APPLICATION NOTE

DVB-IF-Downconverter for Set Top Boxes with AGC and VIF/SIF-demodulator: TDA9819

AN97047

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Semiconductors

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Abstract

The TDA9819 is an integrated circuit for DVB-IF processing which includes the full functionality for vision and sound-IF signal processing with a single reference PLL-demodulator based on the TDA9815 family.

In combination with a QAM demodulator IC like the TDA8046 or TDA8047 and an A/D converter IC a complete demodulation system for QAM modulated cable DVB signals can be implemented in a simple way . The DVB signal handling like gain controlled IF-Amp, Mixing,VCO, internal and external AGC and output level adjust can be done with the TDA9819 so the customer can use this combination of ICs without very deep knowledge of the QAM related parameters.

Also downconversion for the future digital terrestrial VSB modulated TV signals in the USA can be done with the TDA9819 in combination with a high performance QSS concept for the actual analog standard M. Together with a BTSC stereodecoder like the TDA9851 for the US market full stereo decoding can be done.

APPLICATION NOTE

DVB-IF-Downconverter for Set Top Boxes with AGC and VIF/SIF-demodulator: TDA9819

AN97047

Author(s):

Ulrich Rittner
Systems Laboratory Hamburg,
Germany

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Set Top Box

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Summary

This report deals with the application of the TDA9819 as a DVB-IF signal handling device.The intention is to give application hints for using this device in DVB applications especially for QAM-demodulator ICs like the TDA8045/ TDA8046 or TDA8047 for demodulating the QAM modulated cable signals, Also the multistandard Vision/Sound IF demodulation capabilities of this IC are described in this application note. This standard TV mode corresponds to the TDA9815 based IC-family.

Chapter 1 gives a general overview over the features and the history of the TDA9819. A functional block description is given in chapter 2. Chapter 3 includes two block diagrams for applications with the TDA9819.

In chapter 4 the application board is described in detail, chapter 5 gives application hints mainly related to the PINs of the TDA9819 and in chapter 6 frequently asked questions(FAQs) are summarized.

The appendix includes literature to get more information about the TDA9819 or other used components described in this application note.

CONTENTS

1. Introduction

The TDA9819 is an integrated circuit for DVB-IF[1] processing in Set Top Boxes and multistandard vision IF signal processing with single reference FPLL[2] demodulator. The DVB Downconverter- part of the IC brings the QAM-modulated first IF of 36.15 MHz in TV cable systems down to 6.9MHz(for Europe) and includes also an IF processing like internal and external AGC stages. Also included in this IC is a complete Video and QSS-Sound-IF demodulation and processing for conventional analog TV channels. The TDA9819 has a 32 Pin shrink DIL package.

Since 1997 also a DVB-only version of the TDA9819, the TDA9829 is available which is based on the same chip as the TDA9819. It is a bond out of the TDA9819 in a 20 PIN SO package and so it has the same electrical characteristics like the TDA9819 and will be decribed together with the TDA9819 in this application report. Because of his low price the TDA9829 is also applicable for (down)converters for DVB cable modems like for the down or upstream in Out of Band (OOB) applications. Further applications may be all downconversion applications in front of an A/D converter where his inherent AGC capabilities can be used to prevent the overloading of the A/D converter. This report concentrates on the TV Set Top Box applications for QAM modulated TV cable signals.

A data sheet of the TDA9819 and also of other Philips Vision and Sound IF ICs can be downloaded from the internet under the URL: http://www.semiconductors.philips.com/designerindex. You will be asked for the type number of your search. Please type TDA9819 and you will be offered a .pdf type file for download. To see the pdf type file you need to have available the Acrobat type reader. A systematic search structured by application areas of most of the Philips ICs can be done under the URL : http://www.semiconductors.philips.com.

In chapter 1 some general information for the History of the TDA9819 and his background as a son of the big VIF/SIF family of the TDA98XX types is given. Basis informations for the QAM modulated DVB cable system and for the analog TV part of the IC is also described in this chapter including a list of VIF/SIF standards . A short description of the Intercarrier and Qausi Split Sound(QSS) concept for VIF and SIF demodulation should serve for better understanding of the advantages and drwbacks of these concepts.

Chapter 2 describes the internal blocks of the TDA9819 in detail. The blocks are separated in common blocks for both analog TV and DVB - IF processing modes, blocks just for analog TV mode and blocks just used in DVB mode.

Typical blockdiagrams for European and US applications are described in chapter 3. The demo board of the TDA9819 which includes a typical analog TV mode application together with the DVB mode option and the possibility of a UV919M or UV936 tuner is explained in chapter 4. Also for the TDA9829 there is a different small demoboard available for the US or the European market.

Chapter 5 gives some practical aspects and hints for the application of the TDA9819. In chapter 6 some frequently asked questions are listed. The conclusion in chapter 7 summarizes the report very briefly to serve as an abstract for the reader who would like to have a quick information and gives an outlook to future product policy and possible application areas.

1. DVB-IF = Digital Video Broadcast - Intermediate frequency, in Europe 36.15MHz, in the US 43.75 MHz
2. FPLL = Frequency phase locked loop

1.1 General

The main features of the TDA9819 are listed below according to the data sheet:

- 5 V positive supply voltage
- Two switched VIF inputs, gain controlled wide band VIF-amplifier (AC-coupled)
- True synchronous demodulation with active carrier regeneration (very linear demodulation, good intermodulation figures, reduced harmonics, excellent pulse response)
- VCO frequency is able to switch between BG/L IF-picture carrier and Digital Video Broadcast (DVB) frequency
- Separate video amplifier for sound trap buffering with high video bandwidth
- VIF AGC detector for gain control, operating as peak sync detector for B/G and peak white detector for L; controlled reaction time for L
- Tuner AGC with adjustable Take Over Point (TOP)
- AFC detector without extra reference circuit
- SIF input for single reference QSS mode (PLL controlled); SIF AGC detector for gain controlled SIF amplifier; single reference QSS mixer able to operate in high performance single reference QSS mode
- AM demodulator without extra reference circuit
- Stabilizer circuit for ripple rejection and to achieve constant output signals.

DVB functions :

- Mixer for DVB-IF
- Internal and external AGC for DVB
- External VCO control for DVB
- High level DVB operational output amplifier
- DVB output level adjust via AGC adjust.

1.2 History of the TDA9819

The TDA9819 is a child of the TDA9815 multistandard Vision and Sound - IF IC which is on the market since several years. It adds an DVB AGC block and an DVB output buffer and excludes the second path for the stereo demodulation for standards like B/G where two sound carriers are transmitted. But even without this second soundcarrier demodulation part the TDA9819 is able to do the complete stereo demodulation in the USA where just one sound carrier(standard M) is used to transmit the stereo information by the BTSC system. For the stereo decoding for example a TDA9851 can be used.

To give an overview of the family members of the TDA981X family Figure 1 shows a table with the actual ICs from Philips in this area. The TDA9817/TDA9818 are similar to the TDA9808 which might be better known in the USA.

QSS - VIF/SIF - PLL FAMILY

for high performance TV stereo sound applications

Released products

Features	TDA9819	TDA9815	TDA9814T	TDA9813T	TDA9808/T	TDA9810/T	TDA9818	TDA9817
TV standards	ALL+DVB	ALL	ALL	negative mod.	negative mod.	ALL	ALL	negative mod.
IF inputs	1xVIF; 1xDVB 1 x SIF	2 x VIF 1 x SIF	1 x VIF 1 x SIF	1 x VIF 1 x SIF	1 x VIF 1 x SIF	1 x VIF 1 x SIF	1 x VIF 1 x SIF	1 x VIF 1 x SIF
CVBS output	1,0 /2,0 Vpp 2,0 Vpp QAM	1,0 Vpp 2,0 Vpp	1,0 Vpp 2,0 Vpp	1,0 Vpp 2,0 Vpp	1,35 Vpp	1,0 Vpp 2,0 Vpp	1,1 Vpp	1,1 Vpp
Intercarr. output	100mV B/G	100mV B/G	100mV B/G	100mV B/G	100mV B/G	140mV B/G 140mV L/L'	140mV B/G 140mV L/L'	140mV B/G
FM demodulator AM demodulator	1 x 460 mV 1 x 500 mV	2 x 500mV 1 x 500mV	2 x 500mV 1 x 500mV	2 x 500mV - - -	1 x 500mV - - -	- - - 1 x 500mV	1 x 500mV 1 x 500mV	1 x 500mV - - -
Supply voltage	5 V	5 V	5 V	5 V	5 V	5 V	5 V	5 V
Package	SDIP32	SDIP32	SO28	SO28	DIP20/SO20	SDIP24/SO24	SDIP24	SDIP24
Remarks:	FM: 25kHz		pincompatible devices				pincompatible devices	

Fig. 1.2-1 QSS - VIF/SIF - PLL - Family

1.3 Basic informations of the QAM modulated DVB cable system with the TDA9819

There is a huge number of literature available for the QAM modulation principles in communication systems for example basic literature[Lath, Cool,Franz] and also specific for the DVB system[Reimers1,ETS429]. A lot of actual informations about the DVB system can be found in the papers of Prof. Dr. Reimers who is a professor at the technical university of Braunschweig(Germany) and is also the leader of the Technical Module of the DVB platform. His institute offers courses on DVB(web site: www.ifn.ing.tu-bs.de) and the newest version of his book should be available also in english language. The most importent standards for the cable transmission which has an impact on the TDA9819 can be found in [ETS429].

This chapter will give some basic informations about the system to help the reader to find the TDA9819 in the system chain. The baseband and QAM demodulator IC description of the TDA8046 is given in the data sheet of the TDA8046 and in a corresponding application note from Philips System Laboratories Eindhoven [OM5708].

We will start with QPSK and QAM principles to show the influence of the order of n-QAM modulated signals on the required S/N. Figure 1.3-1 shows the blockdiagram of a QPSK modulator[Illch][3]

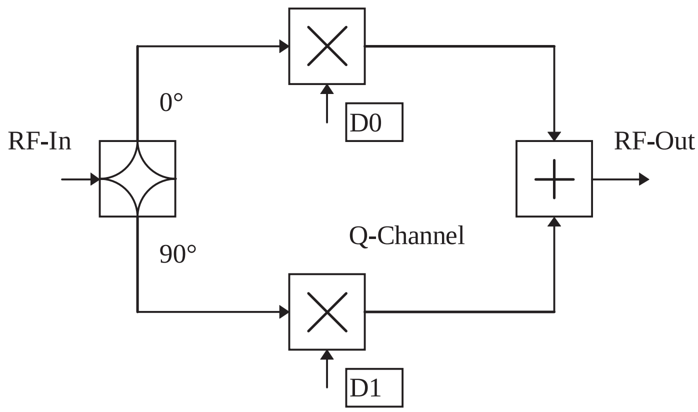


Fig. 1.3-1 Blockdiagram of a QPSK modulator

There are 4 different cases for modulation possible which are shown in table 1.3-1.

symbol numer	D1	D2
0	0	0
1	0	1
2	1	0
3	1	1

Tab. 1.3-1 Possible symbol combinations

3. most pictures of this chapter are taken from this internal report

To distinguish these 4 symbols we need 2 bits so the transfer rate for this kind of modlation is given by:

r = (fs * 2bit)/8bit   r = transfer rate in Byte/sec
fs = symbol clock

With a symbol clock of 6.9 MHz for example we would get:

r = (6.9E6 * 2bit)/8bit -> around 1.7MByte/sec

In a constellation diagram like that in Figure 1.3-2 these 4 symbols would be represented by the outer points of the pattern so in principle this method is just a phase modulation in 90 degree steps. When not only the phase of the output signal is changed in this way but also the amplitude we have a quadrature amplitude modulation.

If we assume the output signal as a vector with an I- component(in phase) and a 90 degree rotated Q - component(quadrature) we can assume all possible output stages as a vector within a I/Q constellation diagram like it is shown in figure 3 for example for a 16QAM.

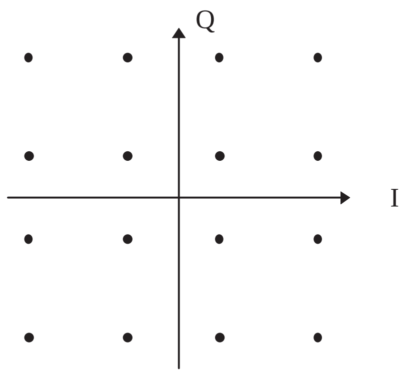


Fig. 1.3-2 Constellation diagram of a 16 bit QAM for example

Now with the 16 possible points in the constellation diagram we have 16 possible symbols. For this 16 symbols we need 4 bits for coding . Compared to the QPSK modulation now we have doubled the transfer rate when using the same symbol clock.

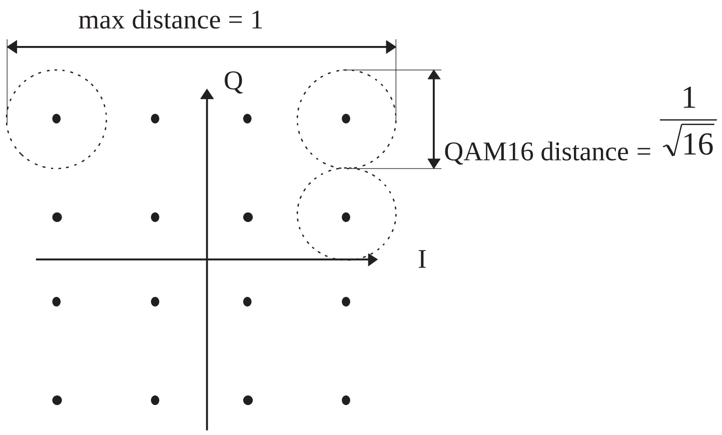


Fig. 1.3-3 Constellation diagram of a 16 bit QAM with noise influence

But compared to the QPSK points we see that the points are closer to each other and so the allowed noise circle radius is decreased. Noise can be interpreted as a vector which turns around the points of the constellation diagram producing a circle with a noise amplitude dependend radius. Figure 1.3-3 shows the noise influence in the constellation diagram.

From this figure we get:

required distance QAM16 -> 1/(SQRT(QAM res.)) = 1/SQRT(16) = 0.25

required distance QPSK -> 1/(SQRT(QPSK res.)) = 1/SQRT(4) = 0.5

So we get a ratio of QPSK/QAM distance required to get no overlap of the points of:

20 * log(o.5/0.25) = 6dB

So to have the same S/N ratio with the same noise level the signal for 16QAM has to be 6 dB stronger than QPSK. From figure 1.3-3 and the above calculations we can derive the following table.

Tab. 1.3-2 QAM resolutions and required S/N ratios

QAM resolution	bits per symbol	min S/N
4 (QPSK)	2	9
16	4	15
32	5	18
64	6	21
256	8	27

From this table we see that with each bit we add to the symbol rate we need a 3 dB better S/N of the received signal. So we see the tradeoff we have to do between the increasing transfer rate and the required S/N ratio.

Of course another way to increase the transfer rate is a higher symbol clock with the same symbol width.

After this calculations we will look to another important question for this report: where do we find this TDA9819 in the QAM modulated cable transmission and receiving chain. To find an answer to this question we have to look to figure 1.3-4 which shows a complete transmission chain of a QAM modulated cable TV system.

The following paragraph describes this block diagram.

Encoding/Decoding Process

The processes in the following subclauses shall be applied as shown in Figure 1.3-4.

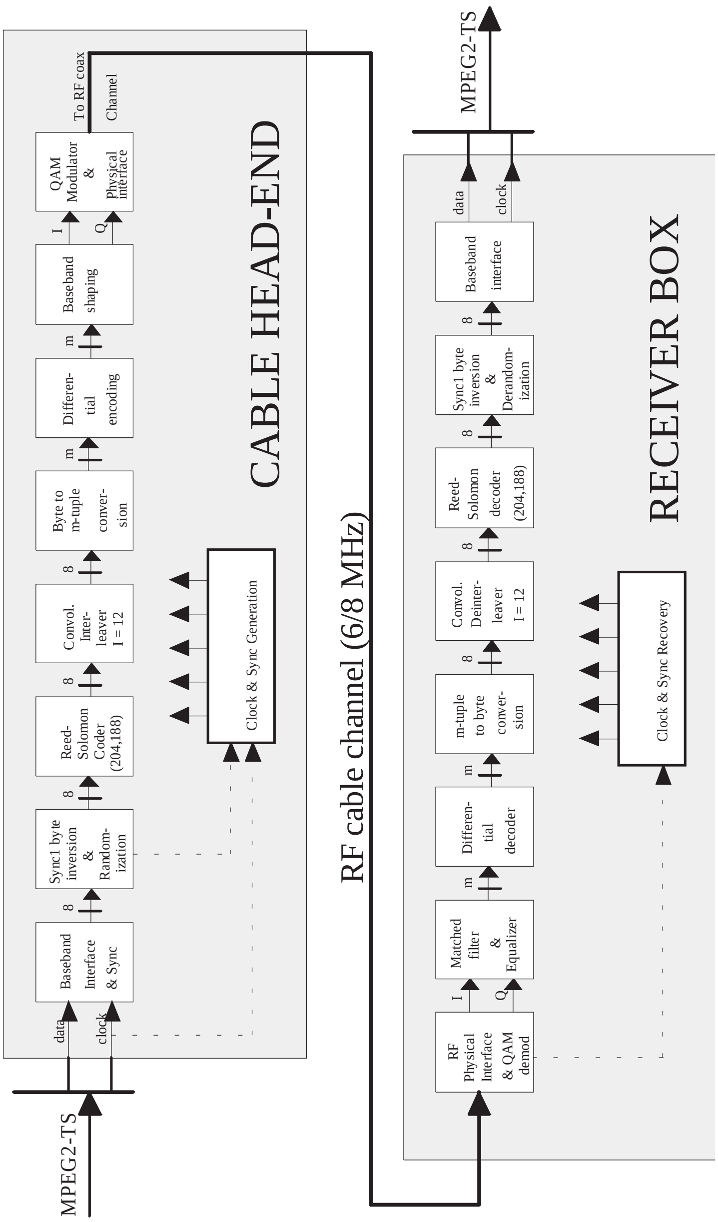


Fig. 1.3-4 [Illch] Conceptual block diagram of elements at the cable haed-end and receiving site.

Baseband interfacing and sync

This unit shall adapt the data structure to the format of the signal source. The framing structure shall be in accordance with MPEG-2 Transport Stream (inlcuding sync bytes).

Sync 1 inversion and randomization

This unit shall invert the Sync 1 byte according to the MPEG-2 framing structure, and randomizes the data stream for spectrum shaping purposes.

Reed-Solomon (RS) coder

This unit shall apply a shortened Reed-Solomon (RS) code to each randomized transport packet to generate an error-protected packet. This code shall also be applied to the Sync. byte itself.

Convolutional interleaver

This unit shall perform a convolutional interleaving of the error-protected packets with I=12/M=17 (for 16 and 64 QAM) and I=204/M=1 (for 256 QAM). The periodicity of the sync bytes shall remain unchanged.

Byte to m-tuple conversion

This unit shall perform a conversion of the bytes generated by the interleaver into QAM symbols.

Differential encoding

In order to get a rotation-invariant constellation, this unit shall apply a differential encoding of the two Most Significant Bits (MSBs) of each symbol.

Baseband shaping

This unit performs mapping from differentially encoded m-tuples to I and Q signals and a square-root raised cosine filtering of the I and Q signals prior to QAM modulation.

QAM modulation and physical interface

This unit performs QAM modulation. It is followed by interfacing the QAM modulated singal to the Radio Frequency (RF) cable channel.

Cable receiver

A System receiver shall perform the inverse signal processing, as described for the modulation process above, in order to recover the baseband signal.

The TDA9819 is located in the “RF Physical Interface & QAM demod.” block of this blockdiagram.

The whole baseband decoding will be done in the QAM demodulator ICs like the TDA8046 or the successor TDA8047 from Philips. An important fact is that the received spectrum at the IF frequency is flat because of the “Randomization” block so we do not have discrete picture and sound or colour carriers like we have it in the analog TV mode.

A typical spectrum of an analog TV channel together with a QAM modulated digital TV channel on cable is shown in figure 1.3-5 (measured in the Systems Laboratory Hamburg/Germany) .

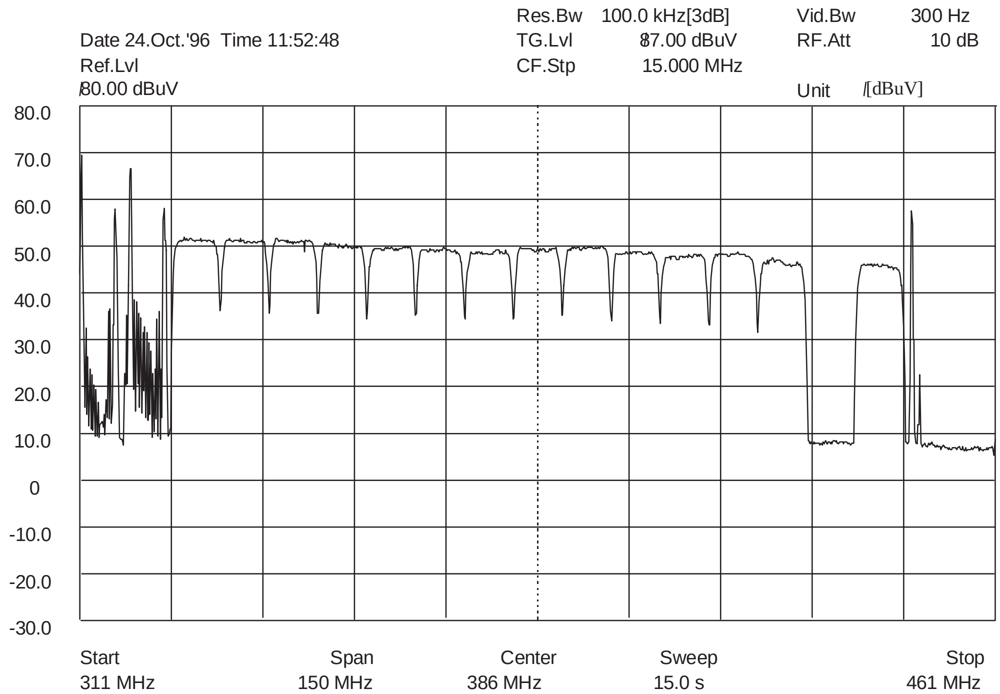


Fig. 1.3-5 Amplitude spectrum of a TV cable system with DVB channels

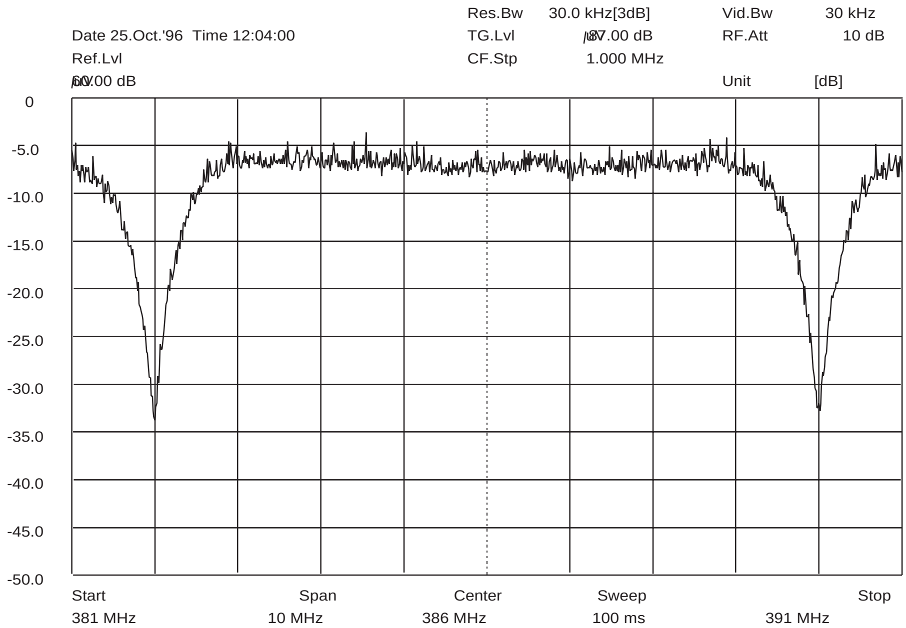


Fig. 1.3-6 Amplitude spectrum of one QAM modulated TV channel

Figure 1.3-6 shows one single QAM modulated channel in the UHF-band in more detail. The flat regulary spectrum can be seen.

The Systems Laboratory Eindhoven(SLE) developed a demoboard which includes the TDA8047 and the TDA9819 [OM5708] . This board together with the TDA8046 allows some more measurements to be taken. Figure 1.3-7 shows the principle block diagram of a board still with the TDA8046.

Demoboards with the TDA9819 only are available seperately from Systems Laboratory Hamburg(SLH).

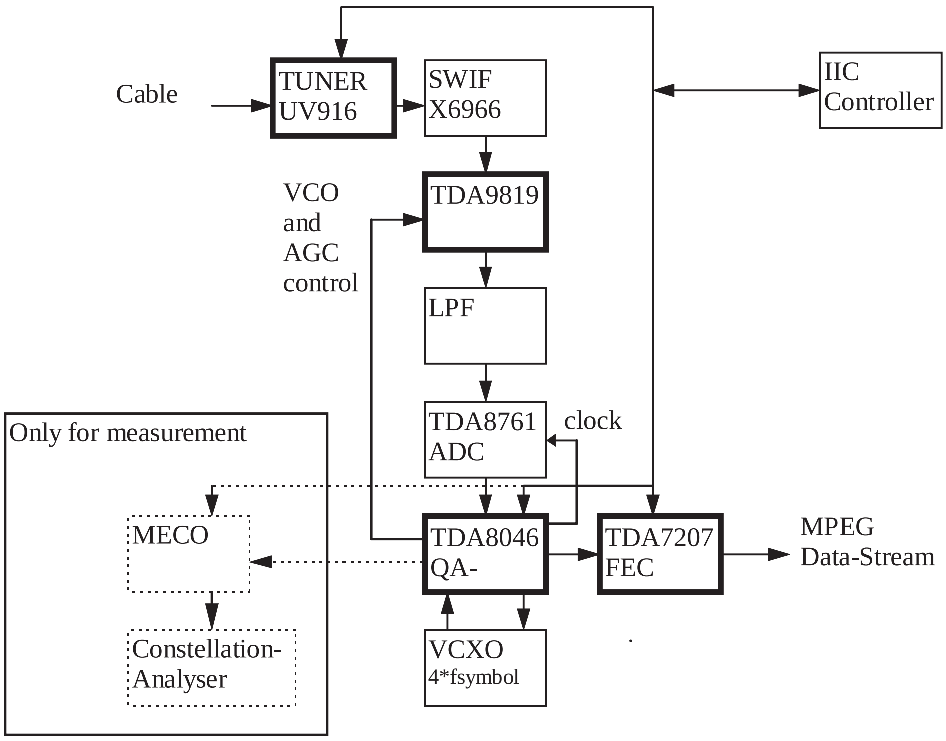


Fig. 1.3-7 Principle block diagram of a DVB demoboard with TDA9819 and TDA8046

This board also provides an output for symbol errors. From this output we get figure 1.3-8 which shows with two measurement curves the qualitativ behaviour of the bit error rate(bit error rate named in the figure) versus an attenuation of the input signal at the tuner RF input.

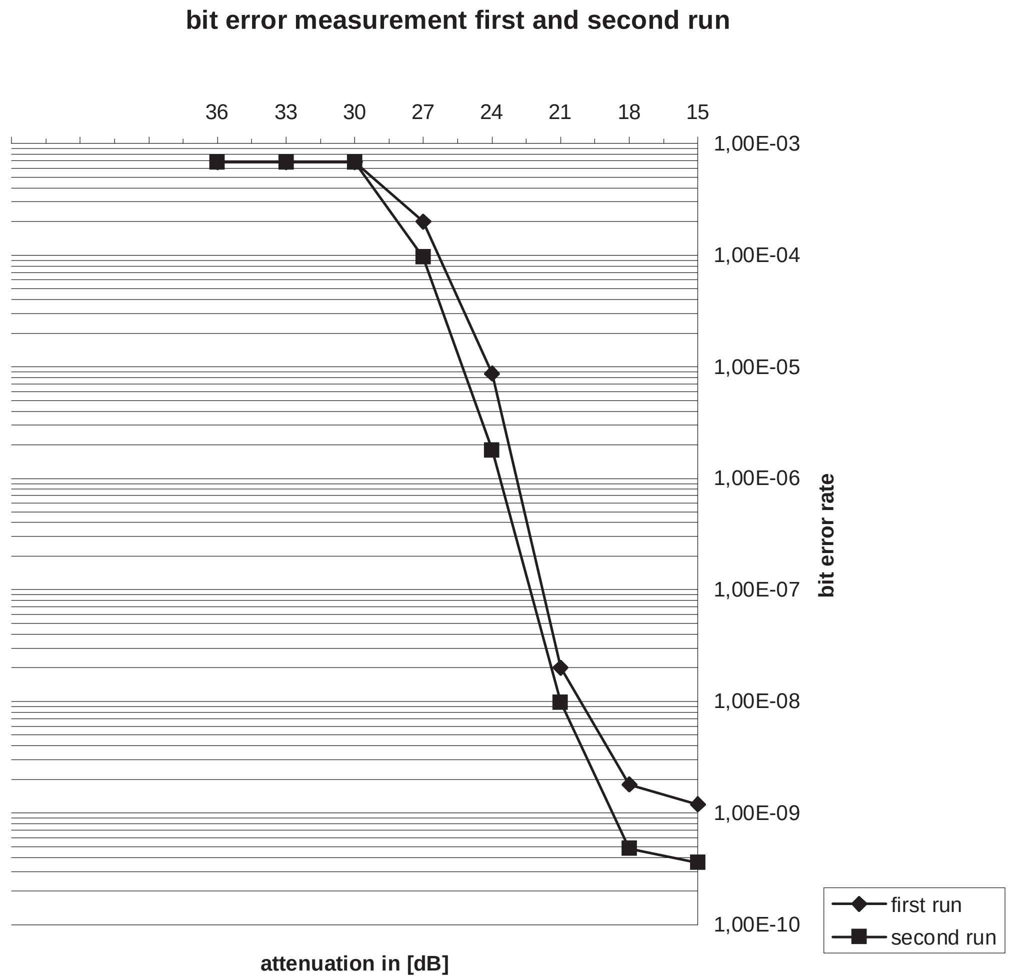


Fig. 1.3-8 Bit Error Rate measurement versus RF input level attenuation

Now what should we conclude from this theoretical pages over DVB concerning the TDA9819 ?

- The phase jitter and the phase noise of the VCO is important. The more symbols the constellation diagram would have the more important this item will become.
- because of the randomizing of the spectrum it looks regulary flat and has no discrete lines for the picture,sound or color carriers.
- from the spectra measurements we can get an impression of the expected shape of the received signals.
- The bit error rate versus RF input level measurement shows the impact of the signal strength on this parameter.
- some literature is given for more enhanced studies.

1.3.1 Intercarrier and QSS concepts

The TDA9819 includes a high performance QSS concept for TV sound processing. To explain the difference compared to a so called Intercarrier concept this subchapter will give some informations.Two main important concepts are known for video and TV sound processing - the quasi split sound concepts (QSS) and the intercarrier concept. The difference between both concerning the sound processing is the generation of the second sound IF like for example 5,5MHz.

In a QSS concept the Vision IF and the Sound IF were splitted by corresponding SAW filter to go trough different pathes of the IC. When using a single reference the VCO which is used for both the Vison IF to bring it down to video baseband and also the sound IF mixer to generate the intercarrier between Vision and Sound IF for example 5,5MHz is locked to the picture carrier. Also in QSS-SR[4] concepts FM modulations or phase distortions will have an influence on the VCO if they are within the loop filter bandwidth. So in this way a FM modulation of the Picture carrier wich would not have a great influence on the AM modulated video signal can also FM modulate the intercarrier (38,9MHz - 33,4MHz = 5,5MHz) and so this could be audible for the FM modulated sound IF after demodulation. So the loop filter has to be designed with regard to the wanted sound performance and timing behaviour of the FPLL for incomming disturbing singals. Figure 1.3-9 shows a principle block diagram for the standard B/G in a QSS concept.t.

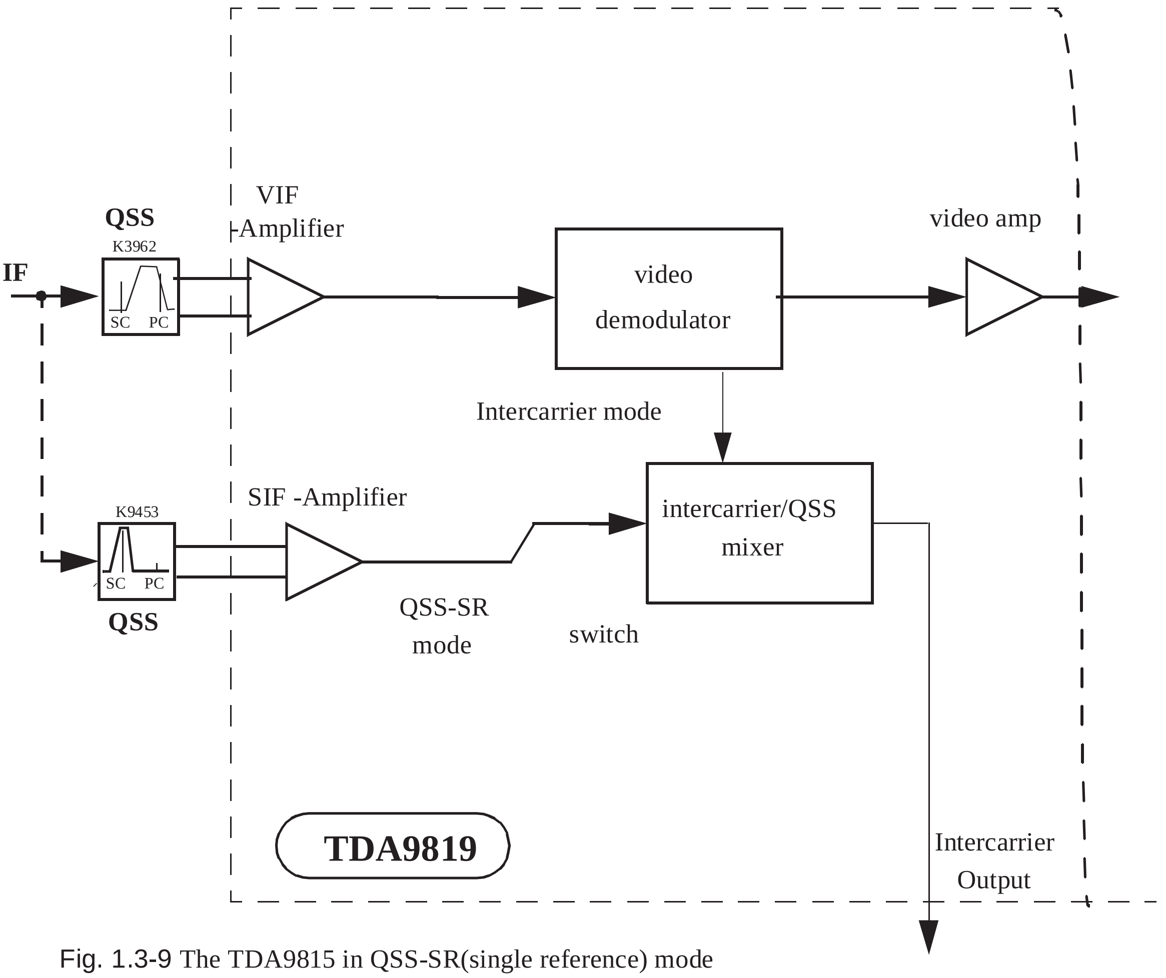


Fig. 1.3-9 The TDA9815 in QSS-SR(single reference) mode

4. QSS-SR - Quasi split sound single reference, older concepts with two references for vision and sound IF are not discussed

The advantage of the QSS concept is the reduced influence from the Sound IF to the Vision IF and vice versa. The disadvantage is the need of an extra SAW filter for QSS. In the intercarrier concept just one filter is needed werde both the picture and the sound IF can pass. To avoid disturbances from the picture to the video path the Sound IF is reduced in the SAW filter. The sound shelf is normally at -20dB or -14dB from the top of the SAW passband.

Fig. 1.3-10 shows a principle block diagram for standard BG in an Intercarrier concept with the TDA9812.

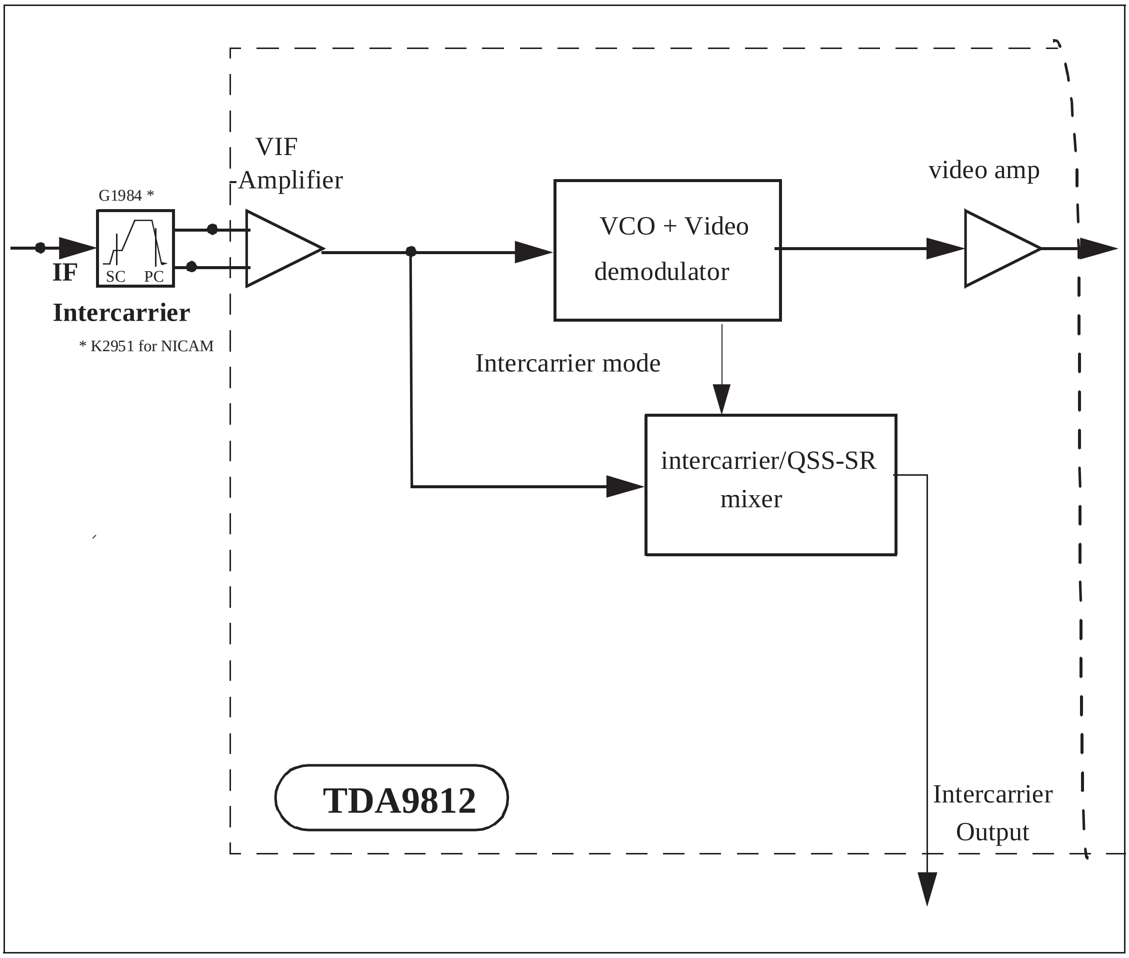


Fig. 1.3-10 The TDA9812 as an example for the Intercarrier mode

The QSS-SR concept has great advantage compared with the Intercarrier concept concerning disturbances from video signal to sound IF because SIF and VIF go through different paths. In the intercarrier principle the chance for unwanted crossmodulation which depends on the linearity of the IF amplifier and video-demodulator is much higher. So for example a 250 kHz videosignal might be crossmodulated to the 5,5MHz first sound carrier and might have an influence on the second sound carrier (5,742 MHz) signal directly or to the ident signal. for further information on this systems and IF ICs which could be used to do this job see the application note given in the literature in the Appendix [AN96142].

1.3.2 TV Sound IF Standards

TV MULTICHANNEL SOUND TRANSMISSION STANDARDS

	M	M	M	B, G, H	B, G, H	I	D/K	D/K	L
Intercarrier 1 (MHz) Intercarrier 2 (MHz)	4.5 -	4.5 -	4.5 4.724	5.5 5.742	5.5 5.85	6.0 6.552	6.5 6.258 *	6.5 5.85	AM dem. at 1st IF 5.85
Vision modulation	neg.	neg.	neg.	neg.	neg.	neg.	neg.	neg.	pos.
Sound modulation IC1 IC2	FM -	FM -	FM FM	FM FM	FM digital	FM digital	FM FM	FM digital	AM digital
Audio coding AF1	M MPX (FM/AM) SAP (FM)	M MPX (FM/ FM)	M L + R A	M (L + R)/2 A	M1	M1	M (L + R)/2 A	M1	M1
Audio coding AF2	-	-	M L - R B	M R B	L, R A, B (NICAM)	L, R A, B (NICAM)	M R B	L, R A, B (NICAM)	L, R A, B (NICAM)
Country of stereo sound transmisssion	USA Brazil Canada Mexico Taiwan Argentina	Japan	Rep. of Korea	Germany Netherlands Italy, Austria Switzerland Slovakia Malaysia Australia Israel Saudi Ara- bia	Scandinavia Belgium Spain New Zealand Singapore	UK Hong- Kong	Czechia Poland Slovakia * Peoples Rep. of China (D) 6.742	Poland (under test, serv- ice expected mid 1997) Hungary (under considera- tion)	France

Fig. 1.3-11 TV Multichannel Sound Transmission Standards

TV TRANSMISSION STANDARDS (IF issues only)

	M, N	M	M	M	B, G, H	B, G, H	I	D, K, K‘	D/K	D/K	L	L
Nominal RF channel bandwidth (MHz)	6	6	6	6	B:7 G:8	B:7 G:8	8	8	8	8	8	8
Vision modulation	neg.	neg.	neg.	neg.	neg.	neg.	neg.	neg.	neg.	neg.	pos.	pos.
Video bandwidth	4.2	4.2	4.2	4.2	5	5	5.5	6	6	5	6	5.2
Colour system / Sub-carrier (MHz)	NTSC 3.58	NTSC 3.58	NTSC 3.58	NTSC 3.58	PAL 4.43	PAL 4.43	PAL 4.43	SECAM4 .4/4.25	PAL 4.43	PAL 4.43	SECAM 4.40/4.25	SECAM 4.40/4.25
Group delay prec.	+170	ns at CC	acc.	FCC	acc. B/G	CCIR	flat	flat or	OIRT		flat	flat
Intercarrier 1 (MHz) Intercarrier 2 (MHz)	4.5 -	4.5 -	4.5 -	4.5 4.72	5.5 5.742	5.5 5.85	6.0 6.552	6.5 -	6.5 6.258 *	6.5 5.85	AM dem. at 1st IF -	AM dem. at 1st IF 5.85
Ratio of Vision- and Soundcarrier (in dB)	-7 -	-7 or -10 -	-8 to -5 -	-13 -20	-13 -20	-13 -20	-13 -20	-10 -	-10/-13 -20	-10/-13 -20	-10 -	-10 -27
Sound modulation IC1 IC2	FM -	FM -	FM -	FM FM	FM FM	FM digital	FM digital	FM -	FM FM	FM digital	AM -	AM digital
Country of transmission		USA Brazil * Canada Mexico Taiwan Argentina* * PAL	Japan	Rep. of Korea	Germany Netherlands Italy, Austria Switzerland Slovakia Malaysia Australia Israel Saudi Arabia	Scandinavia Belgium Spain New Zea-land Singapore	UK Hong-Kong		Czechia Poland Slovakia * Peo-plesRep. of China 6.742	Poland (under test, service expected mid 1997) Hungary (under con-sideration)	France	France

Fig. 1.3-12 TV Transmission Standards

2. Detailed functional block description

2.1 Overview

Figure 2.1-1 shows the block diagram of the TDA9819. The blocks which are used for both modes or each of the DVB or analog TV mode are marked with different filling shapes. Chapter 2 is separated according to the blocks marked in this figure so first blocks for both modes were described and than the blocks only used for either the DVB or analog TV mode.

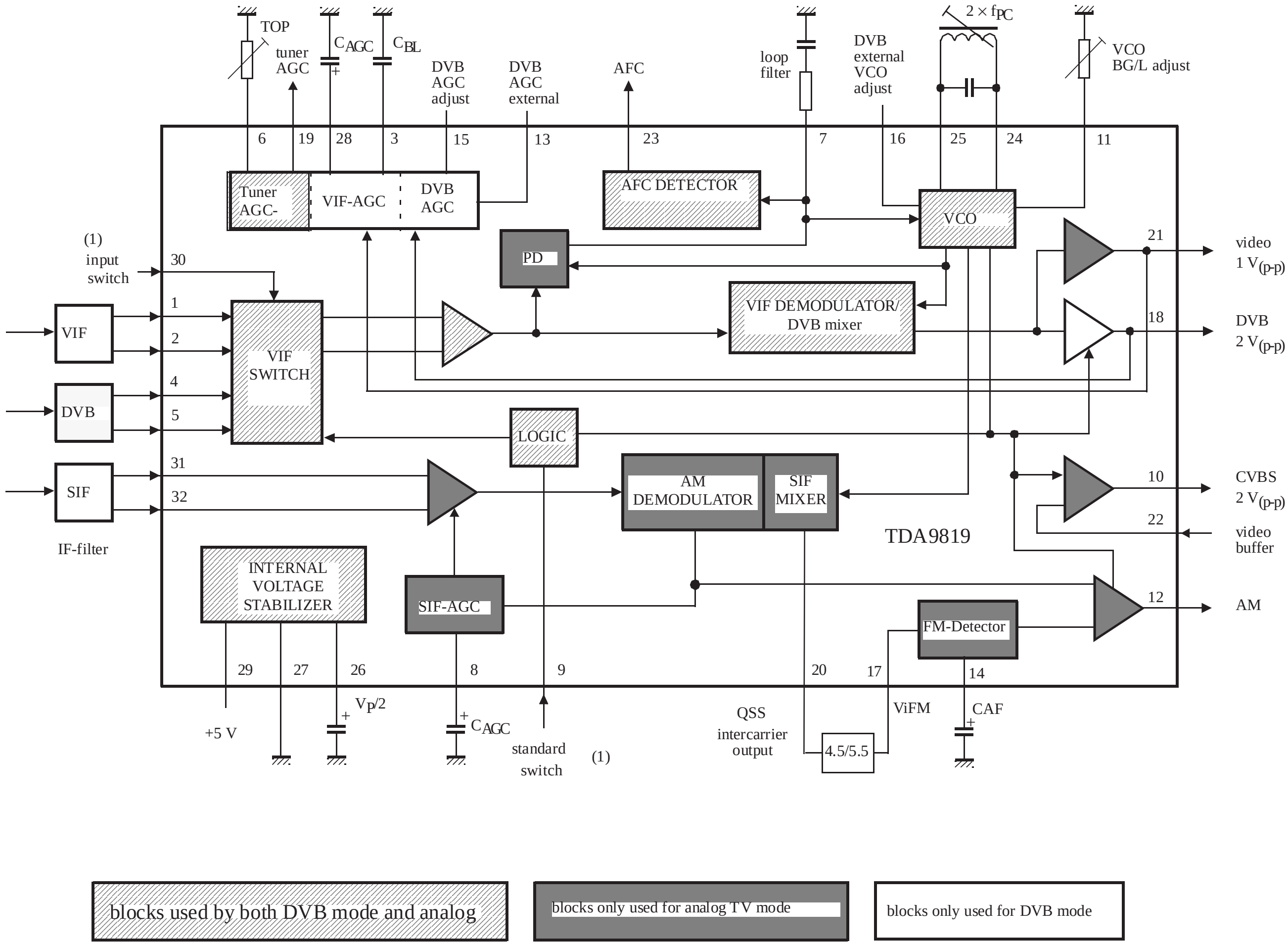


Fig. 2.1-1 Block diagram of the TDA9819 with marked block functions for both modes, DVB or analog TV mode

2.2 Blocks used for both Analog TV and DVB mode

2.2.1 VIF/DVB input switch (pins 1,2,4,5) and IF amplifier

The IF-amplifier consists of 3 AC coupled differential stages. The differential input stage can be switched by deactivating the corresponding current source of one of the two differential input amplifiers. Figure 2.2-1 shows the block diagram of the IF- amplifier .

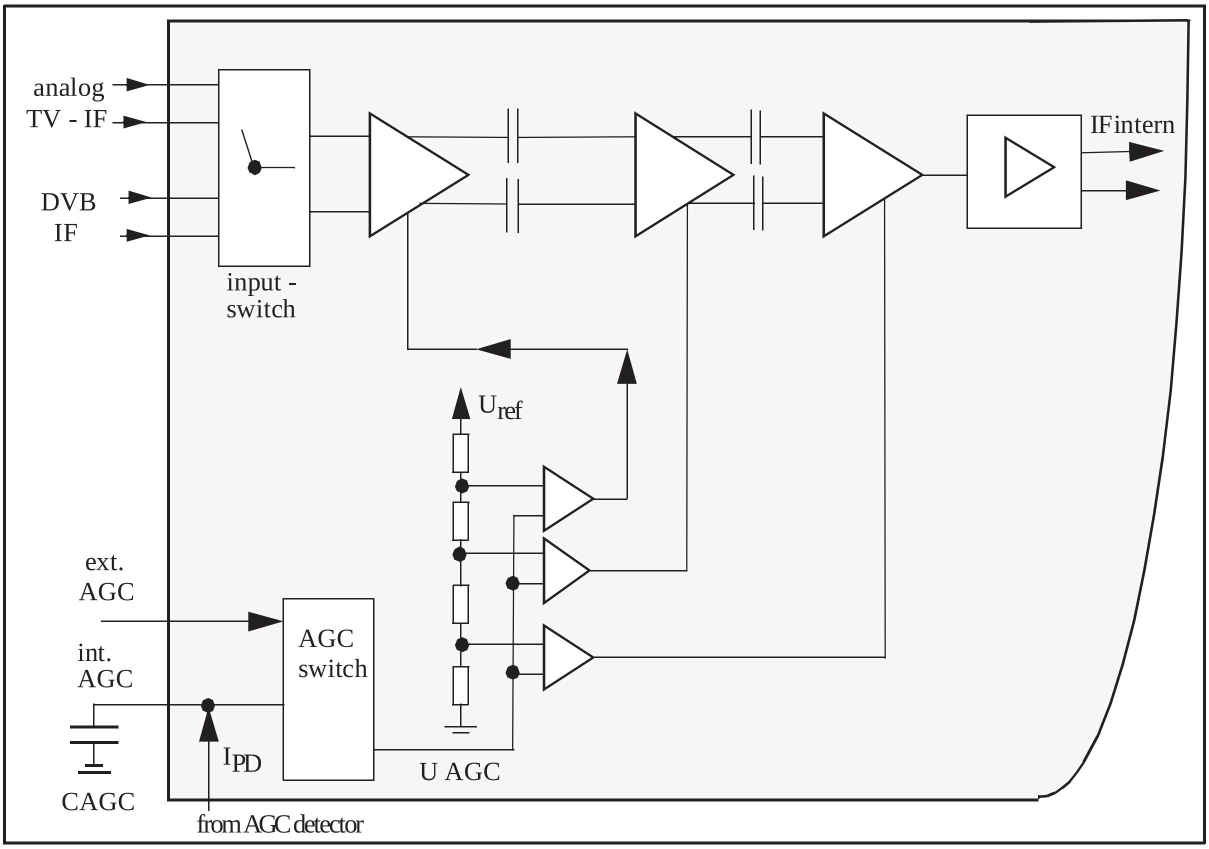


Fig. 2.2-1 Block diagram of the 3- stage IF- amplifier

The AGC block gets a voltage from the AGC detector which monitors in internal AGC mode the DVB output or the baseband 1 Volt Video output. In external mode the AGC(just for DVB mode) the AGC voltage is applied directly over a buffer at this pin. From this figure the three stages can be seen.

The AGC block gets a voltage from the AGC detector which monitors in internal AGC mode the DVB output or the baseband 1 Volt Video output. In external mode the AGC(just for DVB mode) the AGC voltage is applied directly over a buffer at this pin. From this figure the three stages of the amplifier can be seen together with the AGC comparator circuit which decreases the gain of the last stage at first if the IF input level increases. Over an internal buffer the IF goes to the mixing stage. The AGC comes from the CAGC voltage for internal AGC mode or directly from the ext. AGC input pin.

To avoid a great influence on the noise figure in case of an increasing input signal the first stage to reduce its gain is the last of the three stages. The principle is shown in figure 2.2-2.

For cascaded systems with no feedback from the output to the input (S_{21} = 0) the overall noise figure of the system is given

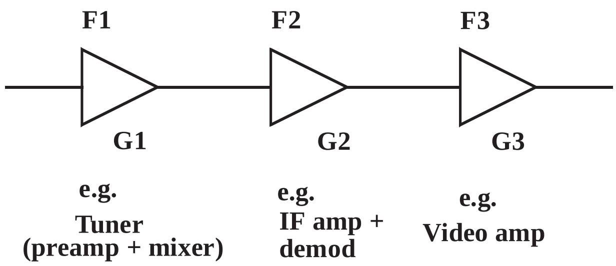


Fig. 2.2-2 Noise figure of a cascaded system of amplifiers

by the formula of de Friis [Young]:

Fges = F1 + (F2-1)/G1 + (F3-1)/(G1*G2) + (F4-1)/(G1*G2*G3) + ...

with NR(noise ratio) = $(S/N)_{input}/(S/N)_{output}$ and Noise Figure NF = 10*log NR

so for example with a S/N of 25 dB at the input and S/N of 15dB at the output the amplifier would have a noise figure NF of 10 dB.

A small example should demonstate the calculation of the overall noise figure. From this example the small influence of the second and third amplifier on the total noise figure of the system can be seen. This formula from de Friis is not only valid for cascaded amplifiers but also for other system components like mixers or passiv components like SAW filters.

NR1 = 2dB => 10*log2 = 1.58, NR2 = 6dB => 3,98, NR3 = 10dB => 10,

G1 = 8dB = 6.3 ,G2 = 12dB = 15.85.

With these values the overall noise ratio(NR) is:

NR = 1.58 + (3.98 -1)/6.3 +(10-1)/(6.3)*(15.85) = 1.58 + 0.47 + 0.09 = 2.14 -> NF =10*log(2.14) = 3.3 dB

Notice that even though NR2 is more than twice NR1 the noise contribution of the second stage is much less than that of the first.

What does this mean for the TDA9819?

From the example we can see the small influence of the TDA9819 on the noise figure of the total system. Figure 2.2-2 shows the principle block diagram of the whole system from the tuner input RF amplifier, the first mixing stage to IF, the SAW filter and after all these stages the IF amplifier. From this we see that the IF amplifier is not the dominant part in the system chain which determines the overall noise figure . Nevertheless when bringing down the gain of the IF amplifier it is wise to bring down the gain of the last stage first as has been explained by the example calculation above. For a typical IC a noise figure of around 13 to 16 dB of the amplifier over his tuning range was measured.

From the data sheet of the TDA9819 we can see a curve (Fig. 2.2-2) which shows the signal to noise ratio as a function of the IF input voltage. This S/N is a common parameter in analog TV mode and is defined according to

“CCIR 567” as the ratio of the black to white amplitude to the black level noise voltage(RMS value) weighted with a LP bandwidth of 5 MHz.

Another important parameter of the IF-amplifier is the behaviour of its gain versus the incomming IF signal level.

Figure 2.2-3 shows this behaviour. Also the tuner AGC currents are shown in this diagram depending on the resistor value applied at the TOP pin which determines the take over point of the tuner.

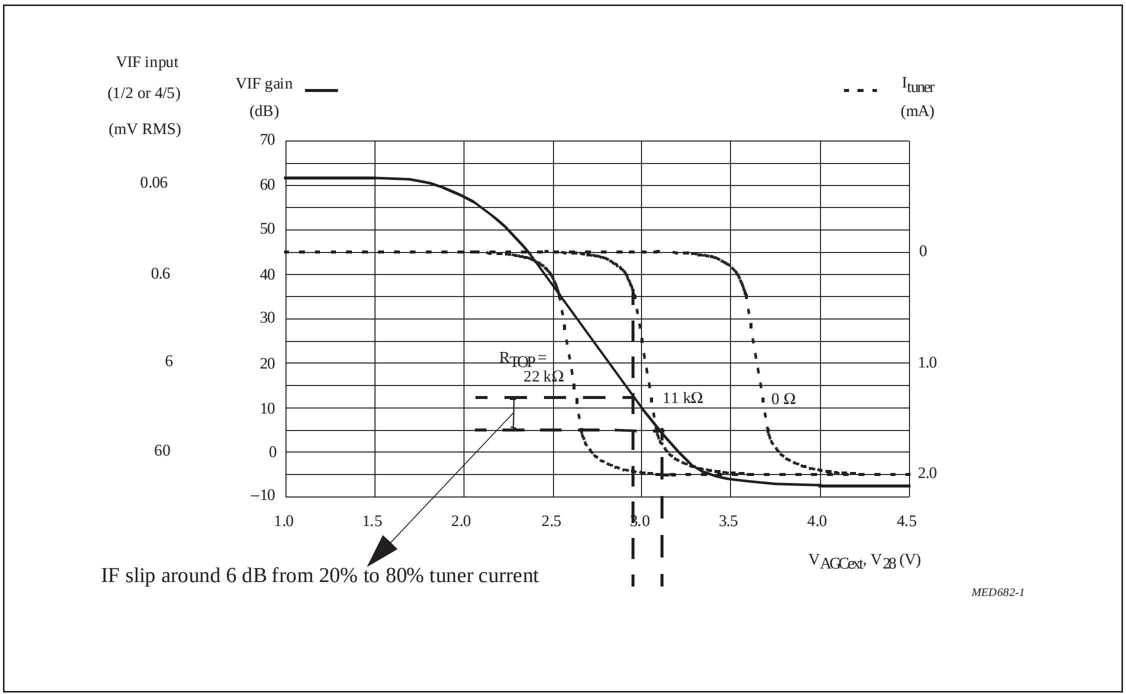
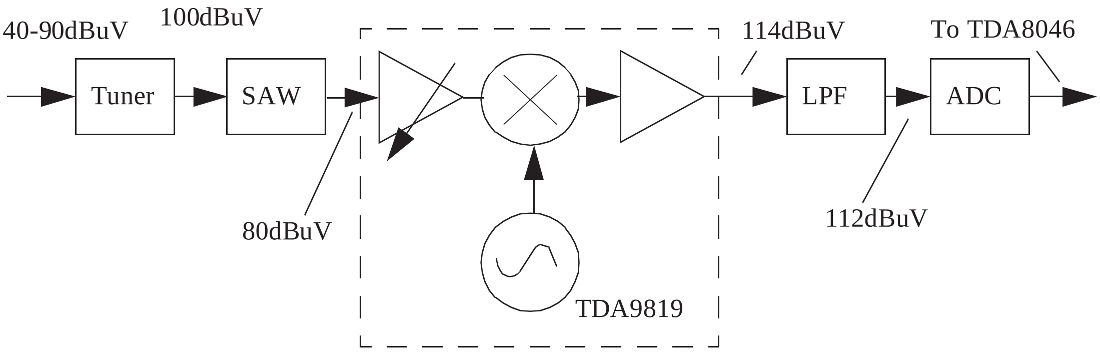


Fig. 2.2-3 Typical VIF and tuner AGC characteristic. [from the data sheet TDA9819]

It can be seen from this curve the behaviour of the tuner gain and IF amplifier gain.The RF input level range where both the tuner gain and the IF amplifier gain is changing is defined as “IF-Slip”. This region should be kept small because of stability it should be avoided to have two AGC control loops working.Therefore for a given IF input level which can be adjusted by a voltage at the TOP pin the tuner current is drawn by an open collector of a transistor inside the TDA9819. These currents are also included in this curve. It is drawn within a very small-VAGC range to avoid a great IF slip. So it is a very small range in the IF amplifier gain curve for the tuner current to increase from 20% up to 80% which is defined as IF slip in the data sheet. If you are looking in the curve for example at the RTOP curve for 11K you see the 6dB on the gain curve going down with the AGC voltage from around 2.9 to 3.1 V.



Voltage levels in the analogue section

Fig. 2.2-4 Typical values for the tuner and IF chain for the DVB mode

At which level at the input of the TDA9819 should the tuner start to reduce its gain ?.

Minimum starting point : V_{IFin} = 5 mV (R_{TOP} = 22K)

Maximum starting point : V_{IFin} = 50 mV (R_{TOP} = 0K)

Recommended starting point : V_{IFin} = 10 mV

For practical measurements in front of the SAW filter you have to add around 20dB to these values in front of the SAW filter

2.2.2 Logic (pins 9, 30)

From table 2 in the data sheet of the TDA9819 the corresponding settings can be seen to switch between the four possible modes:

1. DVB -AGC internal mode
2. DVB - AGC external mode
3. Analog TV mode - negative modulation (like standard B/G, M in the USA, D/K, I)
4. Analog TV mode - positive modulation (Standard L mainly in France)

The switching is done by two pins the standard switch pin(9) and the input switch pin(30).

It should be noted that the not used blocks like for example AF out in DVB mode are muted to avoid disturbances. So also a voltage at the AGC input pin has influence when the IC is used in DVB -external AGC mode. Therefore the AGC adjust pin and the AGC external pin are allowed to get the same voltage. This voltage is interpreted as the external AGC voltage when it is switched in DVB - external AGC mode or as the AGC adjust voltage when it is in the DVB - internal AGC mode.

2.2.3 VCO and travelling wave divider (pin 24 and 25)

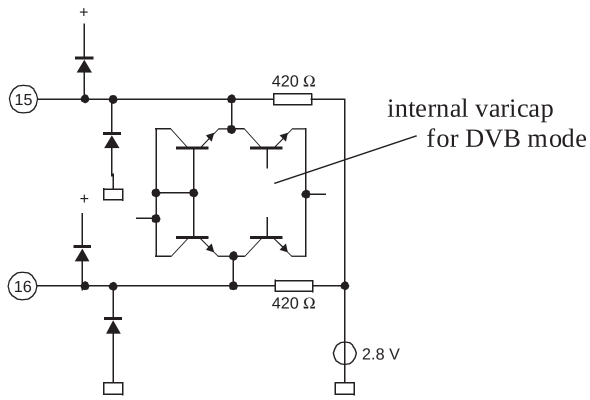


Fig.2.2-5 Internal circuit of the VCO of the TDA9819

The upper transistor pair in this circuit diagram indicate the internal varicaps which are necessary for the tuning of the VCO. The 420 Ohm internal resistors are in parallel to the tank circuit and have an influence on the Q of this circuit.

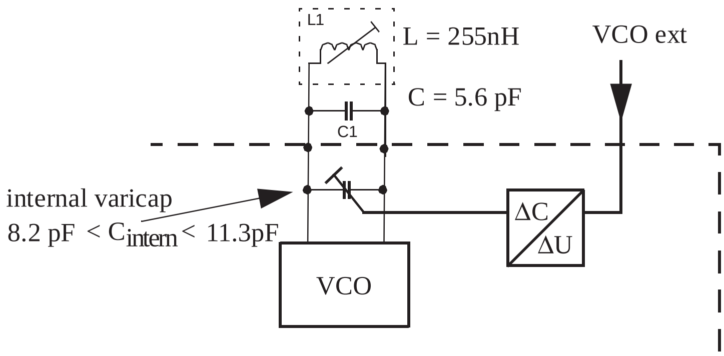


Fig. 2.2-6 Internal block diagram of the VCO in DVB mode

From fig. 2.2-7 it can be seen that the VCO frequency is switched by adding a second internal varicap. The second added varicap pair decreases a bit the phase noise performance of the VCO used for the analog TV mode. In this mode the phase noise is not as critical as in the DVB mode.

Figure 2.2-7 shows the equivalent internal circuit for the frequency adjustment. The process of frequency adjustment of the two frequencies used in the TDA9819 for the DVB mode and the analog TV mode is shortly described in chapter 4.4 which deals with the demo board. This process can be monitored by the AFC current with flows out or in the AFC pin 23. If the current is zero the internal varicap is in the middle of its range. This can be achieved by applying a voltage of around 2.2 Volt at the VCO control input pin 16. In this status the frequency range for the VCO in DVB mode is at the maximum value. By tuning the coil of the tank circuit the DVB output frequency can be adjusted at the DVB output to for example 6.9 MHz when introducing 36.15MHz from a generator. This procedure can also be done by evaluating the AFC voltage information by software.This can be done over the internal ports of the TDA8046 and TDA8047 . They monitor the AFC pin and depending on this information give a voltage to the VCO control input pin 16. After having done the alignment for the DVB frequency the VCO can be switched to analog TV mode and the internal second varicap pair is added. Now the voltage at this second internal varicap pair can be changed to adjust the VCO frequency for the analogTV mode keeping the same voltage at the first varicap pair . This voltage for the second varicap could also be hold constant by a fixed resistor and also in the analog TV mode the voltage of the first internal varicap pair can be changed.

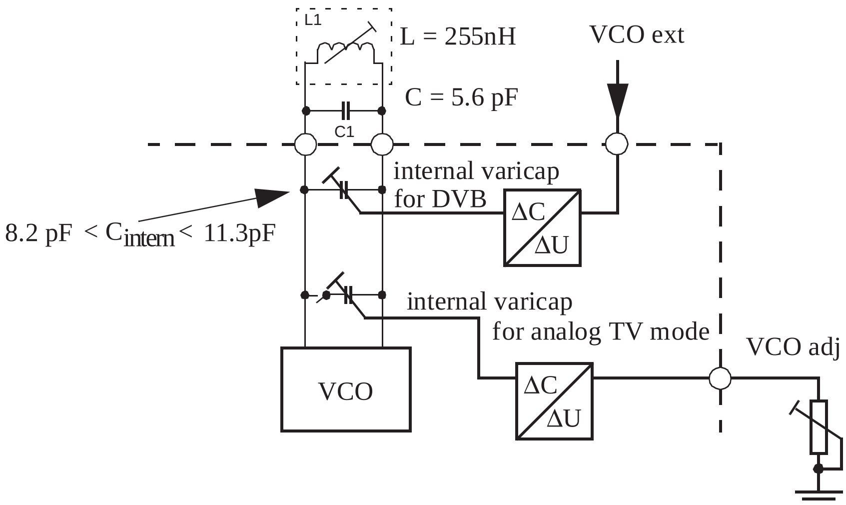


Fig. 2.2-7 VCO adjustment in DVB and analog TV mode

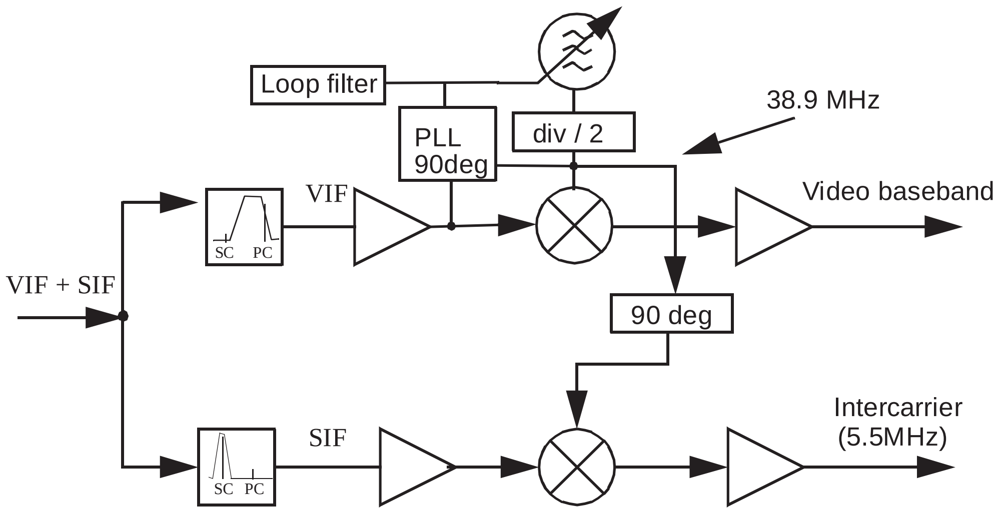


Fig. 2.2-8 Analog TV mode Vision demodulation and intercarrier generation

It can be shown from calculation that the 90 degree shifted VCO signal results in a quasi high pass function for the single sideband part of the vestigal sideband modulated IF in analog TV mode.The DSB part of the VSB signal is reduced.If no Nyquist slope would be there these DSB parts of the VSB part(up to around 750 kHz) would be completely suppressed.

In this mode the Vision carrier (38.9 MHz for example) is located at the middle of the Nyquist slope which goes around 750kHz in both sides from the Picture carrier In this area the signal can be regarded as a double sideband signal with a nyquist slope weighting. This part of the signal is not needed at the intercarrier output where just the intercarrier between the picture and the sound carrier is wanted (5.5MHz for example +/- around 50 kHz for the FM deviation and the sound signals).

This 90 degree phase shift which is mainly needed for the intercarrier mixer in analog TV mode and for generation of the FLL part of the FPLL is not necessary for the DVB mode. The 90 degree phase shift can be derived in a simple way from the travelling wave divider.

2.2.4 AFC (pin 23)

In the actual concepts the AFC serves as a monitor for the frequency of the VCO.This pin voltage can be read out for example by a port of a mixer /oscillator IC(TSA55XX) or also by the TDA8046/47 QAM demodulator ICs and can serve as an input for the tuner software for alignement of the tuner oscillator in analog TV mode. In DVB mode also the VCO can be tuned directly.

To get a better understanding of the AFC interface design on the following pages some basic calculations should give some help. They should explain the function of the AFC DC value and the slope versus frequency and how to design the resistor interface to get the wanted curve which fits best to the tuning concept.

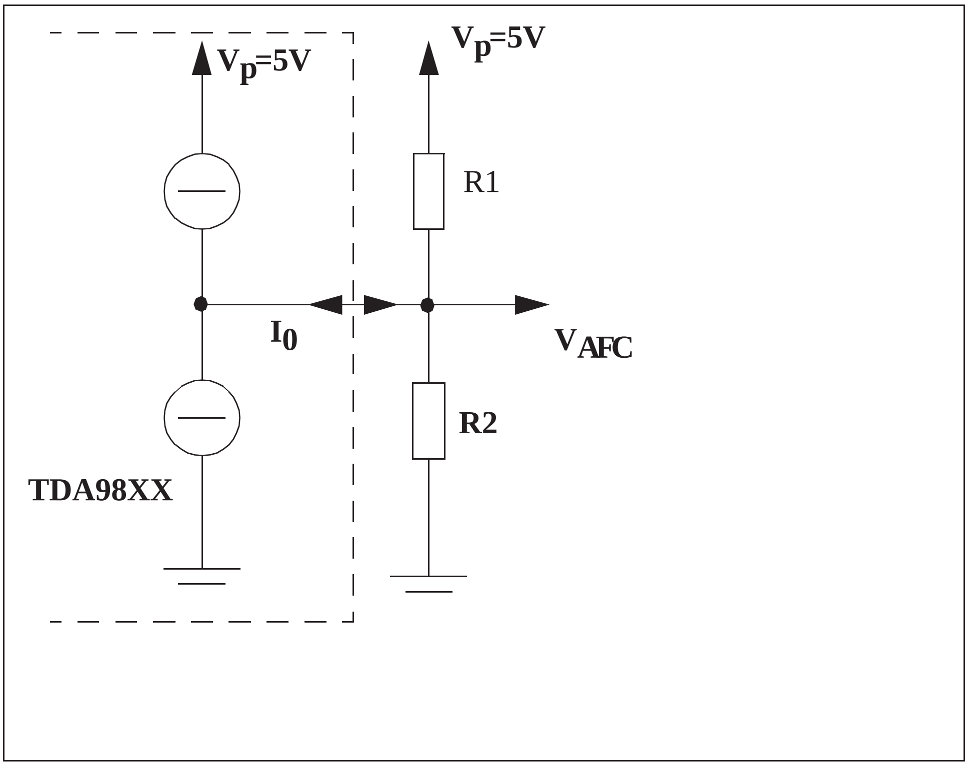


Fig. 2.2-9 Internal and external AFC circuit.

The internal currents correspond to the frequency of the VCO.The exact alignement of the VCO should result in an ideal AFC output current of 0 uA. Depending on the difference to this middle frequency the current source or current sink is working and delivers a current of maximum 200 uA. So when the VCO coil is aligned and R1 = R2 the AFC voltage is UB/2.This corresponds to the picture carrier frequency e.g 38.9 MHz of the input signal.

This AFC voltage is an important information for the tuner oscillator which can be controlled with this frequency information.

The following equations show the calculations of the V_{AFC} output in principle.

The current source can be regarded to be a sink or a source depending on the direction of the current.For the calculation the current sources can be substituted by one. This gives the following circuit diagram :

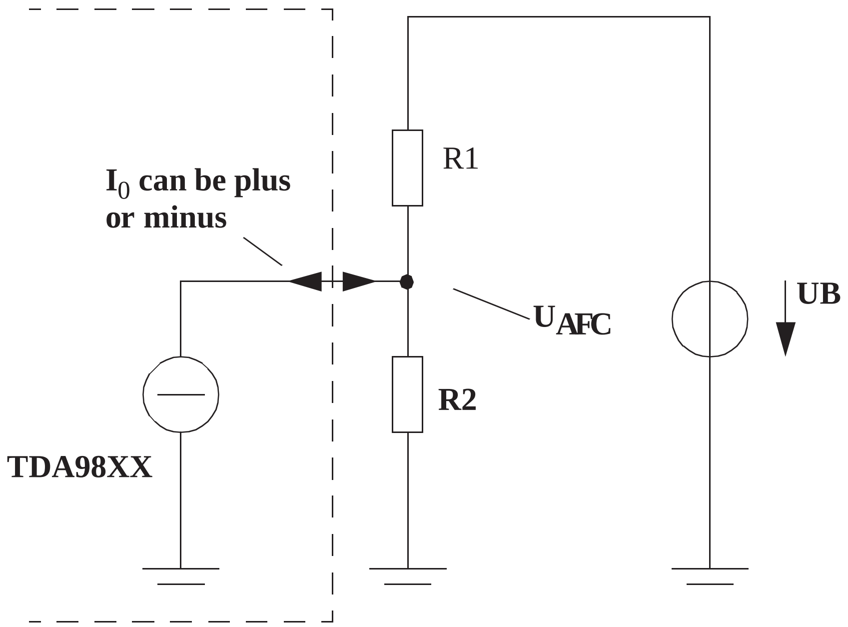


Fig. 2.2-10 Internal and external AFC circuit -network

One possibility to calculate the U_{AFC} is to split up the linear network into as many sub-networks as independant voltage or current sources are present and than superpose all U_{AFC} voltages from all sub-networks. This would lead to 3 sub- networks.Because the current sources are identical except the direction we just take one source with a different direction of the current.We just have to regard one source and short the other voltage sources or disconnect the current sources. This gives the two sub-networks of figure 2.2-11 and 2.2-12 on the following page.:

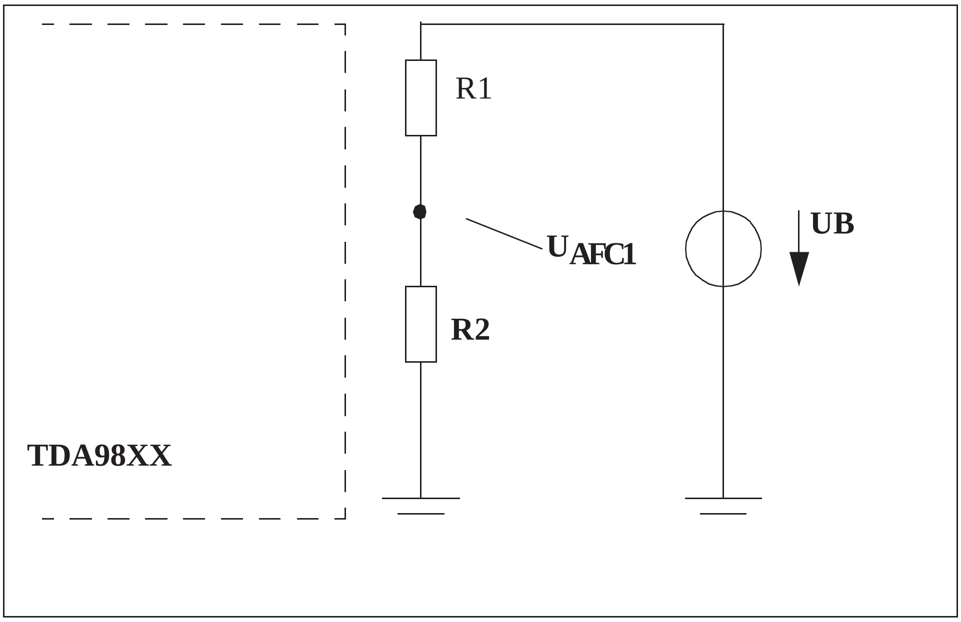


Fig. 2.2-11 First sub-network, current source is an interrupt

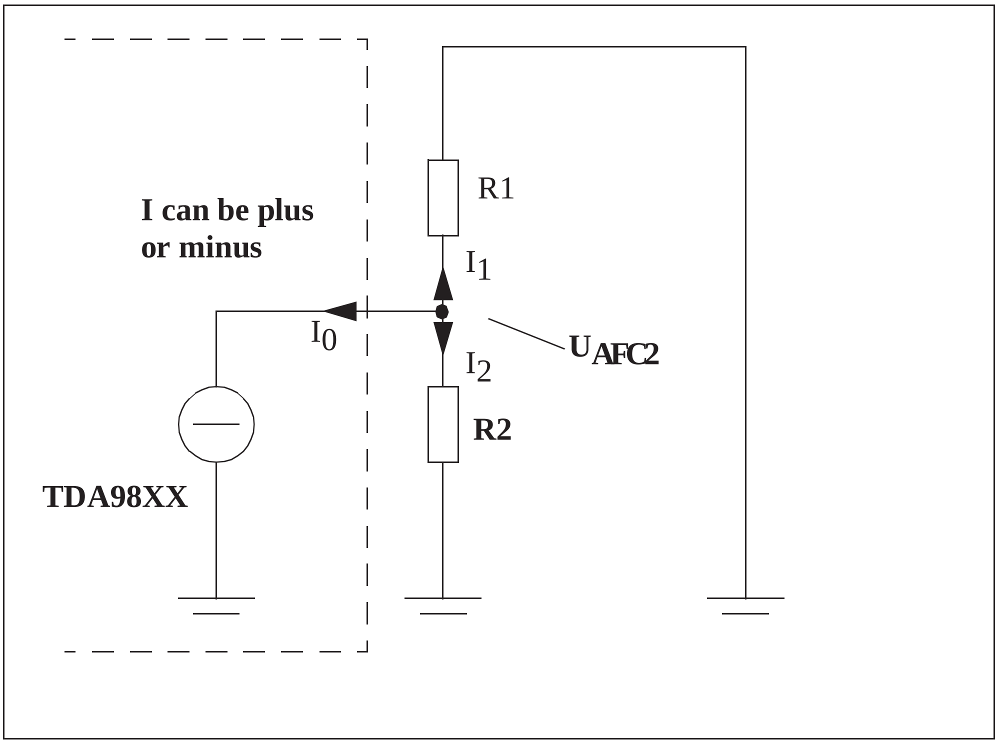


Fig.2.2-12 Second sub-network, voltage source is shorted

Because we have linear networks we can use this superposition principle and we have to add the two voltages UAFC1 and +/- UAFC2 to get UAFC.

So we get:

$$U_{AFC} = U_{AFC1} +/- U_{AFC2}$$ **(**Equation 1.1**)**

From Fig 2.2-11 we have:

$$U_{AFC1} = (R_2 / (R_1 + R_2)) * UB$$ **(**Equation 1.2**)**

From Fig 2.2-12 we get:

$$U_{AFC2} = +/- I_0 * R_1 // R_2$$

$$U_{AFC2} = +/- I_0 * R_1 * R_2 / (R_1 + R_2)$$ **(**Equation 1.3**)**

$$U_{AFC} = (R_2/(R_1 + R_2)) * UB \;\; +/- \;\; I_0 * R_1 * R_2 / (R_1 + R_2)$$ **(**Equation1.5**)**

U_{AFC1} U_{AFC2}

In this equation 1-5 we have two terms which we can interprete like this:

Eq. 2.2-1	1) R2/(R1+R2) is responsible for the average DC level of the AFC voltage
Eq. 2.2-2	2) R1*R2/(R1+R2) is responsible for the swing of the AFC voltage

Because the internal current sources are equal the swing is theoretically always symmetrical So the customer can choose the DC-average level and the swing independently. The next figure shows these results in a graphic:

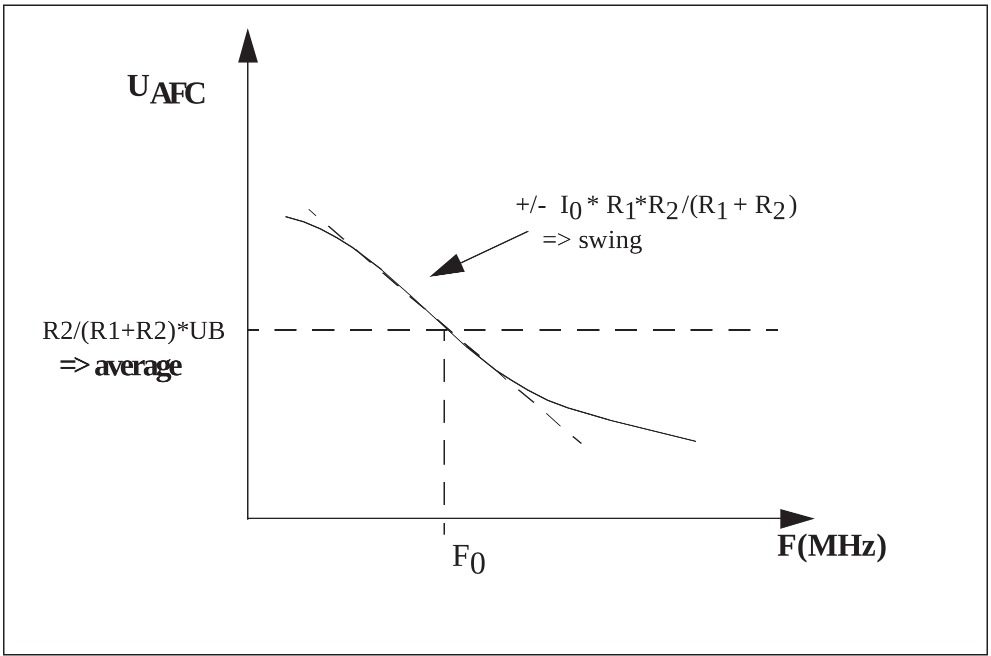


Fig. 2.2-13 Average and swing of the AFC voltage

The pages before should show that the customer has the possibility to adapt the AFC curve easily to his needs. For a better understanding a little example will be calculated:

We assume a supply voltage of 5V, the recommended values from the data sheet of 22K for both R1 and R2 and an AFC output current of 200uA. With these values we get from the Equations 2.2-1 and 2.2-2 :

The customer would like to have the same characteristic than with a 5V supply because he will use the same interface than that for the 5V supply.That means:

1) U_{AFC1} = R2/(R1 + R2) * UB = 22K/(22K + 22K) = 2.5V

2) U_{AFC2} = +/- I_0 * R1*R2/(R1 + R2) = +/- 200 uA * 22K*22K/(22K + 22K) = +/- 2.2V

Now we will discuss the control steepnes of the AFC output per volt. From the data sheet we can see the steepness of the AFC current which is given to be S_{EUR} = 0.72 uA/kHz for example in analog TV mode for Europe. If we neglect the internal parallel resistor of the current source inside the TDA9819 we can write for the control steepness related to the U_{AFC} voltage:

S(V)EUR = 1/(Rp(ges) * SEUR = 1/((22K//22K) * 0.72uA/kHz) = 126 kHz/V

This relations can be seen from figure 2.2-14 (Fig. 7 of the data sheet TDA9819)

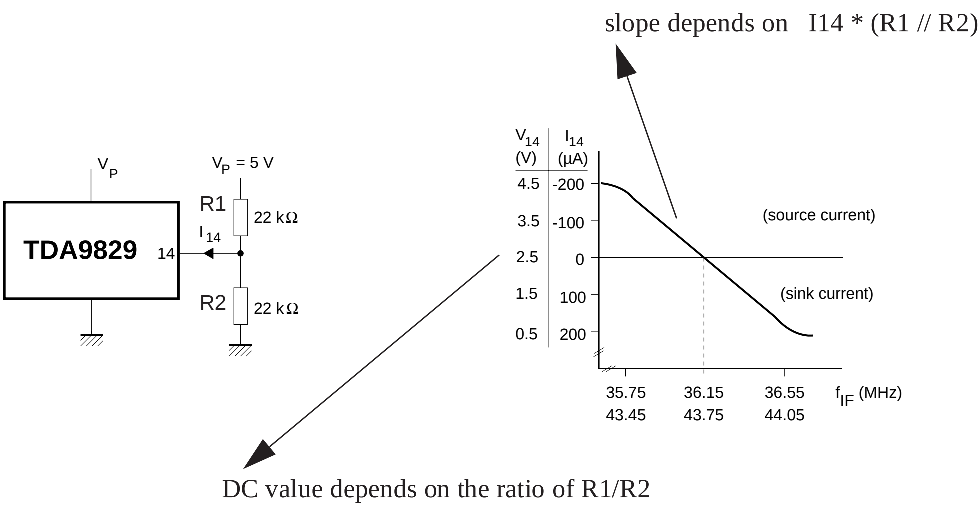


Fig. 2.2-14 Typical AFC characteristic - DC value and slope dependance

2.2.5 Tuner AGC and Take Over Point (pins 6 and 19)

Most of the tuner AGC funcionality is explained in chapter 2.1.1(IF - amplifier). One point that is left to be described is how to dimension the external resistors and the capacitor for this pin 19 TAGC.

The tuner AGC loop has to be more slowly than that of the IF AGC to get a stable loop. Otherwise the AGC behaviour of the total AGC loop with tuner AGC and IF AGC might be able to oscillate. From the data sheet of the TDA9819 we get for the IF AGC the slowest time behaviour for analog TV mode. For an increasing VIF step in standard M or B/G for worst case it is maximum 2.2 ms/dB. For DVB we get less than 0.25ms/dB in both directions for increasing and decreasing input IF level steps.

So as a first requirement for the external AGC circuit we get that the steepness of the tuner AGC has to be less than 2.2 ms/dB. This depends on the choosen elements for the AGC interface which is shown in figure 2.2-15.

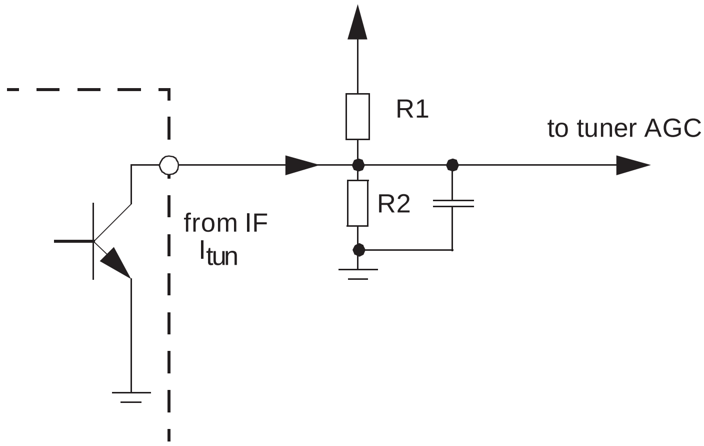


Fig. 2.2-15 External interface circuit at the tuner AGC pin 19

The values for the external resistor divider depend on the tuner AGC characteristic. To demonstrate the design cycle of this tuner AGC interface circuit we will calculate an example. [HAF1]

The tuner AGC input is assumed to be high ohmic(MOS-tetrode). For the calculation we will define the following symbols:

V1	= tuner AGC voltage for start of the tuner gain reduction
V2	= AGC voltage for minimum tuner gain
$I_{TUN\,max}$	= tuner sink current with margin for max tuner gain reduction
VPmax	= max tuner supply voltage
VPmin	= min tuner supply voltage

With this symbols we get:

R1=(VPmax - V2)/I_{TUNmax} for R1 and

R2= R1*(V1/(VPmin -V1) for R2

If we put in these equations some example values like:

Vp = 12V =/- 10%, V1 = 9V, V2 = 1V

we would get :

R1 = (13.2V - 1V)/1.2mA = 10.2K -> R1 = 11K and

R2 = 11K*(9V/(10.8V - 9V)) = 55K -> R2 = 56K

Now we have the values of the resistor divider. The value for the capacitor at the tuner AGC pin is still unsolved. We just know whatever capacitor we will apply it has to fullfill the requirement that the timing behaviour of the interface is more slowly than 2.2ms/dB. For the choice of this capacitor there is another requirement which has to be regarded. It is the allowed voltage ripple on this capacitor which would have an impact on the tilt(gain reduction versus time) of the IF signal.

We will now discuss this ripple first without the capacitor added and than we ask what value of capacitance we need to reduce this ripple to meet an example of a tilt requirement(0.5 dB). When we calculated this capacitor value we will check at the last step whether the timing behaviour of this calculated tuner interface is more slowly than 2.2ms.

So first we have to ask for the expected ripple at the tuner AGC pin without a capacitor added. Because internally the AGC current is deduced from the IF AGC voltage by principle it has a time dependend ripple caused by the video signal which occurs also at the tuner AGC sink current. The range of this change in tuner current depends of its operation point for example do we have 20% or 50% of the maximum tuner AGC current.

From lab measurements the worst case current ripple was found to be 29uA for the TDA9800. Assuming also this value for our example calculation the required time constant of the R/C network can be calculated under the example assumption of a 0.5 dB tilt requirement in the following steps:

1. assumed maximum tuner control characteristic : 100dB/V
2. allowable tuner tilt : 0.5 dB
3. allowable ripple at the tuner capacitor : 0.5dB/100dB/V = 5mV
4. the actual ripple without the capacitor is : v1 = i_{tun} * Rp = 29 uA * 11K/56K = 29uA * 9.2K = 266mV
5. this ripple has to be reduced through the low pass to 5 mV. assuming 2*PI*f*Rp*C >> 1 the damping of the low pass is a= 1/(2*PI*f*T) -> v1=a* v2 -> T=v2/(2*PI*50Hz(field freq.) * 5 mV) = 169 ms
6. From this value we get the required capacitor C = T/Rp = 169ms/9.2K =18.4uF -> C = 22uF
7. Now we have to check the timing behaviour. Within T the signal falls around 1/e = 0.27. This means around 12 dB in 169 ms. From that result we get if we assume linear behaviour tresp = 169ms/12dB -> 14ms/dB which is more slowly than the 2.2ms/dB which we saw as the worst case from the data sheet.

2.2.6 Internal voltage stabilisation (pins29,27,26)

Independently of supply voltage drift or temperature internally a 3.6V reference voltage is derived from a Band-gap circuit. The Vp/2 voltage is mainly needed for a good audio performance of the rail to rail stage of the audio amplifier. If the audio stage is not used (in DVB mode for example) this capacitor is not necessary and can be left out.

2.3 Blocks used for Analog TV mode only

2.3.1 True synchronous videodemodulator (pin 7)

Fig. 2.3-1 shows the blockdiagram of the video demodulator and FPLL detector.

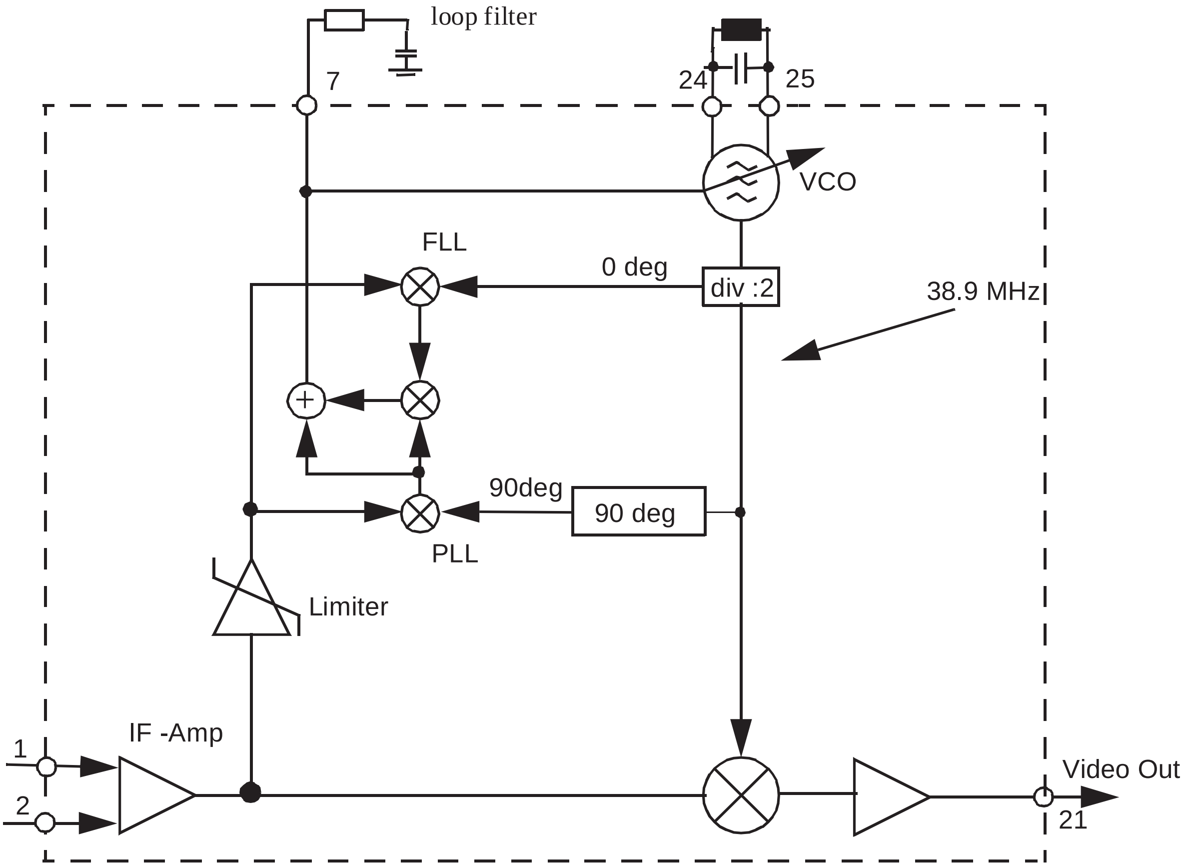


Fig. 2.3-1 Block diagram of the video demodulator and FPLL detector

The incomming vision IF signal will be demodulated by the 0 degree VCO signal and is given to the video amplifier via a low pass filter of around 17 MHz in between both blocks. From the IF input signal a limiter removes the amplitude modulation. The signal is then compared with the 0 degree VCO signal at the IF and also with the combination of the 90 degree shifted VCO signal which corresponds to an differentiation. So not only phase but also frequency differences have an impact on the current which comes out of the phase detector and goes into the loop filter and we have the principle of an frequency phase locked loop (FPLL). For the first part of the locking time when the VCO is not nearby the IF frequency and has a frequency deviation mainly the FLL is working and after this fast tuning nearby the IF frequency the PLL part of the FPLL dominates and tunes out the phase difference. Internally the weighted FPLL output is once more mixed with the PLL output and this output is added to deliver the output current for the loop filter.

These loop filter elements have a great impact on the FPLL behaviour and the recommended values from practical experiences of the TDA9815 are : R=390 Ohm and C = 220nF.

In principle by increasing the loop bandwidth of the PLL the reaction time becomes smaller so the VCO will follow very quickly for example a FM distortion which is on the incomming picture carrier. By making the loop bandwidth smaller the PLL reacts more slowly and would not follow a disturbing phase jump very quickly. This is an advantage for overmodulation distortion because the PLL would not have to compensate a 180 degree phase jump in this case. For FM distortions of the picture carrier which might occur with old test equipment like the PM5518 or also at some transmitters(e.g. in India) this would be a disadvantage. The FM should be followed very quickly to avoid it to become remarkable on the intercarrier and therefore audible on the demodulated sound.

Another point to regard when designing the loop bandwidth is for example in the B/G standard the 250 kHz difference between the first and the second sound carrier IF. Frequencies which fall inside the loop bandwidth will be followed by the VCO. So if the loop filter bandwidth is greater tha 250 kHz picture spectrum contents of 250 kHz signals will be followed by the VCO. This means that the VCO is FM modulated with a 250 kHz signal and this could be audible on the second demodulated sound carrier (e.g. 5.5MHz) because the wanted information on this sound carrier are also FM modulated.To avoid an audio disturbance from video signals which are around 250 kHz +/- 1kHz for example the loop bandwidth has to be smaller than 250 kHz. Error mechanisms and more details are discussed in [AN96142].

The 90 degree shifted frequency from the VCO is used for the SIF mixer. It can be shown by calculation [Buhse1] that a high pass behaviour can be achieved for the part of the video IF spectrum which is the double sided part of the vestigal sideband spectrum. So by mixing with the 90 degree shifted VCO signal a highpass is added to the output of the intercarrier mixer which is usefull to suppress the unwanted frequencies. At the intercarrier output just the intercarrier frequency (5.5 MHz for example) is needed with the FM modulated bandwidth of the sound.

2.3.2 Composite video amplifier (pin 21)

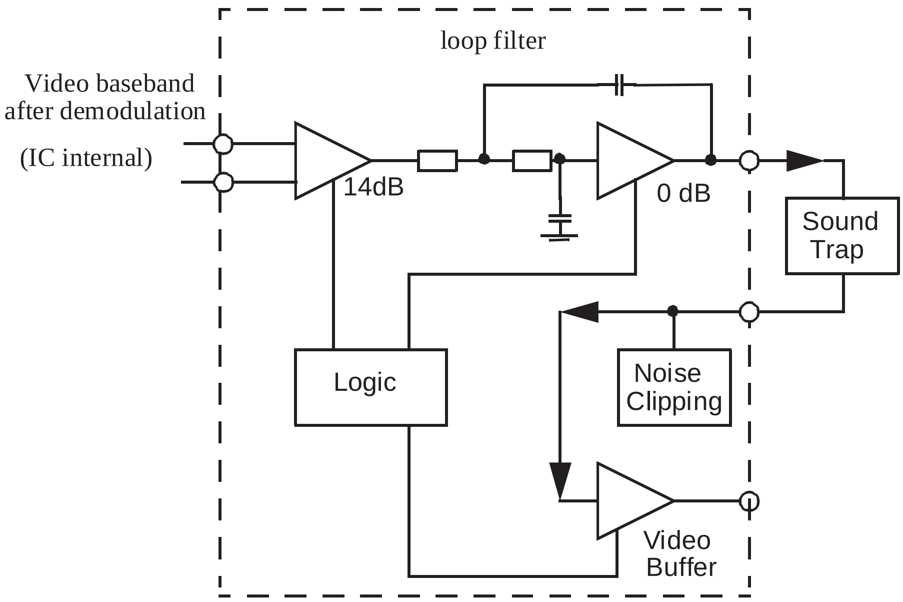


Fig. 2.3-2 Block diagram of the video amplifier with video buffer and noise clipping

The incomming baseband video signal is amplified by 14 dB in the video amp and by 7 dB in the buffer (1dB margin for losses in the external sound trap). The level shift OPAMP1 controlls the DC output level of the Video amp. This DC level is different for positiv modulated signals like they are in standard L and negativ ones like in standard B/G or M. The zero dB internal buffer stage with the Low Pass filter reduces the unwanted harmonics at the video output. Via a sound trap which reduces the residual sound intercarrier in the video baseband spectrum the video signal goes to the 7 dB output buffer which brings the amplitude to 2Vpp to be applied to the Scart interface.

2.3.3 CVBS buffer and noise clipper (pin 22, 10)

The block noise clipping monitors the input signals of the video buffer and limits them if they are greater than the internaly reference values which is not the standard signal condition.

2.3.4 VIF AGC (pin 28)

The AGC for the vision IF is described in chapter 2.1.1 together with the vision IF amplifier. The AGC detector block detects the peak value of the video signal(white for positiv modulation and sync for negativ modulation), compares it with an internal reference voltage and charges or discharges the AGC capacitor to produce the AGC voltage which is necessary to hold the video output at the wanted level.

For positiv modulation(Standard L) the black level of the video signal is detected (-> small signal amplitude for positiv modulation). In case of very small input signals the AGC reaction can be speeded up by an additional current. Also in case of missing white references in the video signal content or VITS pulses this internal circuit prevents for too strong IF gain .

To avoid overmodulation in standard L also the sync pulses are detected by a reference circuit and if the signals pass a threshhold voltage of an internally fixed value the phase detector(PD) current will be fairely disconnected from the AGC capacitor. Just a little rest activity(current in the loop filter) remains. So for standard L the VCO in this case runs without being controlled by the current delivered from the phase detector and so it runs for a moment free without being a controlled oscillator. We talk about “L-gating” for this concept. It avoids a jump of the phase of the VCO by 180 degree inverted phase in case of overmodulated video signals. This concept works directly only for positiv modulation because here for the syncs there should be a rest carrier of around 5% which often is not assured in France.So here simply the detection of the sync pulses is a criterion for small signals in any case whether they are overmodulated or not. All signals which are smaller than an internally fixed value result in a disconnection(without the “rest activity”) of the output of the phase detector to the loop filter.

The black level capacitor(pin 3) which is only needed in standard L holds the black level of the video signal constant. If the black level decreases for 150 mV (-6 dB video amplitude) an additional current sink is activated which helps to discharge the AGC capacitor to bring up the IF gain very quickly.In normal operation in standard L white signals and also the transmitted VITS pulses (originally implemented for standard B/G) are available. The VITS pulses can be assumed to be available every 20ms also in standard L. Then the currents for the AGC capacitor provide a tilt of maximum 1%.

2.3.5 SIF amplifier (pins 31, 32)

Fig. 2.3-3 shows the block diagram of the sound IF amplifier.

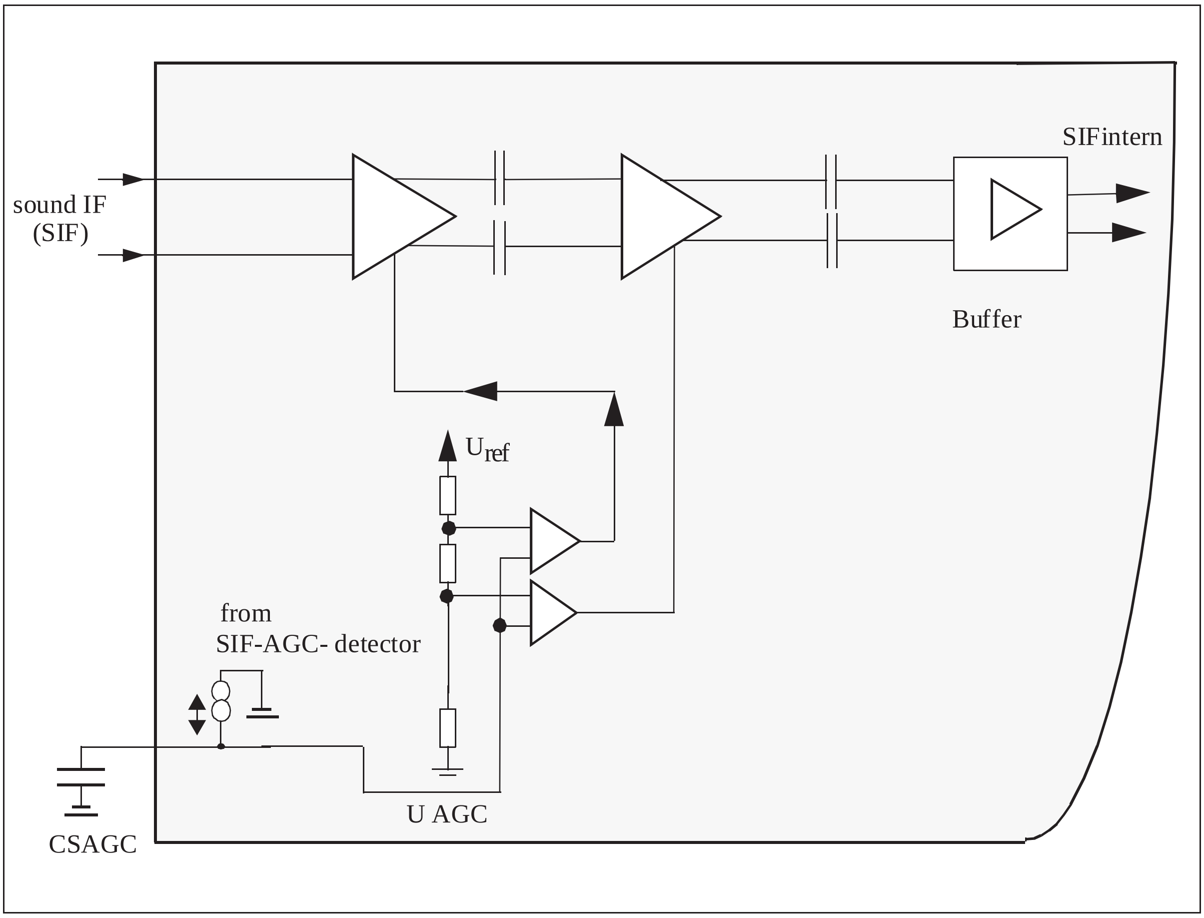


Fig. 2.3-3 Block diagram of the sound IF amplifier

It is very similar to the Vision IF amplifier but has just two stages. His main task is to amplify the incomming sound IF(for example in standard B/G 38.9 -5.5MHz = 33.4MHz for the first sound carrier) and to deliver a constant level at his output to the intercarrier mixer.

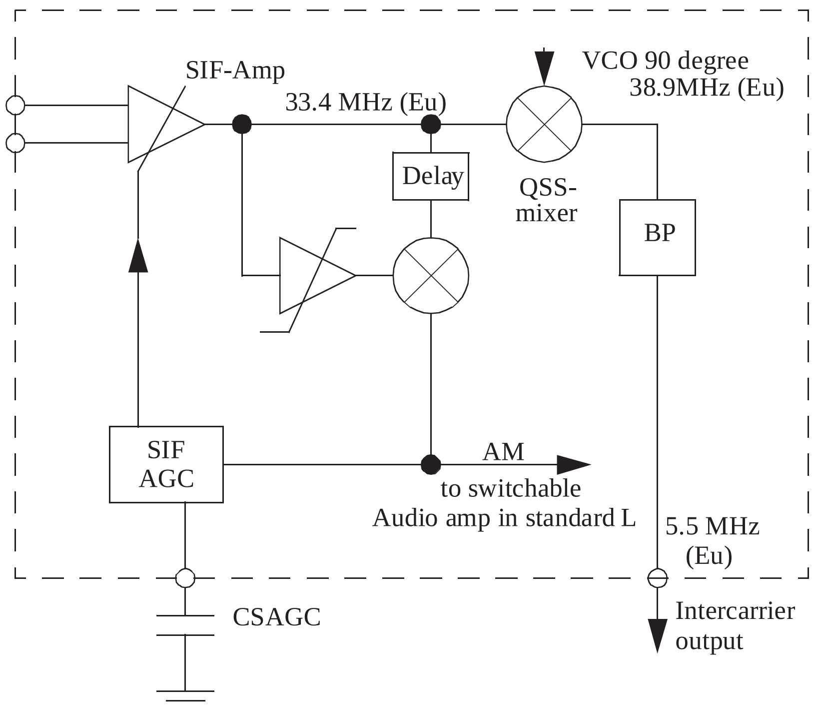


Fig. 2.3-4 Block diagram of the sound IF amplifier together with SIF AGC and intercarrier mixer

The amplified signal goes directly to a mixer where it is mixed with itself after the AM is removed by a limiter. At the output of this mixer(not the intercarrier mixer) a signal level dependend voltage is produced. For AM modulated signals like in standard L the output of this mixer is directly the wanted audio frequency which is given to the audio output amplifier of the TDA9819. For the FM modulated sound carriers like in standard B/G , M or D/K for example this signal can be interpreted as a level information which controlls the current into the SIF AGC capacitor. The voltage at this capacitor controls directly the control input of the SIF AGC amplifier.

The FM modulated sound carrier signals go after the SIF amplifier to the intercarrier mixer where they are mixed with the 90 degree phase shifted VCO signal. The output is the FM modulated intercarrier signal (4.5MHz for example or also the BTSC modulated signal in standard M where even stereo can be done with just one transmitted sound carrier). This intercarrier goes via the corresponding external band pass (for example 5.5MHz for B/G mono or 4.5MHz for the USA) back to the internal limiter and FM demodulator of the TDA9819. Here the signal is demodulated by being mixed with a carrier from a completely integrated R/C oscillator and is given to the audio output.

So here just a BTSC decoding IC like the TDA9850 is needed for a complete analog stereo TV system in standard M for the USA. In standard B/G a complete mono application can be done alone with the TDA9819. For stereo demodulation a second FM demodulator IC is needed or the intercarrier output can be given directly to a digital sound processing IC like the TDA9875.

2.3.6 SIF AGC detector and SIF AGC (pin 8)

The SIF AGC detector is related to the SIF input signals (average level of AM or FM carriers) and controls the SIF amplifier to provide a constant SIF signal to the AM demodulator and single reference QSS mixer. The SIF AGC reaction time is set to ‘slow’ for nominal video conditions. But with a decreasing VIF amplitude step the SIF AGC is set to ‘fast’ mode controlled by the VIF AGC detector. In FM mode this reaction time is also set to ‘fast’ controlled by the standard switch[5]. This block is described together with the SIF amplifier in the previous chapter 2.3.5 in more detail.

2.3.7 Single reference QSS Sound IF mixer (pin 20)

Single reference means that the VCO for the VIF demodulation and for the SIF intercarrier generation has the same reference and that no separate VCOs and tank circuits are necessary in the soundpath like in older concepts. For more detailled description of the mixing block refer also to chapter 2.3.5.

2.3.8 Limiter amplifier and FM detector (pin 17,14)

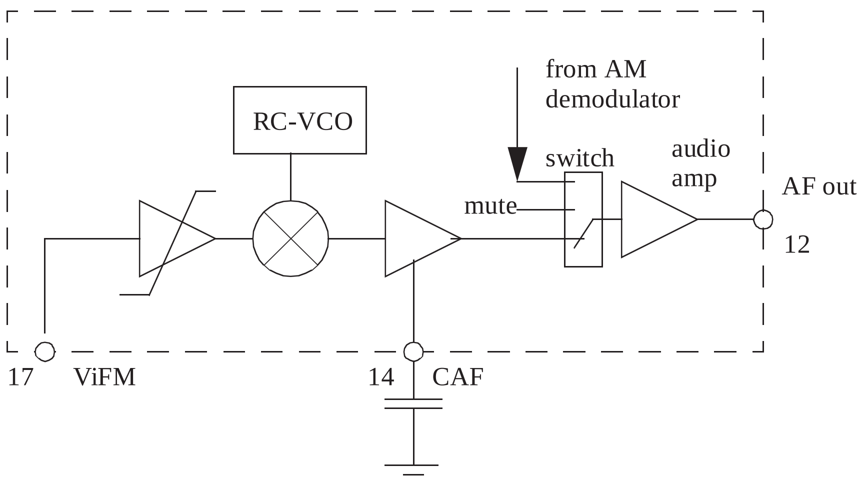


Fig. 2.3-5 Block diagram of the limiter amplifier , FM detector and audio amp(pin 17,14,12)

The FM modulated intercarrier signal(5.5MHz for example) is fed after a limiter to the input of a FM demodulator. The VCO is a completely integrated R/C oscillator. The output goes to the internal audio amplifier which is switched depending on the used mode to the output of the AM demodulator , to the FM demodulator output as described in this chapter or to a mute control signal if it is not used like in DVB mode.

5. data sheet TDA9819

2.3.9 Audio amplifier (pin12)

Figure 2.3.8-1 shows also the block diagram of the audio amplifier. The audio amplifier consists of two sections the preamplifier and the audio output amplifier. The preamplifier is an OPAMP which amplifies due to the decoupling by the external CAF only the AC part of the audio frequency(AF) signal which comes from the FM demodulator. The DC variation which depends on the actual frequency of the demodulator is suppressed. At the output of this stage assuming an FM deviation of 50 kHz an AF voltage of 3Vpp is internally available. The gain of the audio amp can be reduced by inserting a resistor in series with the CAF according to the data sheet. This internally 3Vpp is added to a DC of half the Vp.

This voltage goes internally to the switchable audio output amplifier which selects between the AM demodulated AF and the described FM demodulated AF or a mute status in case of DVB mode.

So just for the AM sound when the FM-demodulator is not used (standard L) the CAF1 is not necessary and can be left omitted. The AF output voltage is 500mVrms either for 54%AM or 27kHz deviation FM. As described before if the audio part is not used(DVB mode) the Cref at the voltage stabilisation block at pin 26 is not necessary and can be omitted.

2.3.10 AM demodulator

This block is described together with the SIF amplifier in chapter 2.3.5.

2.3.11 VCO adjust (pin11)

Following the adjustment procedure described in chapter 4.4 were the demoboard of the TDA9819 is set to work first the DVB frequency has to be adjusted. When setting the oscillator to the analog TV mode an additional internal varicap is added. To tune this frequency without detuning the coil or changing the VCO ext voltage(that would result in a detuning of the middle of the varicap range -> phase noise could be a bit decrease) another adjustment is necessary. This adjustment is done by applying a voltage to the added varicap pair. This adjustment can be done at this VCO adj input in analog TV mode. The block diagram of the internal varicaps is given in chapter 2.2.3 in chapter 2.4.1 some more explanations were given how to tune the VCO frequencies in other ways for example with an external varicap for three possible frequencies if also standard L accent is need

2.4 Blocks used only for DVB mode

2.4.1 DVB mixer and VCO (pin 16)

Pin 16 is the DC voltage input pin to control the VCO frequency. The frequency versus V16 curves are given in the data sheet. It should be noted that if no external voltage is applied to this pin an internal temperature compensated voltage is at this pin so that also in this case the VCO has a defined DC voltage at its control pin. So to run the VCO as an oscillator at a fixed frequency the simplest way is to leave this input not connected.

If the VCO should be used as a quartz stabilized fixed frequency oscillator it is possible to overrule the VCO tank circuit inputs by an external oscillator.

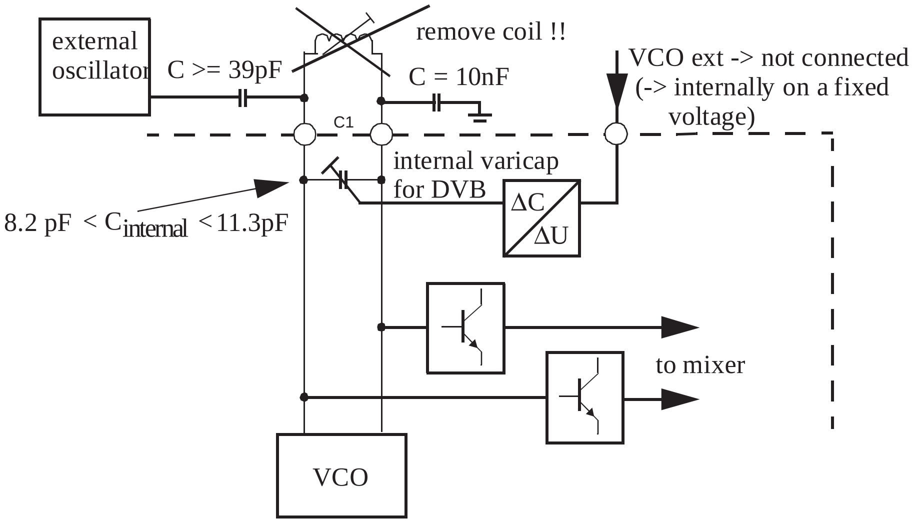


Fig. 2.4-1 Quartz stabilized external oscillator injection into the TDA9819 by removing the tank circuit

From lab tests with an external generator the values in figure 2.4-1 were found. The output frequency of the downconverter(6.9MHz) for example drops very sharply within a 1 or 2 dB step if the oscillator input level is reduced too much. So the needed value can be found with a security margin(3 dB) to be around 103dBuV.

The external oscillator would require just one external transistor and a few components like Cs, the crystal and some resistors for biasing.

* temperature compensation

For the temperature compensation of the tank circuit we will now do some calculations which will result in a recommendation for the temperature coefficients for the TDA9819. Even if you do all the following recommended temperature compensation actions for the analog mode there is at the actual version of the TDA9819 still a problem which requires two external resistors at the tank circuit application.(see chapter 6 - FAQs , question no. 7)

The tank circuit of the TDA9819 consits of an external coil and capacitance in combination with the internal varicap. Figure 2.2-7 shows the principle block diagram. When switched in the B/G mode for Europe for example internally a second varicap is added. The goal of the following calculation is to determine the needed temperature coefficient for the external capacitance to compensate the temperature coefficient of the coil.

The internal capacitances are assumed to be temperature compensated. The temperature compensation will be done for the DVB frequency and we will calculate the impact on the second frequency for analog mode.

To have a compensated tank circuit the following equation has to be valid:

$$f_{DVB} = \frac{1}{2\pi\sqrt{L \cdot (C_{ext} + C_{DVB})}} = \frac{1}{2\pi\sqrt{(L + T_L \cdot \Delta\vartheta_L L) \cdot [(C_{ext} + T_C \cdot \Delta\vartheta C_{ext})_{EXT} + C_{DVB}]}}$$

temp. compensate

$$\Rightarrow \quad L \cdot (C_{ext} + C_{DVB}) = (L + T_L \cdot \Delta\vartheta_L L)\,[\,(C_{ext} + T_C \cdot \Delta\vartheta C_{ext}) + C_{DVB}]$$

$$L \cdot C_{ext} + L \cdot C_{DVB} = (L + T_L \cdot \Delta\vartheta_L L)\,(C_{ext} + T_C \cdot \Delta\vartheta C_{ext} + C_{DVB})$$

$$\Rightarrow \quad LC_{ext} + L \cdot C_{DVB} = L \cdot C_{ext} + L \cdot C_{ext} \cdot T_C \cdot \Delta\vartheta + L \cdot C_{DVB}$$

$$+ T_L \cdot \Delta\vartheta \cdot L \cdot C_{ext} + T_L \cdot \Delta\vartheta \cdot L \cdot T_C \cdot \Delta\vartheta \cdot C_{ext} + T_L \cdot \Delta\vartheta \cdot (L \cdot C_{DVB})$$

sorting for T_C

$$\Rightarrow \quad -L \cdot C_{ext} \cdot T_C \cdot \Delta\vartheta_L = T_L \cdot \Delta\vartheta \cdot L \cdot C_{ext} + T_L \cdot \Delta\vartheta \cdot L \cdot C_{DVB} + T_L \cdot T_C \cdot \Delta\vartheta \cdot \Delta\vartheta \cdot L \cdot C_{ext}$$

$$-T_C \cdot C_{ext} = T_L \cdot C_{ext} + T_L \cdot C_{DVB} + T_L \cdot T_C \cdot \Delta\vartheta \cdot C_{ext}$$

$$= T_L \left(C_{ext} + C_{DVB} + T_C \cdot \Delta\vartheta \cdot C_{ext} \right)$$

$$= T_L \cdot C_{ext} \left(1 + \frac{C_{DVB}}{C_{ext}} + T_C \cdot \Delta\vartheta \right)$$

assumptions: T_C is a value assumed to be some tens or more ppm that means:

$$T_C \sim 10^{-6} \left(1\text{ppm} \quad \text{or} \quad \text{more}\right)$$

$$\Delta\vartheta - 20\ldots + 70 \sim 100 \;=\; 10^{2}$$

$$\Rightarrow \qquad T_C \cdot \Delta\vartheta \sim 10^{-4}$$

$$\Rightarrow \qquad T_C \cdot \Delta\vartheta \ll 1 + \frac{C_{DVB}}{C_{ext}}$$

leads to:

$$-T_C \cdot C_{ext} = T_L \cdot C_{ext} + \left(1 + \frac{C_{DVB}}{C_{ext}}\right)$$

$$\boxed{\Rightarrow \qquad T_C = -T_L \left(1 + \frac{C_{DVB}}{C_{ext}}\right)}$$

with:

8,2 - 1,5pf 8,2 + 1,5pf

$$C_{DVB_{min}} \;=\; 6,7\text{pf} \qquad , \qquad C_{DVB_{ma}} \;=\; 9,7\text{pf}$$

$$C_{ext_{min}} \;=\; C_{ext_{max}} \;=\; 5,6\text{pf}$$

$$C_{ext} \;=\; 5,6\text{pf} \pm \left(0,25\text{pf}\right)$$

$$T_{Lmin} = -120\text{ppm}; T_{Lmax} = +180\text{ ppm}$$

$$\Rightarrow \quad T_{C\,1} = -T_L\left(1 + \frac{C_{DVB}}{C_{ext}}\right) = -(-120\ \text{ppm}) + \left(1 + \frac{6,7\text{pf}}{5,6\text{pf}}\right)$$

$$= +264\ \text{ppm}\ (C_{DVB\ min})$$

$$T_{C2} = -T_L\left(1 + \frac{C_{DVB}}{C_{ext}}\right) = -(-120\ \text{ppm}) + \left(1 + \frac{9,7\text{pf}}{5,6\text{pf}}\right)$$

$$= +328\ \text{ppm}$$

$$T_{C3} = -T_L\left(1 + \frac{C_{DVB}}{C_{ext}}\right) = -(+180\ \text{ppm}) + \left(1 + \frac{6,7\text{pf}}{5,6\text{pf}}\right)$$

$$= -395\ \text{ppm}$$

$$T_{C4} = -T_L\left(1 + \frac{C_{DVB}}{C_{ext}}\right) = -(180\ \text{ppm}) + \left(1 + \frac{9,7\text{pf}}{5,6\text{pf}}\right)$$

$$= -491\ \text{ppm}$$

The Tc of the coils vary very strongly and so the TC for the external C is in the range of:

$$-491 < T_{C\ ext} < +328\ \text{ppm.}$$

This does not lead to a result so a typical coil of the given type for Europe was measured and the T_L was:

$$T_L = +178\ \text{ppm.}$$

This leads to the recommended T_L of the external $C_{ext\ middle}$

$$T_{C\ ext} = -T_L\left(1 + \frac{C_{DVB}}{C_{ext}}\right) = 178\left(1 + \frac{8,2}{5,6}\right) = -440\,ppm$$

With the same calculation we will get for the C_{BG} which is

$$C_{BG} = C_{DVB} + 3,1\ pF$$

added internal vary cap. just the $C_{o\ add}$ - value

$$C_{BG} = 8,2 + 3,1$$

$$= 11,3\ pf$$

$$T_{C\ ext} = -T_L\left(1 + \frac{C_{BG}}{C_{ext}}\right)$$

$$= -178\left(1 + \frac{11,3}{5,6}\right) \Rightarrow T_{C\ ext} = -537\ ppm$$

When switching to the normal TV mode (standard BG, L in Europe and standard M in the USA) an internal vary cap is added. The mid value of this capacitance is around 5,6 pf.

By a voltage at pin 11 (VCO ADJ) this variable capacitance can be tuned within a small range. For the temperature compensation only the mid value was taken.

So with the assumption of :

1) $C_{DVB} \neq \delta(\Delta\vartheta)$ (internal vaibable capacitances are temperature compensated)

2) $C_{BG} \neq \delta(\Delta\vartheta)$ (internal variable capacitances are temperature compensated)

3) $T_L = +178$ ppm (measured)

we get:

$$T_{C\ ext} = -440 \text{ ppm for DVB mode}$$

$$T_{C\ ext} = -537 \text{ ppm for B/G mode}$$

to make a compromise between these results the recommended value for T_{Cext} is

$$T_{C\ ext} = \cap 470 \text{ ppm} \Rightarrow \text{blue strip if not available} \rightarrow \text{n } 330 \text{ (green)}$$

* application for standard L accent

Another point should be mentioned at this place. Because of the internal coupling the VCO will latch up to one side and will not work any more if there is no DC path between pin 24 and 25. So it has to be asured that for every external tank circuit a DC path between these pins is available.

When also L accent is needed for analog TV mode in France a third frequency has to be switched. Standard L accent specifies channels in the lower VHF tuner band where the picture carrier and the sound carrier are switched for 5MHz in the opposite direction, so sound carrier up and vision IF carrier down and so lower than the sound IF carrier at 33.9 for example and the sound carrier is 6.5 MHz above at 40.4MHz. This requires the PLL to lock at the picture IF carrier at 33.9 MHz.

So to drive the DVB mode with 43MHz, analog TV mode B/G or L with 38.9 MHz and also the 33.9MHz for the L accent mode we have to do an external application because the TDA9819 just can switch internally between 2 frequencies. Figure 2.4-2 shows an external tank circuit application by which 3 frequencies can be switched by a voltage given to the external varicap.

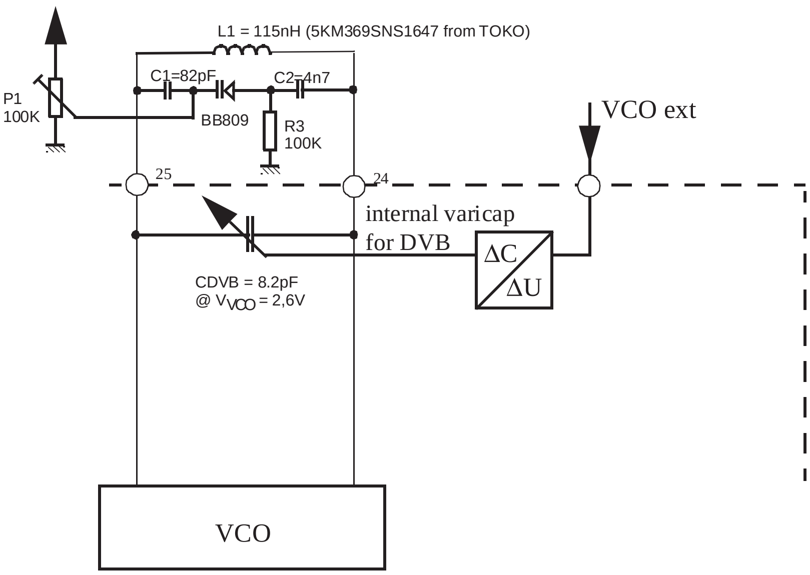


Fig. 2.4-2 External tank circuit with a third frequency for standard L accent mode

2.4.2 DVB output buffer (pin 18)

The DVB output buffer delivers according to the data sheet a peak to peak voltage of 2.1V which can be adjusted in internal AGC mode by applying an AGC adjust voltage. The external DVB AGC has no influence in this case. Also when switched to external AGC mode the voltage at the AGC adjust pin has no influence on the DVB output signal.

2.4.3 DVB AGC, internal, external, AGC adjust (pins 13,15,28)

For the DVB operation a peak AGC detector is activated. The peak value of (digital) QAM signal is detected and controlled to a constant value by the variable VIF amplifier. The detector bandwidth is adapted to the signal frequency (3 to 11 MHz). The external AGC time constant is given by the VIF AGC capacitor at pin 28. The DVB output signal VO DVB can be adjusted in a range of ±3 dB by a control voltage DVadj at pin 15. The internal AGC can be switched off (see Table 2 of the data sheet) and the IF gain can be controlled by an external voltage at pin 13.

It should be noted that either the internal AGC with the AGC adjust is working **or** the external AGC is working allone. In this case the AGC adjust voltage don't have an influence. Therefore the pin's AGC adjust and external AGC can be connected and the voltage applied to this pin is either interpreted as the AGC adjust voltage (internal AGC mode) or as the direct external AGC voltage(ext AGC mode).

3. Application block diagrams

3.1 Principal block diagrams for DVB IF processing and analog TV mode for Europe and USA

On cable systems in the US and European markets a QAM[6] modulated DVB[7] signal is transmitted.The tuner converts the incomming DVB signal to an IF of 43.75 MHz in the USA and 36.15 MHz in Europe. In the USA a channel bandwidth of 6 MHz and in Europe a bandwidth of 8 MHz on the cable allows a second IF of 5 MHz for the USA and 6.9 MHz or 6.875 MHz for Europe. Figure 3.1-1 shows the principle block diagram for the US DVB cable system

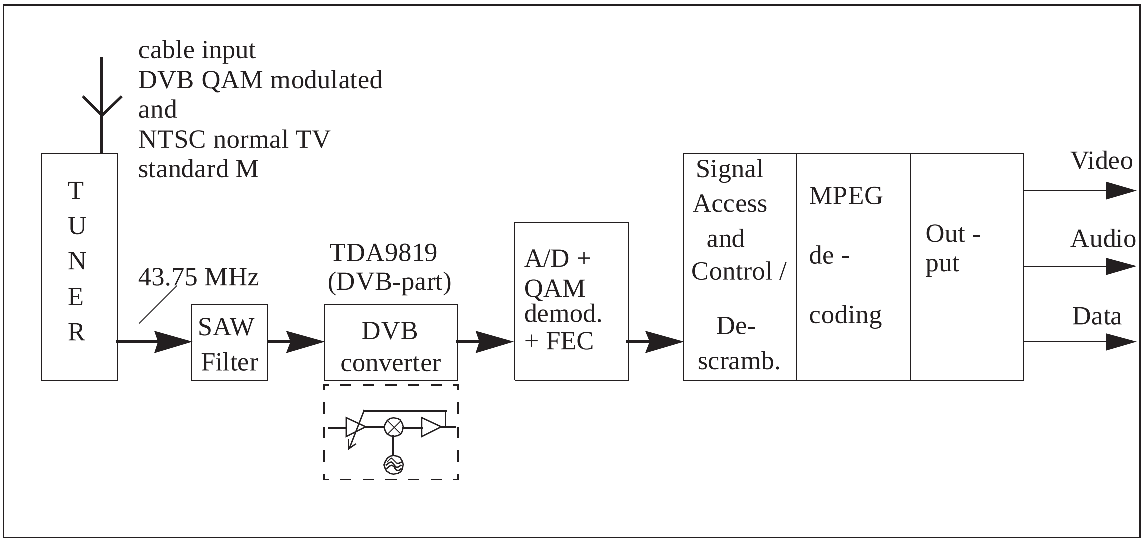


Fig. 3.1-1 Principle block diagram for the US DVB cable system

From the tuner a 43.75 MHz DVB IF signal is delivered. This IF passes a SAW filter (for example the X6964 from Siemens) and is applied to the IF AGC amplifier of the TDA9819. An oscillator which runs at twice the received IF(43.75 MHz) plus twice the symbol frequency (5 MHz) at 97.5 MHz is divided by two and mixed with the incomming IF down to 5 MHz. The LC- VCO is designed to be controlled by the QAM frequency recovery circuit from the Philips TDA8046 for example. Also other QAM demodulator ICs from for example Broadcom, NEC,VLSI (TIM2105),ComStream,Hitachi or others could be used.

The TDA9819 has the option of **internal** and **external** AGC. When using the external AGC the IF amplifier is controlled directly from the AGC recovery loop of the QAM demodulator IC. If this output of an external AGC is not available or should not be used the TDA9819 can be switched to internal AGC mode and so the output voltage is controlled automatically to a predefined value. Optionally the output amplitude can be varied in internal AGC mode to fit in an optimum way to the range of the following A/D converter.

6. QAM = Quadrature Amplitude Modulation
7. DVB = Digital Video Broadcast

In the TDA9819 there is an internal varicap parallel to external components(L,C) providing a resonance frequency of 97.5 MHz. At the DVB output of the TDA9819 also a low pass is included which gives a suppression of fundamental input signals and IF harmonics of typically 40 dB.

The QAM demodulator recovers the QAM modulation, the FEC does an forward error correction, the descrambling, (MPEG) decoding blocks deliver after the output stages the video, audio and data signals.

The TDA9819 is capable to do a conventional IF demodulation for standard M as well.

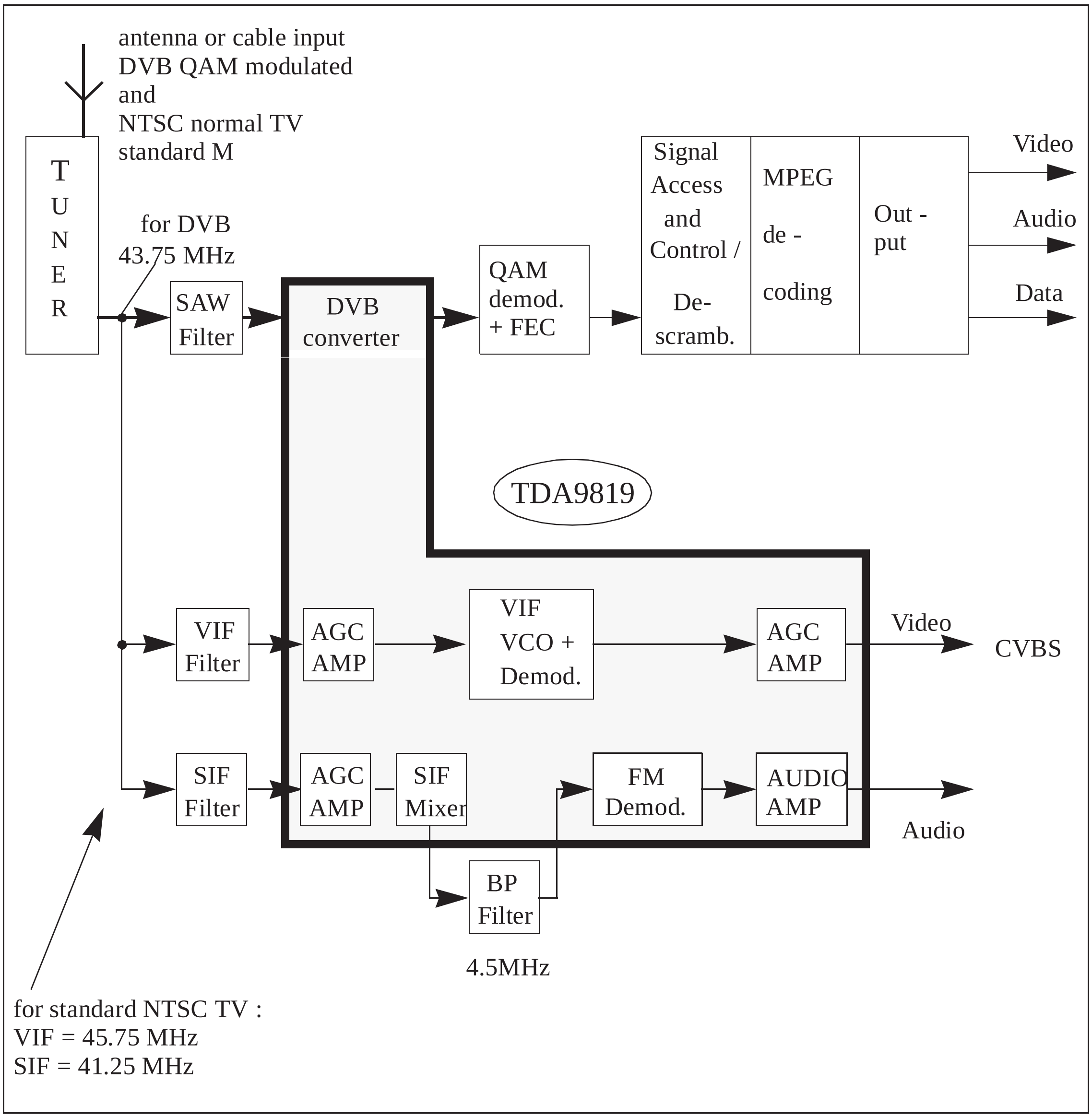


Fig. 3.1-2 Principle block diagram of a QAM modulated DVB cable system **and** standard analog TV (standard M) for the USA

As it can be seen from the above block diagram the complete IF signal handling for both the DVB QAM modulated cable signal and the NTSC standard TV mode signal can be done **within a single chip**.

The TDA9819 is a derivative of the TDA98XX IF IC family which is known on the US market as TDA9808 for several years. Figure 3 shows a block diagram of the TDA9819 chip. The complete data sheet can be loaded from the internet under: http://www.semiconductors.philips.com.

So with the TDA9819 a complete DVB - IF processing can be done. By changing the external components of the tank circuits European TV Standards can be applied as well.

Philips is working on a new QAM demodulator IC(TDA8047) which will include also the A/D converter and the FEC. In a concept with TDA9819 and TDA8047 also variable data rates can be used (under preparation).

Also for Vestigal Sideband (VSB) modulated signals for terrestrial TV in the USA in accordance to the Grand Alliance specification the IF downconversion with internal AGC can be done by the TDA9819. Concepts are under discussion which may use the same filter for VSB as for the QAM cable DVB (43.75MHz).
When switching to the normal US NTSC mode (Standard M) a QSS[8]- IF processing and demodulation can be done comparable to the Philips TDA9808 Vision and Sound IF functionality.

Figure 3.1-4 shows a block diagram with Philips ICs for the DVB cable **and** conventional TV mode application for the US market in a high quality QSS concept. The actual version of the QAM demodulator IC is the TDA8046.

The actual version of the TDA9819 includes **also a FM demodulator** to allow a FM demodulation of the 4.5 MHz intercarrier.

Figure 3.1-5 gives an application for the European market. Also standards like D/K , I and L can be done with the corresponding SAW filters. Standard L accent requires an external tank circuit switching application to meet a the required VCO frequency.

In summary the TDA9819 combines an DVB IF processing circuit for QAM modulated signals which converts 43.75 MHz to 5 MHz, internal and external AGC with conventional standard NTSC TV mode IF processing. For the NTSC mode it performs the same functions as the TDA9808. This allows a high quality QSS concept for the US stereo system.

From Philips there is also a tuner available which includes the TDA9819. This tuner in fact uses just the downconverting part of the TDA9819 .

8. QSS Quasi Split Sound - high sound performance concept with separate pahtes for sound and vision IF

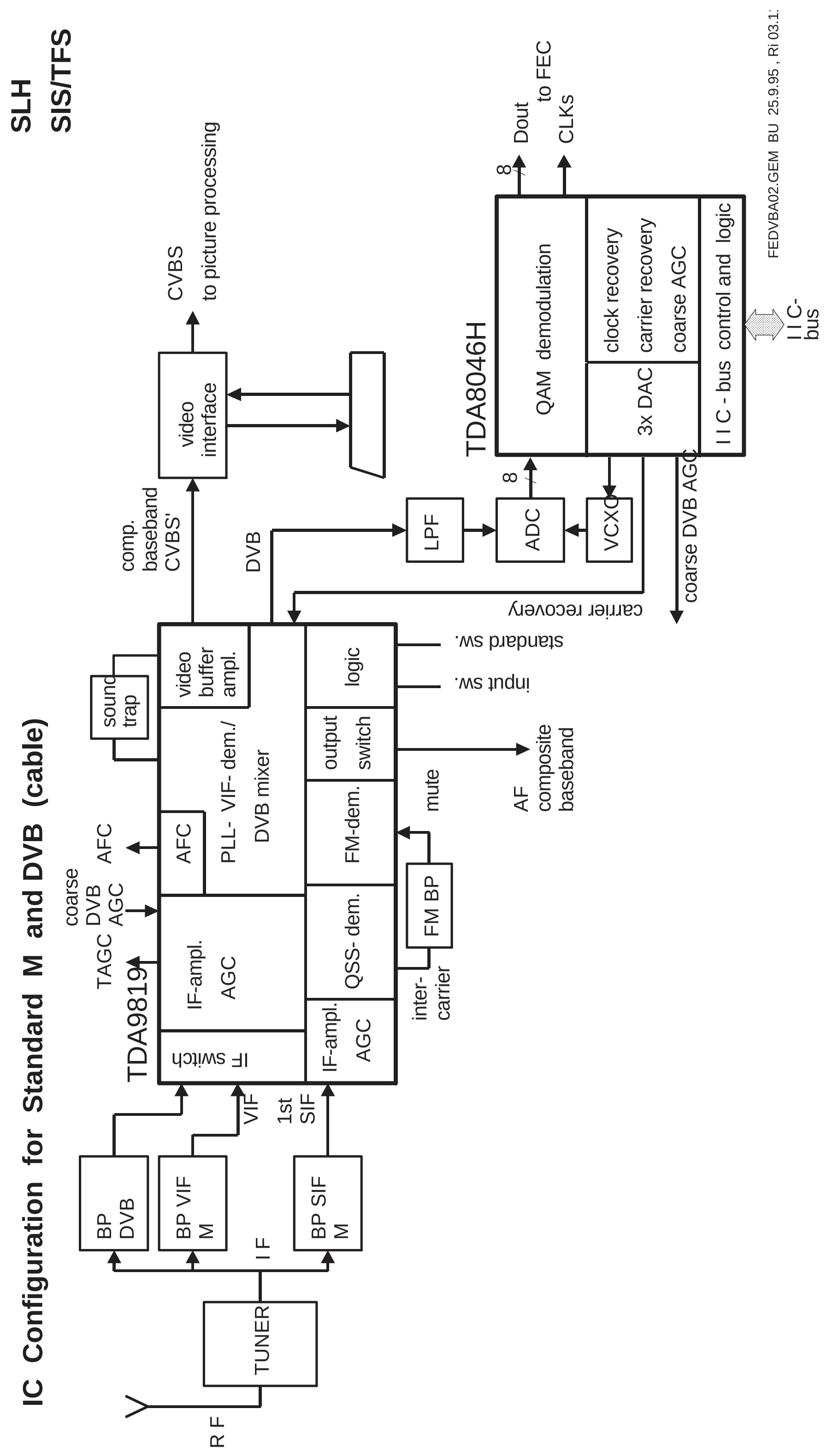


Fig. 3.1-3 DVB-IF and standard analog TV-IF concept with the TDA9819 for the USA

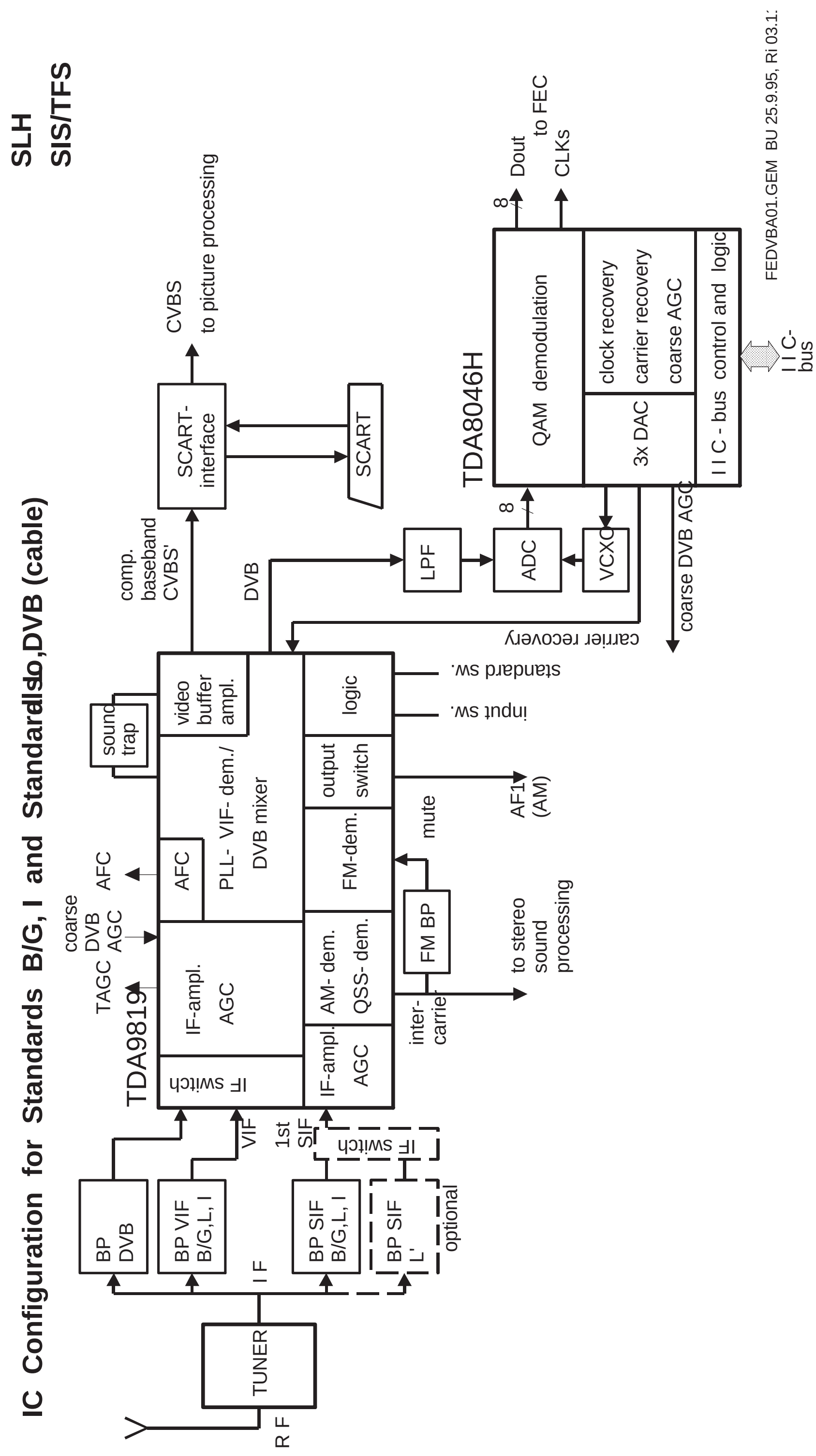
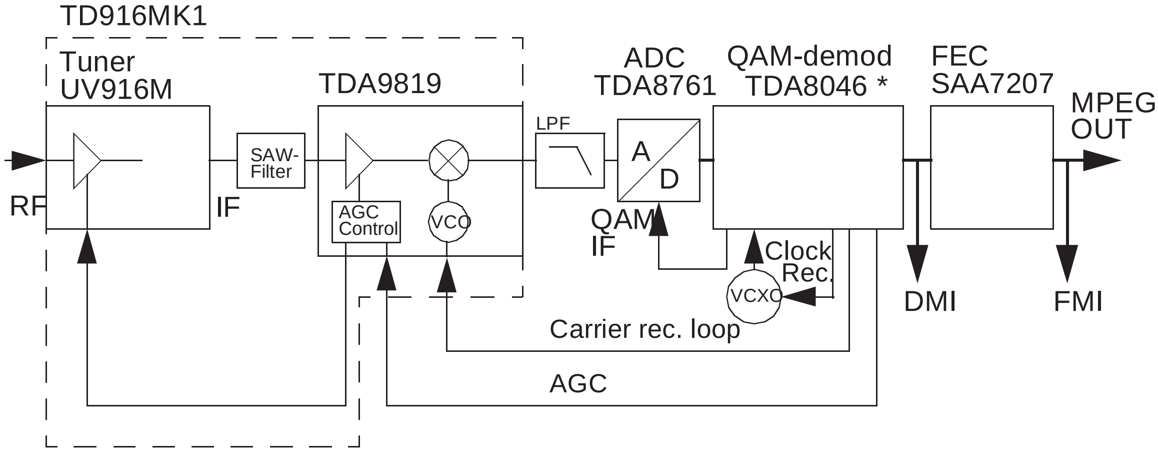


Fig. 3.1-4 DVB-IF and standard analog TV-IF concept with the TDA9819 for Europe

Fig. 3.1-5 shows the block diagram of an available front end from Philips TD916MK1 which includes the TDA9819. The QAM demodulation also here will be done with the TDA8046. So Philips offers a whole concept for the QAM cable demodulation chain. The TDA8046 and the successor TDA8047 both include ports to control and monitor the TDA9819 so the alignement can be done totally by software.



* in downconverter mode also the TDA8047 can be used
in this case A/D converter and FEC are included.

Fig. 3.1-5 Tuner frontend with IF downconverting and AGC control by the TDA9819

Since beginnig of 1997 the specifications of the VSB system in the USA are fairely settled and this system will become the standard for terrestrial transmission in this huge market. Fig 3.1-6 shows a principle block diagram where instead of the QAM modulated cable signals the VSB modulated signals will be downconverted. Also in this application the complete high performance QSS analog TV part could be used for analog TV with full stereo demodulation for the US standard M. The transfer functions of the SAW filters are given to show their principle transfer functions.

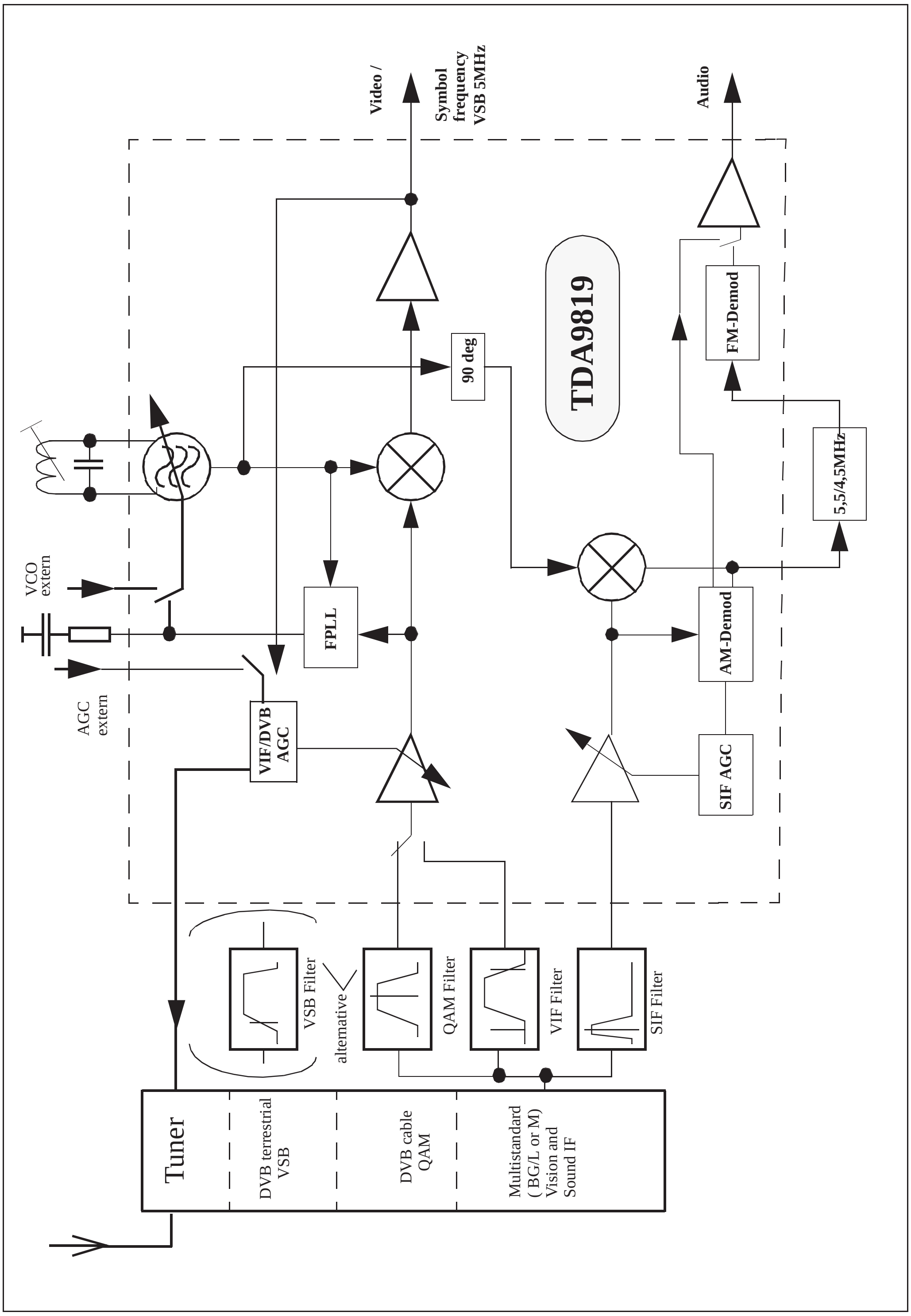


Fig. 3.1-6 Principle block diagram for VSB system IF downconverting and AGC control by the TDA9819

3.2 Example block diagrams and application circuits with the TDA9819 and TDA8046

To give a starting point for the application Fig.3.2-1 shows a basic application with the TDA9819 and TDA8045 which was the predecessor of the TDA8047. The loop filter elements of the TDA8046 have to be adapted according to the corresponding application notes and data sheets. This application just shows the DVB mode for the TDA9819 with the external AGC mode. A lot of customers use also the internal AGC mode a control externally the AGC adjust input. In DVB only mode internal VCO did not have to fit to two standards with the same coil. So there is more flexibility to choose this coil value and the VCO steepness. From that in this mode an optimal L/C ratio for the best phase noise performance can be applied (see chapter 5, application hints).

Figure 3.2-2 shows an application of the TDA9819 together with the TDA8046 in a demoboard of the TDA8046.

Figure 3.2-3 shows the corresponding TDA8046 circuit application of this board [with permission of Philips - System Lab Eindhoven (SLE)].

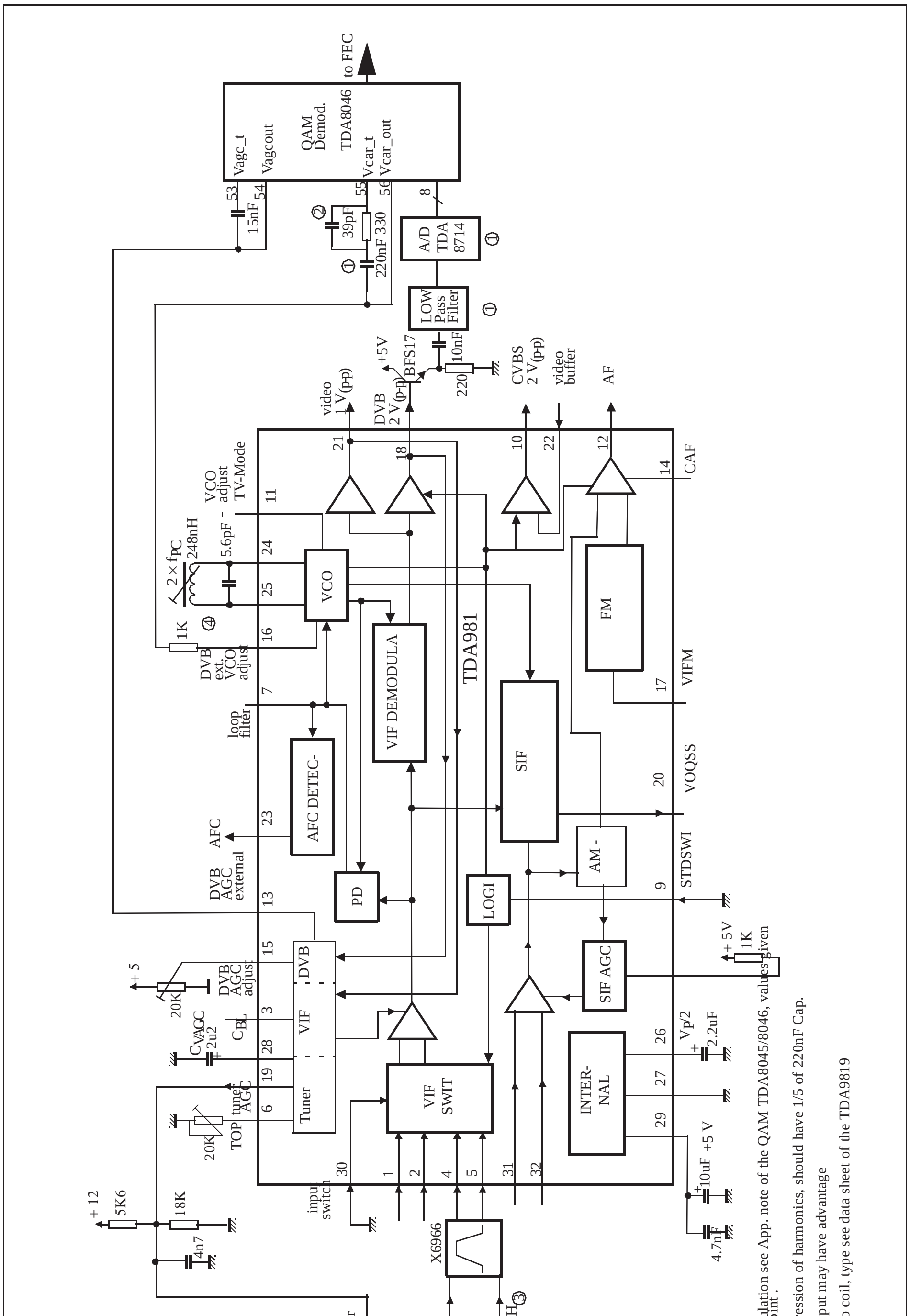


Fig. 3.2-1 Detailled block diagram for a DVB only version for Europe with external AGC

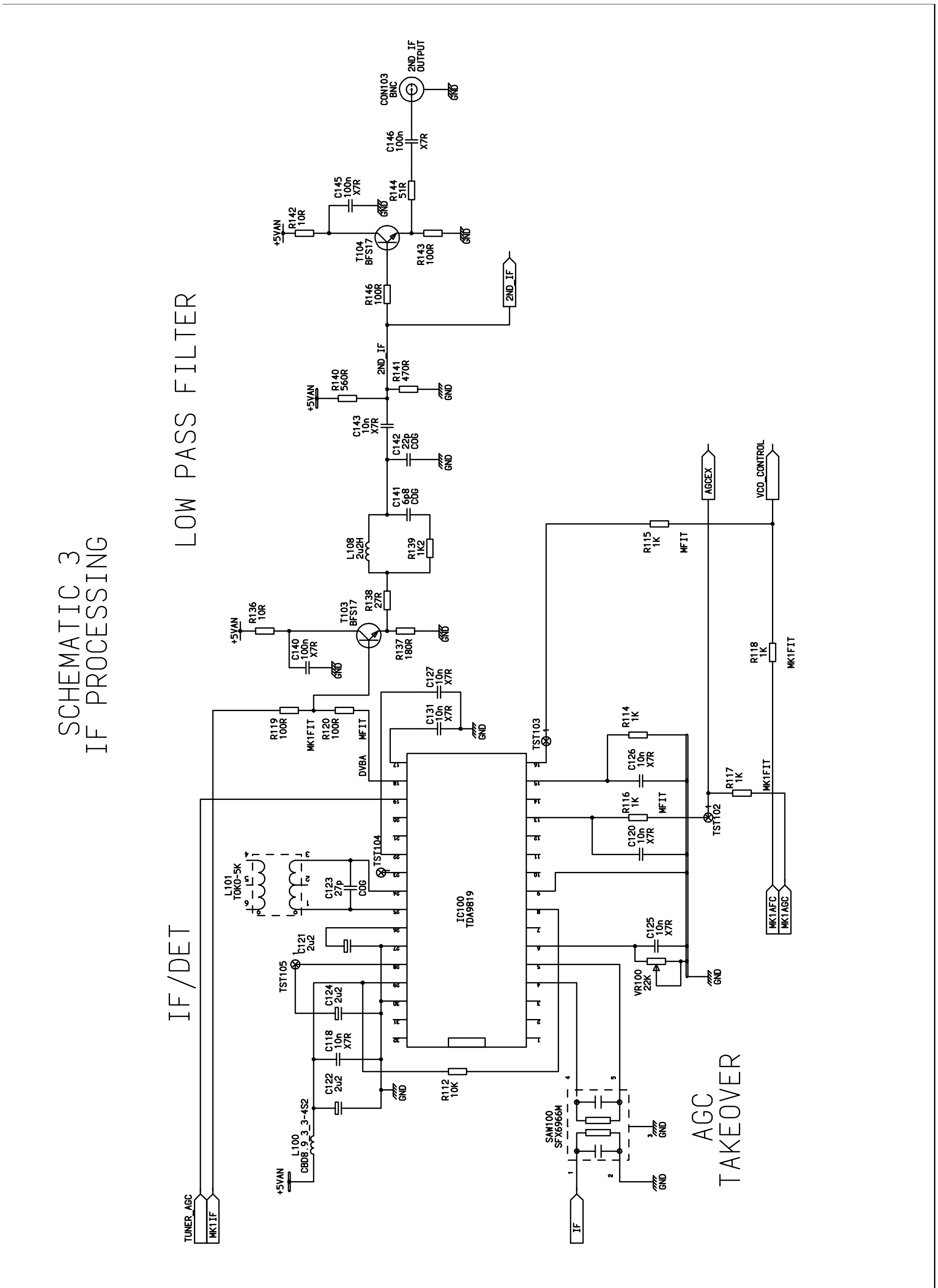


Fig. 3.2-2 Example of the TDA9819 application in a demoboard with the TDA8046 [with permission of Philips SLE]

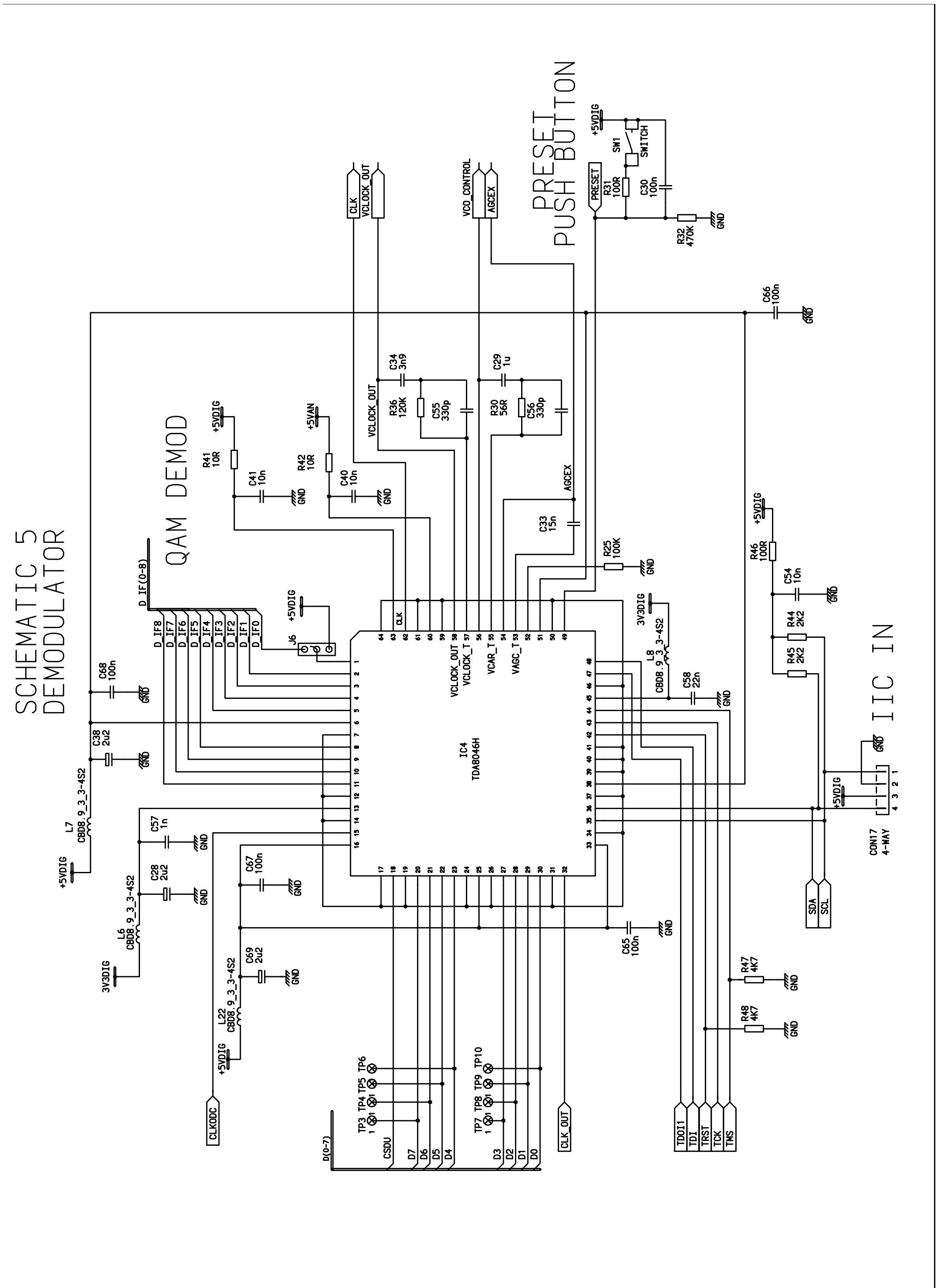


Fig. 3.2-3 Demoboard with the TDA8046 - circuitry for the TDA8046 part [with permission of Philips SLE]

4. Demo-board description of the TDA9819

4.1 General

The demoboard of the TDA9819 should gives the customer the possibility to make:

- measurements in DVB mode with internal and external AGC
- measurements in TV-mode standard M for USA or standard BG/L for Europe depending on applied tank circuit
- applications with the TDA9819

Mode selection:

The following table 1 gives an overview of modes which can be selected on the board by the jumpers J5 to J8 and the switches S1 and S2.

Tab. 4.1-1 Mode Selection of the Demoboard TDA9819

Tuner mode	SIF or SIF + VIF	TV mode	neg. Mod. pos. Mod.	Int. AGC Ext. AGC	Jumpers				Switches	
IF-mode	SIF/VIF	DVB	pos Mod	Ext. AGC	J5	J6	J7	J8	S1	S2
IF-mode	SIF/VIF	DVB	_______	Int. AGC	SIF	VIF	DVB	V+S	DVB	int
IF-mode	SIF/VIF	DVB	_______	Ext. AGC	SIF	VIF	DVB	V+S	DVB	ext
IF-mode	SIF/VIF	B/M	negMod	_______	SIF	VIF	DVB	V+S	VIF	neg
IF-mode	SIF+VIF	L	posMod	_______	SIF	VIF	DVB	V+S	VIF	pos
IF-mode	SIF	B/M	negMod	_______	SIF	VIF	DVB	SIF	VIF	neg
IF-mode	SIF	L	posMod	_______	SIF	VIF	DVB	SIF	VIF	pos
Tu nmode	SIF+VIF	DVB	_______	Int.AGC	TUN	TUN	TUN	V+S	DVB	int
Tu mode	SIF+VIF	DVB	_______	Ext.AGC	TUN	TUN	TUN	V+S	DVB	ext
Tunmode	SIF+VIF	B/M	negMod	_______	TUN	TUN	TUN	V+S	VIF	neg
Tunmode	SIF+VIF	L	posMod	_______	TUN	TUN	TUN	V+S	VIF	pos
Tunmode	SIF	B/M	negMod	_______	TUN	TUN	TUN	SIF	VIF	neg
Tunmode	SIF	L	posMod	_______	TUN	TUN	TUN	SIF	VIF	pos

Jumper J1 gives the possibility to measure the AFC current versus 2.5V , jumper J2 can mute the AF section. Jumper J3 can switch of the DVB output buffer and Jumper 4 the CVBS output buffer.

A tuner UV936E(UV916M for Europe) can be used optionally by inserting it into the prepared part of the board.

For the detailled alignment of the board and for setting the board to work please look at the chapter 4.4 “How to use the demoboard ”.

The PCB is either prepared for standard M or European applications. The values of the components in the tank circuit (L1 and C7) are assembled accordingly. The exact values of these components and the frequencies are given in the schematic and in the data sheet.

The input connectors are located on the one side the output connectors on the other side of the board. The DVB output is buffered to give the opportunity to add a low pass filter or just for easier connection of measurement equipment. On one corner of the board there are also some pads to allow applications directly on board for example the low pass filter.

For the IC two sockets are possible. Very first engineering samples often have a larger package which could be implemented also in this board.

For the second sound IF bandpass two bandpass filter types can be used with this board. For this reason there are 6 pins to connect the corresponding bandpass type. The filters with 3 pins you have to put on the right side of the socket so in pin 4,5 and 6. The right side here is defined the side you have on the right when you are looking on top of the board .

For using a tuner on this board you have to add some components and supply 12V and 40V (min 35V).

The board was tested with a UV936E tuner which is IIC-bus controlled. Please ask for a board with tuner if you are interested in. If you put the components and perhaps another tuner on the board for your own please be aware of the right orientation of connector ST2 which has to be rotated.The white printing on the board for this connector is wrong.

Schematic

The schematic of the board is given at the end of this chapter. On the tuner UV936E pin 17 is the IF output and has to be connected to the Jumpers J1, J2 and J3. Pin 16 has to be connected to ground. In the original schematic these pins are interchanged. Corrections were made by hand. In older demoboards R17 has to be changed to 11K and R18 to 56K.

Layout

The layout of the board is given at the end of this chapter. In the original layout pin 16 and pin 17 are interchanged. Corrections were made by hand on board.

4.2 Schematic

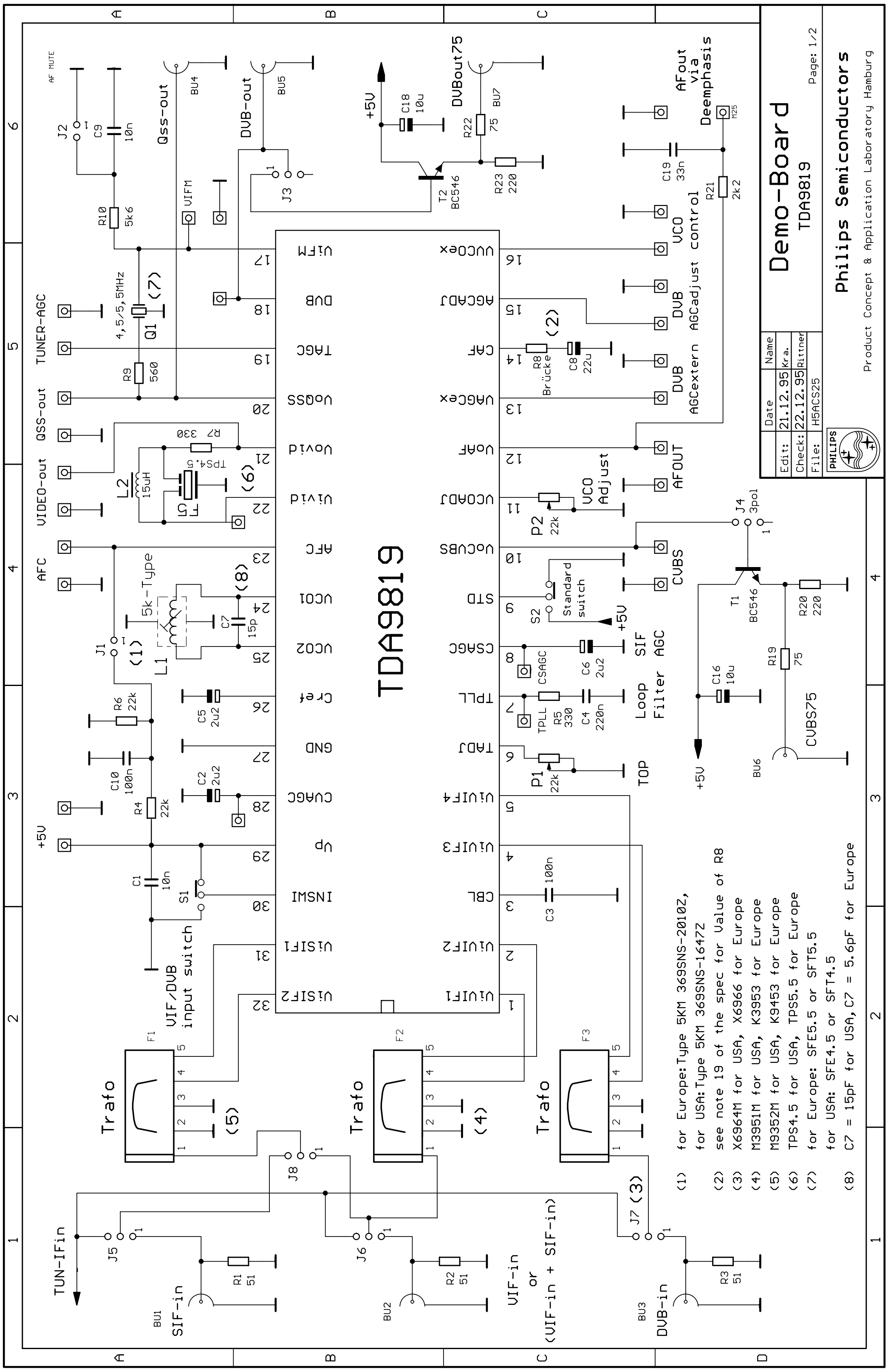


Fig. 4.2-1 Schematics H5VS25, Page 1

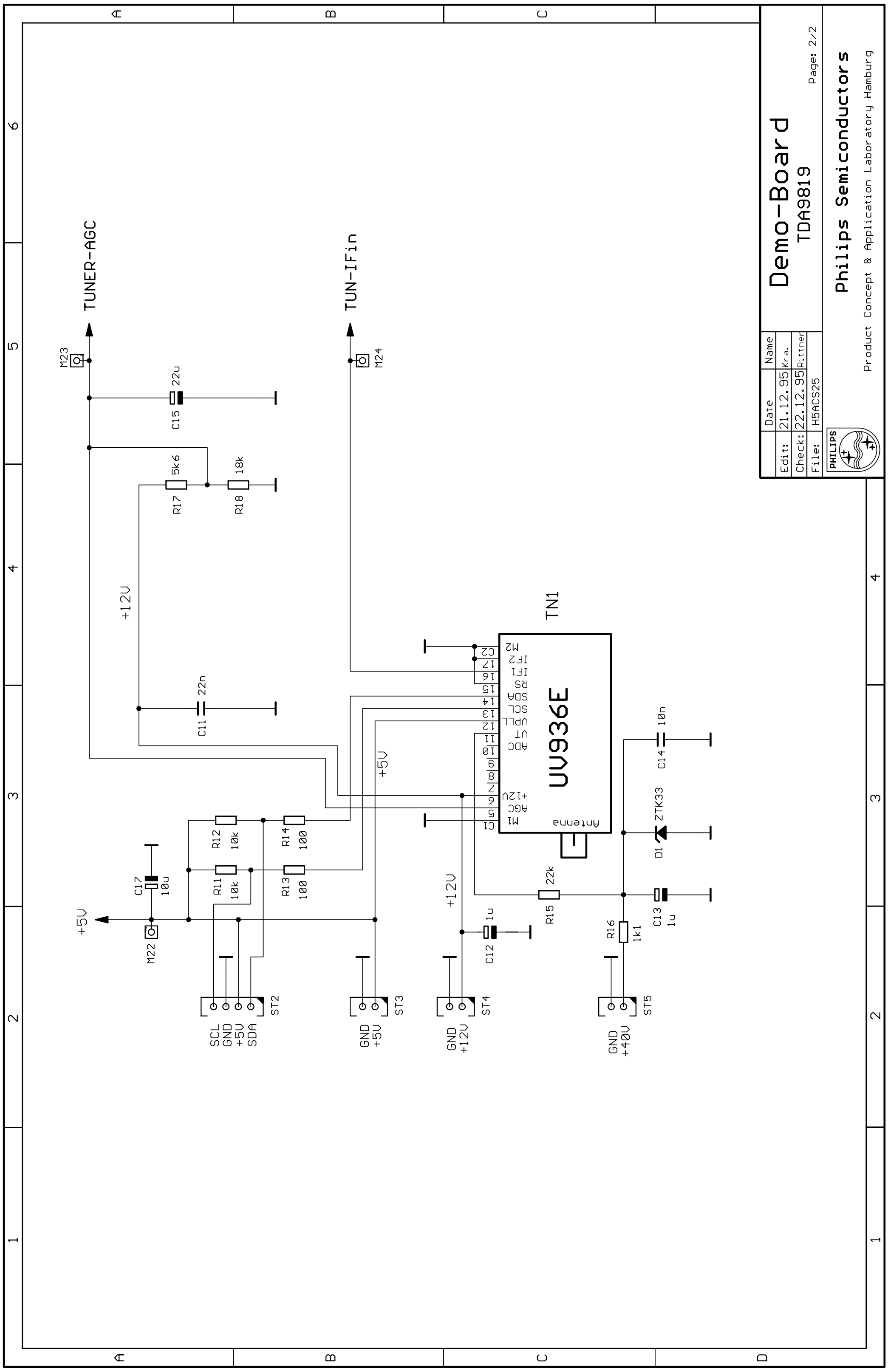


Fig. 4.2-2 Schematic H5VS25, Page2

4.3 Layout

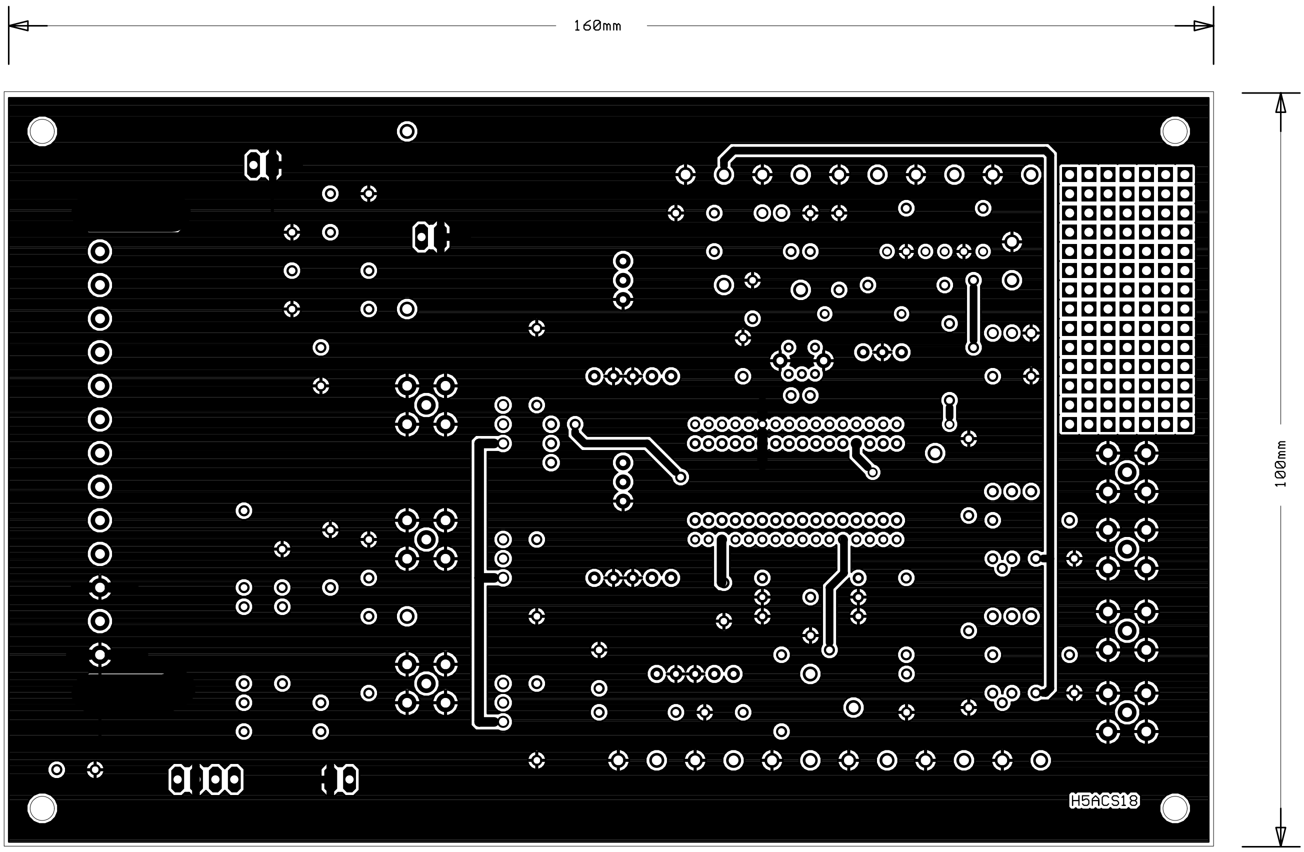


Fig.4.3-1 Board-Layout H5ACS25, Top-Layer

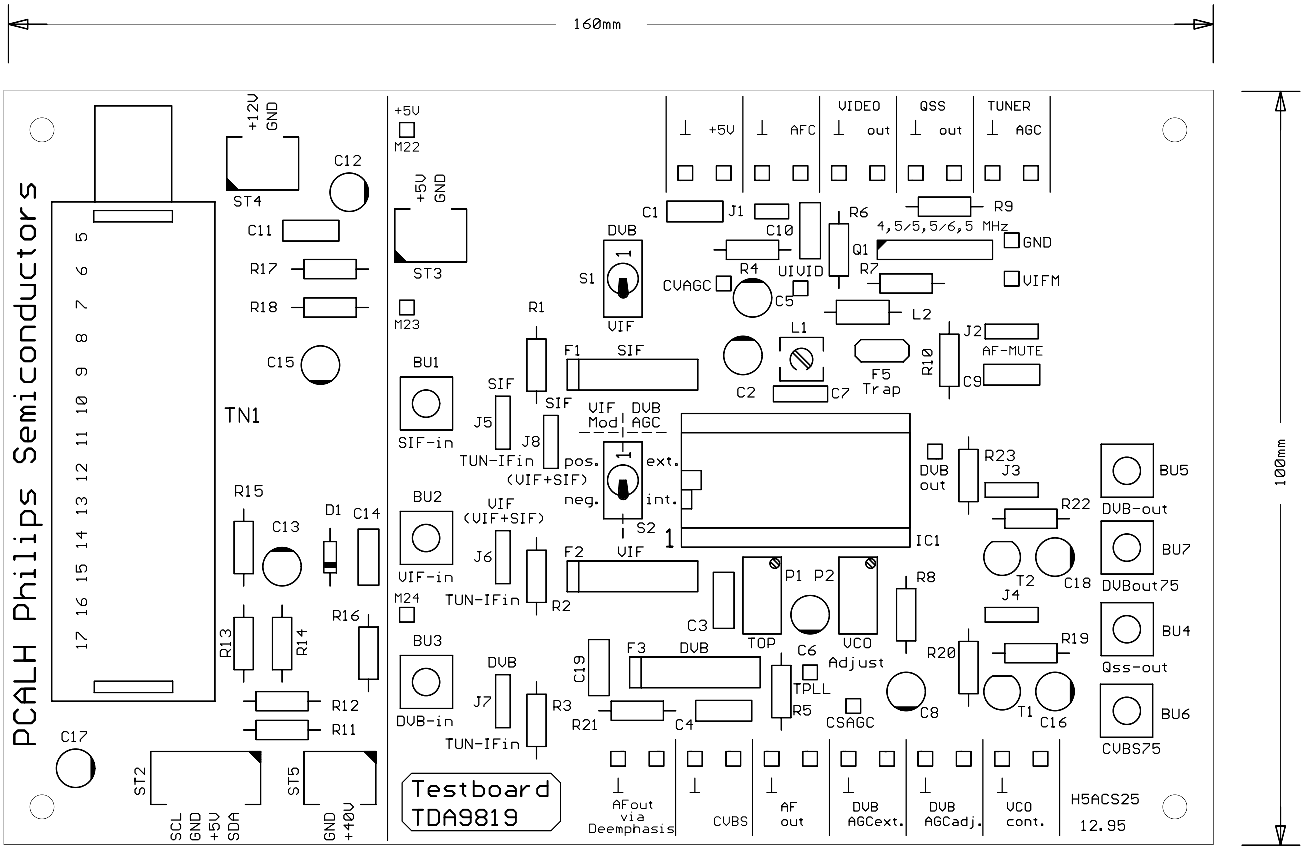


Fig. 4.3-2 H5ACS25, Placement of Topside Components

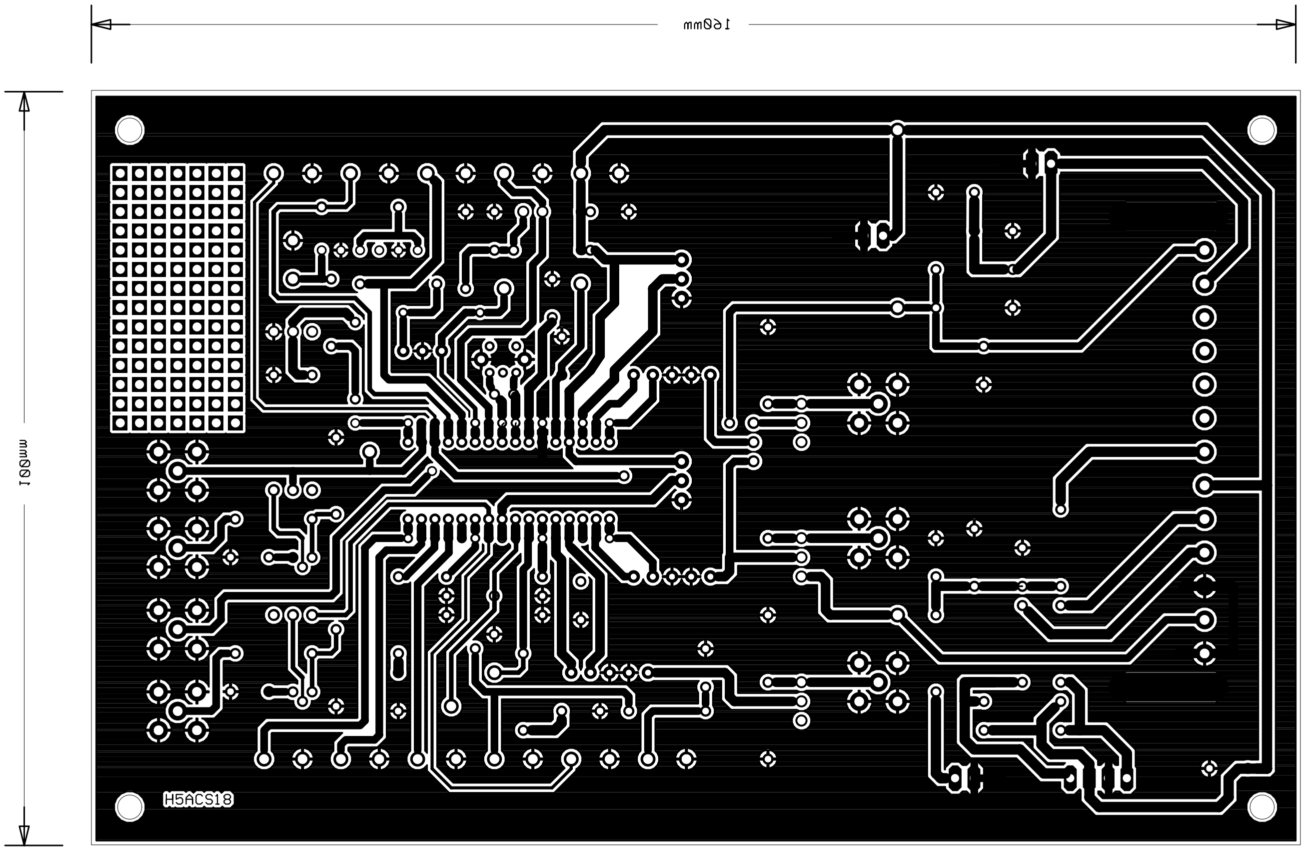


Fig.4.3-3 Board-Layout H5ACS25, Bottom-Layer

4.4 How to use the demoboard

To set the demoboard of the TDA9819 to work please follow the steps described below:

1)
Apply 5 V to the board if you use the IF part only.If you use the tuner UV936 (UV916M for Europe) apply also 12V and 40V (35 V also is sufficient for testing) .Be aware of the right orientation of the connector ST2 as mentioned at the end of chapter 2 . Please check also that pin 17 of the tuner is the IF output and that pin 16 is at ground.

2)
Insert trafos (1:1) or your SAW filter into the filter sockets.

3)
Switch to DVB mode with the input switch S1

4)
Apply a sine wave signal of 43.75MHz (36.15MHz for Europe) to the DVB input BU3 with 10 mV rms if you use a trafo or 100mV rms if you use a SAW filter. The SAW filter is supposed to have around 20 dB insertion loss. In other cases choose the amplitude so that around 10 mVrms are between the input pins 3 and 4 of the TDA9819.

5)
Apply a DC voltage to the VCOext pin on the board until you get 2.5V at the AFC output. This is the middle of the tuning voltage of the VCO.

6)
Tune the tank coil until you get a 5 MHz output signal at the DVB output for Standard M.
(6.9MHz for Europe).

7)
Now switch to TV mode with the input switch S1

8)
Apply a 45.75 MHz(38.9 MHz for Europe) sine wave signal to the input VIF+SIFin with an amplitude of 10 mVrms (trafo) or 100mVrms (SAW-filter)

9)
Tune with the potentiometer P2 at pin 11 until you get around 2.5V +/- 0.1V at the AFC output.
Now the internal varicaps are in the middle of their tuning range and the demoboard is adjusted for IF. For application with a tuner the take over point (TOP) can be choosen with the Poti P1. Figure 3 in the data sheet of the TDA9819 gives information about different TOP adjustments.

10)
With the voltage at the AGCadj input the voltage swing at the DVB output can be controlled (only when using internal AGC).

11)
By putting the standard switch to external AGC you can control the output signal at the DVB output via a voltage applied at the pin named “ExtAGC”.Figure 3 of the datasheet TDA9819 gives information of the AGC characteristic.

5. Application Aspects and practical hints

5.1 General hints

The following general hints can be given:

* keep the distance between SAW filter, tuner and TDA9819 as short as possible
* avoid crossing signal lines between SAW filter and TDA9819
* try to put the tank circuit as close as possible to the IC
* if possible use double sided board for better grounding
* help to hold the power supply clean from ripples by blocking
* if single sided boards were used be aware of the signal current path from the source to the ground. Try to sketch the signal loops of your signals from source to sink with different colors in the layout an find out where critical signals are close together.

5.2 Pin related hints

On the following pages every pin of the TDA9819 will be discussed, the function will shortly be explained and hints for the application are given:

---

pin : 1,2

function : symmetrical input of the IF amplifier

critical points : SAW filter , tuner and IF input should be as close together as possible; attention has to be payed for the layout

hints, remarks : when using DVB input pins 4,5 have to be used.

---

pin : 3

function : Capacitor for Fast AGC in Standard L

critical points : -

hints, remarks : not used in DVB only application

---

pin : 4,5

function : symmetrical input of the IF amplifier, switchable between pin1,2 and 4,5

critical points : -

hints, remarks : for the logic see data sheet. PIN 4,5 are selected by applying GND to pin 30. Pin 1,2 can be left not connected when pin 4,5 are selected as the input pins

---

pin : 6

function : TOP. Take over point of the tuner can be adjusted by a voltage at this pin. First the AGC of the TDA9819 is working . When the gain of the IF amplifier is reduced to a certain level depending on the TOP the tuner has to take over and to reduce his gain. In this case a current is drawn by an internal open collector transistor.

critical points : -

hints, remarks : The tuner AGC should be adjusted so that it is just not working when 10 mVrms are at pin 4,5. This depends on the used tuner and SAW filter. For further detail of the AGC characteristic please refer to figure 3 of the datasheet of the TDA9819.

---

pin : 7

function : loop filter output

critical points : -

hints, remarks : not used for DVB.

pin : 8

function : control input of the sound-IF amplifier

critical points : when not used please apply 5V to this pin via a resistor of around 1K.

hints, remarks : 5V reduces the gain of this amplifier. The corresponding inputs pin31,32 can be left not connected in this case.

pin : 9

function : standard switch

critical points : -

hints, remarks : switches between internal and external AGC when the input switch has selected DVB mode.

pin : 10

function : CVBS output in TV mode

critical points : -

hints, remarks : not used in DVB mode.

pin : 11

function : VCO adjust for TV mode

critical points : -

hints, remarks : not used in DVB mode

---

pin	**:**	12
function	**:**	audio amplifier output
critical points	**:**	-
hints, remarks	**:**	not used in DVB mode

---

pin	**:**	13
function	**:**	external AGC Voltage input. A DC- voltage at this input of the VIF amplifier controls the gain.
critical points	**:**	-
hints, remarks	**:**	For the AGC characteristic of the IF amplifier see figure 3 of the datasheet.

---

pin	**:**	14
function	**:**	capacitor for the FM demodulator
critical points	**:**	-
hints, remarks	**:**	not used in DVB mode

---

pin	**:**	15
function	**:**	DVB AGC adjust. Adjusts the output amplitude at the DVB output(pin18)
critical points	**:**	-
hints, remarks	**:**	only valid when using internal AGC. When using external AGC the voltage at the output is directly controlled by the voltage at pin 13.

---

pin	**:**	16
function	**:**	External VCO control for DVB. Voltage at this pin controls the frequency of the VCO
critical points	**:**	the carrier recovery loop has to be designed according to the application note of the TDA8045 with the Kvco given in the datasheet of the TDA9819.
hints, remarks	**:**	the calculation of the components of the carrier recovery loop is analog to the calculation in the application note of the TDA8045 with the Kvco given in the datasheet of the TDA9819.

pin	**:**	17
function	**:**	FM demodulator input
critical points	**:**	-
hints, remarks	**:**	not used in DVB. Can be left not connected in DVB only mode

pin	**:**	18
function	**:**	DVB output voltage
critical points	**:**	-
hints, remarks	**:**	the output resistor is around 10 Ohm. The internal DC bias current for the emitterfollower is around 2.3mA. The maximum AC and DC output sink current is 1.5 mA. The maximum AC and DC output source current is 2 mA.

pin	**:**	19
function	**:**	tuner AGC output current
critical points	**:**	-
hints, remarks	**:**	corresponding to the setting of the take over point potentiometer at pin 6 at a certain input level at the IF amplifier the output transistor begins to draw a current. The pin 19 is the collector of the internal open collector transistor.

pin	**:**	20
function	**:**	QSS output
critical points	**:**	-
hints, remarks	**:**	not used for DVB

pin	**:**	21
function	**:**	1V Video output
critical points	**:**	-
hints, remarks	**:**	not used for DVB

pin	**:**	22
function	**:**	Video buffer input
critical points	**:**	-
hints, remarks	**:**	not used for DVB

pin	**:**	23
function	**:**	Automatic frequency control output (AFC)
critical points	**:**	-AFC temperature problem for analog standard.
hints, remarks	**:**	used for adjustment of the demoboard . See docu of the demoboard for the alignment of the tank coil with the help of the AFC output. Additional application recommended. See also chapter 6, FAQs, with two external resistors 5k6 to ground at the tank circuit.

pin	**:**	24, 25
function	**:**	VCO tank circuit
critical points	**:**	put the tank circuit as close as possible to the IC
hints, remarks	**:**	other values can be chosen .For the internal capacitor values see figure 10 of the datasheet. By taking other values the Kvco is changed. Be aware that also the frequency tuning range changes. In DVB only mode the value of the coil is more flexible than in the combined mode where analog TV and DVB downconversion is required because the internal VCO did not have to fit to two standards with the same coil. From that in this mode an optimal L/C ratio for the best phase noise performance can be applied.

pin	**:**	26
function	**:**	reference voltage
critical points	**:**	-
hints, remarks	**:**	2.2 uF recommended. Not necessary when audio output is not used (in DVB mode).

pin	**:**	27
function	**:**	ground
critical points	**:**	-
hints, remarks	**:**	-

pin	**:**	28
function	**:**	CVAGC. Sums the current which is given from the AGC detector in TV-mode and also in DVB- internal AGC mode. The voltage at this capacitor controls the gain of the IF amplifier. In external AGC mode for DVB the voltage at pin 13 controls the IF amplifier.
critical points	**:**	-
hints, remarks	**:**	only used in DVB mode with internal AGC and in analog TV mode

pin	**:**	29
function	**:**	+5V supply voltage
critical points	**:**	-
hints, remarks	**:**	-

pin	**:**	30
function	**:**	standard switch. In DVB mode internal and external AGC can be selected by this pin.
critical points	**:**	-
hints, remarks	**:**	Positive or negative modulation are choosen in normal TV -mode.

pin	**:**	31,32
function	**:**	sound IF input pins.
critical points	**:**	-
hints, remarks	**:**	not used for DVB. See also remarks to pin 8.

6. Frequently asked questions (FAQs)

Q1 :
Can I change the recommended coil type and value ?

A1 :
Yes you can but please be aware of the switching of the frequencies if you are using both the analog TV and the DVB mode. In this case you have two internal varicaps with fixed typical values and also with a fixed range which you can tune. These are the given fixed limits which you have to regard for your external application.
Another point is the temperature compensation which will be affected also as described in chapter 2.4.1.

Q2 :
How can I change the AFC voltage swing ?

A2 :
By the external resistor divider. See chapter 2.2.4

Q3 :
Can I apply a quartz crystal oscillator ?

A3 :
You can remove the tank circuit and feed in the signal from an external discrete quartz oscillator. An external transistor and some elements for biasing and capacitors are required. See chapter 2.4.1.

Q4 :
Were can I get more help ?

A4 :
You can find the data sheet on the website from philips.: http://www.semiconductors.philips.com. Look also for new informations and announcements on this site. The next step for getting help should be to contact your local sales man. If he can not solve the problem with our field application engineers he will contact one of the engineers in the worldwide Philips Systems Labs to get the problem solved.

Q5 :
What is the tolerance of the internal varicap in DVB mode ?

A5 :
This value is not measured in the production because it is not specified and therefore it can not be guaranteed.
As an indication you can calculate with a setting tolerance of around +/- 17% assuming a C_0 of 8.2 pF @2.6V external VCO voltage.
The assumption of +/-17% holds also for the analog TV mode wher you come to a total value for C_0 of 11.3 pF. (see table 3 of the data sheet)

Q6 :

I have a Philips Design Guide from 1996 and there I do not find an FM demodulator inside. Can I do stereo audio demodulation in the USA with the TDA9819 ?

A6 :

Yes, you can !! You can do stereo in NTSC analog TV mode for the US market and mono for the European market. The TDA9819 includes a FM demodulator for the intercarrier signal(4.5MHz for the USA) and also a sound processing stage according to the data sheet. Unfortunately there was a mistake in the Multimedia Design Guide from 1996. This will be corrected in the new edition.

Q7 :

The AFC voltage drifts very strongly when I am in analog TV mode and the temperature increases. I did all the recommended temperature compensation methods. Is there an application available for this problem ?

A7 :

Yes, the problem is well known and the cause of it is within the IC. An operation point of an internal resistor shifts too much when the IC is heatet up.This has an impact on the frequency.For new vesions of the TDA9819 this point will be redesigned.

Recommended action: Insert two resistors of 5K6 outside the IC from each pin of the tank circuit (pin 24 and pin 25) to ground. This small application brings down the operation point of the internal transistor to a more stable situation also for higher temperatures. This problem just affects the analog mode.

7. Conclusion

This application note describes the multistandard vision and sound -IF PLL with DVB-IF processing TDA9819.

Most often the TDA9819 is used and optimized to be used together with the Philips QAM demodulator ICs TDA8046 and TDA8047. These ICs include ports which are especially implemented to control the TDA9819 by software via the TDA8046/TDA8047. But the TDA9819 itself does not need an IIC bus and so it can also be used for an AGC preprocessing for other QAM demodlator ICs like those from Broadcom, Hitachi or VLSI or others.

On top of this QAM downconverter features a complete high performance analog TV demodulation IC is inside the TDA9819 so a complete IF solution for the both transmissions are available. The TDA9829 is the downconverter - only version of the TDA9819 in an economic SO20 package.

APPENDIX 1

A1. Literature

[AN96142]	Rittner, Ulrich App. Note AN96142: TV Processing with QSS or Intercarrier Demodulation, 1996
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[Young]	Young, Paul H. Electronic Communication Techniques, 1994