.

The A.F. -output level V_{56}= 290mVrms at 30% modulation over an IF2 input signal range V_{6-3}= 0.1 to 400mV; THD at m=80% is 0.3 % for a signal with 400Hz modulation.

* **Mute**

A mute function at the output of the detector gives a possibility for soft mute setting. Switched by Bus, one can change the -10dB audio output from 6µV IF2 input signal towards 24µV (see example in Fig. 34). This 12dB mute function is driven from the AGC-detector, not from the level detector.

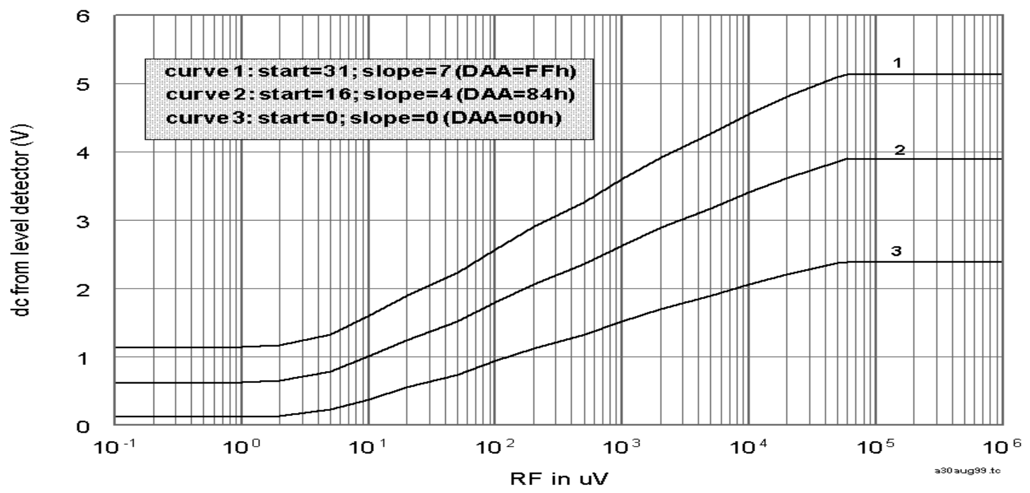
* **The Level detection**

To obtain fieldstrength information, the level detector delivers dc-information over a signal range of about 20µV to 1 Volt at IF2 input (pins 6-3). The dc-information (see Fig. 11), available at pin 70, is obtained via a second IF-channel (limiter / detector), such to have a fast operating level detector. The slope and the starting point can be controlled by Bus for customers' flexibility as well as to match on product-spread: Digital Automatic Alignment DAA (see Appendix 2). *The slope, typical 800mV/20dB, will mostly not be aligned.*

Special attention has been paid to the temperature compensation of the level info.

Fig. 11 AM level voltage

990kHz, 15p/60p dummy



Inside the IC the AM level information is only is only used to desensitize the AM noise blanker, which occurs for levels >2V at pin 70.

* **The AM-stereo info**.

Mono/Stereo-controlled by the I^2C-Bus; pin 56 can deliver (instead of mono a.f. output) a limited, gain controlled, AM-IF2 signal to drive an AM Stereo decoder.

The IF2 output is 180mV$_{rms}$ at V_{6-3}= 5mV, where at pin 56 the output resistance is

500 Ohm max.
The output is matched to the spec. of an AM-Stereo demodulator, like Motorola MC 13022.

4.1.4 AM Noise Blanking

At the output of the first mixer (ignition-) interferences are detected, while blanking is realised in the second mixer. The noise blanker is active only when the (digital-) aligned level voltage at pin 70 is below 2 Volt, corresponding with e.g. V_a <150µV (determined by DAA setting). The trigger sensitivity can be modified by changing the voltage at pin 5. A resistor connected from pin 5 to V_{cc} or to ground (e.g. 68kOhm) will increase respectively decrease sensitivity. The noise blanker will be de-activated by adjusting the voltage at pin 5 to ~2V with a resistor to ground. Blanking time typical 7.5µsec with C= 6.8nF at pin 55.

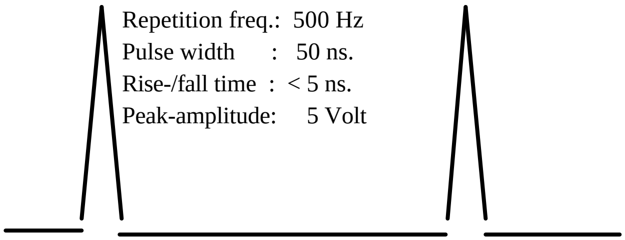


Fig. 12 AM Noise Blanking Test Pulse

In Fig. 12 a definition of interference pulse, as used for testing, has been given.

4.1.5 Search -stop information

For station detection the signal quality is analysed in terms of fieldstrength and IF2 frequency.
At a search the AM the tuning step is 1kHz (at a reference frequency of 20kHz, with the VCO-divider M= N1*N2= 20).
The IF AGC-amplifier delivers the fieldstrength **level information** analogue to pin 70, to be used in the Car Audio Signal Processor. For this and for the AM-noise blanker triggering the starting point must be aligned with the help of the DAA.
Besides the fieldstrength level, the exactness of the IF can be used for stop-information :
An **IF-counter** counts the 450kHz IF signal with 8µV sensitivity (at aerial-dummy input for m=0%).
In the AM-mode the counter counts the output signal of the IF-amplifier fast.
The resolution is $\Delta F_o = 1/t_c$ = 500Hz for t_c = 2ms.
or 50Hz at t_c = 20ms; to be selected by Bus.
The I^2C-Bus transmits this IF-count information to the µComputer; for IF=450kHz the readout (Hex) is 084H with t_c = 2ms and 028H at t_c = 20ms.
The reference frequency for the counter **window** is obtained, via **dividers**, from the X-tal oscillator.

4.2 FM-signal channel.

The FM receiver has also a double conversion architecture with the same IF frequencies as the AM channel for maximum component sharing. The 2nd oscillator, a crystal oscillator, operates in a linear mode to avoid interferences to the sensitive RF parts.

Only two relatively wide ceramic filters are required for the first IF selectivity. The second frequency conversion provides quadrature signals at 450kHz, obtaining integrated IF2 image rejection. The rest of the IF selectivity is then carried out by the integrated adaptive filter section, which has adjustable centre frequency and bandwidth. Fig. 13 gives this interesting part of the FM-channel.

The centre frequency is aligned by Bus, but the bandwidth is dynamically controlled. The bandwidth control circuit determines the instantaneous bandwidth of the filter for dynamic conditions.

The FM-channel can be set to receive weather band. In the Weather band (WX) mode, the integrated IF2-filter is automatically switched to its narrowest bandwidth to give adequate WX channel selectivity.

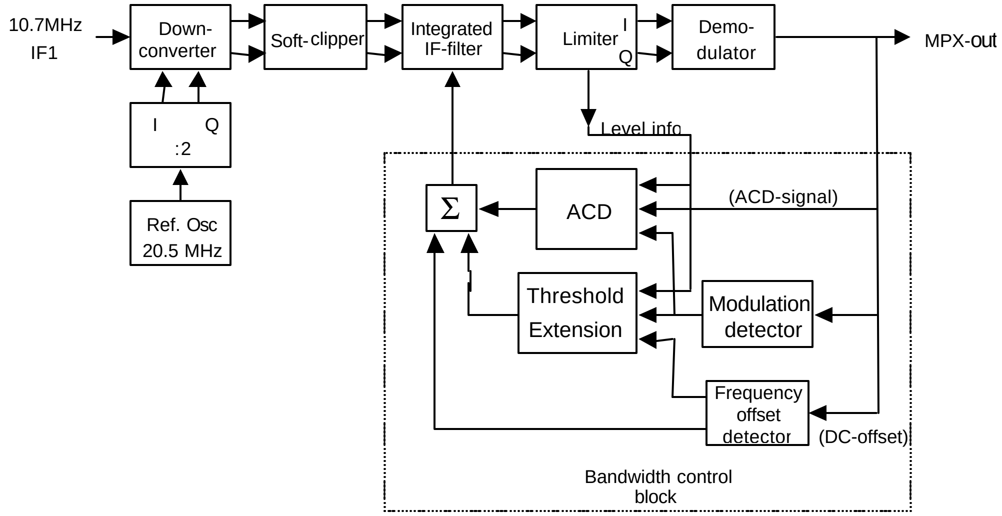


Fig. 13 FM-channel with IF functional diagram

Note that special functions are added for IF1- & IF2- image rejection / Digital RF-alignment / Circumstantial IF2-Bandwidth Control and RDS AF- updating.

4.2.1 RF

The first conversion stage utilises a quadrature-input stage combined with a wide band phase shift circuit for 30dB internal image rejection at 10.7MHz. The RF input filtering requirements are therefore reduced and can be met with a single tuned stage. The RF Digital Alignment (DAA) block achieves the tracking of this tuned circuit. The linear FM AGC has programmable start points and offers an optional Keyed AGC function. The input quadrature mixers are designed for low noise and large signal handling so that no FET Low Noise Amplifier (LNA) is required.

The RF-part contains
- . Aerial-input selectivity
- . Mixer
- . Image Frequency filter
- . RF-agc
- . Keyed AGC

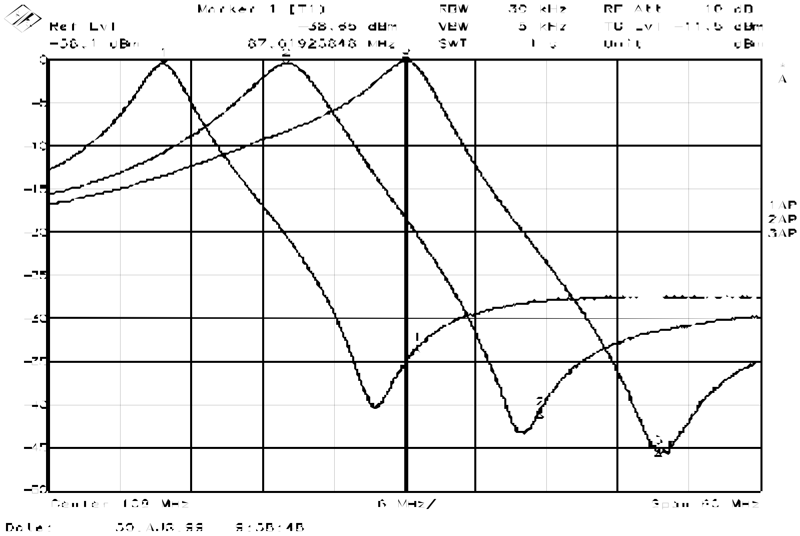


Fig. 14 FM RF Tuned bandpass Filter

*** Aerial-input selectivity**

The aerial signal has been coupled to a single tuned filter via a wideband bandpass and the agc-pin-diode circuitry. Having passed the tuned filter with varicap BB814, a transformer couples the a-symmetrical rf-signal to the symmetrical mixer input at pins 30/33. The tuned filter, having a quality figure Q of about 25, and a transfer characteristic as shown in Fig.14 (measured for the application of Fig.44) is aligned automatically, see chapter 4.4.1. The tuned circuit has an additional rf notch filter, using a printed coil to the midpoint tap of the coil of the parallel tuned circuit. This external notch takes care for

>30 dB rejection at all image frequencies.

*** Mixer**

The RF-signal, which enters the IC symmetrically at pins 30/33 (pin 31 is the RF-ground), passes the voltage to current converter, the mixer and a quadrature filter block (90° block in Fig.15). The mixer, with a bias current of 12mA (having optimum source impedance of ~200Ω), has a noise figure of 3dB and a signal handling of 100mV$_{pp}$ for -1dB compression. Input impedance 2.7kOhm // 4pF; output >100kOhm. Third order intermodulation IP3 is 117dBµV at the input of the mixer.

With its conversion transconductance of 12.5mA/V the mixer gain from dummy aerial to the IF transformer input is 33dB and 16dB to the 1st IF amp. input. Such with the given 10.7MHz IF selectivity, which, by the way, has been common used with AM 1st IF.

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Fig. 15 Quadrature mixing

*** Image Frequency filtering**

To avoid the necessity of 'High RF-selectivity for image rejection', the image frequencies are suppressed on chip with a quadrature mixer, driven by sin- and cos-oscillator signals. With a 90° phase shifter and adder, Fig.15, image cancellation of 30dB is realised (see Fig.16).

Note: A reference voltage for the Q-mixer is decoupled by 22nF, pin 29; D.C 7.1V at FM (3.6V at AM).

The oscillator signals are delivered from the VCO via a :2 divider.

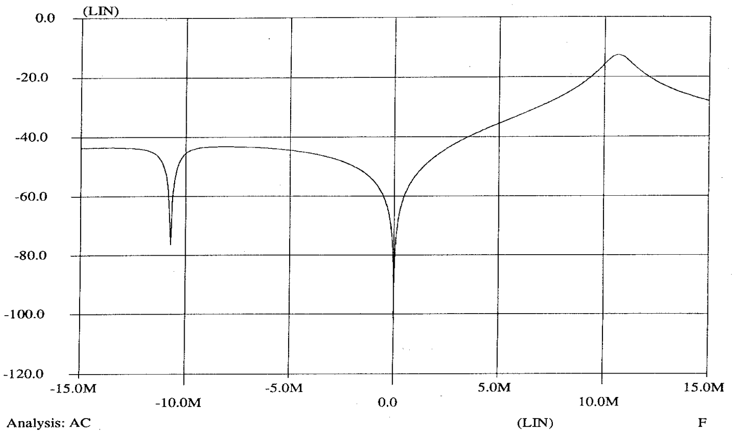

Fig.16 FM image cancelling with quadrature Mixer ***computer simulation)***

*** RF-agc**

The RF-signal at the mixer input has been detected for RF-agc (see Fig.17), delivering a current up to 11.5 mA (from pin 35) to control pin-diodes in front of the tuned RF-circuit.

The application of Fig. 44 shows a pin-diode-control where parallel damping is applied with two pin-diodes.

Note that for high stability in the agc loop a series resistor of at least 47 Ohm with a 47µF decoupling capacitor at the diode-current output (pin 28) is recommended.

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Fig. 17 The Wide band RF AGC

As RF-agc in front of the RF-stage is always a compromise between signal handling and desensitization, the wide-band agc starting point can be influenced by Bus (2 bits) e.g. setting starting points at 4 or 8 or 12 or 16 mV_{rms} at mixer inputs.

By Bus the FM receiver can be set via this agc in local-mode at standard applications (USA/ Europe/Japan), giving a gain reduction (about 12dB in Fig.44 application) by 0.5mA current in the pin-diodes. The local-mode can be used for search tuning; tuning to the strongest stations only.

In the application, Fig.44, the sensitivity is typ V_a= 1.4mV for S/N= 26dB (Df=±22.5kHz), at input signal (from a 75 Ohm antenna) with 50µsec de-emphasis.

. **Keyed AGC**

RF gain control has to be done only if necessary. To that end the amount of agc can be limited with the help of the narrow-band IF-level signal, see Fig.18.

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Fig. 18 The keyed RF-AGC at FM

- Influenced by a strong transmitter, the weak signal is reduced till level voltage is decreased to 0.95 Volt, corresponding with about 4.5µV antenna input-signal, dependent on Level-DAA alignment.
- Then the wideband agc is fixed and larger signals cannot drive the weak signal further into noise.
- Although large signals can give incidentally interferences (in case their frequency difference equals IF) the keyed agc can be preferred to maintain sensitivity (minimum desensitization by large signals).
- The keyed agc function can be switched on/off by I^{2}C Bus in case a better Inter-modulation free dynamic range has performance priority.

Two AGC time constants are to be connected at pins 36 and 37 respectively.

With one time constant, C=1µF for the wideband AGC at pin 36, the attack and decay time-constants are about 5ms. With at pin 37 a C=1µF added (for keyed-AGC), the attack time is 90ms, decay constant is 5ms.

4.2.2 IF and demodulation

* The mixer output signal (pins 18/19) passes a **tuned 10.7 MHz LC-filter and a ceramic SFE filter,** common used with AM-1st-IF, with bandwidth of 180kHz, and enters the IF at pins 14/15. To minimise coupling with other functions the IF has its own supply pin (pin 13).

In the IF of the **NICE/PACS system** only two relatively wide ceramic filters are required. This because the rest of the IF selectivity is carried out by an integrated adaptive filter section, which centre frequency is adjustable by Bus and which bandwidth is dynamically controlled (see Fig. 19) by circumstantial conditions. This eliminates the need for different filters for global applications.

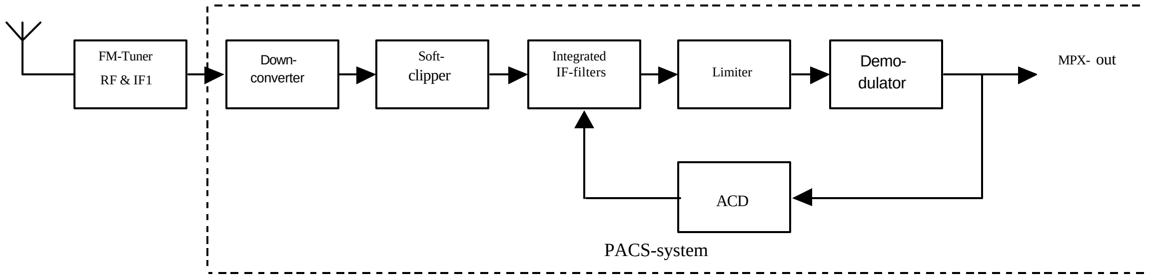


Fig. 19 NICE / PACS IF2

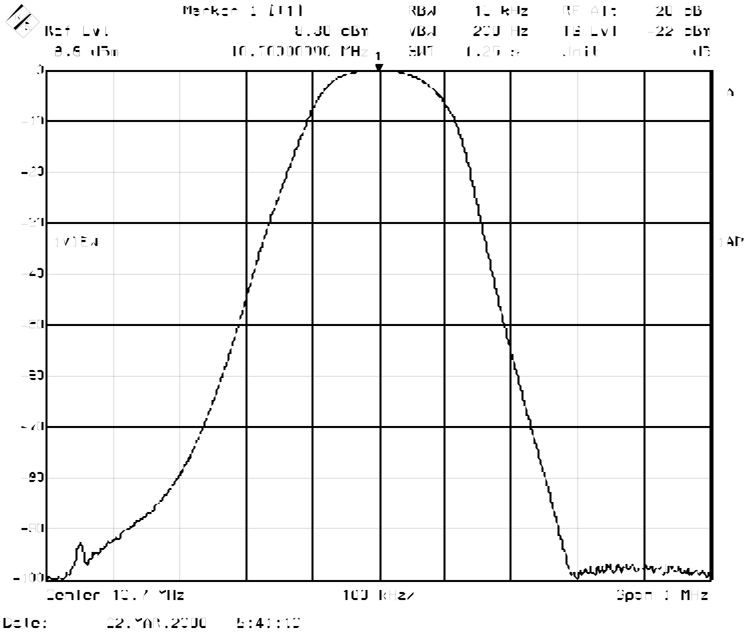


Fig. 20 FM IF1 Selectivity

* **The first IF selectivity** at 10.7MHz has two ceramic filters (180kHz bandwidth, so no special attention on group delay character or on centre frequency tolerance is required). They realize S200= >45dB, see curve Fig. 20.

- An **IF amplifier** is used between the filters, having a high linearity and dynamic range. The IF-amplifier (pin 14 to pin 12) has a Gain of 18dB and >200mV$_{peak}$ input for the -1dB compression point.
  At the input (pins 14/13) as well as at the output (pins 12/11) the impedance is matched for ceramic filters (330 Ohm).
  Noise figure 10dB at 330 Ohm source; third order intermodulation (IP3) at 116dBµV.
- The 2nd **FM-Mixer**. To go for integrated dynamically controlled IF the 10.7MHz IF1 has been converted to 450kHz in a mixer. To keep the power dissipation and chip area acceptable, the IF2 frequency should not be much higher than the required filter bandwidth. 450kHz is chosen for convenience; conversion signals are already available for AM. With mixer2-input at pins 8/10 and with the output direct coupled to the integrated FM-IF2 (via a soft clipper, to avoid overload of the integrated filters) the IF2 performance will be defined from pins 8/10 onwards.
- The **IF2 selectivity** has been build with integrated time-continuous adaptive filters, whose instantaneous bandwidth is determined by all relevant system parameters. The improved of the filter structure and its bandwidth control algorithm deliver higher dynamic selectivity, improved sensitivity and low THD at high frequency deviation without any audible artefacts. The automatic alignment of the centre frequency eliminates IF channel tolerances (<1.3kHz using a 7 bits DAC) and makes it suitable for global receiver applications. The integrated filter of transconductance resonance amplifier topology (see Fig. 21) gives the possibility to adjust the centre frequency and the bandwidth by currents. This because the centre frequency is determined by $F_t=G_t/2\pi C$ and the bandwidth $B=1/\pi R_d C$, with $R_d=R/(1-RG_b)$. Complex realisation of the 4th order filter takes care for image rejection, optimum group-delay characteristic and symmetrical filter behaviour.

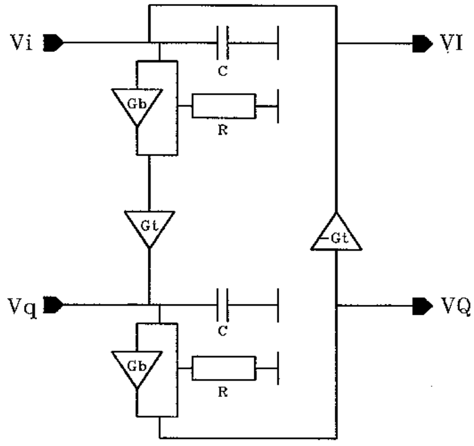


Fig.21 Resonance Amplifier model

Fig. 22 gives an idea of the static selectivity of the integrated filter only.

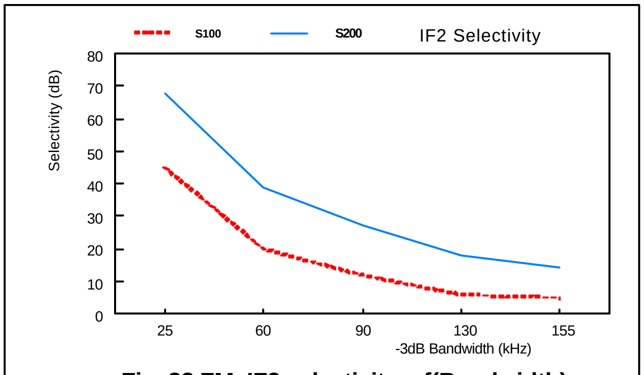


Fig. 22 FM_IF2 selectivity = f(Bandwidth)

Gain alignment with a 4 bits DAC takes care for a constant gain during bandwidth control (error typ ±0.35dB over the total bandwidth in dynamic mode).

- A **limiter** creates the quality signal to drive the FM-demodulator and delivers the signal for fieldstrength level detection. The limiter starts (-3dB) at V_{8-10}= 4.5μV. AM-suppression over a signal range of V_{8-10}= 0.5mV to 300mV is 45dB.

- The **Quadrature Demodulator** has an integrated resonator circuit, matched to and aligned with the filter. The demodulator circuit, shown in Fig. 23, utilizes modulation feedback to reduce distortion. The combination of the above gives a superior receiver with THD performance at high modulation depths: overall (including 2 ceramic filters), 0.2% at ±75kHz deviation. The detector output (FM-RDS_MPX) at pin 57 is 230mVrms at ±22.5kHz deviation. Detector output signal is also available via a **mute** function. Pin 58 delivers 230mVrms; bandwidth >200kHz at Rload >20kOhm at pin 58. Mute depth 80dB; attack- and decay- times are 1ms., in case the mute time constant is set by C=6.8nF at pin 55.

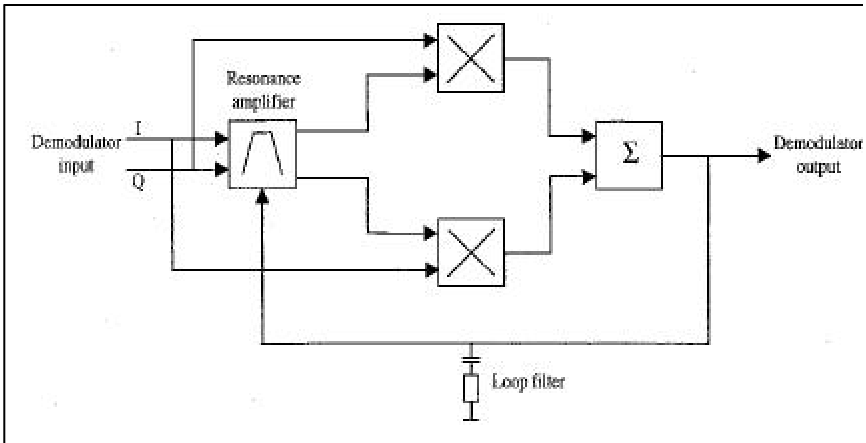
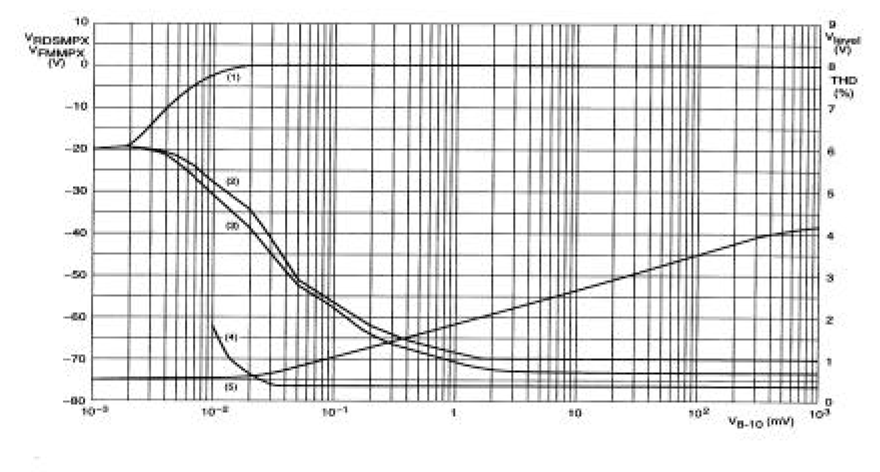


Fig. 23 FM Demodulator circuit

The IF and limiter signal and noise behaviour from pins 8/10 onwards are shown in Fig.24.



(1) Output voltage for FMMPX and RDSMPX: f_{IF} = 10.7 MHz; Δf = 22.5 kHz; f_{mod} = 1 kHz.
(2) Noise: unweighted B = 250 Hz to 15 kHz with de-emphasis 50 μs for FMMPX.
(3) Noise: unweighted B = 250 Hz to 15 kHz with de-emphasis 50 μs for RDSMPX.
(4) THD for FMMPX and RDSMPX.
(5) Level for standard setting of level DAA, byte 6 = 84H.

Fig.24 FM-IF Signal and Noise behaviour

4.2.3 IF Bandwidth Control

The IF2 bandwidth can be fixed by Bus to narrow-/ medium-/ wide- bandwidth (60/ 90/ 130 kHz) or to a dynamic control (25 to 155kHz). The block diagram of the bandwidth control circuit is shown in Fig. 25.

The dynamic bandwidth control operates different in two areas: the area where R.F. input signal V_a > 4.5µV, and the area below that V_a level. The definition of mentioned V_a depends on the level-DAA alignment.

- At input signals **V_a >4.5µV**, the bandwidth is controlled to reduce adjacent channel interferences. The **Adjacent Channel Detector** delivers the information for the bandwidth control.

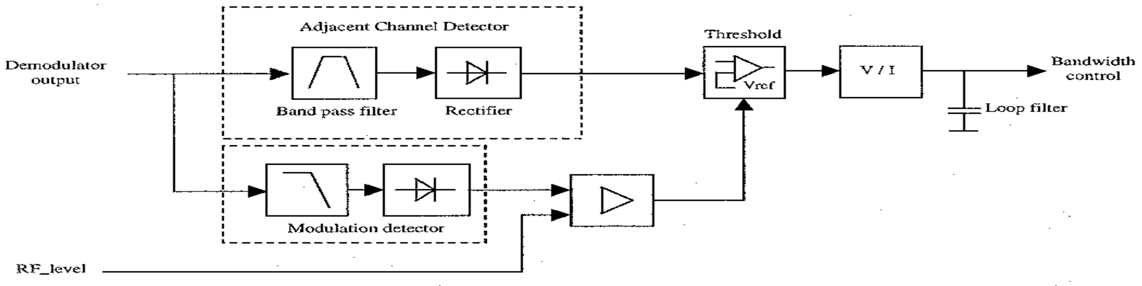


Fig. 25 The FM IF Bandwidth Control Circuit.

The adjacent channel detector (**ACD**) measures the ultrasonic residues in the demodulator output in the 100kHz to 250kHz range, beat-signals caused by adjacent channel breakthrough. The rectified signal, available at pin 65, will be compared with a **dynamic threshold** and, when the threshold is exceeded, IF2 filter bandwidth is reduced in such a way that the dynamic selectivity is constant. The sensitivity of the ACD can be influenced setting the threshold with the voltage at pin 75. The nominal voltage of 380mV at pin 75 can be adjusted (if needed) with a resistor to ground or one to +5V.

The example in Fig. 26a shows the bandwidth (to be monitored by a dc voltage at pin 65, ranging from 2.2 to 0.3 Volt at IF2-bandwidth from 25 to 155kHz).

Care has been taken for control currents creating fast attack and slow decay to obtain graceful bandwidth control. The capacitor at pin 69 influences these time constants.

- **The Modulation Detector.**

At low, noisy, RF levels and high modulation, the demodulator output generates its own ultrasonic residues. This can cause a latch-up effect in the bandwidth control circuit. To prevent this, the threshold level for the ACD-sensitivity consists of, next to a fixed setting, a variable setting, controlled by modulation, which, at high- (or over-) modulation, reduces the sensitivity of the ACD-loop. To take care for operation at '(stereo-)modulation frequencies' only, the MPX signal passes external high- and low-pass filters before entering the modulation detector input at pin 60 (R_i=40kOhm). At the output, pin 68, a time constant of about 0.4 ms makes the modulation detector an 'average' detector. At input signals **V_a <4.5µV** (or the level fixed by Level-DAA alignment), the deviation dependent threshold becomes not sufficient anymore to avoid latch-up effects. Therefore the ACD-loop will be set out of order (setting threshold voltage to maximum).

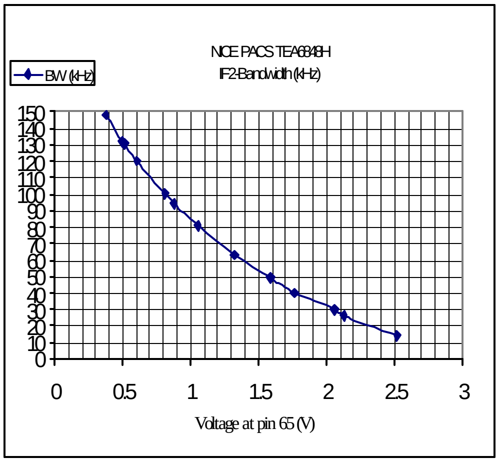


Fig. 26a. Bandwidth versus voltage at pin 65

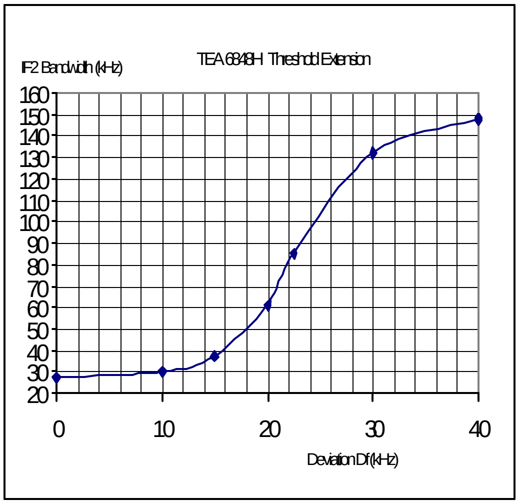


Fig. 26b IF-Bandwidth = f (freq. deviation)

- **Threshold Extension:** An extra benefit of this control loop is that at low modulation-deviation the IF noise bandwidth can be reduced at low RF levels, when permitted (see Fig. 26b) by the modulation detector. This has been done for input signals **V_a <4.5µV.** As a consequence, the demodulator threshold is lowered and <u>the effective receiver sensitivity is improved</u> (Fig. 27).
  On/off switching of the threshold extension can be done by Bus.

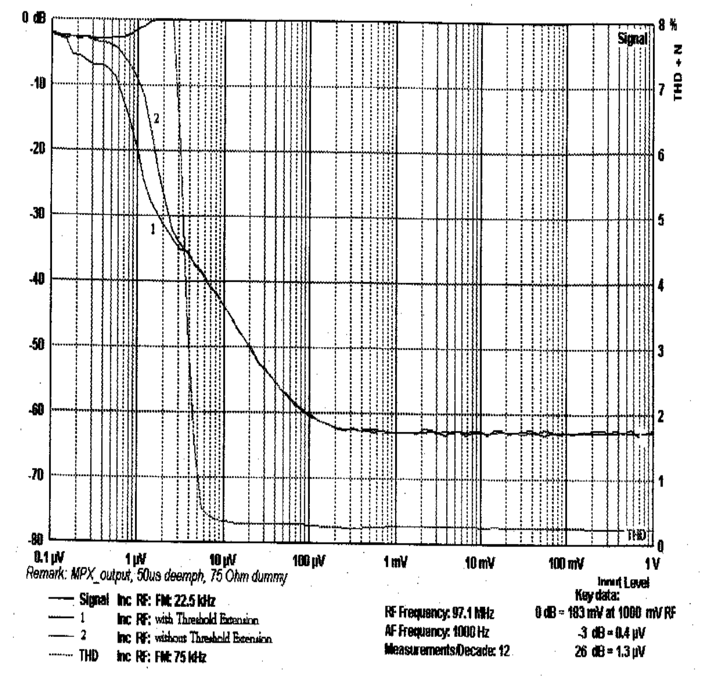


Fig. 27 Threshold Extension at FM

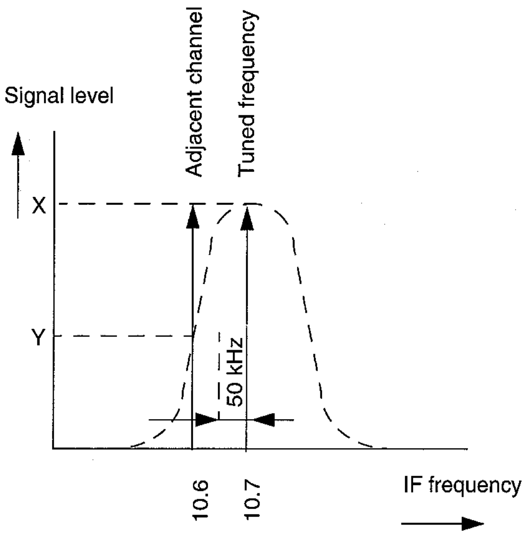
- **The Frequency-offset Detector** will reduce the bandwidth of the IF-filter when the detected frequency offset in the demodulator is too large. This avoids a kind of plop effect that could occur under certain input signal conditions. For example when tuned to a (very) weak desired signal with a strong undesired neighboring signal at 100kHz with relatively high deviation, the bandwidth will switch continuously from maximum to minimum and vice versa. To avoid the resulting audible effect the frequency-offset detector is implemented at the demodulator output of the TEA6848H. To measure the offset, a large time constant has been used (with C=10µF at pin 79, commonly used with AM IF_2 AGC amplifier). To cope with spread of the demodulator, the frequency offset must be aligned (a 4 bits DAC for matching within ±1.5kHz, typical).
  Notes:
  Bus switching to the freq.-offset alignment (with bit 4 of data byte 5) will set the offset detector voltage to pin 62, where it can be monitored for minimum voltage. At dynamic control to a bandwidth < 42kHz, pin 62 gives indication (a flag) which could be used in special radio-system applications where large delay due to low bandwidths is not acceptable.

4.2.4 Search -stop information

FM tuning steps of 100, 50, 25, 20 or 10kHz can be chosen by Bus (reference frequency setting). With a reference frequency of 100kHz and the VCO divided by 2, the tuning step is 50kHz.

Station quality is detected on 2 items: fieldstrength and IF-accuracy, necessary in areas where the FM-band is crowded, illustrated in the figure.

Next to that this special NICE-IC detects adjacent channels to control selectivity as explained in previous chapter. Once stopped, a station far from the wanted one will be neglected by IF-counting; a station close to the wanted one will influence the IF-bandwidth due to the ACD, thereby reducing its field-strength delivery.

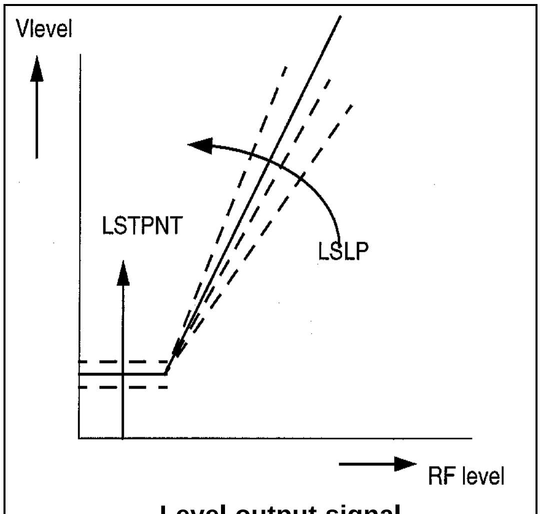


a. Fieldstrength:

The IF limiter delivers a well defined fieldstrength-dependent DC-**level information,** analogue available at pin 70, to be used in the audio signal processor

. for soft mute at weak signal handling
. for stereo blend
. for signal dependent response (high cut control etc.).

In a signal range $V_{8\text{-}10}$=10µV to 1 Volt the level-detector delivers 1 to 4 Volt dc.



Level output signal

Special attention has been paid to the temperature behaviour of the level amplifier. Over the operating temperature range, the level-change is just as much as ±3dB RF-signal change.

Search stop sensitivity can be adapted with the help of the **Level DAA** such to cope with spread on fieldstrength level information.

For production starting point as well as the slope of the level detector need alignments.

(Note that level depending parameters, like keyed AGC and Threshold Extension, are influenced).

Example:

* *FM level-start: The level-detector output is set to 940mV at a RF input level of 4.5µV. (Note: 940mV at FM is the switch-off level of keyed AGC and start of threshold extension, e.g. if selected by Bus keyed AGC=on and threshold extension=on below 940mV).*

* *The level-slope is aligned in such a way that the difference in level-detector output between RF levels of 20 and 200µV is 800mV with the level-start value found in the first alignment. These alignments cannot be seen separately.*

More about alignments in Appendix 2.

b. IF-Counting:

Next to the fieldstrength level, the exactness of **the IF frequency** is counted for stop information. To this end the TEA6848H has an 8-bit-IF-counter with a programmable counting window of 2 or 20ms. The counter counts the output frequency of the limiter amplifier which is divided in a programmable divider, the pre-scaler. For FM the dividing ratio N can be set to 10 or 40. The content of the counter can be read out via the I^{2}C-Bus. It is not necessary to read out the full value of the IF-frequency to get information about correct tuning. It is sufficient to use only the 8 least significant bits. The counter resolution is given by the counting time and the dividing factor of the pre-scaler.

The number of counted cycle's n, counted during the counting window t_c (2 or 20ms) is

$$n = \frac{F_{if}}{N} . t_c$$

where N is the dividing factor of the pre-scaler and F_{if} is the output frequency of the IF amplifier. The resolution ΔF_{if} of the system is the frequency difference, which corresponds to the least significant bit of the counter (LSB).

$$\Delta F_{if} = \frac{N}{t_c}$$

Next table gives an overview of the possible combinations of read back values and the corresponding resolutions; not only for FM in different markets, but for weather-radio and AM as well.

TABLE 1 IF counter		***read out and IF count resolution***		
Application	**Tc**	**IF prescaler**	**Read out value**	**Resolution**
	(ms)	**(N)**	**(Hex)**	**(kHz)**
FM-standard/-east/-weatherband	2	10	5A	5
FM-standard/-east/-weatherband	2	40	16	20
FM-standard/-east/-weatherband	20	10	84	0.50
FM-standard/-east/-weatherband	20	40	E1	2
LW / MW / SW	2	1	84	0.5
LW / MW / SW	20	1	28	0.05

The counter sensitivity voltage: 2µV antenna signal for a 30% modulated FM signal.

Note that the counter is reset after each Bus transmission, taking care that the count-info is correct from reset onwards.

4.3 Oscillators

4.3.1 VCO

The VCO, tunable from 159.9 to 248.2MHz, serves FM and AM and Weather-band application on global scale. At FM the mixer is driven with 'high' injection oscillator for Europe/ USA and Weather band, where in Japan and Eastern Europe FM band the mixer is driven with a 'low' injection oscillator.

			Divider	VCO	Tuning Voltage
FM	Europe/USA	87.5 to 108MHz	2	196.4 to 237.4MHz	2.6 to 5.5V
	Japan/Far East	76 to 91MHz	3	195.9 to 240.9MHz	2.5 to 5.8V
	Eastern Europe(OIRT)	64 to 74MHz	3	159.9 to 189.9MHz	1.1 to 2.7V
Weather-band		162.4 to 162.55 MHz	1	173.1 to 173.25 MHz	1.22V
AM	LW - MW	144 to 1710kHz	20	216.88 to 248.2MHz	3.9 to 6.5V
	SW 49m	5.73 to 6.295MHz	10	164.3 to 169.95MHz	0.8 to 1.06V

FM As the **VCO at FM** defines the final S/N ratio at full limited FM-channel, care has been taken to the VCO **C**arrier to **N**oise **R**atio. Therefor a high quality VCO-coil (Q_0=130) has been used. For a required (S+N)/N = 65dB, defined at $\Delta f = \pm 22.5$kHz modulation at 50µsec de-emphasis, the CNR at 10kHz distance has to be 101dBc/√Hz for the oscillator signal. The oscillator signal is obtained from the VCO via a :2 divider. A VCO with, at 200MHz, a CNR of 97dBc/√Hz at 10kHz distance.

AM The target for **AM** is based on avoiding reciprocal mixing by interfering neighbouring (Δ=10kHz) signals. With a neighbouring signal 75dB attenuated and with 5kHz IF bandwidth the oscillator signal CNR target at 10kHz distance becomes 75 + log(5000) = 112dBc/√Hz, delivered from a VCO via 10 times divider (at SW).
So for the VCO 112-20 = 92dBc/√Hz is good enough for AM.

4.3.2 X-tal oscillator

The X-tal Oscillator (pins 71-73, with pin 72 for x-tal osc. ground)) operates at 20.5MHz, having low interferences and using no additional components. The oscillator is fully balanced with respect to the crystal pins, such to have low cross-talk towards sensitive receiver pins.
The current of the sinusoidal signal at the crystal pins is well defined by internal control to obtain low power / low harmonics operation. The 5th harmonic at 102.5MHz is >70dB down.
A special circuit takes care for start-up of the oscillator using start-up current of 9mA and an operating current 1.5mA.
The oscillator is used for

- **AM and FM second conversion**,
- **synthesizer reference** frequencies,
- clock frequency generation for the **sequential RDS-update circuit,**
- **time-base** for **IF-Counter,**
- **reference frequency** of 75.368kHz for **C**ar **A**udio **S**ignal **P**rocessors (**CASP**);
  the last with signal level 100mV from 50kOhm source at pin 45.

Required is a crystal with the following specification:

. motional resistance (at start of operating):	< 50 Ohm
. shunt capacitance:	< 3 pF
. load capacitance:	10 pF
. motional capacitance:	9 fF

resulting in ± 34 ppm pulling for ±1.25 pF capacitance variation.
Together with the other requirements on

Accuracy:	± 20 ppm
Ageing:	± 5 ppm
Temperature stability:	± 30 ppm,

the application of NICE with this x-tal oscillator permits a worst case max. deviation of ±1.8kHz (which is ±89ppm) from the 20.5MHz oscillator frequency.

4.4. Tuning System

The adaptive PLL tuning system combines low phase noise and reference spurious breakthrough with a fast tuning response. The internal RDS, sequential, control circuit co-ordinates the tuning operation. The tuning algorithm combined with the mute circuit provides inaudible signal quality checks on FM. The crystal oscillator generates all the necessary reference signals for the tuning operation and frequency conversions.

Functional information on the tuning system is shown in Fig. 28.

4.4.1 Digital Automatic Alignment

In the application described, the design of the tuned input circuit with capacitance diode BB814 is, in combination with VCO tank-circuit, containing a diode BB156, optimised for low padding deviation by digital automatic alignment. Usually three alignments are necessary and sufficient for a good tracking performance. (Padding max. 400kHz, where the Q of the RF circuit is about 25), to which end the tuning voltage of the oscillator is converted in the DAA to a controlled alignment voltage for the FM antenna circuit.
After having the phase lock loop of the NICE synthesiser locked to a new tuning position, the analogue tuning voltage at the loop filter is used as reference for RF-tuning.
Starting with a certain input level at the selected input frequency, the level detector output is measured and stored, where after the DAA value is increased by one. This sequence is repeated for a certain time and from all measured values the maximum value is calculated. When this value is stable for some measurements, the centre is calculated and the corresponding DAA value is stored in the memory (EEPROM). This can be done for lower limit- / upper limit- and mid-frequency of the frequency band.
A NICE alignment recipe ”Autonice” is available on request.

As the VCO charge pump may not be loaded, the DAA buffer input (pin 40) has very high impedance (input current <10nA).

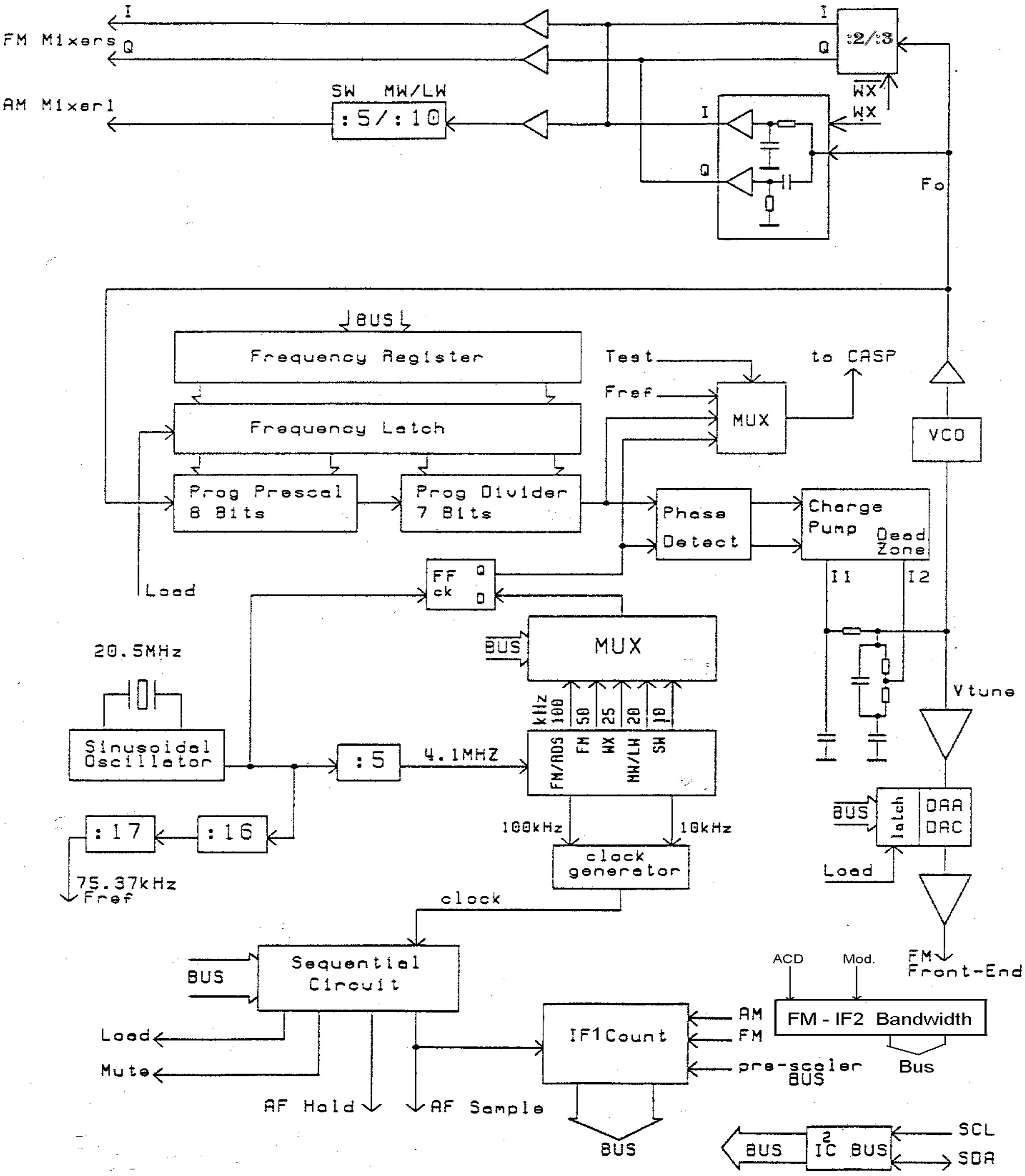


Fig. 28 Tuning System

The input voltage of the DAA can be multiplied by 0.25 up to 1.75 by the 7 Bits setting of the conversion gain.

The output voltage (>0.5 to <8 Volt) at pin 38 has a low noise level: <100µV, measured acc. dB(A); ripple rejection is >50dB. The settling time of the DAA output at max. step is <30µsec at 270pF load at pin 38.

Next to the minimum leakage currents, low-noise and high ripple rejection, the temperature dependency is an item. As the silicon varactor diode in the VCO is temperature dependent, a compensating diode has been connected at pin 39. This diode is not on chip, such to have its temperature behaviour the same as that of the varactor diode. Temperature drift over -40°C < Tamb < 85°C is < ±8mV. The output voltage at pin 38 of the antenna DAA is

$V_{38} = [2 \times (0.75 \times (n/128) + 0.25) \times (V_{40} + V_{39})] - V_{39}$, where n=0 to127,

in which V40 is the DAA input voltage and V39 depends on the diode connected at pin 39 (V_{39} is about 0.46 Volt in case a diode has been used).

4.4.2 The RDS updating (Sequential circuit)

To provide best reception quality, a control is used in car radio to check for alternative frequencies with equal programming; such with the help of a system like RDS (Radio Data System). This usually can cause audible breaks in the main channel received, as the audio has to be muted for the moment while the receiver is tuning to other frequencies. Gaps in the audio signal may be perceived if the muting time is not short enough. In practice, with actual audio signals, muting times below 5ms. with gentle slopes of 1ms are inaudible, see Fig.29.

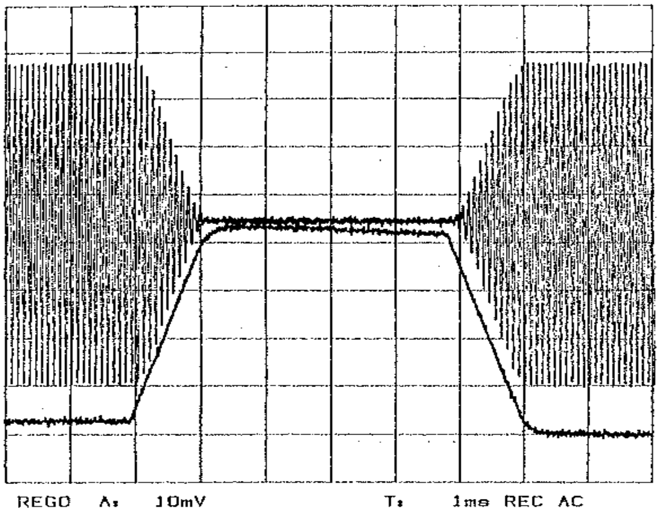


Fig. 29 Inaudible mute behaviour

To achieve FM quality signal checks of 5ms, the tuning times have to be reduced to below 1ms. and the frequency jumps have to be made independent of the (slow) Bus communication times. The first requirement has to be accomplished by the tuning system, whereas the latter was solved by local intelligence in the form of a sequential circuit that controls tuning operations during quality checks.

This sequential circuit responds on an AF-label in the frequency word (signifying a quality check request) by

a. muting the audio with a 1ms slope
b. jumping the PLL to another frequency in less than 1ms.
c. sensing the quality of the new signal with the level- and IF-sensors in 2ms.
d. writing this information into latches
e. jumping back to the main frequency
f. de-muting the audio with the mentioned 1ms slope.

Inaudible Quality Check Control Signals Timing

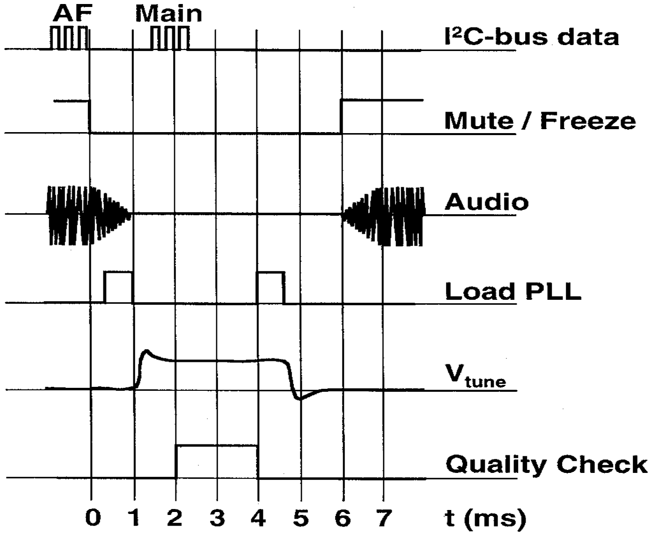


Fig. 30 RDS Alternative Frequency check

A complete cycle (see Fig. 30):

- Starts with a Bus command to go to an alternative frequency;
- Next the AF-signal will be muted by reducing the audio-signal linear in 1ms.;
- Then the tuning voltage jumps due to an in between PLL-load command;
- After 1ms the new tuning position is reached and a quality check (level-info) can be done. For this the counter-period is automatically switched to 2ms. The prescaler can be chosen freely.
- Then a PLL-load command can start Vtune to jump back to the original main-channel as asked by Bus-data.

For application with audio processors (like CASP or CDSP) sample and hold info is available from pins 53 and 54 respectively (Sample- like the 'quality check' and Hold-info like 'mute/freeze' in Fig. 30). The latched info can be read via the I2C Bus at any time with simple software (with minimum load of the µC). Attention has to be paid to the timing of the main-command and the fact that during AF-update no other Bus transmissions to the receiver are permitted then those related to frequency and DAA-level. The time constant for mute behaviour at RDS AF update is defined by the capacitor at pin 55.

4.4.3 Adaptive Synthesizer

The tuning system uses a PLL synthesizer, supplied via pin 44 (analogue 8.5 Volt) and at pins 46/47 (digital 5 Volt)

The VCO frequency is divided in **a programmable divider**, controlled by the I^2C Bus.

The Bus data define the divider ratio of the divider, N, which determines the RF at which the system is tuned.

The divider ratio is

$$.N = \frac{F_{vco}}{F_{ref}}$$

where F_{vco}= M * F_{osc} = M * (F_{tuned} ± F_{if}) with F_{if}= 10.7 MHz both for FM and AM (**+** for high side and **–** for low side injection).
M is the divider ratio of the divider N1, which sets the oscillator frequency for the RF-Mixer.
In next table an overview is given for divider ratio calculation in different applications.

TABLE 2 Frequency Divider Ratio range					
Application	**Fif (MHz)**	**Fref (kHz)**	**M**	**Ftune**	**N**
FM-standard	10.70	100	2	87.5-108	1964-2374
FM-Japan	10.70	100	3	76-91	1959-2409
FM-east (OIRT)	10.70	20	3	64-74	7995-9495
FM-weatherband	10.70	25	1	162.4 - 162.55	6924-6930
SW	10.70	10	10	5.85-9.99	16550-20690
LW	10.70	20	20	0.144-0.288	10844-10988
MW	10.70	20	20	0.53-1.71	11230-12410

The divider-output is connected to **a phase detector**, and the divided frequency is compared with **the reference frequency F_{ref}.** The output of the phase detector drives, via **a charge pump circuit** (output pin 42/43), the **loop filter** (between pin 42/43 and 40), which in turn delivers the VCO **tuning voltage** (at pin 40).

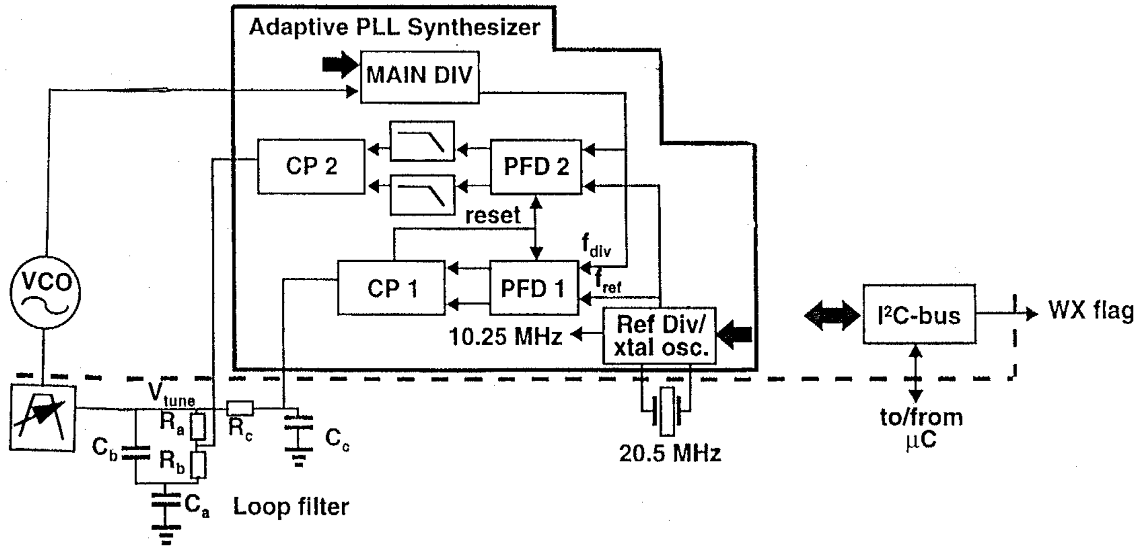


Fig. 31 Adaptive Synthesizer currents to different nodes of the loop filter.

Spectrum purity, small tuning steps and fast settling times are contradictory requirements for the PLL synthesizer. With the adaptive PLL solution of Fig. 31 two loops work in parallel with a smooth take-over to guarantee inaudibility. The phase detector outputs of the Loop-2 are low-pass filtered before the high current charge pump CP2; CP2 is active only during tuning.

Some information in more detail:
The low-pass filters give a smooth transition into a well defined dead-zone when lock is being achieved. The Loop-1 phase detector has no dead zone and directly steers the low current charge pump CP1.
Good centring of the two charge-pump outputs (by careful symmetrical design etc) is essential for low noise in lock. Additional freedom for optimisation of loop parameters is obtained using two separate charge pump outputs, and by applying the charge pump.

During frequency jumps both CP1 and CP2 are active. The loop filter zero-gain frequency is $[1/(2\pi.R_b.C_a)]$ and lies at a high frequency, resulting in stability and fast tuning. After the frequency jump only CP1 (to pin 43) is active. The loop filter zero-gain moves, without switching of loop filter components, to a lower frequency $[1/(2\pi.(R_a+R_b).C_a)]$, increasing the in-lock phase margin. Furthermore, when the loop is in-lock, an extra pole is introduced $[1/(2\pi.R_c.C_c)]$ increasing the 100kHz reference breakthrough suppression by about 20dB.
To obtain a fast tuning step the charge pump CP2 (pin 42) can deliver 3mA current to the loop filter. After tuning the active charge pump CP1 delivers 130µA at FM to 1mA at AM (Weather-band and East-Europe FM at 300µA). The pre-set time for FM tuning to bandlimits is within 1 ms (using 100kHz reference-freq. in the synthesizer, like in RDS AF-updating).
The loop-filter as shown in application, Fig.44, is optimum for fast PLL tuning (< 1ms for a tuning-step 88 to 108MHz).
* The **reference frequency,** delivered by the 20.5MHz crystal oscillator, can be set by Bus.
For fast AF-updating at RDS, PLL control is on chip.

4.5 I^{2}C-Bus control

For details: see APPENDIX 1.
The basic functions and the specification of this Bus system are described in a special Philips brochure: **"The I^{2}C-Bus and how to use it" (December 1998, document order number 9398 393 40011)**.
The I^{2}C-Bus, with data and clock lines at pins 63/64, is structured as shown in Fig. 32.
The Bus communication starts with a "start"-signal given by the system controller. The first transmitted byte is the address byte (byte 0). The following bytes (1 to 8) are used to transmit information to the IC or to receive information from the IC. When the Bus communication is used partially the transmission must be ended by a stop condition. In this case the remaining bytes will contain the old information.
The complete information to set the IC TEA6848H consists of the address byte and 8 data bytes.

Byte	0	1		2	3		4				5						6		7		8	
Bits	7+R/W	1	7	8	1	7	1	3	1	3	1	2	1	1	1	2	5	3	1	7	4	4
Com-mand	Address	AF-mute	PLL-Freq.	PLL-Freq.	Mute	Ant DAA	Count-time	Ref. Freq.	IF-Pre-scaler	Band	Keyed AGC	AGC AM/FM	AM Soft mute	Lo / Dx	Soft-ware flag	IF2 band width	Level DAA start	Level DAA slope	FM-thres hold	IF2 centre DAA	FM-Demod Offset DAA	IF2 filter Gain DAA
							ms	kHz		FM		mV				kHz						
							2	10	10	FM-Japan		150 / 16				Dynamic						
							20	20	40	FM-OIRT		275 / 12				130						
								25		WX		400 / 8				90						
								50		SW		525 / 4				60						
								100		MW /LW-mono												
										MW /LW-stereo												

Fig. 32 TEA6848H Bus-structure

The address byte is 1100001R/W, with a 2nd address 1100000 R/W, to be selected by connecting pin 45 via 68kOhm to ground. For Read/Write: logic 1=read and logic 0 =write.

TABLE 3 Frequency Band Setting					
Application	**Bit 1 AM/FM**	**Bit 2 Bnd1**	**Bit 3 Bnd2**	**VCO-divider**	**Charge Pump Current**
FM-standard	0	0	0	2	130µA + 3mA
FM-Japan	0	1	0	3	130µA + 3mA
FM-east (OIRT)	0	0	1	3	1mA
FM-weatherband	0	1	1	1	300µA
SW-mono	1	0	0	10	1mA
SW-stereo	1	1	0	10	1mA
LW/MW-mono	1	0	1	20	1mA
LW/MW-stereo	1	1	1	20	1mA

4.6 Supply

The main **supply Vcc1=8.5 Volt, pin 61,** which has to deliver typical 65mA at FM and 50 mA at AM. In addition **5 Volt supply** is needed at pins 46/47 for digital functions and at pin 59 for analogue functions with 33 to 46mA current consumption, application dependent.

The external voltages create internal reference voltages and currents, taking care for the required stabilization and temperature behaviour.

Notes :

. Switching performance in this report refers to switching both 8.5 and 5 Volt supplies simultaneously.

. Care has to be taken for a good ripple rejection of the VCO-supply (pins 51/48).

5. LAYOUT GUIDELINES

Application of the TEA 6848H simplifies the PCB design of a digital tuned AM/FM receiver dramatically. With a complete tuner LSI for low design costs, special measures have been taken during the IC design for good internal separation of the analogue-receiver and digital-tuning parts in order to minimize interferences.

Because of these measures, the PCB given in this Application Note (see Fig. 44) is rather simple and a large list of layout tips is not necessary. However, being a radio application in which the gain in several parts of the receiver is considerably high and where RF and oscillator signals should not enter the final IF stages etc. still some attention has to be spend on the PCB design. When the two-sided layout, given in this application note, is used, problems are not to be expected (see Appendix 3 for a two-sided PCB, version TEA 6848H).

Some layout hints are:

VCO:

The VCO coil needs to be put close to the IC pins, also the grounding of the VCO varactor diode (BB156) via the 270pF capacitor (C63); and the grounding of VCO coil and capacitor C63 needs to be done directly to the VCO-GND pin 48.

FM-Mixer:

The connections of the FM input transformer to the mixer pins should have the same length. The first FM PIN diode (D3) needs to be put close to the antenna connection to prevent large signals from entering the PCB.

AM:

Using an FM intrusion trap (L3+C4), it needs to be placed close to the antenna connection and its grounding.

Reference crystal:

The 20.5MHz crystal can best be put close to the IC-pins.

I^{2}C-Bus tracks:

To suppress I^{2}C-Bus interferences, 330 Ohm resistors are placed in the SCL and SDA lines. It is important to keep these tracks away from the VCO coil (and its tracks connecting it to the IC pins). An RC- filter in the I^{2}C-Bus outputs of the embedded micro-controller has been used to round-off the I^{2}C-Bus pulses a little.

Coils:

Since the coils need no mechanical alignment you don't need physical holes. It is advised however to have holes in the copper pattern below FM-coils L10, L14 and L15. See our demo module-board. (A solid copper plain below these three coil- functions will act as a 'short-circuited turn', so will deteriorate the coil-performance!).

SMT-components:

In order to minimise surface area, change over the coils to SMT types. Companies TOKO and SAGAMI know the (leaded) coils and their specs needed for the Nice_Pacs tuner, so they should be able to advise what's the best SMT replacement for them.

To help with this process please find below a short description of the used coils with some back-ground info.

FM aerial input; L12 & L18:

These coils are in series with the antenna input; therefor any series resistance of this coil will have a negative effect on the FM sensitivity. In our current NICE tuner modules we use Murata coils, Q_0 >85, F_{res} >300MHz, R_{series} <0.7 Ohm.

When a cheaper coil is desired an increase of the series resistance R_{series} <2 Ohm giving a Q_0 >30 could still be usable. The coil's resonance frequency however should be well above the FM band so remain F_{res} >300MHz !

Note that the PIN diode decoupling capacitors of 1nF (C37, C38) need to be of the NP0 type (0805 SMD's have the best quality at 100MHz)

Tuned FM-RF coil (L14):

To have a good selectivity this coil needs to have a Q_0 of at least 60.

With our tuned coil and with it's tap chosen as we have the SLINE coil is about 20 - 30nH. The Q of this coil is not very critical as long as the image suppression of the front -end is about 30dB. (Please note that the rest of the needed image suppression is made by the I-Q mixer system inside the chip!).

FM RF coil (L10)

The output impedance of this coil is about 200 Ohm (to match mixer input) so it doesn't need to have a very high Q_0. Loaded Q of about 20.

VCO coil (L15)

The coil used for the VCO needs to have a good Q of >120 to guarantee a good carrier to noise ratio !! If required also an air-coil can be used (most air coils have a Q_0 >300 !). Use always NP0 type capacitors in the VCO circuit.

FM mixer (L1)

This is a normal 10.7MHz mixer transformer with a Q_0=50-70

AM mixer (L4)

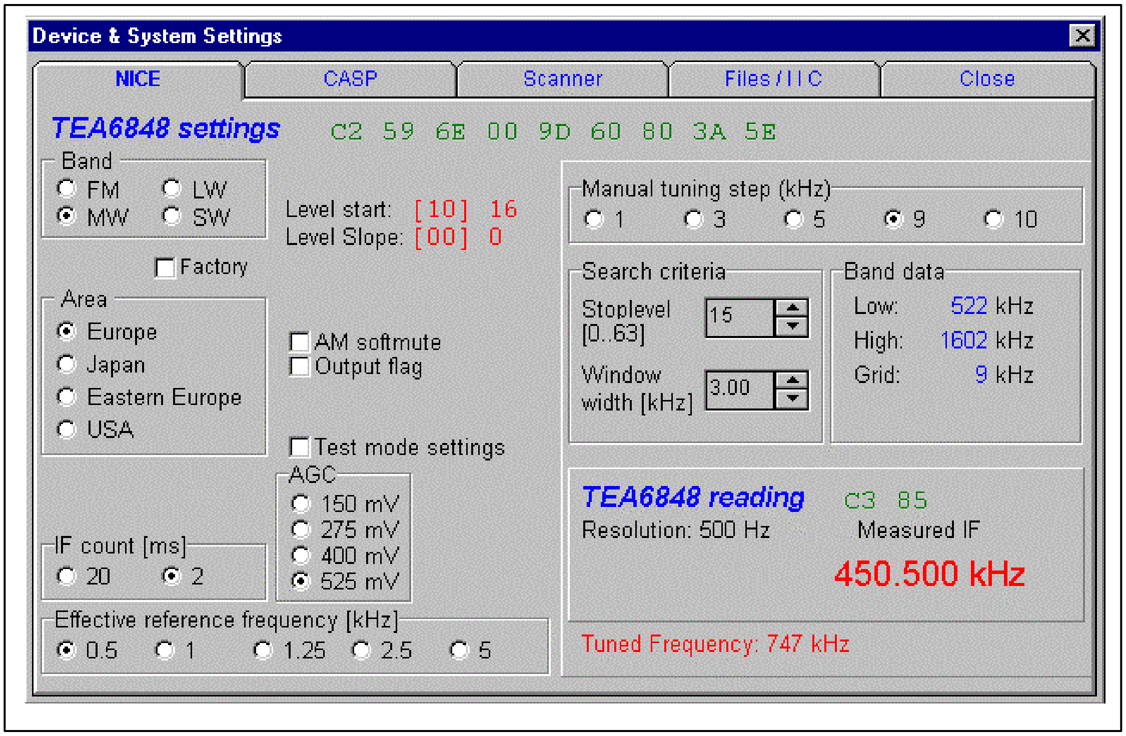
This is a normal 450kHz mixer transformer with a Q_0=50-70.

20.5MHz Xtal specification

- *motional resistance (at start of operating): < 50 Ohm*
- *shunt capacitance: < 3 pF*
- *load capacitance: 10 pF*
- *motional capacitance: 9 fF*
- *Accuracy: ± 20 ppm*
- *Ageing: ± 5 ppm*
- *Temperature stability: ± 30 ppm*

6. APPLICATION.

6.1. Application AM



TEA6848 settings C2 59 6E 00 9D 60 80 3A 5E

Band
○ FM ○ LW
● MW ○ SW

☐ Factory

Area
● Europe
○ Japan
○ Eastern Europe
○ USA

IF count [ms]
○ 20 ● 2

Level start: [10] 16
Level Slope: [00] 0

☐ AM softmute
☐ Output flag

☐ Test mode settings

AGC
○ 150 mV
○ 275 mV
○ 400 mV
● 525 mV

Effective reference frequency [kHz]
● 0.5 ○ 1 ○ 1.25 ○ 2.5 ○ 5

Manual tuning step (kHz)
○ 1 ○ 3 ○ 5 ● 9 ○ 10

Search criteria
Stoplevel [0..63]: 15
Window width [kHz]: 3.00

Band data
Low: 522 kHz
High: 1602 kHz
Grid: 9 kHz

TEA6848 reading C3 85
Resolution: 500 Hz
Measured IF
450.500 kHz

Tuned Frequency: 747 kHz

For the Module TEA6848H (Fig.43, application acc. Fig. 44) the ***Gain*** *distribution in the AM-channel is as shown in Fig. 33.*

TEA 6848H AM –MW signal channel

	Dummy-Aerial	**Input selectivity**		**Pre-ampl.**		**Low-Pass Filter**		**Mixer 1**		**1st IF, LC+SFE**		**Mixer 2**		**2nd IF, LC+SFP**		**IF 2 Ampl. / Det.**
Result:			*		*		*		*		*		*		*	
Measuring Point:	0		1		2		3		4		5		6		7	
Equivalent Noise Voltage	10			0.8				5.5				14			6	nV/√Hz
S/N= 26dB at Vi =	47														45	µV
Relative Levels	0		-20		5		4.5				6				11	dB
Stage Gain		-20		25		-0.5		18		-16.5		10		-5		dB

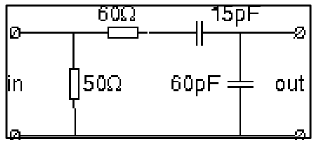
Fig.33 AM Gain Distribution

1

*Fig. 34 shows **MW Signal and Noise** behaviour as a function of fieldstrength with selectivity acc. to Fig.6, 7, 8 and 9; the THD (Total Harmonic Distortion) behaviour is given too.*

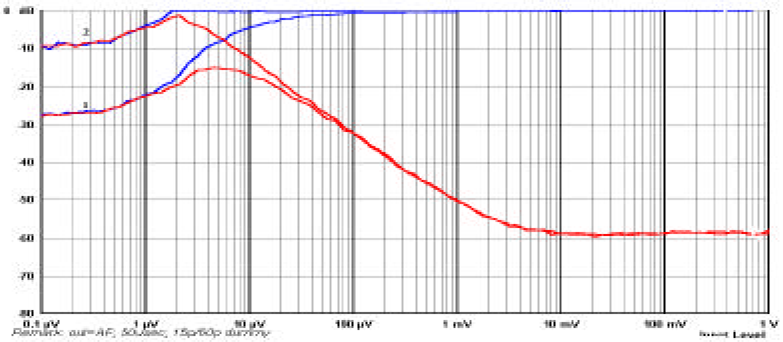
*The noise limited **Sensitivity**: S/N=26dB at standard modulation*

Dummy-antenna at loaded generator	*S/N = 26 dB at relative V_a =*
15 to 80pF	*55mV*
15 to 60pF	*47mV*
27 to 47pF	*28mV*
50 Ohm	*3.4mV*



AM dummy aerial

Fig. 34 AM Signal and Noise behaviour; 1=with and 2=without soft-mute



This sensitivity is constant over the MW band. At LW the value is higher: 70mV. In case lower inter-station noise is required (or lower Figure Of Merit), one can reduce gain, switching on the AM soft mute function, see curves 1 & 2 in Fig. 34.

***Intermodulation**:*

Reception of sum and difference frequencies due to 2 strong signals (F2 and F3); combinations of it cause IP3, cross-modulation related 3rd order non-linearity. The Intermodulation Points: see Fig.35, with IP2 caused by 600 and 800kHz (F2 and F3) at 1400kHz (F1) tuning and IP3 caused by 1040 and 1090kHz (F2 and F3) at 990kHz (F1) tuning; as a function of the input voltage at the dummy aerial.

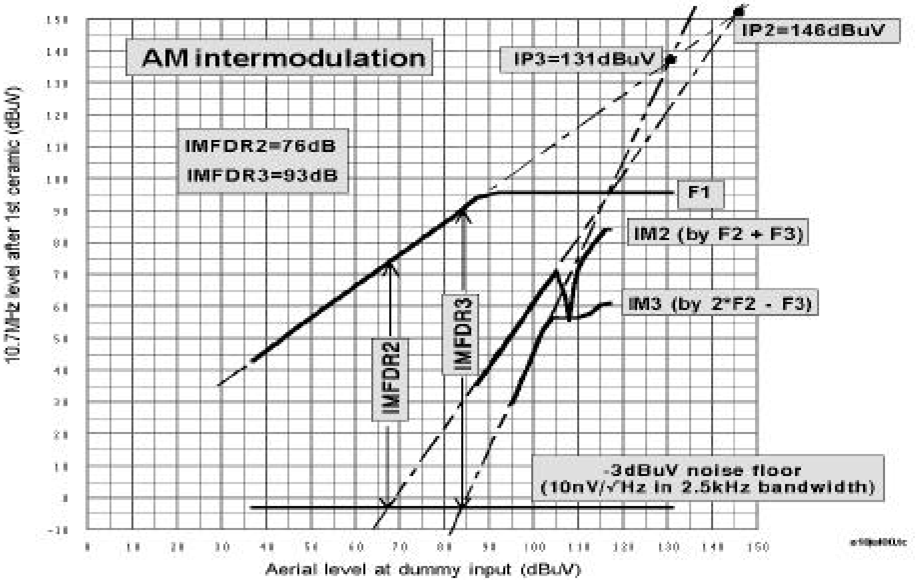
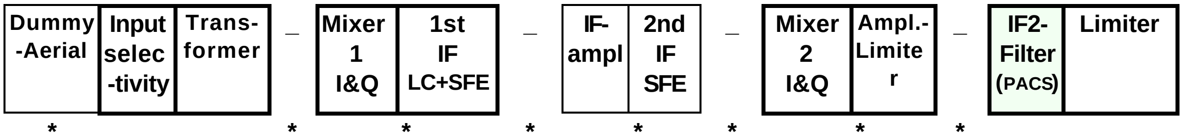


Fig. 35 AM Intermodulation characteristic

6.2. Application FM.

*For the given application the **FM-Gain Distribution** is given below:*



Measuring Point:	0		1		2		3		4		5		6		7		
Noise Figure	6			3				9.5									dB
S/N= 26dB at Vi =	1.3														10		µV
-1dB Compression				>70				>400									mV_{pp}
IP3				117				116									$dB\mu V_{rms}$
Relative Levels	0		1		32.5		16		34		29.5		39.7		43		dB
Stage Gain		-0.5		33		-16.5		18		-4.5		10.2		3.3		0	dB

Fig. 36 FM Gain Distribution

*Fig. 37 shows **Signal, Noise and SINAD** characteristics / **Total Harmonic distortion** and **AM-Suppression and level-information** in this application.*

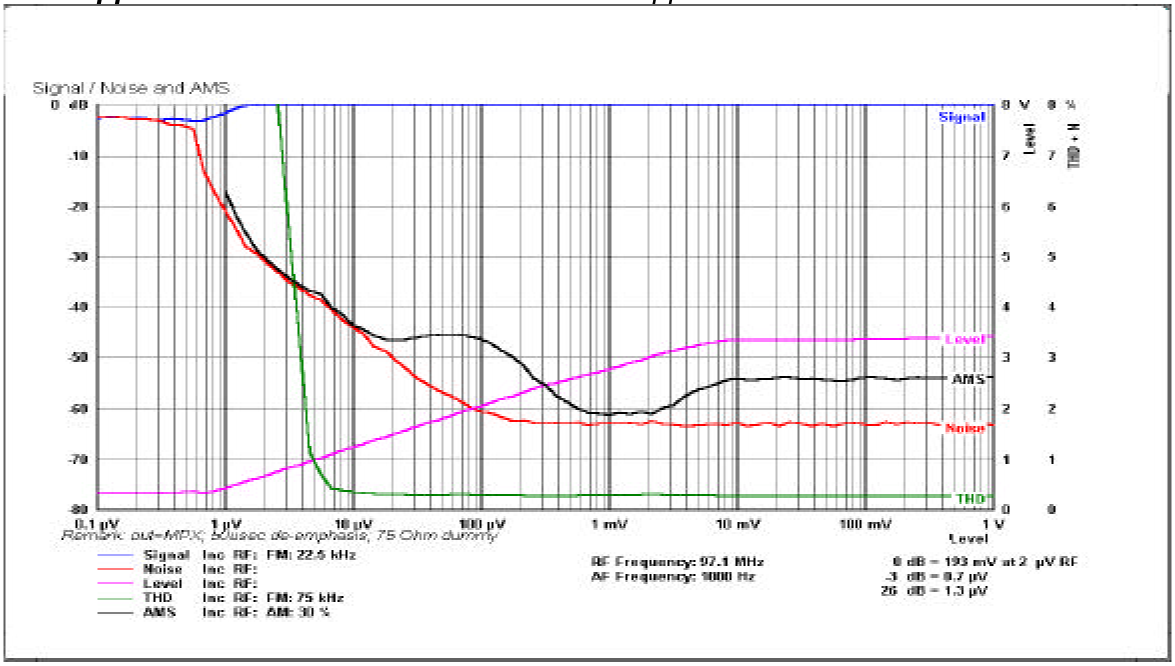
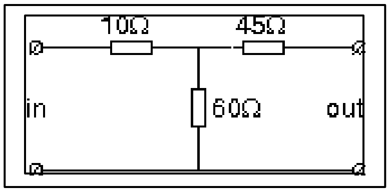


Fig.37 FM Signal, Noise and Distortion

1

R_antenna	*-3dB Limiting at V_a:*	*S/N = 26 dB at V_a:*
75 Ohm	*1mV*	*1.4mV*



75 W / 6dB FM-dummy aerial

6.3 Global Applications :

1. **Europe**: Standard application;
   FM-band 87.5 to 108MHz, channel grid 100kHz, de-emphasis 50µsec
   AM- LW 144 to 288kHz
   MW 522 to 1620kHz, channel grid 9kHz
2. **USA**
   FM-Band 87.9 to 107.9MHz, channel grid 200kHz, de-emphasis 75µsec
   AM-Band 530 to 1710kHz, channel grid 10kHz.

Some items, characteristic for USA applications, influencing choice of components:

- De-emphasis-C's to be matched to USA situation (*75µs instead of 50µs)*; to be done by software setting in the audio processor (CDSP or CASP).
- Narrow spaced FM-broadcast transmitters located at one position (city) ask special attention for certain intermodulation products suppression and AM-interference breakthrough (so called ‘FM intrusion’; see note below).

Note: To reduce FM intrusion e.g. for USA-markets, where two FM-transmitters F1 and F2 can have frequency difference |F1-F2| which can fall inside an AM-band, a special filter can be designed to block the FM frequencies.

With such a filter included, 2 FM-signals having 800kHz freq. offset, need to deliver 450mV aerial input level, before they give, at 800kHz AM-tuning, an audio-interference of 20dB below standard (30% modulated) AM a.f. output.

Other signals to be attenuated at the AM-input are **mains-interferences** from high-tension wires and ultra-sonor signals (used at deep-sea research). These signals are suppressed by coil L18 at the input to ground, which improves the 50/60Hz suppression at some loss of sensitivity at Long Wave.

6.4. Optional applications:

Option 1. AM - SW 49m reception.

Compared to the given MW/LW application, the main difference is that after the rf-pre-stage the signal passes **a low-pass filter** which can be for LW/MW/SW-49m a 5th order filter, see Fig. 38 for a filter which passes short wave up to about 8MHz.

This filter gives additional 10.7MHz suppression (about 55dB by notch-filtering).

Moreover the VCO divider is set at 10, with the VCO in a range 164.3 to 169.95MHz to tune 5.73 to 6.295MHz. Tuning step 1kHz, using a synthesiser reference frequency of 10kHz.

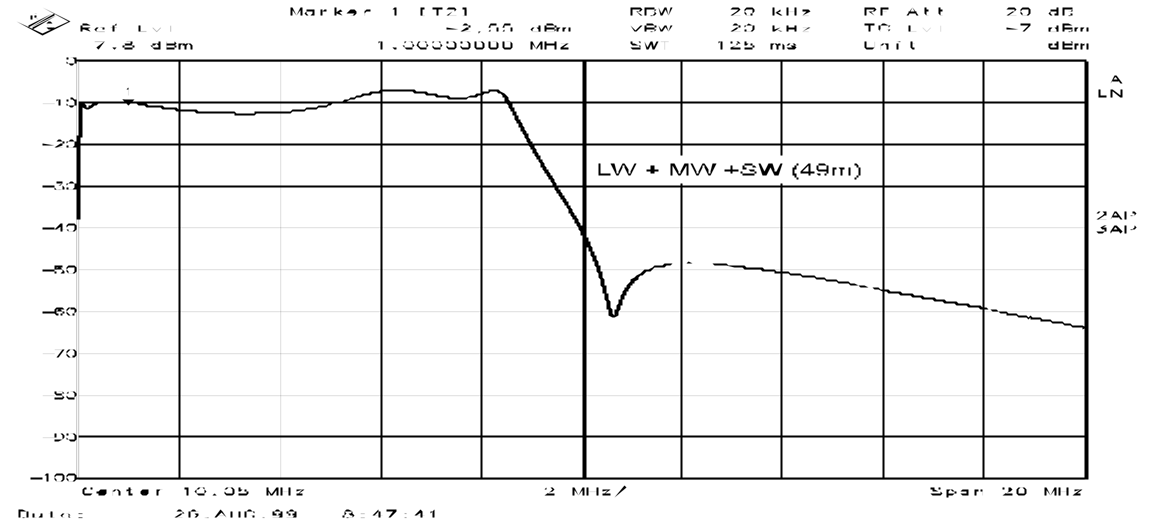


Fig.38. AM LW/MW/SW-49m 5th order Low-Pass Filter.

Fig. 39 shows the S/N and distortion at SW 49m.

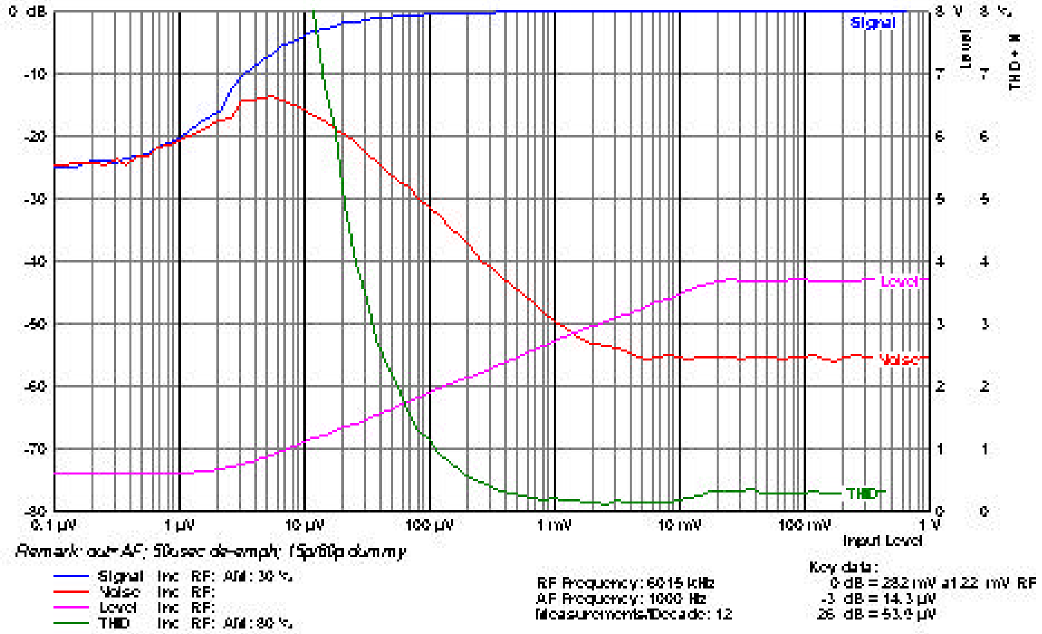


Fig. 39 AM SW - 49m Signal and noise behaviour

Option 2. System applications.

* **RDS:** After FM-demodulation, before entering the mute function, an MPX-RDS signal is available, to drive the RDS-demodulator (like SAA6579). A sensitivity of 13µV (using 75Ohm dummy) can be obtained; defined from 50% good blocks detection at RDS signal modulation with Δf=±2kHz.

* **Weather-Band (WX-mode):**

For FM Weather band applications at frequencies 162.4 to 162.55MHz,
the IC has to receive data byte 4 the bits 0,1,2 set to 011,
Then the Nice_Pacs concept provides:

1. Delivery, at pin 34, of a WX-flag for switching the rf-input from FM- to WX-band.
2. Setting of the divider N1 at N1=1 to use the VCO at (WX-IF1) = 173.1 to 173.25MHz;
3. Activation of a quadrature phase shift network to drive the quadrature mixer, to achieve 25dB of integrated image rejection.
4. Switching the audio-amplifier at WX to 15 times higher gain to obtain standard a.f.-output level at the small WX-deviation.
5. Switching of the integrated IF filter to minimum bandwidth, providing a selectivity of typ 23dB at ±25kHz and 10dB additional gain in front of integrated IF filter (see App.5).

More application information in Appendix 5.

*** Audio Signal Processors (CASP/ CDSP)**

The application of NICE with Audio signal processors CASP (TEA6880H) or CDSP (SAA7709) gives extra functional advantages;
e.g. with CASP (see Fig. 40):

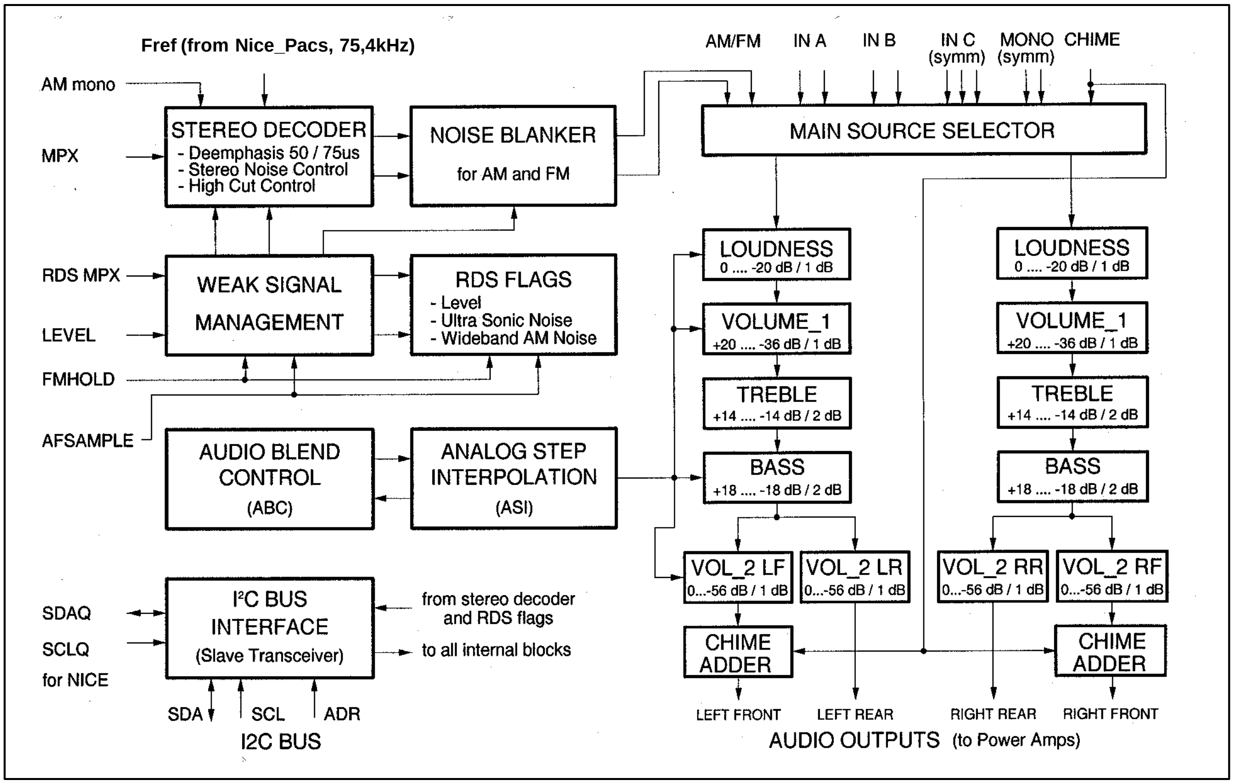


Fig. 40 CASP Functional Block-diagram

- For RDS updating NICE delivers AF-sample and AF-hold output, taking care that RDS update will be done with a mute according to timing and a behaviour which gives no audible interferences. To that end at a start of AF-update the AF-hold freezes the status of the audio weak-signal functions. When AF-sample arrives the audio signal processor starts detecting signal quality and at the end AF-hold gives free the audio weak signal controls and tells the processor that the outcome of the update check can be transferred by I^2C-Bus.

- For FM-stereo decoding NICE delivers a 75.368kHz reference signal, pre-setting the oscillator for sub-carrier regeneration. This reference signal has been used for all other timing too.
- After a pre-cancelling of AM noise-interferences in NICE, CASP in turn cancels the rest of spikes in the AM-audio signal. (In addition CASP delivers an AMHOLD pulse to operate the gate into an external AM-stereo processor.)
- The I^2C-Bus interface in CASP has an I^2C-Bus output for NICE. As it is preferred to have the NICE-Bus switched off if no NICE Bus commands are asked for (such to eliminate interference risks) this can be done with one Bus, both for CASP and NICE.
- For weak signal management NICE delivers AM/FM fieldstrength levels, well defined in start and slope points. Note that CASP has six signal quality detectors: noise/ fieldstrength/ multipath, and those both in average and peak detection.

Additional functions of interest in CASP are the Rear Seat Audio source-selector and a Chime Adder circuit to sum the chime signal with audio.

I^2C-BUS TEA6848H APPENDIX 1

Byte 0: Device address:

1	1	0	0	0	0	ADDR	R/Wn

ADDR=0: Device address=$C0 ADDR=1: Device address=$C2
R/Wn=0: Write mode R/Wn=1: Read mode

Byte 1:

AF	PCA6	PCA5	PCA4	PCA3	PCA2	PCA1	PCA0

AF=0: Normal operation AF=1: AF update mode
PCA6..PCA0: Upper byte PLL divider word

Byte2:

PCB7	PCB6	PCB5	PCB4	PCB3	PCB2	PCB1	PCB0

PCB7..PCB0: Lower byte PLL divider word

Byte 3:

MUTE	ANT6	ANT5	ANT4	ANT3	ANT2	ANT1	ANT0

MUTE=0: Normal operation MUTE=1: FM MPX output muted, Load progr. counter AM/FM
ANT6..ANT0: Setting of antenna DAA

Byte 4:

IFMT	REF2	REF1	REF0	IFPR	BND1	BND0	AMFM

IFMT=0: IF measuring time=20ms IFMT=1: IF measuring time=2ms
REF2..REF0: Reference frequency
IFPR=0: IF prescaler ratio=40 IFPR=1: IF prescaler ratio=10
BND1..BND0: Band switch
AMFM=0: FM AMFM=1: AM

REF2	REF1	REF0	Reference Frequency
0	0	0	100 kHz
1	0	0	50
0	1	0	25
1	1	0	20
0	0	1	10
1	0	1	10
0	1	1	10
1	1	1	10

BND1	BND0	AMFM	Frequency band	VCO Div
0	0	0	FM standard	2
0	0	1	AM SW mono	10
0	1	0	FM Japan	3
0	1	1	AM SW stereo	10
1	0	0	FM OIRT	3
1	0	1	AM MW/LW mono	20
1	1	0	FM Weather	1
1	1	1	AM MW/LW stereo	20

Byte 5:

KAGC	AGC1	AGC0	AMSM/ FMBW	LODX	FLAG	BW1	BW0

KAGC=0: FM keyed AGC=OFF KAGC=1: FM keyed AGC=ON
AGC1..AGC0: AM/FM wide band AGC
AMSM/FMBW=0: AM mode: AM soft mute =OFF FM mode: standard AMSM/FMBW=1: AM mode: AM soft mute =ON FM mode: FM align mode, BW=minimum
LODX=0: Local =OFF LODX=1: Local =ON
FLAG=0: Flag pin 21=HIGH FLAG=1: Flag pin 21=LOW
BW1..BW0: IF2 bandwidth setting

AGC1	AGC0	Start Wideband AGC	
		AM	FM
0	0	150 mV	16 mV
0	1	275	12
1	0	400	8
1	1	525	4

BW1	BW0	IF2	Bandwidth [kHz]
0	0	Dynamic	25..155
0	1	Wide	130
1	0	Medium	90
1	1	Narrow	61

Byte 6:

LST4	LST3	LST2	LST1	LST0	LSL2	LSL1	LSL0

LST4..LST0: Level starting point for level DAA LSL2..LSL0: Level slope setting for level DAA

1

Byte 7:

TE	CF6	CF5	CF4	CF3	CF2	CF1	CF0

TE=0: Threshold extension =OFF TE=1: Threshold extension =ON
CF6..CF0: Setting of IF2 centre frequency

Byte 8:

FOF3	FOF2	FOF1	FOF0	FGN3	FGN2	FGN1	FGN0

FOF3..FOF0: Setting of Frequency offset detector FGN3..FGN0: Setting of IF filter gain

APPENDIX 2: ALIGNMENTS

The Nice_Pacs tuner concept requires a number of (software) alignments for optimum performance to be done in the sequence as given below:

1. FM-IF2 Filter DAA alignment.

The FM-IF2 filter needs alignment for centre-frequency, gain alignment.

1.1 IF2 Centre Frequency alignment

Due to spread of the crystal frequency and spread in the integrated IF2_filter, the center frequency of the IF filter/demodulator has to be aligned. Spread on the crystal frequency however causes spread on both IF frequencies, 10.7MHz(IF1) and 450kHz(IF2), which is related to the tuned frequency.
It is recommended to align the centre frequency of the IF_ filter/demodulator in the middle of every tuning band to the exact value. When the standard FM band is aligned on 97.8MHz, the worst case frequency offset in this band is 560Hz, which adds to the alignment accuracy of 700Hz to a total centre frequency accuracy in standard FM band of ±1.3kHz.
The centre frequency alignment goes for maximum dc-output at the level detector (pin 70).

1.2 IF2 Gain alignment

Bandwidth variations of the IF filter are wished to suppress neighboring channels or for increasing sensitivity by threshold extension. Changing the bandwidth dynamic or fixed (by Bus) causes gain variations in the IF filter of the TEA6848H. These gain variations will influence the field strength RF level information and this can influence for example the level dependent weak signal handling parameters of the audio backend processor.
A 4 bits filter gain alignment reduces the change in IF filter gain from ±5dB to ±0.35dB when the bandwidth is changed in dynamic mode from maximum 155kHz to minimum 25kHz.
The procedure to align is as follows:
. *Set at FM the IF2 bandwidth to dynamic; byte 5: bits 0, 1 and 4 (FMBW) at 0.*
. *With an RF input signal of 200µV and byte 5: bit 4 = 0 the IF2 bandwidth is maximum (155kHz).*
. *While varying bits 0 to 3 in Byte 8, read and store the dc output levels at pin 70.*
. *Set the FMBW bit (byte 5: bit4) at 1 (= align-mode), so the bandwidth will be minimum (=25kHz).*
. *Again vary bits 0 to 3 in Byte 8, read and store the dc output levels at pin 70.*
. *The proper setting of the IF2 Filter Gain (FGN bits in byte 8) is the value where the difference between the two readings is at its minimum.*

2. Antenna DAA alignment at FM.

The DAA values take care of the tracking between front-end and oscillator by applying an offset between the tuning voltage to the front-end and the tuning voltage of the oscillator circuit. Usually only three alignments are necessary and sufficient for a good tracking performance: lower band limit, upper band limit and in the centre of the band.

In the user application the proper DAA value for any given tuning frequency may be interpolated from the aligned values. When also the weather-band is included in the final application one extra alignment is required.

The procedure to align the antenna DAA value is as follows:

Set a generator (no modulation) with an RF level of about 200 µV to the frequency to be aligned and tune NICE to this frequency. Next ramp the DAA word from 0 to 127 while measuring the DC-output of the level detector of NICE (pin 70) for each DAA value. The proper DAA value to be stored is the DAA word where the level has its maximum value. To speed-up this process an 'intelligent' algorithm can be used.

3. AM & FM level slope and level start.

The DC-output of the level detector (pin 70) is used to control the NICE_PACS tuner functions: FM Keyed AGC, FM threshold extension and AM noise canceller inside the tuner, where weak signal behaviour, search criteria etc. are controlled either by CASP (Car Analogue Signal Processor) or by CDSP (Car Digital Signal Processor). For (re) production purposes the starting point of the level detector output should be aligned as well as the slope of the level detector output. These level alignments (done on different frequency bands to compensate for gain variations over frequency) require three different steps:

FM:

- The level detector output is aligned to e.g. 950mV at an RF input level of 4.5µV.
- The level slope is aligned in such a way that the difference in level detector output between RF levels of 20 and 200µV is 800mV with the level start value found in the first alignment.
- The level detector output at 4.5µV RF level is re-aligned to 950 mV with level slope at the value found at the previous alignment.

(Note: 950mV at FM is switch-off level of keyed AGC as well as start of threshold extension).

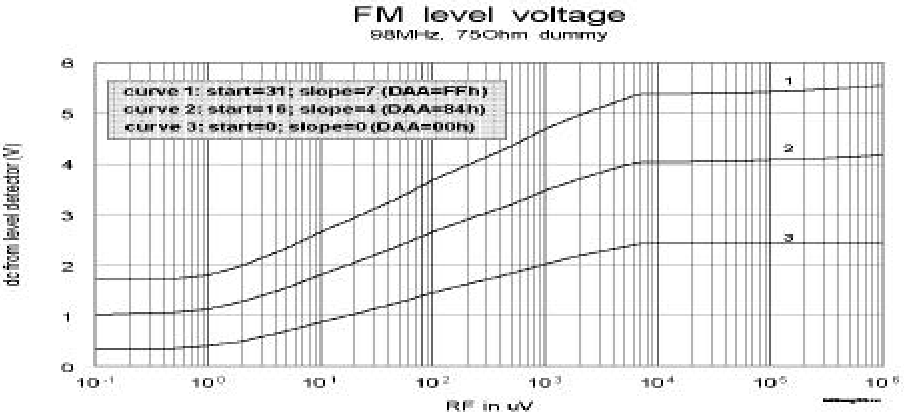


Fig. 41 FM Level Voltage

AM:

- The level detector output is aligned to 2 Volt (switch-off level of the noise blanker) at an RF input level of e.g.150µV.
- Dependent on backend (ASP) requirements, the level slope could be aligned, and then in such a way that the difference in level detector output between RF levels of 20 and 200µV is 800 mV with the level start value found in the first alignment.
- The level detector output at 150µV RF level is re-aligned to 2000mV with level slope at the value found at the previous alignment.

The procedure to align the start and slope values is as follows:

1

*Initially set level start to 11 and tune NICE to 97.5MHz (990kHz for AM). Set the frequency generator to 97.5MHz (990kHz for AM) without modulation. In the first alignment the level start is ramped down until the proper level detector output has been found (950mV at 4.5µV RF level at FM or 2000mV at 150µV RF level for AM). In the second alignment the level slope is ramped down until the difference in signal level output between 20 and 200µV RF level is 800mV (both for FM and AM *)). Finally the level start value is re-aligned to 950mV at 4.5µV RF level or 2000mV at 150µV RF level for AM.*

*) Note: Normally the AM slope alignment is of no importance for the performance of the NICE system, so this alignment could be skipped and the slope may be set to e.g. 0 in the final application. Only in case AM soft-mute feature in the CDSP is used the AM slope alignment has to be done.

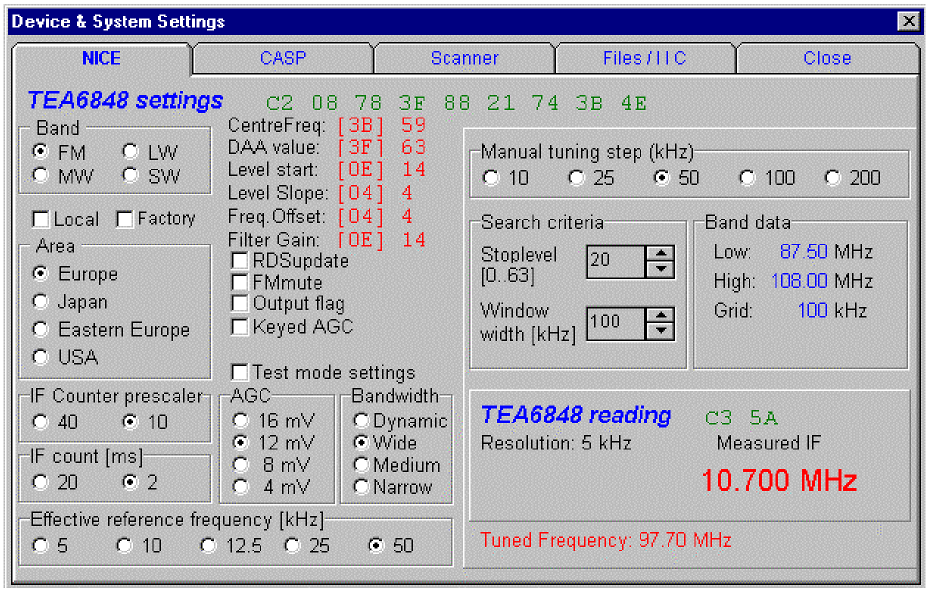
4. Frequency offset detector alignment.

When tuned to a (very) weak desired signal with a strong undesired neighboring signal at 100kHz with relatively high deviation, the bandwidth could switch continuously from maximum to minimum and vice versa (with resulting audible effects). To avoid this a frequency offset detector is implemented in the TEA6848H to reduce the bandwidth of the IF filter when the detected frequency offset in the demodulator is too large. This avoids the so-called pop effect what otherwise could be present under certain input signal conditions.
Due to spread the frequency-offset detector itself must be aligned with 4 bits. This will reduce the frequency offset due to spread and temperature to a low value. The ± 1.5kHz on resulting accuracy with ± 5kHz on temperature dependency (so max. ± 7kHz) results in a good performance. It is recommended to align the frequency offset detector in the middle of each frequency band covered by the application.

The procedure to align:
. The FM bandwidth in align-mode by FMBW, byte 5_bit 4=1,such to have minimum IF2 bandwidth (25 kHz). The frequency offset detector output will then be routed to pin 62.
. Vary bits 4 to 7 in Byte 8 (FOF-bits) until a minimum voltage is found at pin 62.

Note: We only put a separate alignment-data EEPROM on the tuner PCB so we can test and align the tuner independently of the car radio (or CASP/CDSP demo boards). If that is not required it is very well possible to use only one EEPROM. Because the NICE tuner needs about ten bytes MAX for alignment data, it is nearly always possible to find that memory space in the main EEPROM.

Fig. 42 is an example of aligned settings in an FM-Europe application.



TEA6848 settings C2 08 78 3F 88 21 74 3B 4E

Band
● FM ○ LW
○ MW ○ SW

☐ Local ☐ Factory

Area
● Europe
○ Japan
○ Eastern Europe
○ USA

IF Counter prescaler
○ 40 ● 10

IF count [ms]
○ 20 ● 2

CentreFreq: [3B] 59
DAA value: [3F] 63
Level start: [0E] 14
Level Slope: [04] 4
Freq.Offset: [04] 4
Filter Gain: [0E] 14
☐ RDSupdate
☐ FMmute
☐ Output flag
☐ Keyed AGC

☐ Test mode settings

AGC
○ 16 mV
● 12 mV
○ 8 mV
○ 4 mV

Bandwidth
○ Dynamic
● Wide
○ Medium
○ Narrow

Effective reference frequency [kHz]
○ 5 ○ 10 ○ 12.5 ○ 25 ● 50

Manual tuning step (kHz)
○ 10 ○ 25 ● 50 ○ 100 ○ 200

Search criteria
Stoplevel [0..63] 20
Window width [kHz] 100

Band data
Low: 87.50 MHz
High: 108.00 MHz
Grid: 100 kHz

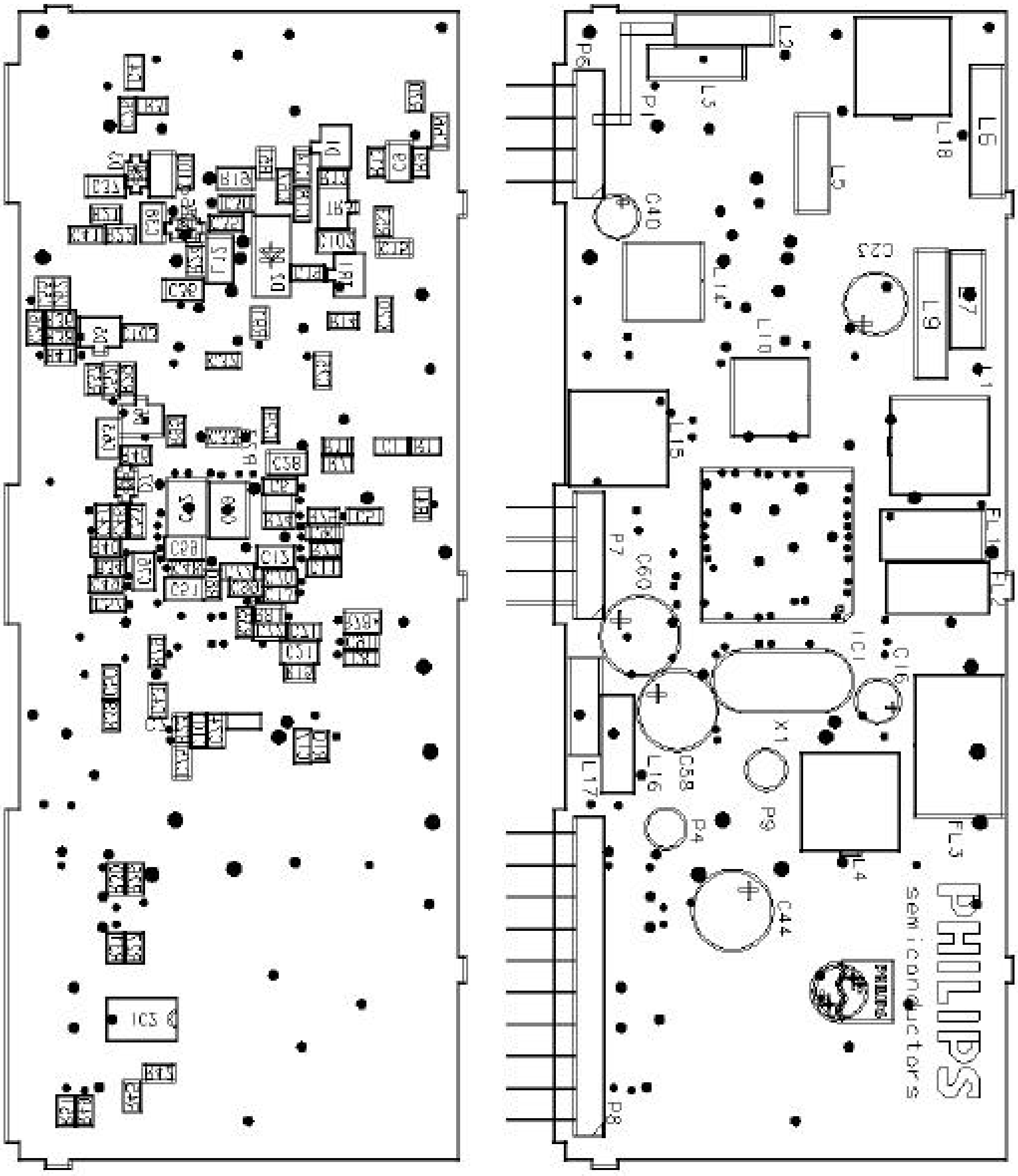
TEA6848 reading C3 5A
Resolution: 5 kHz
Measured IF
10.700 MHz

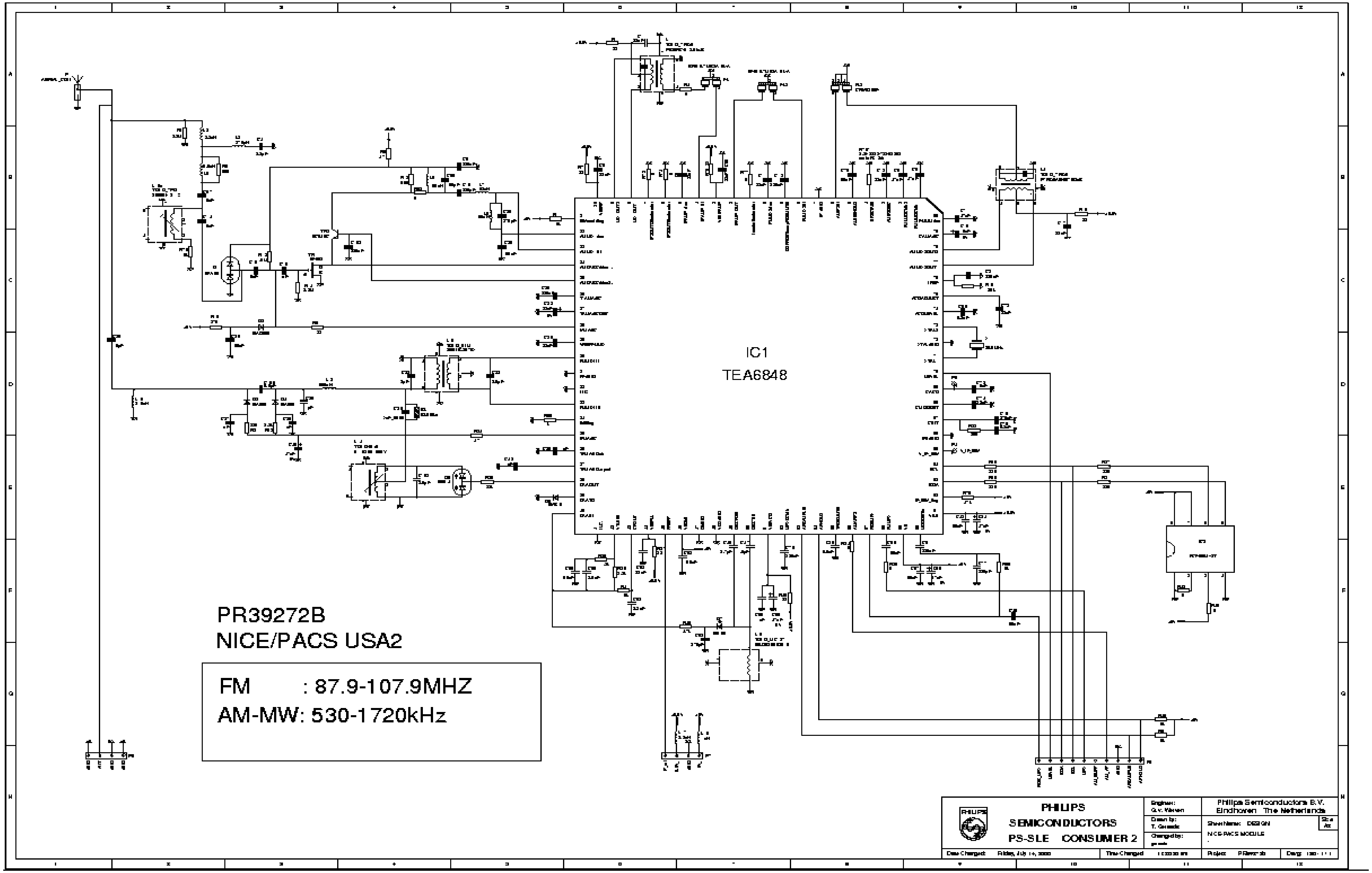
Tuned Frequency: 97.70 MHz

Fig. 42 Settings in an FM-Europe application

MODULE APPENDIX 3.

a. Module PCB **Fig. 43**


IC3
P6
L2
L3
P1
L6
L18
L5
C40
C23
L14
L10
L9
P7
L15
FL1
FL2
C60
IC1
C16
X1
C58
L16
L17
P9
P4
FL3
L4
C44
PHILIPS
semiconductors
P8


IC1
TEA6848
PR39272B
NICE/PACS USA2
FM : 87.9-107.9MHZ
AM-MW: 530-1720kHz
PHILIPS
SEMICONDUCTORS
PS-SLE CONSUMER 2
Engineer:
G.v. Wersen
Drawn by:
T. Gerards
Changed by:
Philips Semiconductors B.V.
Eindhoven The Netherlands
Sheet Name: DESIGN
NICE-PACS MODULE
Size
A3
Date Changed: Friday, July 14, 2000
Time Changed
Project:
Design

b. Module application diagram **Fig. 44**

1

c. COMPONENTS

From the NICE-Module with TEA6848H, acc. to the given application, the components are:

ITEM	CNT	PART_NO	COMPONENT	SERIES	TOLERANCE	RATING	VENDOR	GEOMETRY	REFERENCE
1	1	8222-411-39272b	BOARD PR39272b				PS-SLE	BOARD	
2	1	2322-732-63302	3.3K	RC12G	1%	0.1W	PHILIPS	R0805	R78*
3	1	CAP-CER-590-nF	XnF_0805	C0805-X7R	10%	63V	PHILIPS	C0805	C36'
4	3	2222-950-16654	220nF	X7R	10%	16V	PHILIPS	C0805	'C102' 'C28' 'C9'
5	4	2222-910-19854	220nF	Y5V	-400	25V	PHILIPS	C0805	'C12' 'C21' 'C51' 'C76'
6	1	2322-730-61271	270	RC11	5%	0.1W	PHILIPS	R0805	'R19'
7	1	PN-BAQ806	BAQ806	Pin diode			PHILIPS	SOD106	'D2'
8	1	LQN1HR50K04	500nH	LQH			muRata	LQH1N	'L12'
9	3	2222-861-12102	1nF	NP0	5%	50V	PHILIPS	C0805	'C37' 'C38' 'C59'
10	1	2222-861-12271	270pF	NP0	5%	50V	PHILIPS	C0805	'C63'
11	1	LAL03NA101K	100uH	LAL03NA	10%	TAIYO_YUDEN		uChoke_3e	'L9'
12	1	LAL03NA151K	150uH	LAL03NA	10%	TAIYO_YUDEN		uChoke_3e	'L6'
13	1	LQN1HR21K04	215nH	LQH			muRata	LQH1N	'L16a'
14	1	LAL02NA1ROK	1uH	LAL02NA	10%	TAIYO_YUDEN		uChoke_2e	'L16'
15	2	2222-872-16663	1uF	X7R	10%	25V	PHILIPS	C1210	'C39' 'C42'
16	1	2322-702-60102	1k	RC21	5%	0.063W	PHILIPS	R0603	'R95'
17	6	2322-702-60103	10k	RC21	5%	0.063W	PHILIPS	R0603	'R11' 'R41' 'R49' 'R51' 'R80' 'R70'
18	1	2322-702-60122	1.2k	RC21	5%	0.063W	PHILIPS	R0603	'R36'
19	1	2322-702-60124	120k	RC21	5%	0.063W	PHILIPS	R0603	'R15'
20	1	2322-702-60185	1.8M	RC21	5%	0.063W	PHILIPS	R0603	'R12'
21	2	2322-702-60222	2.2k	RC21	5%	0.063W	PHILIPS	R0603	'R22' 'R38'
22	1	2322-702-60223	22k	RC21	5%	0.063W	PHILIPS	R0603	'R29'
23	2	2322-702-60225	2.2M	RC21	5%	0.063W	PHILIPS	R0603	'R14' 'R3'
24	1	2322-702-60479	47	RC21	5%	0.063W	PHILIPS	R0603	'R24'
25	8	2322-702-60229	22	RC21	5%	0.063W	PHILIPS	R0603	'R1' 'R10' 'R37' 'R40' 'R7' 'R75' 'R91'
26	5	2322-702-60331	330	RC21	5%	0.063W	PHILIPS	R0603	'R21' 'R26' 'R27' 'R30' 'R31'
27	1	2322-702-60391	390	RC21	5%	0.063W	PHILIPS	R0603	'R23'
28	1	2322-702-60472	4.7k	RC21	5%	0.063W	PHILIPS	R0603	'R46'
29	1	2322-702-60479	47	RC21	5%	0.063W	PHILIPS	R0603	'R9'
30	2	2322-702-60561	560	RC21	5%	0.063W	PHILIPS	R0603	'R13' 'R5'
31	1	2322-702-60563	47k	RC21	5%	0.063W	PHILIPS	R0603	'R79'
32	9	2322-702-96001	0	RC21	5%	0.063W	PHILIPS	R0603	'R34' 'R39' 'R4' 'R42' 'R45' 'R53' 'R73' 'R74' 'R77'
33	1	388BN-1211Z	388BN-1211Z	7PS			TOKO	7PD_1	'L18'
34	1	LN-G102-587	20.5MHz	Crystal			NDK		'X1'
35	1	9332-153-70212	BAV99	Gen. purpose			PHILIPS	SOT23	'D1'
36	2	LAL02NA3R3K	3.3uH	LAL02NA	10%	TAIYO_YUDEN		uChoke_2e	'L17' 'L2'
37	2	2222-134-35109	10uF	RLP5 134	20%	16V	PHILIPS	CASE_R52_TFA	'C16'
38	1	2222-134-55229	22uF	RLP5 134	20%	16V	PHILIPS	CASE_R54_CA	'C23'

39	4	2222-134-55479	47uF	RLP5 134	20%	16V	PHILIPS	CASE_R55_CA	'C44' 'C58' 'C60' ‘C40’
40	1	9340-555-19215	BF862	Fet			PHILIPS	SOT23	'TR1'
41	1	P826RC-5134N-S		7PSG			TOKO	7PS_p2	'L1'
42	1	PN-PCF8594--2T		IC Universal			PHILIPS	SOT96	'IC2'
43	1	PN-BB156	BB156	Tuner Diode			PHILIPS	SOD323	'D7'
44	2	2222-596-16606	270pF	X7R	10%	50V	PHILIPS	C0603	'C101' 'C20'
45	2	2222-596-16607	330pF	X7R	10%	50V	PHILIPS	C0603	'C15' ‘C77’
46	1	2222-596-16614	1nF	X7R	10%	50V	PHILIPS	C0603	'C19'
47	1	2222-596-16621	3.3nF	X7R	10%	50V	PHILIPS	C0603	'C62'
48	1	2222-596-16622	3.9nF	X7R	10%	50V	PHILIPS	C0603	'C56'
49	1	2222-596-16625	6.8nF	X7R	10%	50V	PHILIPS	C0603	'C48'
50	2	2222-596-16626	8.2nF	X7R	10%	50V	PHILIPS	C0603	'C75' 'C99'
51	3	2222-916-16736	10nF	X7R	20%	25V	PHILIPS	C0603	'C14' 'C18' 'C67'
52	1	2222-916-16738	18nF	X7R	20%	25V	PHILIPS	C0603	'C73'
53	6	2222-916-16741	22nF	X7R	20%	25V	PHILIPS	C0603	'C11' 'C13' 'C5' 'C72' 'C74' 'C90'
54	3	2222-786-16745	47nF	X7R	20%	16V	PHILIPS	C0603	'C71' 'C8' 'C91'
55	9	2222-786-16749	100nF	X7R	20%	16V	PHILIPS	C0603	'C25' 'C30' 'C43' 'C49' 'C50' 'C53' 'C55' 'C57' 'C70'
56	5	2222-586-19807	22nF	Y5V	-400	50V	PHILIPS	C0603	'C1' 'C17' 'C29' 'C52' 'C6'
57	1	9334-606-20212	BAS16	Gen. Purpose			PHILIPS	SOT23	'D6'
58	1	9335-896-40215	BC848C	Gen. Purpose			PHILIPS	SOT23	'TR3'
59	1	LAL02NA6R8K	6.8uH	LAL02NA	10%	TAIYO_YUDEN		uChoke_2e	'L5'
60	1	2222-867-12108	1pF	NP0	0.25pF	50V	PHILIPS	C0603	'C35'
61	1	2222-867-12129	12pF	NP0	5%	50V	PHILIPS	C0603	'C32'
62	1	2222-867-12151	150pF	NP0	5%	50V	PHILIPS	C0603	'C66'
63	1	2222-867-12188	1.8pF	NP0	0.25pF	50V	PHILIPS	C0603	'C47'
64	1	2222-867-12189	18pF	NP0	5%	50V	PHILIPS	C0603	'C26'
65	1	2222-867-12278	2.7pF	NP0	0.25pF	50V	PHILIPS	C0603	'C46'
66	1	2222-867-12338	3.3pF	NP0	0.25pF	50V	PHILIPS	C0603	'C4'
67	2	2222-867-12398	3.9pF	NP0	0.25pF	50V	PHILIPS	C0603	'C103' 'C33'
68	1	2222-867-12688	6.8pF	NP0	0.5pF	50V	PHILIPS	C0603	'C100'
69	1	LAL02NA820K	82uH	LAL02NA	10%	TAIYO_YUDEN		uChoke_2e	'L7'
70	1	PN-TEA6848	TEA6848	IC Universal			PHILIPS	SOT315	'IC1'
71	2	Q62702-A952	BA595	Pin diode		**SEE REMARK below**	SIEMENS	SOD323	'D3' 'D4'
72	1	Q62702-B372	BB814	Tuner Diode			SIEMENS	SOT23	'D5'
73	1	CFWS450F		IF-Filter			muRata	SFR450H	'FL3'
74	1	396INS.3076X		5KM			TOKO	TOKO_5km	'L10'
75	2	SFE10.7MS3	SFE10.7MS3A10k-A	IF-Filter			muRata	SFE_3p	'FL1' 'FL2'
76	1	611SNS-1066Y		5KM			TOKO	TOKO_5KM_m2	'L14'
77	1	P7PSGAE-5078D=S		7KM			TOKO	TOKO_7km_m2_m5	'L4'
78	1	LAL02NAR27K	270nH	LAL02NA	10%	TAIYO_YUDEN		uChoke_2e	'L3'
79	1	E543SNS-02010		MC137			TOKO	MC137	'L15'

REMARK: Alternative FM pin diode: KP2311E from TOKO.

TEA6848H Module Specification

APPENDIX 4

In a Car Radio application (see Fig. 44) TEA 6848H performs typical as given in next specification.

AM-MW reception:

At F_a = 530 to 1710 kHz,
and at F_{if1} = 10.7 MHz,
F_{osc1} = 11.23 to 12.41 MHz, obtained via divider N2 =:20 , so
F_{vco} = 224.6 to 248.2 MHz.
With F_{if2} = 450 kHz,
F_{osc2} = 10.25 MHz, obtained via a divider N =:2
from
X-tal osc = 20.5 MHz.

FM reception (USA/W-Europe application):

At F_a = 87.5 to 108 MHz,
and at F_{if1} = 10.7 MHz,
F_{osc1} = 98.2 to 118.7 MHz, obtained via divider N=:2, so
F_{vco} = 196.4 to 237.4 MHz,
With F_{if2} = 450 kHz,
F_{osc2} = 10.25 MHz, obtained via a divider N=:2
from
X-tal osc = 20.5 MHz.

RATINGS

Parameter	**min unit**	**typ**	**max**
Supply Voltage: Operation	8	**9**	**Volt**
Temperature : Operating	-40	+85	°C

AM-SIGNAL-CHANNEL.

Test with dummy aerial **15/60pF** from 50 Ohm source

Conditions (a.o. for standard output), unless otherwise specified :

V_a= 10mV, F= 1MHz, f_{mod} = 400Hz, m = 0.3;

Vsupply = 8.5 Volt/ Tamb = 25°C

AM Performance:		**Typ.**	**Unit**
1. Sensitivity			
Signal to Noise at V_a = **6**μV	:	10	dB

Signal to Noise at V_a = **45**µV	:	26	dB
		Typ.	Unit
2. AM-Signal to noise ratio			
Signal to Noise at V_a = 10mV	:	**58**	dB
3. A.F. output at m=30%	:	**290**	mV
4. Figure of Merit at soft mute on			
V_{a2} for ΔVout_a.f. at = -10dB with respect to V_{a1} =5mV: V_{a1}/V_{a2}	:	61	dB
5. Distortion (THD) at m= 0.8	:	0.3	%

Further AM-performance:		**Typ.**	**Unit**
6. Selectivity S_9	:	**75**	dB
7. Dynamic Selectivity ($DS_{\pm 20}$)	:	73	dB
V_{ref}= V_{out} at standard mod. of V_{a1}.			
When V_{a1} has m=0 and			
F_{a2}= F_{a1}+20kHz resp -20kHz; m=30% 1kHz,			
V_{a2}/V_{a1} at V_{out}=V_{ref}-10dB			
8. IF-rejection (at 600kHz); F_a= IF1	:	**>75**	dB
F_a= IF2	:	**>80**	dB
9. Image rejection(at 1600kHz) F_a+ 2*IF1	:	**75**	dB
F_a + 2*IF2	:	**70**	dB
F_a + 2*(IF1-IF2)	:	**>100**	dB
10. Second Harmonic Rejection	:	49	dB
Tuned at 1340 kHz for V_{out1} at m= 30%;			
V_{a2} (m= 30%) for V_{out2}=V_{out1} at F_{a2}= 670kHz.			
11. Large signal handling			
at THD= 10% where m= 80%.	:	>140	dBµV
12. Intermodulation IP3 for in-band interference	:	130	dBµV
(interfering transmitters at ± 100kHz offset)			
13. Desensitization at V_a=1Volt	:	19	dB
for F_{a2}= F_{a1}-40kHz at F_{a1}= 1310kHz			
14. FM to AM switching time	:	1	sec

FM-SIGNAL-CHANNEL

Test with 50 Ohm (gen.) + dummy aerial = **75 Ohm** source.

Test conditions, unless otherwise specified :

V_i = 1mV_{rms}, F_a = 98MHz,

mono with f_{mod} = 400Hz, Δf= ±22.5 kHz. De-emphasis 50 µsec.

Vsupply = 8.5 Volt/ $T_{amb.}$= 25°C

FM PERFORMANCE

		Typ.	Unit
1. Sensitivity			
at Δf = ± 22.5kHz			
- Signal to Noise ratio at V_a = **1.4**µV	:	26	dB
2. Signal to noise ratio			
- S/N at V_a = 1mV	:	63	dB
3. A.F. output at Δf= ±22.5kHz	:	**230**	mV
4. Distortion (THD) at Δf = ±75kHz	:	**0.3**	%
5. AM signal suppression (m= 0.3)	:	**>50**	dB

Further FM-Performance:

			Typ.	**Unit**
6. -3dB limiting at V_i		:	**1**	µV
7. Dynamic Selectivity DS±100		:	**35**	dB
Dynamic Selectivity DS±200		:	**72**	dB
8. IF2 accuracy (incl. temperature influence)		**:**	**< 6**	kHz
9. IF-rejection (at 87.9MHz),	IF1	:	**> 90**	dB
	IF2	**:**	**>100**	**dB**
10. Image rejection (at 107.9MHz)	F_a+ 2*IF1	:	70	dB
	F_a + 2*IF2	:	**>100**	dB
	F_a + 2*(IF1-IF2)	:	**>100**	dB
11. Fieldstrength dc-level info range		:	**>80**	dB
12. Adjacent Channel Selectivity (static) SS±200				
	at Bandwidth 60 kHz	**:**	**82**	**dB**
	Bandwidth 90 kHz	**:**	**71**	**dB**
	Bandwidth 130 kHz	**:**	**62**	**dB**
Standard signal at V_{a1}= 100uV as reference,				
then unmodulated and F_{a2} at + resp. -200kHz,				
causing a S/N= 30dB at a ratio V_{a2} to V_{a1}		:		
13. Intermodulation IP3		:	**117**	dBµV
14. Desensitization on limiting sensitivity				
by F_{a2}= F_{a1}+1.5MHz		:	34	dB
15. PLL In-lock time 108 to 88MHz		:	0.8	ms

Weather-band Receiver APPENDIX 5

The weather-band as currently in operation in the USA consists of a nation-wide network of radio stations broadcasting continuous weather information direct from various (local) stations throughout the US for general public use. The network is provided as a public service by the National Oceanic & Atmospheric Administration (NOAA), and as such it is controlled by the federal government. When necessary, warnings, watches and other hazard information can be broadcast for the region involved in addition to weather forecasts. Broadcasts are found at seven (narrow-band FM modulated) voice channel frequencies ranging from 162.400 MHz to 162.550 MHz.

A weather-band receiver with Nice_Pacs, using the integrated narrow-band IF2 filter provides a cost-effective quality solution. The sensitivity achieved with Nice_Pacs module including the IF2 filter set at **13** kHz is **2.0** µV for 20dB S/N ratio (@ Δf= 1.5kHz and 110µsec de-emphasis).

Weather-band

Frequency		162.4 to 162.55 MHz
Modulation		Narrow Band FM (NBFM)
Deviation		Δf nominal = ±1.5kHz (Δf maximum = ±5kHz)
De-emphasis	Approx.	110 µsec (2nd order filter)

Weather-band reception with the TEA6848H

The Nice_Pacs IC TEA6848H has several on-board provisions for the reception of the weather-band. The Nice_Pacs IC utilises the signal path used for the standard broadcast FM band also in weather-band mode. This means the IF1 is at 10.7MHz, the local oscillator operates at 173.1 to 173.25 MHz.

When programmed through the I2C Bus for weather band reception:

1. A weather-band flag is set (pin 34), indicating to switch the front-end filter to the weather-band frequency. A current switch at pin 34 is used to switch a coil in parallel with the LC resonant circuit to move the tank resonant frequency to about 162MHz.
2. The internal local oscillator divider is switched off (division ratio one).
3. A quadrature phase shift network is activated to drive the quadrature mixer with image cancelling.
4. The IF2 bandwidth is switched to its minimum (13kHz) with 10dB additional IF2 amplifier gain *).
5. The MPX amplifier/buffer following the FM demodulator is switched to a 15x higher gain, otherwise the demodulated FM signal level when receiving the weatherband should be smaller than the demodulated wideband FM signals, due to the frequency deviation of the narrow band FM signals in weatherband. So the A.F.-output in Wx mode is 230mV at ±**1.5 kHz modulation**.

*) IF-filter switching: The allocation of the frequencies for the (neighbouring) transmitter stations is such that adjacent channel interference is hardly anywhere present in the USA. This means a larger bandwidth for the IF filter is tolerable. It is indeed of more importance, judging from the frequency allocation scheme, that the rejection at the next adjacent channel (at twice the channel spacing: 50kHz) is sufficient.

A 2nd order filter with a low pass response (-3dB point) at about 1400Hz can serve de-emphasis and limit the audio bandwidth, thereby increasing the S/N ratio and enhancing the audibility of the speech information.

Performance:

The following characteristics are measured with a 75Ω dummy antenna;
f_{af} = 1 kHz; Δf =± 1.5kHz; AF double pole filtering with –3dB at ~1400Hz.
Wide band FM AGC threshold is set to 4mV.

Sensitivity for 20dB S/N	2.0µV
Image rejection ratio	43.5 dB
Distortion at Δf = ±5kHz	< 0.5 % for V_a >10µV
Static selectivity : ± 25kHz	23 dB typ
AM suppression	> 25 dB
IF rejection	86 dB