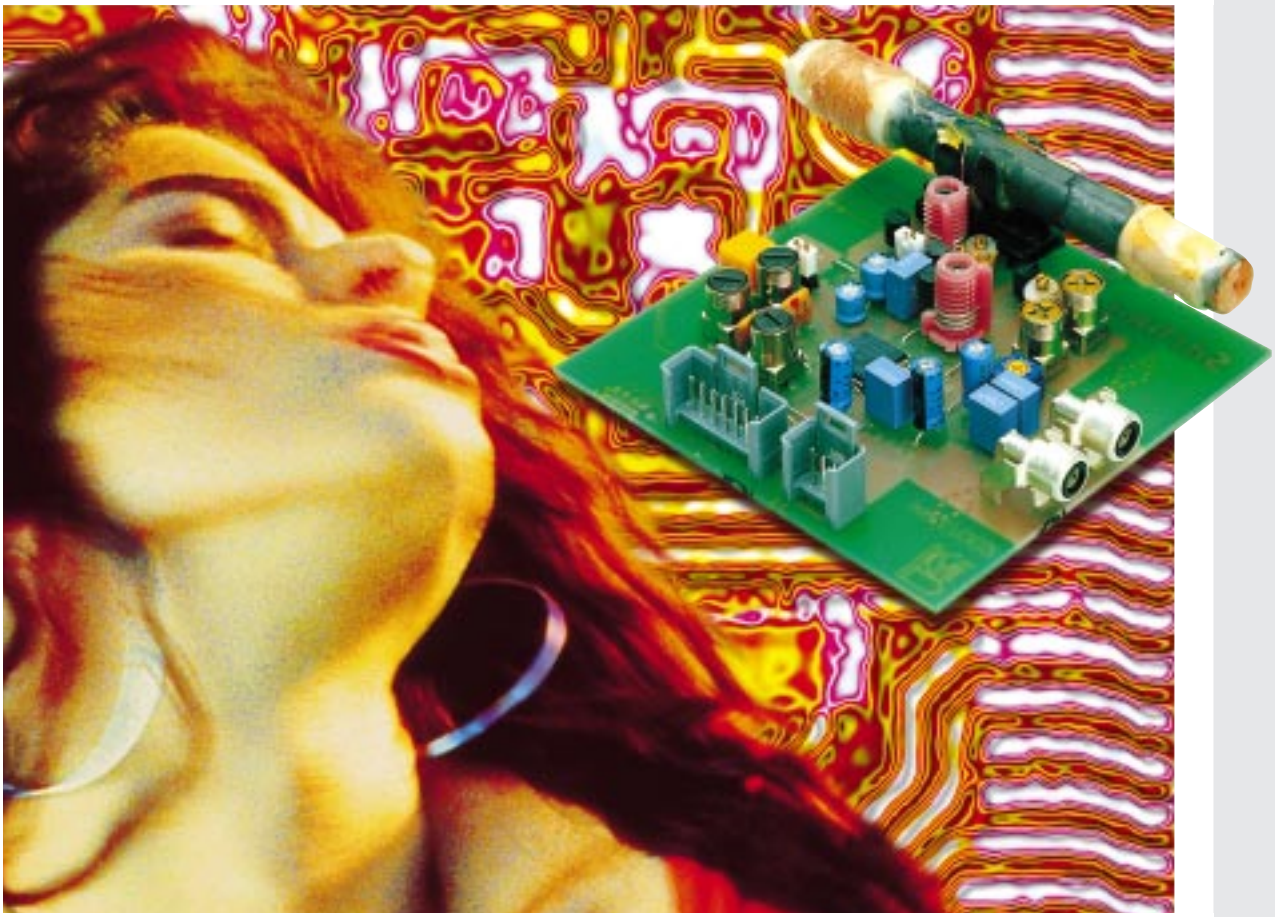

Portable and home hi-fi/radio designer's guide

June 1996

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CONTENTS

INTRODUCTION

The last few years have seen a revolution in the popularity of portable and home audio equipment. It's a revolution brought about by a greater choice of equipment for the consumer, ranging from pocket-sized radios and personal hi-fi to top quality music centres, at a price to suit all pockets. And it's almost entirely due to increased integration of electronic components and smaller packaging. This revolution is, of course, self-perpetuating: the enormous number of FM stereo stations that can now be received, and the availability of cassettes & CDs, has spurred on the production of even higher performance portable and domestic radio/audio with more features.

For the semiconductor manufacturer, minimizing the number of peripheral circuit components is the norm, thus improving quality and reliability, and reducing the overall equipment size and cost. However integrating radio receivers presents its own special problems; overcrowded wavebands, small aerials and close proximity of components all increase the chances of interference. By fully exploiting the experience gained from our close relationship with radio setmakers, and combining it with our unrivalled experience of developing ICs using advanced circuit techniques, we've developed our present comprehensive range of completely-integrated radio systems that does more and performs better than ever before. Our range comprises ICs and discrete semiconductors for portable radios, mains-powered radios including Digital Satellite Broadcast (DSB) receivers, and radios for multimedia PCs. All are optimized for performance (distortion, sensitivity, etc.), minimum peripheral components and adjustments, and the best possible reception.

For miniature 'credit-card' or pocket-sized radios, we have an AM mono receiver IC that operates from a 3 V battery with minimum power consumption and requires very few peripheral components. This IC overcomes the difficulty of providing manual tuning for such a small radio by incorporating a simple search tuning facility operated by two push-buttons.

For personal radios, clock radios, portable radios and portable radio-recorders, we offer a variety of highly-integrated two-chip manually-tuned AM/FM configurations; for mono and stereo reception. We also have an AM/FM stereo configuration that is optimized for use with a computer-controlled PLL frequency synthesizer for digital tuning. All these ICs operate from as little as 2 V or up to 18 V with minimum power consumption and require very few, if any, peripheral components. This minimizes costs and simplifies design.

The latest addition to our range of radio ICs is an innovative computer-controlled AM/FM Self-Tuned Radio (STR) which operates from a 2.2 V to 12 V supply. This single-chip self-tuned radio performs all the functions from the aerial input to the stereo decoder outputs. The tuning concept used in the STR combines the advantages of manual tuning with electronic tuning facilities and features. The inherent fuzzy logic behaviour of the STR mimics manual tuning (coarse tuning followed by fine tuning) and achieves fast and reliable tuning to the desired frequency.

The performance, flexibility and wide supply voltage range of our ICs for personal radios and portables also allows them to be combined with other ICs from our radio/audio range to form chipsets for all performance classes of mains-powered stereo FM, MW and LW hi-fi tuners mini/midi systems and music centres. ICs that can be added include a PLL frequency synthesizer plus microcontroller for electronic tuning and control, source selector, tone/volume/balance control circuits, power amplifiers, CD player ICs, Dolby[1)] B/C noise reduction circuits for cassette recorders, and remote control ICs.

And with the advent of multimedia systems we offer a range of radio PC cards based around the OM56xx family of tuners. These radio PC cards offer full R(B)DS capabilities and are fully shielded against the extreme electrical noise found within a PC to deliver clear, hi-fi quality FM stereo radio signals in a multimedia system.

1) Dolby is a registered trademark of the Dolby Labs Licensing Corporation, San Francisco, CA, USA.

1. SINGLE CHIP AM POCKET-SIZED RADIO (TEA5551T)

The TEA5551T is a complete AM radio IC incorporating a dual AF amplifier with low quiescent current. It is primarily designed for pocket radios operating from a 3 V supply (maximum output power is with a 4.5 V supply, with a power output of 2×60 mW when used with 32 Ω headphones or 100 mW in bridge-tied load (BTL) with a 50 Ω loudspeaker). This IC has an AF part with low radiation (HF noise) and good overdrive performance.

Features

- very high sensitivity
- good IF suppression
- built-in dual AF amplifier with soft clipping and limited bandwidth
- AM mute switch
- low current consumption
- AF inputs are accessible for source selection, e.g. as in AM/FM radio (with TDA7021T).

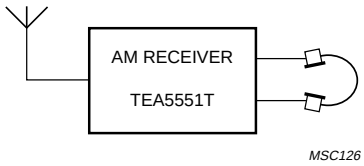


Fig.1 Single-chip card-size AM radio

Table 1 Typical radio data

Characteristic	Value
supply voltage (V_S)	3 V
supply current	5 mA
frequency range	up to 30 MHz
IF	468 kHz
temperature range	−25 to +60 °C

Table 2 TEA5551T data (specified for 3 V supply)

Characteristic	Value
supply voltage (V_S)	1.8 to 4.5 V
AM characteristics (modulation depth, m = 0.3)	
sensitivity	
for 10 mV AF output	1.5 μV
for (S+N)/N = 26 dB	15 μV
for (S+N)/N = 50 dB	10 mV
signal handling (m = 0.8, THD = 10%)	80 mV
THD	0.8 %
AF characteristics	
output power per channel (THD = 10%, R_L = 32 Ω)	25 mW
voltage gain	32 dB
channel separation	50 dB
package	SO16 (SOT109A)

2. MONO FM CARD-SIZED RADIO (TDA7088T + TDA7050T)

The TDA7088T is the latest of our single-chip FM receivers for pocket radios. Previous single-chip receivers have used trim-capacitor tuning systems which meant using a very small tuning knob to cover the whole FM band. The TDA7088T overcomes this by incorporating a simple search tuning facility which can be operated by two push buttons.

The TDA7088T contains all stages needed for FM reception. Operation is based on a Frequency-Locked Loop (FLL) system with conversion to an IF of 75 kHz. We recommend using this receiver in conjunction with the TDA7050T (or the TDA7052) audio amplifier.

TDA7088T features

- contains all stages of a mono FM receiver from antenna to audio output
- mute circuit
- search tuning with a single varicap diode
- mechanical tuning also possible with integrating AFC
- AM application is supported
- power supply polarity protection
- power supply voltage down to 1.8 V.

TDA7050T features

- no external components
- operates from a 1.6 to 6 V supply
- fixed gain of 32 dB (BTL).

The TDA7052 amplifier produces 39 dB gain with a 3 V supply. See page 22 *Audio amplifier ICs* for more amplifier details.

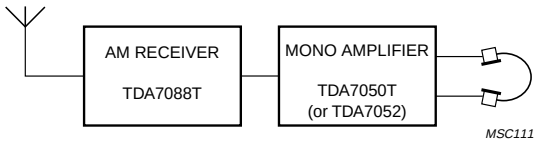


Fig.2 Two-chip card-size mono FM radio

Table 3 Typical overall radio data

Characteristic	Value
supply voltage (V_S)	3 V
supply current	8.4 mA
frequency range	0.5 to 110 MHz
IF	75 kHz
temperature range	−10 to +70 °C

Table 4 TDA7088T data (specified for 3 V supply)

Characteristic	Value
supply voltage (V_S)	1.8 to 5 V
supply current	5.2 mA
AF output voltage (V_O; R_L = 22 kΩ)	85 mV
THD	1 %
sensitivity (EMF for −3 dB limiting) mute off mute on	 3 μV 6 μV
signal handling (Δf = ±75 kHz, THD < 10%)	200 mV
S/N	56 dB
package	SO16 (SOT109A)

Note: f_{rf} = 96 MHz, Δf = ±22.5 kHz and f_{mod} = 1 kHz unless stated otherwise

Table 5 TDA7050T data (specified for 3 V supply)

Characteristic	Value
supply voltage (V_S)	1.6 to 6 V
quiescent current	3.2 mA
BTL output power (P_O; R_L = 32 Ω, THD = 10 %)	140 mW
noise voltage at output	140 μV

3. PORTABLE MONO AM/FM RADIO (TEA5710(T) + TDA7052/52A/52B)

The TEA5710(T) is an AM/FM receiver IC for use in clock radios, portable radios, mains-fed radios and medium-fi sets. It incorporates all circuitry from the AM/FM front-end to the detector outputs. Only a minimum number of external components are required to complete a radio set. We recommend using it with the TDA7052 or TDA7052A/52B amplifier.

The TEA5710(T) has many features such as distributed selectivity on both AM and FM, and a symmetrical AFC for tuning. The distributed IF gain allows a simple PCB layout. A new aspect in AM reception is the high impedance AM RF input made by a differential MOST pair. This enables connection to the top of the input selectivity (e.g. the ferroceptor) which simplifies radio design and reduces the number of necessary contacts.

TEA5710(T) Features

- wide supply voltage range
- low current consumption
- high selectivity with distributed IF gain
- LED driver for tuning indication
- high input sensitivity
- good strong-signal behaviour
- low output distortion
- designed for simple and reliable PCB layout
- high impedance MOSFET input on AM.

Amplifiers

The A and B versions differ from the TDA7052 in that they have a DC volume control with mute mode.

See page 22 *Audio amplifier ICs* for more amplifier details.

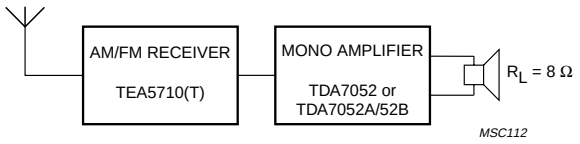


Fig.3 Portable mono AM/FM radio

Table 6 Typical overall radio data (specified for 3 to 6 V supply)

Characteristic	Value
supply voltage (V_S)	3 to 12 V
supply current	11.5 to 16 mA
frequency range AM FM	 up to 30 MHz 87.5 to 108 MHz
temperature range	−15 to +60 °C

Table 7 TEA5710(T) data (specified for 3 V supply)

Characteristic	Value
supply voltage (V_S)	2.0 to 12 V
AM performance	
supply current	7.5 mA
AF output voltage (V_O)	45 mV
THD	0.8 %
sensitivity (EMF for −3 dB limiting)	1.6 mV/m
FM performance	
supply current	9.0 mA
AF output voltage (V_O)	65 mV
THD	0.3 %
sensitivity (EMF for −3 dB limiting)	1.2 μV
Note: AM: f_{rf} = 1 MHz, m = 30 % and f_{mod} = 1 kHz FM: f_{rf} = 100 MHz, Δf = ±22.5 kHz and f_{mod} = 1 kHz	

Table 8 TDA7052 data (specified for 6 V supply)

Characteristic	Value
supply voltage (V_S)	3 to 18 V
quiescent current	4 mA
output power (P_O; R_L = 8 Ω, THD = 10 %)	1.2 W
THD	0.2 %

Table 9 TDA7052A/53B data (specified for 6 V supply)

Characteristic	Value
supply voltage (V_S)	4.5 to 18 V
quiescent current	7 mA
output power (P_O; R_L = 8 Ω, THD = 10 %)	1.1 W
THD	0.3 %

4. PORTABLE MONO AM/FM RADIO/CASSETTE RECORDER (TEA5710(T) + TDA1016)

With the same receiver as the previous radio, this design features the TDA1016 recorder/playback amplifier IC. This couples all the qualities of the TEA5710(T) with those of the TDA1016 for a high-performance portable radio-recorder.

The TDA1016 incorporates an audio power amplifier, preamplifier and ALC circuit. Its wide supply voltage range makes it suitable for both portable and mains applications.

TDA1016 features

- separate record/playback preamplifier and power amplifier
- incorporates ALC (automatic level control) for recording
- voltage stabilization (2.6 V)
- short-circuit protection
- thermal protection
- standby switching facility to minimize current drain.

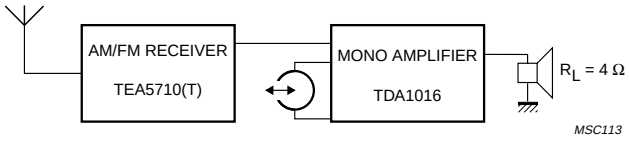


Fig.4 Portable mono AM/FM radio/cassette recorder

Table 10 Typical overall radio-recorder data (specified for 6 V supply)

Characteristic	Value
recommended supply voltage (V_S)	6 to 12 V
supply current	19 mA
frequency range AM FM	 up to 30 MHz 87.5 to 108 MHz
temperature range	−15 to +60 °C

Table 11 TEA5710(T) data (specified for 3 V supply)

Characteristic	Value
supply voltage (V_S)	2.0 to 12 V
AM performance	
supply current	7.5 mA
AF output voltage (V_O)	45 mV
THD	0.8 %
sensitivity (EMF for −3 dB limiting)	1.6 mV/m
FM performance	
supply current	9.0 mA
AF output voltage (V_O)	65 mV
THD	0.3 %
sensitivity (EMF for −3 dB limiting)	1.2 μV
Note: AM: f_{rf} = 1 MHz, m = 30 % and f_{mod} = 1 kHz FM: f_{rf} = 100 MHz, Δf = ±22.5 kHz and f_{mod} = 1 kHz	

Table 12 TDA1016 data (specified for 6 V supply)

Characteristic	Value
supply voltage (V_S)	3.6 to 15 V
quiescent current	10 mA
output power: V_s = 6 V; R_L = 4 Ω, THD = 10 % V_s = 9 V; R_L = 4 Ω, THD = 10 %	1 W 2 W

5. PORTABLE STEREO AM/FM RADIO (TEA5711(T)/12(T) + TDA7053(A)A/57(A)Q)

For a portable stereo radio, we offer a variety of two-chip solutions, depending on your performance requirements. The TDA7057Q/57AQ amplifiers offer outputs as high as 3 W per channel while the TDA7053/53A offer 1.2 W per channel. All ICs can operate from a 3 to 12 V supply and require no peripheral components.

Both the TEA5711 and TEA5712 receiver ICs differ from the TEA5710 in that they include a stereo decoder. Principally, their applications include portable radios, Mini/Midi receiver sets and personal headphone radios. The TEA5712 also facilitates digital tuning. Details of all three receivers are given in section 7.

TEA5711(T)/12(T) features

- wide supply voltage range
- low current consumption
- high selectivity with distributed IF gain
- high input sensitivity
- good strong-signal behaviour (10 V/m AM, 500 mV FM)
- low output distortion
- simple, reliable PCB layout
- high impedance AM input
- LED driver for stereo indication
- soft mute
- signal-dependent stereo
- signal-level output (TEA5711)
- stop-signal output (TEA5712)
- IF output signals available for IF counting (TEA5712).

Amplifiers features

- fixed closed-loop voltage gain (39 dB for TDA7053(A), 40 dB for TDA7057(A)Q)
- DC volume control with mute mode (TDA7053A/57AQ only).

See page 22 *Audio amplifier ICs* for more amplifier details.

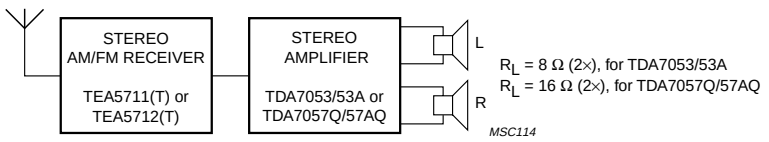


Fig.5 Portable stereo AM/FM radio

Table 13 Typical overall radio data (specified for 6 V supply)

Characteristic	Value
supply voltage (V_S)	3 to 12 V
supply current	18 mA
frequency range AM FM	 up to 30 MHz 87.5 to 108 MHz
temperature range	−15 to +60 °C

Table 14 TEA5711(T) and TEA5712(T) data (specified for 3 V supply)

Characteristic	Value
supply voltage (V_S)	2.0 to 12 V
channel separation	30 dB
AM performance	
supply current	14 mA
AF output voltage (V_O)	45 mV
THD	0.8 %
sensitivity (EMF for −3 dB limiting)	1.6 mV/m
FM performance	
supply current	16 mA
AF output voltage (V_O)	65 mV
THD	0.3 %
sensitivity (EMF for −3 dB limiting)	1.2 μV

Note:
AM: f_{rf} = 1 MHz, m = 30 % and f_{mod} = 1 kHz
FM: f_{rf} = 100 MHz, $\Delta f = \pm 22.5$ kHz and f_{mod} = 1 kHz

Table 15 TDA7053/53A data (specified for 6 V supply)

Characteristic	Value
supply voltage (V_S)	3 to 18 V
quiescent current	9 mA
output power/channel (P_O; $R_L = 2 \times 8\ \Omega$, 10% THD)	1.2 W
THD	0.2 %

Table 16 TDA7057Q/57AQ data (specified for 11 V supply)

Characteristic	Value
supply voltage (V_S)	3 to 18 V
quiescent current	10 mA
output power/channel (P_O; $R_L = 2 \times 16\ \Omega$, 10% THD)	3 W
THD	0.25 %

6. PORTABLE STEREO FM RADIO (TDA7021T + TDA7040T + TDA7050T)

The TDA7021T stereo FM receiver circuit is for pocket-sized radios and is fully compatible with applications using the low-voltage micro tuning system (MTS).

The IC has a frequency locked loop (FLL) system with intermediate frequency of 76 kHz. The selectivity is obtained by active RC filters.

Because of the low-pass characteristics of the FLL, a 50 kHz roll-off compensation is performed by the integral LF amplifier. For mono applications, this amplifier can be used to drive an earphone. The field-strength detector enables field-strength dependent channel separation control. We recommend using this receiver in conjunction with the TDA7040T PLL stereo decoder and the TDA7050T stereo audio amplifier.

TDA7021T features

- RF input stage
- mixer
- local oscillator
- IF amplifier/limiter
- frequency detector
- mute circuit
- loop amplifier
- internal reference circuit
- LF amplifier for mono earphone amplifier or MUX filter
- field-strength dependent channel separation control facility.

TDA7040T features

- built-in four pole low-pass filter with 70 kHz corner frequency
- integrated 228 kHz oscillator
- pilot presence detector and soft mono/stereo blend
- built-in interference suppression
- adjustable gain.

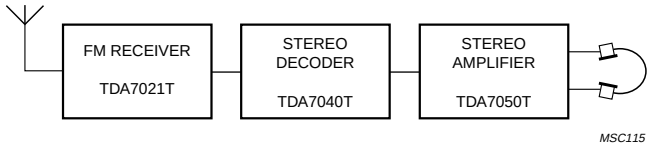


Fig.6 Three-chip card-size stereo FM radio

Table 17 Typical overall radio data

Characteristic	Value
supply voltage (V_S)	3 V
supply current	9.5 mA
frequency range	1.5 to 110 MHz
temperature range	−10 to +70 °C

Table 18 TDA7021T data (specified for 3 V supply)

Characteristic	Value
supply voltage (V_S)	1.8 to 6 V
supply current	6.3 mA
AF output voltage (V_O; R_L = 100 kΩ)	90 mV
THD (Δf = ±22.5 kHz)	0.7%
sensitivity	
muting disabled	4.0 μV
muting	5.0 μV
signal handling (Δf = ±75 kHz, THD < 10%)	200 mV
S/N	60 dB
Note: f_{rf} = 96 MHz, Δf = ±22.5 kHz and f_{mod} = 1 kHz unless stated otherwise	

Table 19 TDA7050T data (specified for 3 V supply)

Characteristic	Value
supply voltage (V_S)	1.6 to 6 V
quiescent current	3.2 mA
noise voltage at output	140 μV

Table 20 TDA7040T data (specified for 3 V supply)

Characteristic	Value
supply voltage (V_S)	1.8 to 6 V
supply current	3.0 mA
total harmonic distortion	0.3%
signal to noise ratio	70 dB

TDA7050T features

- no external components
- operates from a 1.6 to 6 V supply
- very low quiescent current (typ. 3.2 mA with 3 V supply).

7. PORTABLE SELF-TUNED RADIO SYSTEM (CPR120)

The CPR120 computer-controlled personal radio system comprises an FM, MW, LW and SW stereo self-tuned radio.

The system contains functions such as search tuning, preset control, LCD display and an interface for a cassette player (optional).

The ICs at the heart of the music centre system are:

P83CLX34

- CPR120S masked programmed microcontroller. See page 26 *Microprocessor control and display* for more information.

TEA5757H

- AM receiver (LW, MW and SW)
- FM stereo receiver
- tuning synthesizer and radio on one chip
- microcontroller bus interface
- auto-search and preset-mode
- high input sensitivity
- low output distortion
- tuning is independent of channel spacing
- low power consumption due to standby mode.

See page 21 *Self-tuned AM/FM radio IC* for more details on the TEA5757H.

TDA7050(T)

- 150 mW BTL or 2 × 75 mW headphone amplifier
- operates with battery supplies from 6 V down to 1.6 V
- very low quiescent current (typically 3.2 mA with 3 V supply).

TDA1308T

- 60 mW stereo headphone amplifier
- 110 dB signal-to-noise ratio
- low current drain (typically 3 mA with 5 V supply).

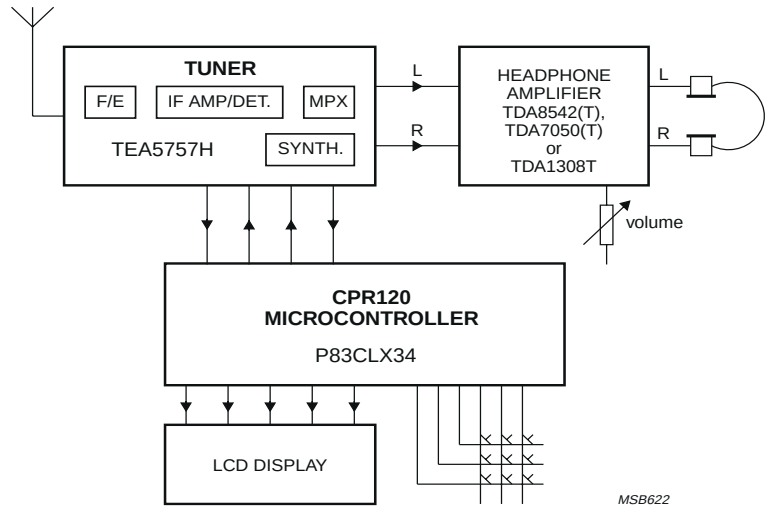


Fig.7 CPR120 electronically tuned personal radio

TDA8542(T)

- 2 × 1 W headphone amplifier
- Standby mode controlled by CMOS compatible levels
- Gain can be fixed with external resistors.

CPR120 features

Tuning

- FM, MW, LW and SW bands
- Search up/down tuning with wrap round. Actual search is done by the TEA5757 IC and the frequency found is read by the microcontroller
- Manual up/down tuning
- Frequency scan-up function, searching for the next station in the band and pausing 6 s before the next station is searched
- 5 presets for FM, MW, LW and SW
- AST (Automatic Store Tuning) searches for and stores the strongest (FM and MW) transmitters
- Saving last band and frequency of the station at power off (in standby mode)
- Preset up/down or preset 1 to preset 5 select keys
- 16 geographical area options (programmable).

Clock functions

- 24 hr clock display function, also in standby mode
- Switch on timer function
- Sleep timer function.

Sound control

- Mute output to mute headphone or power amplifier.

Standard or extended LCD

Icons: SLEEP, TIMER, STEREO, TUNED, FM, MW, LW, SW, MHz, kHz, AST, P1 to P5 (preset number), 5 (5 kHz in SW band), MEMORY.

Cassette deck

- Tape play detection by means of the mute pin.

Local control

- 9 local keys.

Switching on/off

- Momentary on/off switch
- Continuous mains power supply allows the RAM to save preset data and clock functions
- Recall of last band, preset and frequency when switching on from standby
- Output allows power supply to be controlled by the timer functions
- Input detects static power-on switch.

8. ELECTRONICALLY-TUNED MINI/MIDI AM/FM STEREO RECEIVER SYSTEM

This mains-fed, mid-fi radio design offers a wide degree of flexibility in terms of features and power output.

The design is based on the TEA5712(T) AM/FM stereo receiver, which includes a stereo decoder. Remote-controlled digital tuning is managed by a microcontroller (P83Cxxx family) operating a PLL frequency synthesizer (TSA6060(T)) via the I^2C-bus. The TDA1524A audio controller facilitates bass, treble and volume control for each channel. A variety of amplifiers are available for a wide range of power outputs.

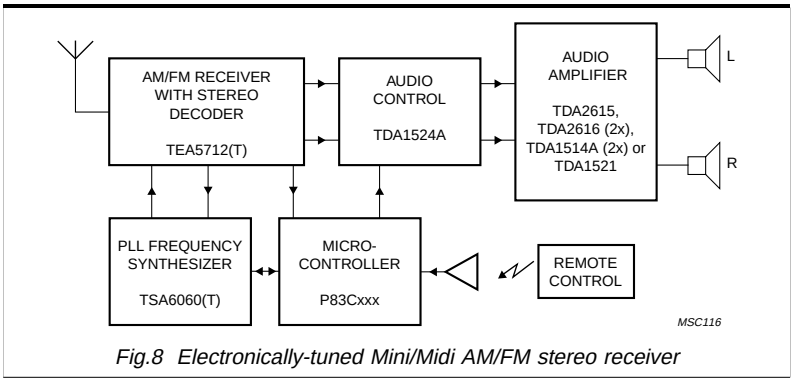


Fig.8 Electronically-tuned Mini/Midi AM/FM stereo receiver

Table 21 Typical overall radio data

Characteristic	Value
frequency range AM FM	 up to 30 MHz 87.5 to 108 MHz
temperature range	−15 to +60 °C

TEA5712(T) features

- wide supply voltage range
- low current consumption
- high selectivity with distributed IF gain
- high input sensitivity
- good strong-signal behaviour (10 V/m AM, 500 mV FM)
- low output distortion
- simple, reliable PCB layout
- high impedance AM input
- LED driver for stereo indication
- soft mute
- signal-dependent stereo
- stop-signal output
- IF output signals available for IF counting.

TDA1524A features

- few external components required
- low noise
- bass emphasis can be increased by a double-pole low-pass filter
- wide power supply voltage range
- mute switch via external pin
- loudness function.

TSA6060(T) features

- on-chip, high input-sensitivity AM & FM prescalers
- on-chip, high-performance 1 input (2 output) tuning voltage amp. for AM & FM loop filters
- on-chip, multi-level current amp to adjust loop gain
- high-speed tuning due to a powerful digital memory phase detector
- oscillator frequency ranges of 512 kHz to 30 MHz, 30 to 200 MHz
- 1 reference oscillator for both AM & FM
- selectable reference frequencies for both tuning ranges
- serial 2-wire I^2C-bus.
- in-lock detector output pin

Amplifier features (R_L = 8Ω)

- TDA2615 - 2 × 6 W
- TDA2616 (×2) - 2 × 20 W
- TDA1514A (×2) - 2 × 40 W
- TDA1521 - 2 × 12 W.

Full details of all these ICs are given in the appropriate sections of this guide.

9. MUSIC CENTRE SYSTEM (CCA210)

The CCA210 computer-controlled music centre system comprises an FM, MW, LW and SW stereo radio (for battery and mains-fed portables, and mini/midi audio systems), combined with a cassette player deck and a CD player. The entire system is controlled by a CMOS microcontroller.

The ICs at the heart of the music centre system are:

TEA5757H
An AM/FM STR (self-tuned radio) receiver including synthesizer and stereo decoder.

TDA2615/16(Q) 2 × 10/20 W (maximum output power) hi-fi audio amplifier with mute.

PCF8577CT I^2C-bus controlled LCD driver providing 32 segment drive lines and 2 backplane select lines (64 segments total).

SAA3010T RC-5 remote control transmitter (optional).

Main features of the CCA210:

Tuning
- Four bands FM, MW, LW and SW
- FLL tuning principle
- Search up/down tuning with wrap round. Actual search is done by the TEA5757 IC and the frequency found is read by the microcontroller
- Manual up/down tuning
- 10 presets for FM; 5 presets for MW, LW and SW
- Preset scan pausing for 10 s on every station before selecting the next preset in that band
- AST (Automatic Store Tuning) searches for and stores the strongest (FM, MW LW and SW) transmitters
- Saving last band and frequency of the station at power off (in standby mode)
- 16 geographical area options (programmable).

Sound control
- Volume up/down control by means of a motor-controlled potentiometer
- Volume, balance, bass and treble control by means of an I^2C-bus controlled audio processor or by potentiometers
- Audio select key to select the audio function bass, treble and balance controls by means of the audio up/down keys
- Selectable inputs: radio, CD, tape and auxiliary
- Mute output to mute the power amplifiers (via pin or audio processor)
- Saving last sound settings at power off (standby mode).

Control
- 36 local keys and/or RC-5 remote.

Clock functions
- 12/24 hr clock display function, also in standby mode
- Switch on/off timer functions
- Sleep timer function.

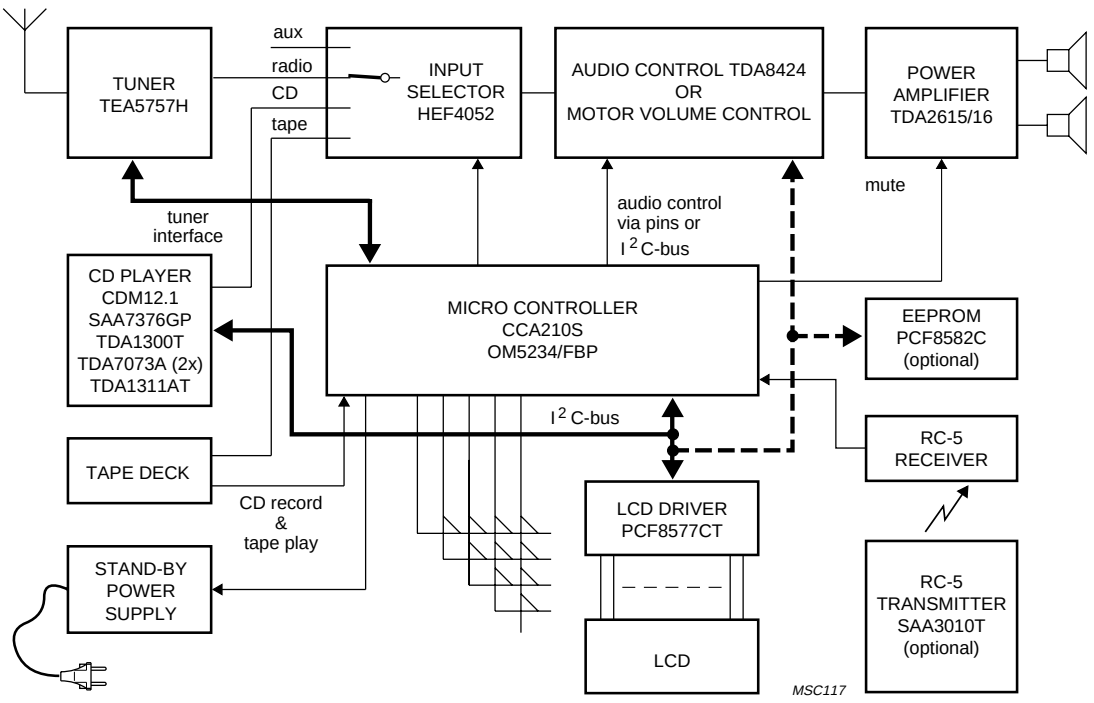


Fig.9 CCA210 music centre using a self-tuned radio

Display

Icons: CD INTRO, CD REPEAT, CD RANDOM, SLEEP, TIMER ON/OFF, CD MEMORY, CD TRACK, FM, MW, LW, SW, MHz, kHz, CH, AM/PM CLOCK, STEREO

Other: two 7-segment digits for CD TRACK or PRESET, and four 7-segment digits for frequency and time.

CD player

- 3-beam CDM 12.1 mechanism and motorized tray loader
- full CD control including: random and scan play, track programming features, track/ search up/down control, A-B repeat, track and disc repeat, direct track selection, various display formats, and a service mode
- CD system to be used with a tray loader (L1210) or a top loader

Cassette deck

- Key to select tape mode
- Automatic detection of play mode when the play key is pressed
- Interfaces with a mechanically-controlled deck
- CD synchro record mode. In CD mode the CD starts playing when the record key is pressed.

Auxiliary input

- Key to select auxiliary mode.

Switching on/off

- Momentary on/off switch
- Continuous mains power supply allows (RAM to save the preset data when no EEPROM is used) clock functions
- Recall of last mode (radio/CD/ tape/aux.). In radio mode, last band, preset and frequency, analog sound settings when switching on from standby
- Output to allow the power supply to be controlled by the timer functions.

Non-volatile memory

A 256 byte non-volatile memory can be installed to store the following information:

- 10 presets for each band
- Last selected band, preset number and frequency
- Audio settings (volume, balance, bass, treble) and selected source
- Status and settings of the switch on/off timers.

10. ASTRA DIGITAL RADIO

Our Astra digital radio (ADR) design is based on the SAA2530 ADR/DMX digital receiver, and the SAA2502 ISO/MPEG audio source decoder.

SAA2530 features

- full ADR frequency range
- gain control amplifier
- buffered clock output of 12.288 MHz and 8.192 MHz or 4.096 Mhz
- 8-bit ADC
- QPSK demodulation
- depuncturing
- decimation and matched filters
- soft decision thresholds for Viterbi decoding
- differential decoding
- descrambling
- DMX (digital music express) decryption
- MPEG layer 2 synchronization and output
- additional programmable clock output
- FEC for ancillary data
- L3- and I^2C-bus interface
- QFP44 package.

SAA2502 features

- DAC output (256 or more times oversampled
- internal dynamic range compression algorithm
- CRC protection of scale factors (ADR/DAB)

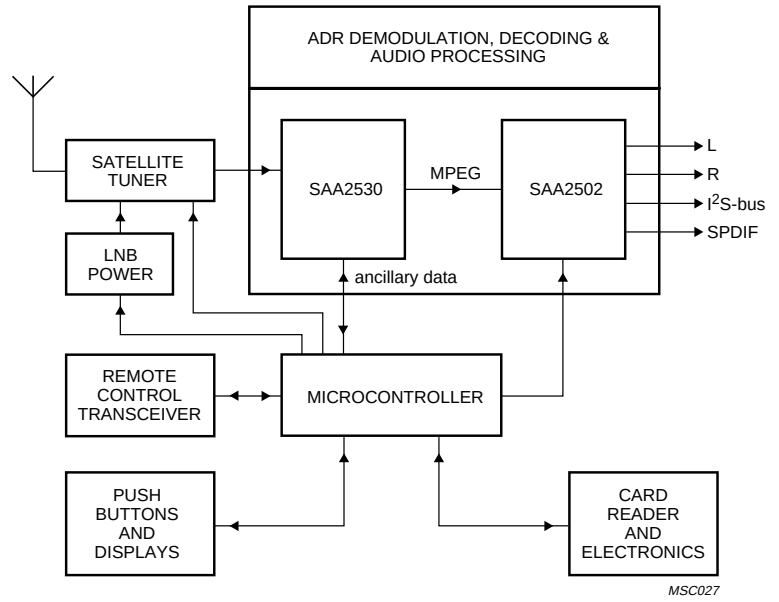


Fig.10 ADR receiver block diagram

- low sampling frequency decoding possibilities (24 kHz, 22.05 kHz and 16 kHz)
- SPDIF and I2S output
- bit-rate and sampling frequency may be overruled by the microcontroller while the SAA2502 is trying to establish frame synchronization
- L3- and I^2C-bus interface
- QFP44 package.

Full details of other peripheral ICs in the ADR receiver are given in the appropriate sections of this guide.

11. MULTIMEDIA RADIO TUNERS (OM5604/06/08)

The OM5604, OM5606 and OM5608 FM tuner modules are designed to operate in the harsh electrical environment of the PC and deliver clear, hi-fi quality stereo radio signals in a multimedia system. The modules are fully shield for the PC environment and offer MPX output for Radio (Broadcast) Data Systems (R(B)DS) decoding. Both modules have an 75 Ω RF aerial input (the OM5604 has an F-connector and the OM5606 and an IEC-connector).

The OM5604/06 modules comprise three ICs: the TEA5757H, the PCF8574T and the TDA1308T.

The TEA5757H self-tuned radio (STR) FM receiver lies at the heart of the modules. It is an FM receiver, stereo decoder and tuning synthesizer on one chip. After searching for the desired channel, it automatically locks onto the signal for the best possible reception. If the receiver is tuned to a strong local transmission, local/DX switching ensures reception is not overpowered.

More details on the TEA5757H STR are given in the section *Self-tuned AM/FM radio IC.*

The PCF8574T is a bus converter that provides I^2C-bus control and has three I/O lines for additional control functions. The TDA1308T is a line amplifier with two line outputs.

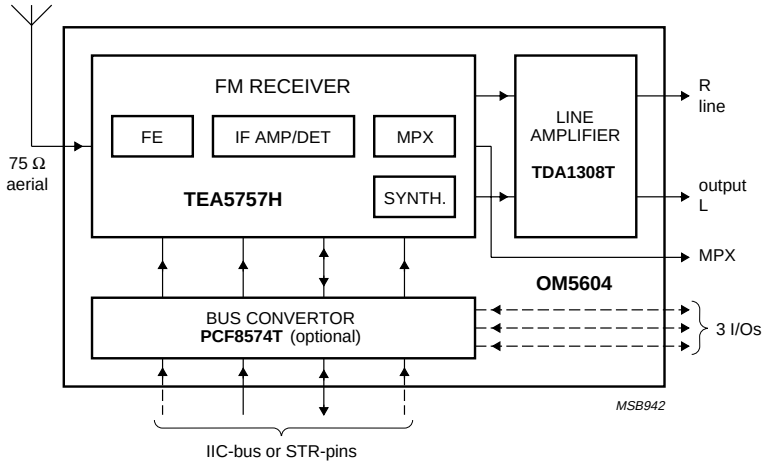


Fig.11 PC-radio base module

Table 22 OM5604 and OM5606 data

Characteristic	Value
supply voltage (V_S)	4.5 to 5.5 V
audio output	900 mV RMS
RF input connector	75 Ω
frequency range	87.5 to 108 MHz
FM stereo	
signal-to-noise ratio	63 dB
channel separation	28 dB
channel imbalance	0.5 dB
stereo blend function	10 dB
total harmonic distortion	3%
FM mono	
signal-to-noise ratio	71 dB
3 dB limiting sensitivity	3.5 dBμ
RF sensitivity	2.2 dBμ
AM suppression	58 dB
total harmonic distortion	1.5%

Features

- local/DX switching
- MPX output for R(B)DS decoding
- I^2C-bus controlled with three I/O ports for additional control functions
- small package size (34 × 86 × 14 mm)
- electronic fast tuning system
- meets FCC requirements on radiation.

12. R(B)DS SYSTEMS

RDS system

This demodulator & decoder system is based around two ICs: the SAA6579T RDS demodulator and the CCR910, CCR911, CCR912 or CCR921 RDS decoder. These ICs recover the bi-phase inaudible frequency/programme information which is serially transmitted with FM radio broadcasts that use the Radio Data System (RDS).

The information is converted into data for controlling the tuning/display functions of the radio via the I^2C-bus and the main microcontroller of the radio.

In the RDS demodulator, the RDS signal is separated from the MPX signal by a 57 kHz bandpass filter, and digitized using a comparator. The digitized signal is then synchronously demodulated to recover the bi-phase data symbols. For this function, the suppressed 57 kHz subcarrier is regenerated by a special PLL system (Costas loop). The demodulated data symbols are further processed in an integrate and dump circuit followed by a differential decoder which generates the RDS data (RDDA) signal. The bit rate RDS clock (RDCL) is recovered by a second PLL. The integrate and dump circuit also generates a quality signal (QUAL) for every data bit.

The RDS decoder is an 80C51 family microcontroller with intelligent RDS data decoding and/or pre-processing software. The software incorporates automatic error detection/correction. A subset of the decoded RDS data is present within the serial interface protocol and also made available on the pins of the decoder IC.

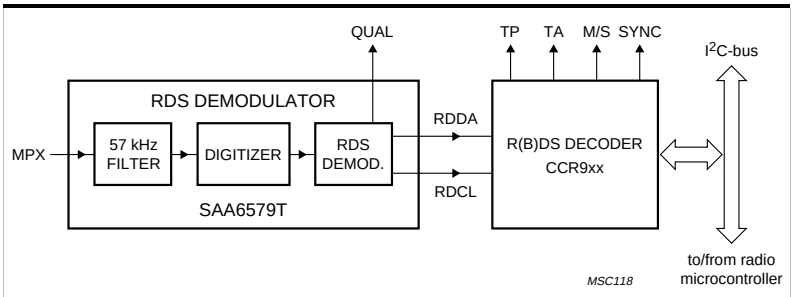


Fig.12 RDS demodulator and decoder system

Table 23 SAA6579T data

Characteristic	Value
supply voltage (V_S)	5 V
supply current	6 mA
oscillator frequency	4.332/8.664 MHz
min. RDS input amplitude (RMS)	1 mV
temperature range	−40 to +85 °C
package	DIL16, SO16

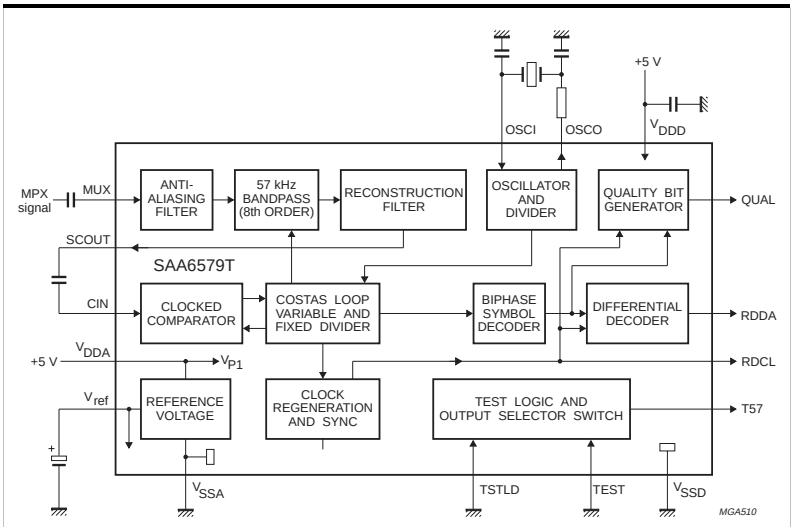


Fig.13 RDS demodulator (SAA6579T)

RDS/RBDS system

This is similar to the RDS system described above, except a CCR921 R(B)DS decoder is used.

The CCR921 supports all types of R(B)DS groups and is easy to use via the I^2C-bus interface. Furthermore, as the timing requirements of the (main-) set controller of the R(B)DS data processing are reduced, radio control software can be developed specifically for radio features.

SAA6579T features

- on-chip preamplifier
- on-chip 57 kHz bandpass filter
- on-chip comparator
- quality signal output
- CMOS-level digital outputs.

CCR910/911/912 features

- synchronization on binary RDS data stream from demodulator
- synchronization available via pin
- error detection & correction:
  - checks for transmission error
  - corrects errors when enabled
  - pin-programmable correction (no correction; max. 2 bits or 5 bits burst error)
- decoder control via I^2C-bus (CCR910 and CCR912) or via extra input pins (CCR911)
- decoding of clock time and date information (CCR912 only).

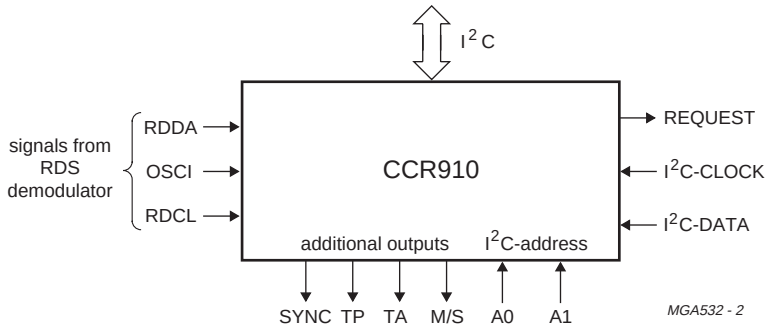
CCR921 features

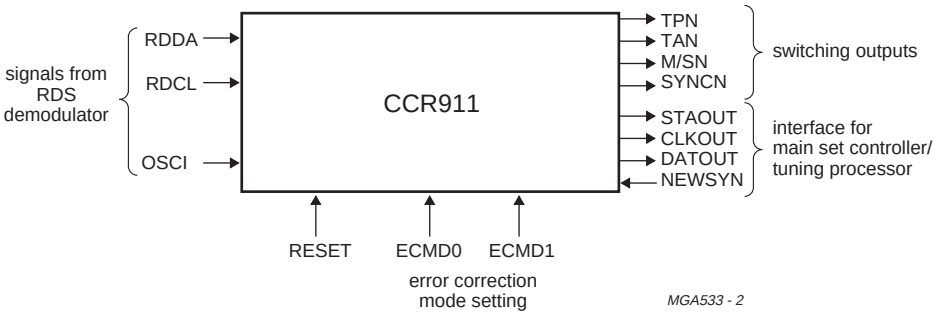
- all R(B)DS group types supported
- simplified hard-software development for setmakers
- capable of storing last received R(B)DS blocks for 700 ms
- fast synchronization with block type A search
- error processing with correction status for every block
- decoder control via I^2C-bus.
- decoder is always an I^2C-bus slave - no multimaster bus required

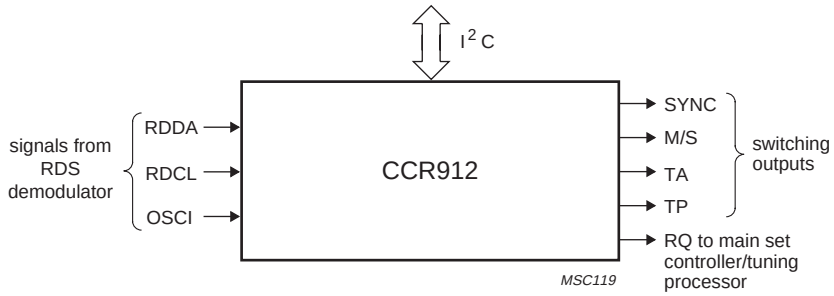
The following table gives a comparison of the four decoders.

Table 24 CCR91xx data

Characteristic	CCR910	CCR911	CCR912	CCR921
supply voltage (V_S)	5 V	5 V	5 V	5 V
supply current	24 mA	20 mA	24 mA	24 mA
oscillator frequency	4.332 MHz	8.664 MHz	6.664 MHz	8.664 MHz
decoder control	I^2C-bus	extra pins	I^2C-bus	I^2C-bus
output prepared data via	I^2C-bus	3-wire bus	I^2C-bus	I^2C-bus
I^2C-bus outputs:				
programme service name (group 0)	PS		PS	
programme identification (all groups)	PI		PI	
alternative freq. (group OA, method A+B)	AF		AF	decoding is
traffic programme (all groups)	TP		TP	done by
traffic announcement (groups 0 & 15B)	TA		TA	main µC
programme type (all groups)	PTY		PTY	
decoder identification (groups 0 & 15B)	DI		DI	
music/speech (groups 0 & 15B)	M/S		M/S	
clock time			CT	
output decoded data via extra pins:				
traffic programme	TP	TPN (active LOW)	TP	TP
traffic announcement	TA	TAN (active LOW)	TA	TA
music/speech	M/S	M/SN (active LOW)	M/S	M/S
synchronized RDS			SYNC	SYNC
all RDS data available for main µC		✓		✓
continuous updating of RDS data	✓		✓	
RDS information decoding, collection and request information	✓		✓	
no real-time decoding operations for main µC	✓		✓	
supports Enhanced Other Network		✓		
supports RDS/RBDS				✓
based on microcontroller	P83C652FFB	P80CL51HFH	P83C652FBB	P83652FBB
package	QFP44, DIL40	QFP44	DIL40	QFP44







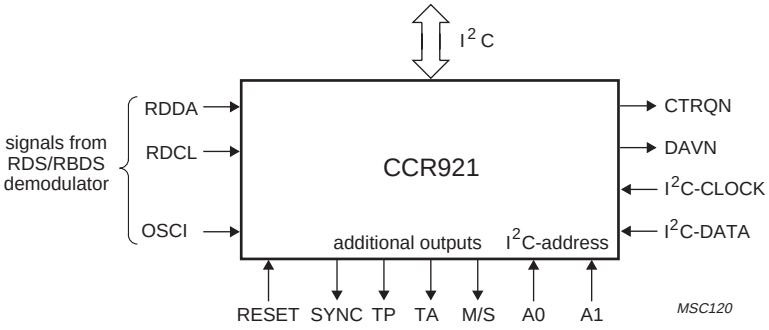


Fig.14 CCR9xx RDS and RDS/RBDS decoders

13. RADIO PC CARDS

Philips has a range of radio PC card applications available based around the OM56xx family of radio tuners. These tuner modules are all fully shielded against the extreme electrical noise found within a PC and deliver clear, hi-fi quality FM stereo radio signals in a multimedia system.

A user-friendly Windows-based program mimics the controls of a high-end system and gives the user full control over all the functions at the click of a mouse.

Furthermore, designing the PC radio cards in a modular fashion, set makers can specify the feature they require, resulting in a single board design for various modes of the final radio.

The most advanced system offers full R(B)DS capabilities and includes:

- CCR912 or CCR921 - R(B)DS decoder
- SAA6579T - R(B)DS demodulator
- OM56xx - FM stereo tune
- TEA6360T - audio preamplifier
- TEA6320 - sound processor
- TDA1517P - 2 × 6 W audio power amplifier
- ISA-bus interface.

For more details about these components, refer to the relevant sections within this Designer's Guide.

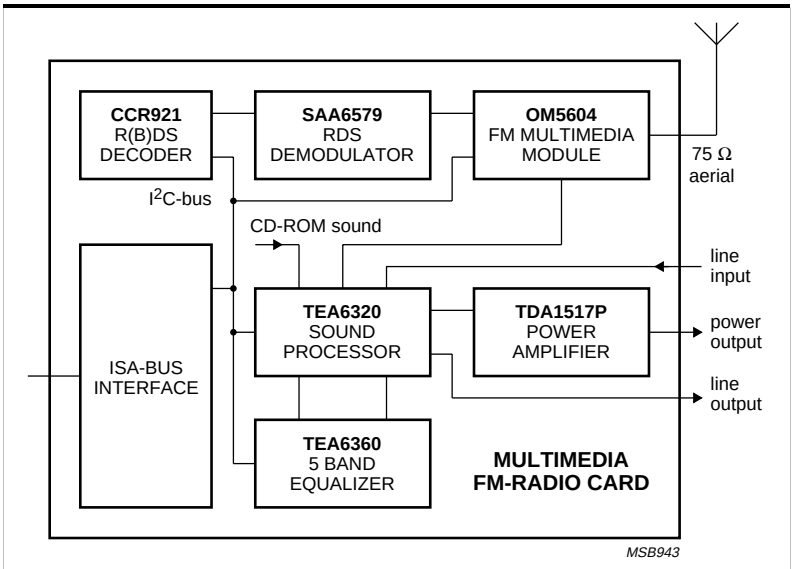


Fig.15 Radio PC-card with R(B)DS

PC radio features

- FM stereo radio with
  - search, step and preset tuning
  - AST (automatic storage of up to 100 presets)
  - local/DX switch
  - instalable search level
  - one-click precision manual tuning
- full R(B)DS capabilities, including PTY search and text display
- 5-band equalizer with 5 predefined and 4 user presets per source
- loudness filter
- mute key
- separate line and power outputs with input level scaling
- 3-line inputs (e.g. CD audio, TV sound and auxiliary)
- master volume control
- simple CD player interface
- three versions available:
  - OM5604 for Europe: 87.5 to 108 MHz IEC-connector
  - OM5606 for USA: 87.5 to 108 MHz F-connector
  - OM5608 for Japan: 76 to 91 MHz F-connector.

14. DAB RECEIVER

Philips' DAB (Digital Audio Broadcast) concept contains all the key components for the Eureka-147 DAB system.

The three main IC at the centre of the decoder are the FADIC, the SIVIC and SAA2501 or SAA2502. The complete chip-set supports all the main features of the ETS specification.

DAB Features

- supports DAB modes I, II & III
- key components comply with Eureka-147
- supports all the main features of the EBU ETSI draft prETS 300 401
- real-time processing of the fast information channel (FIC) and up to 6 service components
- error protection for audio and data services
- soft decision Viterbi decoder
- suitable for small DAB receivers.

The key digital processing ICs are:

FADIC - Differential demodulator and DSP interface

The FADIC is frame independent and operates on a symbol basis. It is able to process all the symbols contained in the baseband frame, which it does in an identical way.

Features

- input symbol buffering
- frequency transposition
- 2048-point, 512-point or 256-point complex FFT
- differential demodulation
- metric generation
- four interfaces
  - an 8-bit parallel input interface
  - a 16-bit parallel control interface
  - an 8-bit parallel output interface
  - a boundary scan-test interface (IEEE 1149-1)

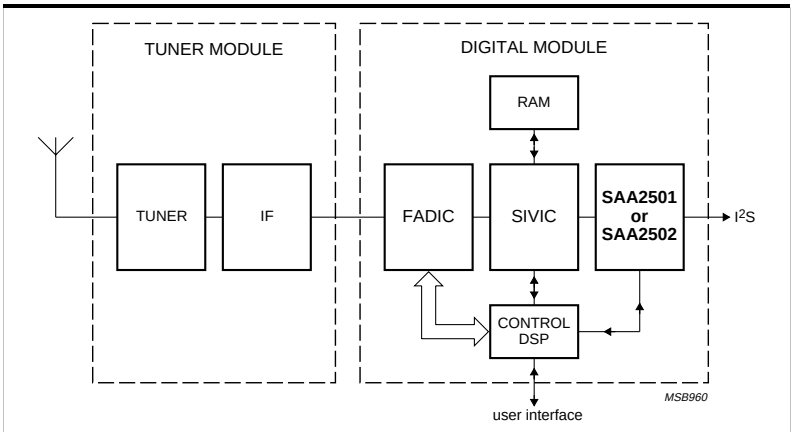


Fig.16 DAB receiver

Table 25 FADIC and SIVIC data

Characteristic	FADIC	SIVIC
supply voltage (V_S)	5 V	5 V
total power dissipation	500 mW[1)]	350 mW
operating temperature range	0 to 70 °C	0 to 70 °C
package	PLCC68	QFP64

1) depending on the number of symbols processed

SIVIC - Program selector

The SIVIC performs service selection, frequency and time de-interleaving and Viterbi decoding.

Features

- decoding of the fast information channel and up to 6 service components
- 4-bit soft decision Viterbi decoder, with a code rate ≥ ¼
- maximum decoding capacity of 320 Kbytes (excl. FIC)
- de-interleaving capacity maximum of 432 capacity units
- error flag generated by re-encoding
- CRC syndrome calculation on each FIB
- five interfaces
  - a 4-bit parallel input interface
  - a serial output interface (DAB3)
  - a serial microcontroller interface (L3)
  - a 256K × 4 DRAM interface
  - a boundary scan-test interface (IEEE 1149-1)

SAA2501 - ISO/MPEG audio source decoder

- layer I and layer II combatable
- Eureka-147 combatable
- decoded sub-band signal output for concealment
- I^2C interface
- processing of programme and audio service synchronized data
- L3 microcontroller interface

SAA2502 - ISO/MPEG audio source decoder

- low sample frequency decoding possibilities (MPEG2 half sample frequencies)
- L3 and I^2C-bus interface
- DAC output (≥ 256 times oversampled)

15. STANDARD AM/FM RADIO RECEIVER ICs

The TEA5710(T), TEA5711(T) and TEA5712(T) are all high-performance, BiCMOS ICs for use in portable AM/FM radios. All necessary functions are integrated, from the AM & FM front end to the detector output stages, to make a complete radio.

The TEA5710(T) design has new features to improve performance and tuning behaviour. Performance features include distributed selectivity on both AM and FM, and minimal variation with supply voltage. Tuning is improved by using a symmetrical AFC. The distributed IF gain allows a simple PCB layout. Furthermore, the AM/FM inputs and the varicon are referred to ground. A new aspect in AM reception is the high impedance AM RF input made by a differential MOST pair. This enables connection to the top of the input selectivity (e.g. the ferroceptor) which simplifies radio design and reduces the number of necessary switches in multiband radios.

The TEA5711(T) and TEA5712(T) have all the features of the TEA5710(T). In addition, they also have a built-in stereo decoder with stereo blend controlled by field strength. They also feature a soft mute to suppress inter-station noise.

The TEA5712(T) differs from the TEA5711(T) in that it is optimized for digital tuning systems: the AM/FM IF output signal is available for IF counting.

Common features

- wide supply voltage range
- low current consumption
- high selectivity with distributed IF gain
- high input sensitivity
- good strong-signal behaviour (10 V/m AM, 500 mV FM)
- low output distortion
- simple, reliable PCB layout
- high impedance MOSFET input on AM.

Specific features

- TEA5710(T)
  - LED driver for tuning indication
- TEA5711(T)
  - LED driver for stereo indication
  - soft mute
  - signal-dependent stereo
  - signal-level output
- TEA5712(T)
  - LED driver for stereo indication
  - soft mute
  - signal-dependent stereo
  - stop-signal output
  - IF output signals available for IF counting.

The figure on the following page shows the FM performance of the of the TEA5711(T) and TEA5712(T).

Table 26 Comparison of TEA5710(T), TEA5711(T) and TEA5712(T)

Characteristic	TEA5710(T)	TEA5711(T)	TEA5712(T)
supply voltage (V_S)	2.0 to 12 V	2.0 to 12 V	2.0 to 12 V
AM performance			
supply current	7.5 mA	14 mA	14 mA
AF output voltage (V_O)	45 mV	45 mV	45 mV
THD	0.8 %	0.8 %	0.8 %
sensitivity (EMF for −3 dB limiting)	1.6 mV/m	1.6 mV/m	1.6 mV/m
FM performance			
supply current	9.0 mA	16 mA	16 mA
AF output voltage (V_O)	65 mV	65 mV	65 mV
THD	0.3 %	0.3 %	0.3 %
sensitivity (EMF for −3 dB limiting)	1.2 μV	1.2 μV	1.2 μV
MPX performance			
channel separation	−	30 dB	30 dB
package	SDIL24/SO24	SDIL32/SO32	SDIL32/SO32

Note:
AM: f_{rf} = 1 MHz, m = 30 %, f_{mod} = 1 kHz, V_S = 3 V
FM: f_{rf} = 100 MHz, Δf = ±22.5 kHz, f_{mod} = 1 kHz, V_S = 3 V

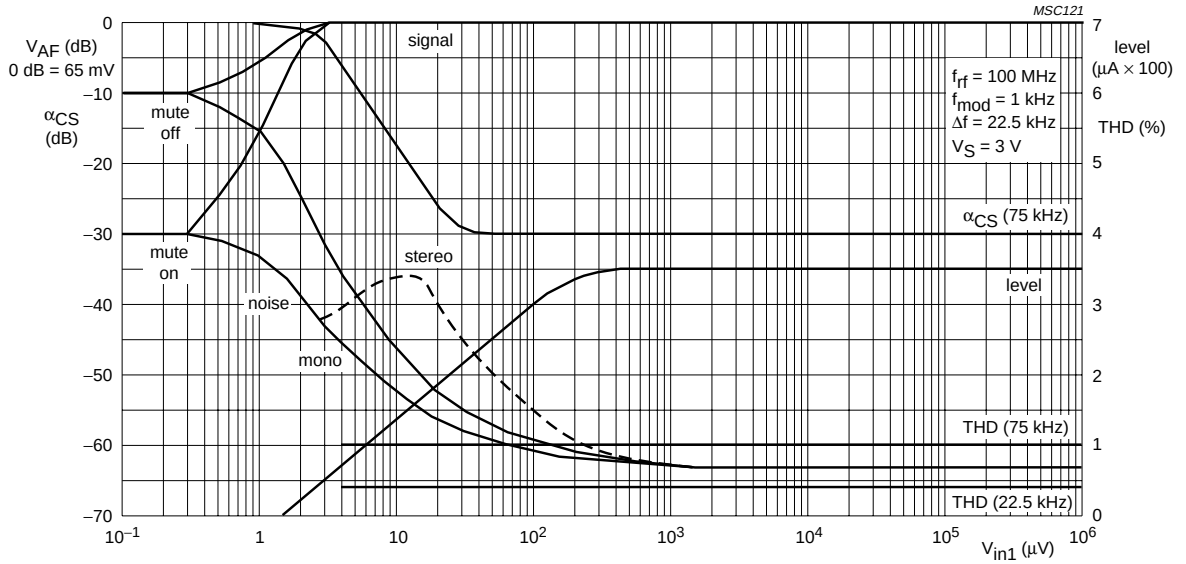


Fig.17 FM performance of the TEA5711(T)/12(T)

16. SELF-TUNED AM/FM RADIO IC

The TEA5757H IC is single-chip, self-tuned radio (STR). It contains a complete AM/FM receiver, stereo decoder, self-tuning VCO, stop circuitry and bus interface. As such it perform all the functions from the aerial input to the stereo decoder outputs. The tuning concept used in the IC combines the advantages of manual tuning with the facilities and features associated with electronic tuning. This is because of the inherent fuzzy logic behaviour of the STR which mimics manual tuning (course tuning followed by fine tuning) and achieves fast and reliable tuning to the desired frequency.

The STR searches for strong signals and allocates them to preset channels, typically identifying 40 stations within just 20 seconds. When the station is selected the signal is locked and the IC goes into a standby mode. If at any time the quality of the signal weakens, the chip “wakes up” and fine-tunes itself again. Also, local/DX switching ensures reception is not overpowered when tuned to a strong local transmitter.

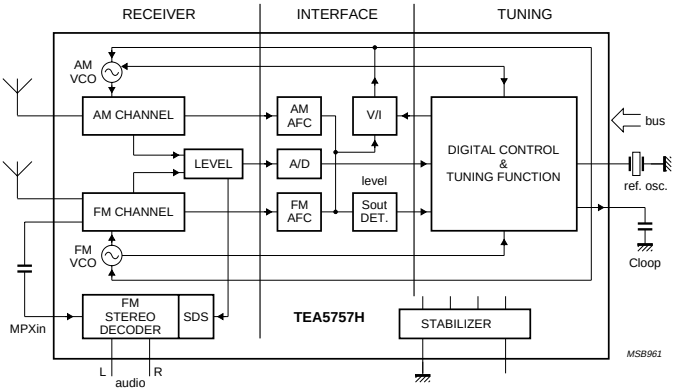


Fig.18 TEA5757H self-tuned radio

Table 27 TEA5757H data

Characteristic	Value
static supply voltage (V_{CC1})	2.2 to 12
secondary supply voltage for tuning (V_{CC2})	12
supply current (I_{VCC1})	
AM	12 to 18 mA
FM	13 to 19 mA
tuning voltage	0.7 to V_{CC2} − 0.75 V
AM performance	
frequency range	0.144 to 30 MHz
RF sensitivity	40 to 70 μV
AF output voltage	36 to 70 mV
total harmonic distortion	0.8%
FM performance	
frequency range	50 to 150 MHz
RF sensitivity	0.4 to 3.8 μV
AF output voltage	40 to 57 mV
total harmonic distortion	0.3%
MPX performance	
channel separation	30 dB
package	QFP44 (SOT307)

Features

- AM receiver (LW, MW and SW)
- FM stereo receiver
- tuning synthesizer and radio on one chip
- stop detection circuitry
- microcontroller bus interface
- manual-search, auto-search, auto-store and preset-mode
- few external components required
- high input sensitivity
- low output distortion
- tuning is independent of the channel spacing
- low power consumption due to standby mode.

Two other derivatives of the TEA5757H are also available: the TEA5759H for Japanese frequency ranges, and the TEA5762H with external FM front-ends for CENELEC applications.

17. AUDIO AMPLIFIER ICs

The tables below gives an overview of our audio amplifier ICs for portable and mains-powered radio/audio systems. For more details on each type, refer to our publication *Design-in guide: Audio amplifier ICs*, ordering code 9398 706 66011.

Table 28 Audio amplifiers for portable systems

Type No.	P_o (W)	Supply (V)	Package	Remarks
TDA1016	2	3.6 to 15	DIL16	record/playback + ALC
TDA1308T	2×0.06 (d_{tot} = 0.1%)	3 to 7	SO8	stereo headphone driver
TDA7050	[0.15]/2 × 0.075	1.6 to 6	SO8	no peripheral components
TDA7050T	[0.15]/2 × 0.075	1.6 to 6	DIL8	no peripheral components
TDA7052	1	3 to 18	DIL8	no peripheral components
TDA7053	2 × 1	3 to 18	DIL16	no peripheral components
TDA7052A	1	4.5 to 18	DIL8	DC volume control; 35.5 dB gain
TDA7052AT	0.5	4.5 to 18	SO8	DC volume control; 35.5 dB gain
TDA7052B	1	4.5 to 18	DIL8	DC volume control; 40 dB gain
TDA7052BT	0.5	4.5 to 18	SO8	DC volume control; 40 dB gain
TDA7053A	2 × 1	4.5 to 18	DIL16	DC volume control; 40 dB gain
TDA7053AT	2 × 0.5	4.5 to 18	SO16	DC volume control; 40 dB gain
TDA7056	3	3 to 18	SIL9	no peripheral components; 39 dB gain
TDA7057Q	2 × 3	3 to 18	SIL13	no peripheral components; 39 dB gain
TDA7056A	3	4.5 to 18	SIL9	DC volume control; 35.5 dB gain
TDA7056B	5	4.5 to 18	SIL9	DC volume control; 40 dB gain
TDA7057AQ	2 × 5	4.5 to 18	SIL13	DC volume control; 40 dB gain
TDA8541	1	2.2 to 18	SO8, DIP8	BTL amplifier with standby/mute logic
TDA8542(T)	2 × 1	2.2 to 18	SO16, DIP16	BTL amplifier with standby/mute logic
TDA8559(T)	2 × 0.35	1.8 to 30	SO16, DIP16	low-voltage stereo headphone amplifier
Note: Output powers are RMS and quoted at d_{tot} = 10% unless stated otherwise and depend on supply voltage and loudspeaker impedance. Figures in brackets are for higher loudspeaker impedance.				

Table 29 Audio amplifiers for mains-powered systems

Type No.	P_o (W)	Supply (V)	Package	Remarks
TDA1514A	50 (d = 0.1%)	15 to 60	SIL9	mono 1-end amp., super hi-fi, 20 - 46 dB gain
TDA1517(P)	2 × 6	8.5 to 18	SIL9	20 dB gain
TDA1521(Q)	2 × 12 (d = 0.5%)	15 to 42	SIL9, DBS9	automatic mute; hi-fi
TDA1521A	2 × 6 (d = 0.5%)	15 to 42	SIL9	automatic mute; hi-fi
TDA1560Q	[40]	8 to 18	DBS17	BTL class-H amplifier, [30]dB gain
TDA1561Q	2 × 23	8 to 18	DBS13	SE-BTL power amplifier
TDA2611A	4 to 10	6 to 35	SIL9	adjustable input impedance
TDA2613	6 (d = 0.5%)	15 to 42	SIL9	automatic mute; hi-fi
TDA2614	6 (d = 0.5%)	15 to 42	SIL9	TDA2613 with extra mute pin
TDA2615	2 × 6 (d = 0.5%)	15 to 42	SIL9	TDA1521A with extra mute pin
TDA2616(Q)	2 × 12 (d = 0.5%)	15 to 42	SIL9, DBS9	TDA1521(Q) with extra mute pin
TDA8577	dual line receiver	5 to 18	SIL9	completely separated inputs
TDA8578(T)	dual line receiver	5 to 18	DIL16, SO16	completely separated inputs
TDA8579(T)	dual line receiver	5 to 18	DIL8, SO8	inverting inputs linked
Note: Output powers are RMS and quoted at THD = 10% unless stated otherwise and depend on supply voltage and loudspeaker impedance. Figures in square brackets refer to performance in BTL configuration.				

18. PLL FREQUENCY-SYNTHESIZER ICs

Our AM/FM PLL synthesizer range for radio tuning systems comprises three I^2C-bus controlled ICs: TSA6057(T)/60(T)/61(T).

All these ICs have sensitive prescalers and receive VCO signals directly from AM and FM tuners. Their loop gain can be bus-controlled to combine fast search tuning with stable locking. The two-loop amplifiers allow the loop characteristics to be independently set for AM and FM. Some of them incorporate an in-lock detector.

Common features

- on-chip, high input-sensitivity AM & FM prescalers
- on-chip, high-performance 1 input (2 output) tuning voltage amp. for AM & FM loop filters
- high-speed tuning due to a powerful digital memory phase detector
- serial 2-wire I^2C-bus.

TSA6057(T) specific features

- on-chip 2-level current amplifier (charge pump) to adjust loop gain
- 1 reference oscillator (4 MHz) for both AM & FM
- 40 kHz output reference frequency for FM IF system & microcomputer based tuning interface
- oscillator frequency ranges of 512 kHz to 30 MHz, 30 to 150 MHz
- 3 selectable reference frequencies for both tuning ranges (1, 10, 25 kHz)
- software-controlled bandswitch output.

TSA6060(T) specific features

- on-chip 2-level current amplifier (charge pump) to adjust loop gain
- 1 reference oscillator (8 or 4 MHz) for both AM & FM
- 40 kHz output reference frequency for FM IF system & microcomputer based tuning interface
- oscillator frequency ranges of 512 kHz to 30 MHz, 30 to 200 MHz
- 4 selectable reference frequencies for both tuning ranges (1, 10, 25, 50 kHz)
- software-controlled bandswitch output
- in-lock detector output pin.

Table 30 Comparison of TSA6057(T) and TSA6060(T)

Characteristic	TSA6057(T)	TSA6060(T)
supply voltage (V_S)	4.5 to 5.5 V	4.5 to 5.5 V
frequency range of AM prescaler	0.5 to 30 MHz	0.5 to 50 MHz
frequency range of FM prescaler	30 to 150 MHz	30 to 200 MHz
frequency divider programmable: swallow counter:	 13 bits 4 bits	 17 bits
reference oscillator pins: frequency:	 2 4 MHz	 1 4/8 MHz
reference frequencies	1,10,25 kHz	1,10,25,50 kHz
control bus	I^2C	I^2C
separate loop amplifier outputs	AM/FM	AM/FM
charge pump current (CP=0; CP=1)	5 μA; 500 μA	50 μA; 500 μA
in-lock detector output	–	wired
IF counter for 10.7 MHz AM/FM & 450 kHz AM	–	–
6-bit ADC	–	–
ports	1 output	1 output
40 kHz reference output	✓	✓
package	DIL16, SO16	DIL16, SSOP20

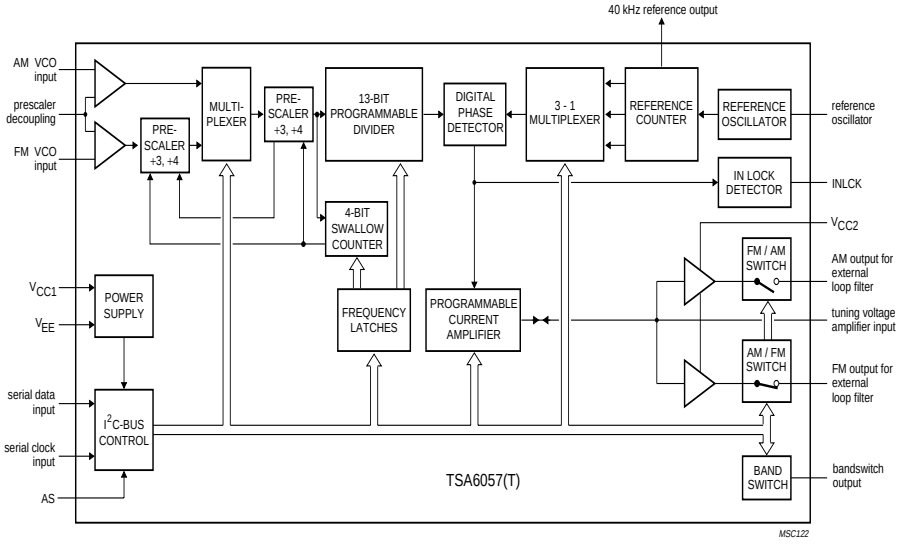


Fig.19 TSA6057(T) PLL frequency synthesizer

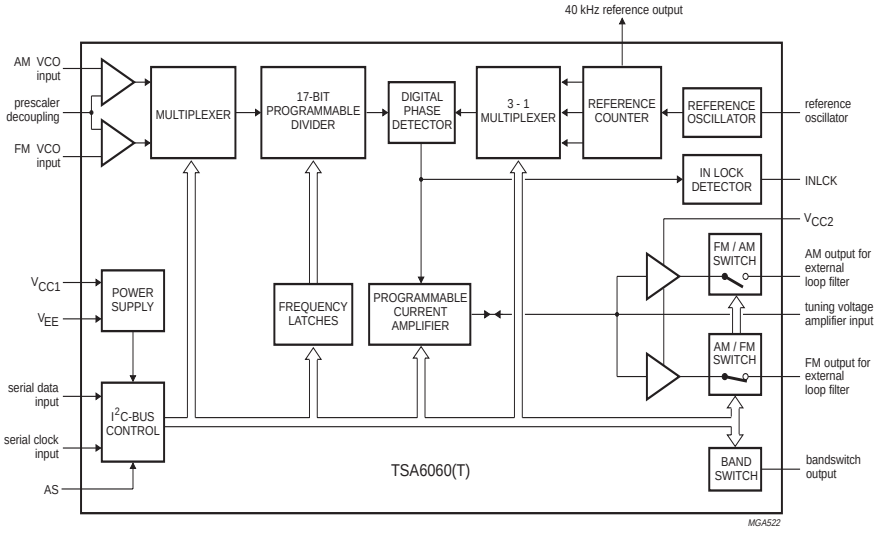


Fig.20 TSA6060(T) PLL frequency synthesizer

19. DOLBY NOISE-REDUCTION ICs

TEA0665(T) Dolby B/C IC

This IC is designed for use in Dolby B and Dolby C type audio noise reduction (NR) systems. It provides the high and low level stages for one channel of a Dolby C type NR system, including NR on/off switching and all electronic switching necessary for Dolby C type systems. In addition the TEA0665 includes a preamplifier for the record and playback functions and a multiplex buffer amplifier. The circuit offers two different line-output levels (-6 & 0 dBm) and a low-pass filter, which can be fed into the signal path in playback mode.

The TEA0665 comes in a SOT117 28-lead plastic DIL package. The TEA0665T comes in a surface-mount 28-lead mini-pack (SO28; SOT136A).

Features

- few external components
- includes record/play preamplifiers plus multiplex filter buffer amplifier
- two line-output levels
- all electronic switching.

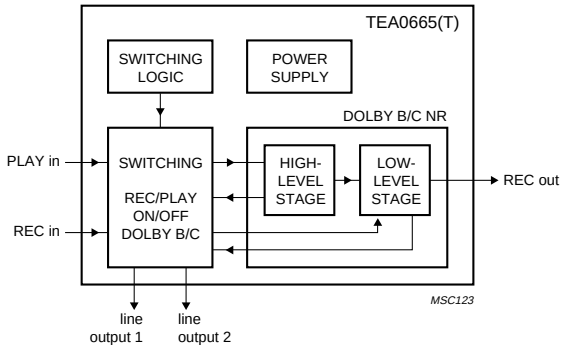


Fig.21 The TEA0665(T) Dolby B/C noise reduction circuit

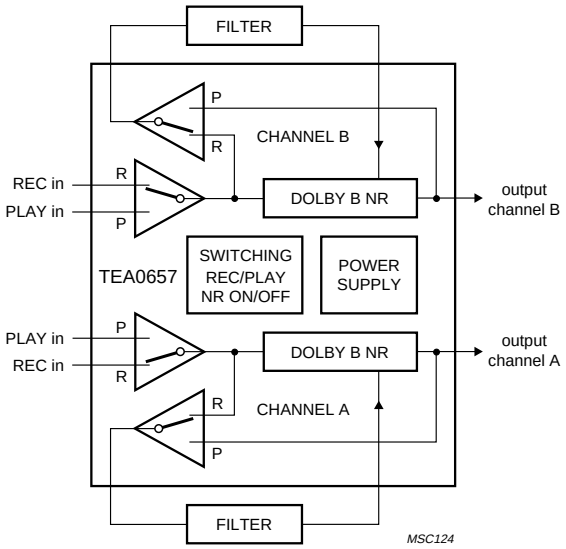


Fig.22 The TEA0657 Dolby B noise reduction circuit

TEA0657 Dolby B IC

This IC provides two channels of Dolby B noise reduction. The circuit contains all internal electronic switching to provide playback or record functions. In addition, the TEA0657 includes preamplifiers for the playback and record modes and multiplex filter buffers for both channels.

The IC will operate with power supplies ranging from 9 to 15 V, output overload level increasing with supply voltage. Current drain varies with supply voltage and noise reduction on/off, so it is advisable to use a regulated power supply or a supply with a long time constant.

Table 31 TEA0665(T) and TEA0657 data

Characteristic	TEA0665(T)	TEA0657
supply voltage (V_S)	8.0 to 16.0 V	9.0 to 15.0 V
supply current (typ.)	17 mA	19 mA
signal + noise to noise ratio record mode: playback mode:	 66 dB 66 dB	 72 dB 90 dB
package	DIL28 (SOT117)/ SO28 (SOT136A)	DIL24 (SOT101B)

The TEA0657 comes in a 24-lead DIL plastic package (SOT101B).

Features

- dual NR channels
- full playback/record switching
- separate playback/record inputs
- multiplex filter buffers
- simultaneous switching on both channels
- dual or single supply operations
- Dolby reference level = 580 mV
- input sensitivity = 30 mV.

20. MICROPROCESSOR CONTROL AND DISPLAY

Over the years, the continually expanding range of Philips' ICs for radio and audio has allowed set manufacturers to implement remote control and extend microcomputer control to virtually all the functions of a radio and hi-fi system. This has led to incorporation of many new facilities such as electronic tuning with search facilities, preset station selection, digital frequency indication and operation in conjunction with Radio Data System (RDS) information.

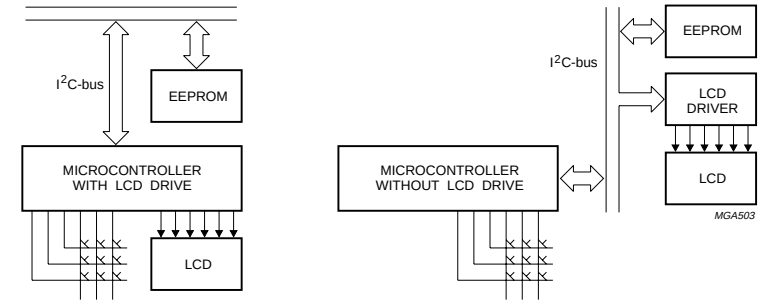


Fig.23 Typical radio control and display systems

Microprocessor control

To assist audio equipment manufacturers incorporate computer control into their circuit designs, Philips supply one of the widest available ranges of 8-bit CMOS microcontroller derivatives. All are based on the industry standard 8051, with architectural enhancements that make them suitable for radio and hi-fi control systems. They all include an 80C51 CPU, use the 80C51 instruction set, and have a wide variety of on-chip peripheral functions; expansion of I/O lines, A to D conversion, I^2C-bus interface, expanded program ROM and data RAM, watchdog timer, UART, 16-bit timer/event counters, and on-chip oscillator and timing circuits.

Our microcontrollers are supported by a range of 1K to 8K CMOS static EEPROMs. Most of these non-volatile memories have an I^2C-bus interface and unique Philips' circuitry for improving reliability by correcting single-bit failures.

Display drivers

To simplify the user interface of hi-fi equipment, it is necessary to have a multitude of parameters displayed by LCD segments. Examples of such displays are tuning information, analog control settings, RDS/RBDS functions, CD and tape information etc.

Philips' extensive range of I^2C-bus controlled LCD drivers are ideal for driving LCD segments or dot-matrix LCD graphics panels either directly or at multiplex rates up to 1:4 (segment displays) or 1:32 (dot-matrix displays).

Table 32 Features of microcontrollers with LCD drive

	P83CL434	P83CL834
ROM capacity	4 Kbytes	8 Kbytes
RAM capacity	128 bytes	256 bytes
supply voltage	3.3 to 5.5 V	
I/O ports	12 pins	
clock frequency	0.7 to 12 MHz	
1 second interrupt	✓	
power-on reset	✓	
timers	2	
LCD driver	22-24 segments 1-4 backplanes	
packages	DIP42, QFP44	

Table 33 Features and performance of microcontrollers without LCD drive

Type number	ROM capacity (Kbytes)	RAM capacity (bytes)	Timers	I/O ports	Serial interfaces	Frequency range (MHz)	Special features
P83C750	1	64	1	2-3/8	−	3.5 to 40	
P83C748	2	64	1	2-3/8	−	3.5 to 16	
P83C749	2	64	1	2-5/8	−	3.5 to 16	
P83C751	2	64	1	2-3/8	I^2C	3.5 to 16	
P83C752	2	64	1	2-5/8	I^2C	3.5 to 16	
P80CL51	4	128	2	4	UART	0 to 16	low voltage
P80C51	4	128	2	4	UART	1.2 to 30	
P83CL410	4	128	2	4	I^2C	0 to 12	low voltage
P83C451	4	128	2	7	UART	3.5 to 16	
P83C550	4	128	2 + watchdog	4	UART	3.5 to 16	8-input ADC
P83C851	4	128	2	4	UART	1.2 to 16	
P83CL580	6	256	3 + watchdog	5	UART, I^2C	0 to 12	low voltage
P80C52	8	256	3	4	UART	3.5 to 24	
P83C552	8	256	3 + watchdog	6	UART, I^2C	1.2 to 30	8-input ADC
P83C562	8	256	3 + watchdog	6	UART	1.2 to 16	8-input ADC
P83C652	8	256	2	4	UART, I^2C	1.2 to 24	
P83C524	16	512	3 + watchdog	4	UART, I^2C	1.2 to 16	
P83CE654	16	256	2	4	UART, I^2C	1.2 to 24	EMC optimized, 8-input ADC
P83C654	16	256	2	4	UART, I^2C	1.2 to 24	8-input ADC
P83CL781	16	256	3	4	UART, I^2C	0 to 12	low voltage
P83CL782	16	256	3	4	UART, I^2C	0 to 12	low voltage
P83C528	32	512	3 + watchdog	4	UART, I^2C	1.2 to 16	
P83CE528	32	512	3 + watchdog	4	UART, I^2C	1.2 to 16	EMC optimized
P83CE558	32	1024	3 + watchdog	6	UART, I^2C	1.2 to 16	EMC optimized, 8-input ADC, PLL oscillator 32 kHz reference
P83CE598	32	512	3 + watchdog	6	UART, CAN	1.2 to 16	EMC optimized, 8-input ADC
P89CE558	32	1024	3 + watchdog	5	UART, I^2C	3.5 to 16	EMC optimized, flash EEPROM, PLL oscillator 32 kHz reference
P83CE559	48	1536	3 + watchdog	6	UART, I^2C	1.2 to 16	EMC optimized

Table 34 Features and performance of CMOS static EEPROMs with I²C-bus interface

Type number	Capacity (K bit)	Temp. range (°C)	Supply voltage (V)	Error correction	Write cycles over temp. range	Write cycles at 22 °C	Package
PCF8581(T)	1	−40 to +85	4.5 to 5.5		10^4	10^5	DIL8 (SO8)
PCF8581C(T)		−40 to +85	2.5 to 6		10^4	10^5	DIL8 (SO8)
PCF8582C-2(T)	2	−40 to +85	2.5 to 6	✓	10^5	10^6	DIL8 (SO8)
PCD8582D-2(T)		−25 to +70	3 to 6	✓	10^4	10^5	DIL8 (SO8)
PCF8582E-2(T)		−40 to +85	4.5 to 5.5	✓	10^4	10^5	DIL8 (SO8)
PCA8582F-2(T)		−40 to +125	4.5 to 5.5	✓	10^5	10^6	DIL8 (SO8)
PCA8522E(T)		−40 to +85	2.7 to 5.5		10^5		DIL8 (SO8)
PCF8594C-2(T)	4	−40 to +85	2.5 to 6	✓	10^5	10^6	DIL8 (SO8)
PCD8594D-2(T)		−25 to +70	3 to 6	✓	10^4	10^5	DIL8 (SO8)
PCF8594E-2(T)		−40 to +85	4.5 to 5.5	✓	10^4	10^5	DIL8 (SO8)
PCA8594F-2(T)		−40 to +125	4.5 to 5.5	✓	10^5	10^6	DIL8 (SO8)
PCA8524E(T)		−40 to +85	2.7 to 5.5		10^5		DIL8 (SO8)
PCF8598C-2(T)	8	−40 to +85	2.5 to 6	✓	10^5	10^6	DIL8 (SO8)
PCD8598D-2(T)		−25 to +70	3 to 6	✓	10^4	10^5	DIL8 (SO8)
PCF8598E-2(T)		−40 to +85	4.5 to 5.5	✓	10^4	10^5	DIL8 (SO8)
PCA8598F-2(T)		−40 to +125	4.5 to 5.5	✓	10^5	10^6	DIL8 (SO8)

Table 35 Features and performance of the LCD segment drivers with I²C-bus interface

Type number	PCF8566(T)	PCF8576T	PCF8576C	PCF8577C(T)
Segment drive outputs	24	40	40	32
Multiplex rate	1:1, 1:2, 1:3, 1:4	1:1, 1:2, 1:3, 1:4	1:1, 1:2, 1:3, 1:4	1:1, 1:2
Segments driven per IC	96	40	40	32
Max. ICs per system	16	16	16	8
Max. segments driven per system	1536	2560	2560	512
Supply voltage V	2 to 6	2 to 9	2 to 6	2.5 to 9
Max. supply current:				
operating at 5 V µA	90	180	120	250
power saving mode µA	40	60	60	
Display data RAM bits	24 × 4	40 × 4	40 × 4	
Blinking modes Hz	0.5, 1, 2	0.5, 1, 2	0.5, 1, 2	
Package	DIL40, VSO40	VSO56	VSO56, LQFP64	DIL40, VSO40

21. REMOTE CONTROL CIRCUITS

In the past, insufficient command capacity of remote controllers and non-standardization of commands and protocols made it impossible to operate all remotely controlled equipment from a single remote-control handset. To solve this problem, Philips has developed a remote control protocol (RC-5) and the ICs to support it.

The RC-5 protocol provides unified remote control of consumer equipment. It can handle up to 4096 commands organized as two sets of 64 commands in 32 individually addressable groups, each of which can be allocated to a separate unit or system. Since many of the 128 commands can control the same function in each different pieces of equipment (e.g. a tuner or an amplifier), RC-5 allows a single remote control handset with relatively few keys to control any individual item of equipment or an entire integrated system. Obviously, to ensure that there are no spurious responses to commands given to items of equipment from different manufacturers, it is essential to have some degree of standardization in the allocation of system addresses and command codes. This standardization, and a procedure for the allocation of new or additional codes, already exists within Philips and is available to our customers.

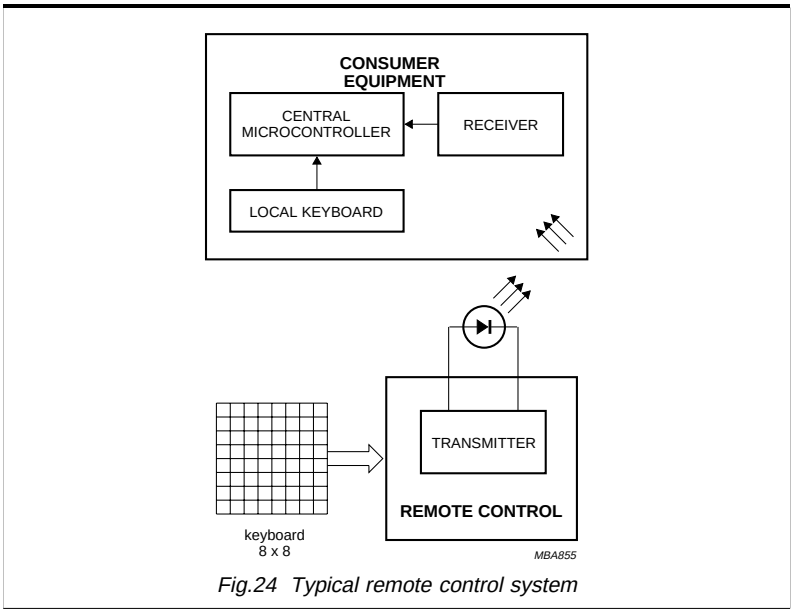


Fig.24 Typical remote control system

Remote control system architecture

The remote control system consists of an infrared transmitter, a receiver, and decoding software in the central microcontroller of the equipment being controlled.

The transmitter is a dedicated PCA84CX22 microcontroller for the required digital data output. A biphase-coded bitstream modulates a 36 kHz carrier which is subsequently converted into an infrared signal by an IR LED.

At the receiving end, the infrared signal from the transmitter is detected, demodulated, amplified and filtered.

If local control is required, amplified output from the keyboard scanner is passed directly to the central microcontroller of the equipment for decoding.

PCA84CX22 - remote control transmitters

Philips' PCA84CX22 family of transmitters are dedicated low-voltage, stand-alone 8-bit microcontrollers that can be mask-programmed to generate the control command codes in accordance with the RC-5 protocol or any other protocol of a set manufacture's choice. Each contains an 84CXXX CPU with ROM, RAM and the following additional on-chip peripherals:

- interrupt gate
- modulator for providing adjustable pulse bursts, pulse duration and pulse duty factor
- watchdog timer to prevent malfunction or the transmitter being locked
- 8-bit programmable timer/event counter with 5-bit prescaler
- 1 Mhz to 6 Mhz oscillator.

Input/output expanders

We also have two I/O expanders to complement our remote control ICs - the PCF8574(A) and the SAA130. These two ICs provide remote I/O expansion for most microcontrollers via the I^2C-bus.

22. MPEG ICs

The perceptual audio encoding/ decoding scheme defined within the ISO/IEC MPEG-1 (Motion Picture Expert Group) Audio Standard (11172-3) results in considerable reduction of the quantity of data required for digital audio, yet maintains a high level of perceived sound quality. The coding is based on a psycho-acoustic model of the human auditory system and exploits the fact that weak spectral components are inaudible if they are in the proximity (in both time and frequency) of loud components. This phenomenon is called masking.

Layers I and II of ISO/MPEG-1 reduce the data by splitting the broadband audio source signal into 32 sub-bands of equal width. The masking threshold (the amount of imperceptible audio energy as a function of frequency) is determined for the given signal by using the psycho-acoustic model. The sub-band samples are then re-quantized to an accuracy that ensures that the spectral distribution of the re-quantization noise does not exceed the masking threshold. This reduction of representation accuracy provides the reduction of the audio data. The re-quantized sub-band samples are multiplexed with side information concerning the actual re-quantization to form the MPEG audio bitstream.

During decoding, the MPEG audio bitstream is de-multiplexed and the side information is used to reconstruct the sub-band signals which are combined to form a broadband audio output signal.

We have two MPEG audio decoders suitable for hi-fi systems: a Digital audio broadcast decoder (SAA2501H) and an MPEG-1/2-compatible audio decoder (SAA2502H).

Depending on features (see below), both products are ideally suited for use in ADR and DAB receivers.

Table 36 Comparison of SAA2501H and SAA2502H

Type number	SAA2501H	SAA2502H
ISO/MPEG audio source decoder	✓	✓
Layer I and Layer II compatible	✓	✓
Suitable for DAB (Eureka-147 compatible)	✓	✓
Decoded sub-band signal output for concealment	✓	
Processing of programme and audio service synchronized data	✓	
Dynamic range control		✓
MPEG 2 compatible (for stereo output)		✓
Handles byte- and non-byte-aligned input data		✓
I^2C microcontroller interface		✓
IEC 958 digital output		✓
Integrated DAC		✓
$256 \times f_s$ clock locked to external reference		✓
I^2S interface	✓	✓
Low power consumption	✓	✓
L3 microcontroller interface	✓	✓
Clock generator	✓	✓
Microcontrolled and stand-alone modes	✓	✓
Error concealment	✓	✓
Burst mode data input	✓	✓
Stereo	✓	✓
Sample clock switching	✓	✓
Variable bit precision	✓	✓
Supply voltage	5 ±10% V	5 ±10% V
Package	QFP44	QFP44

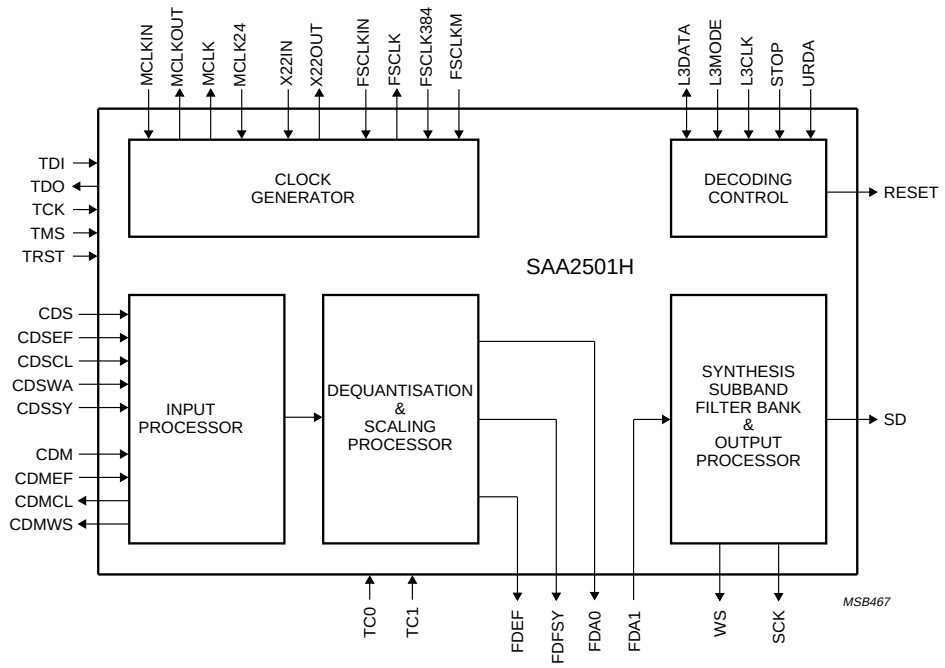


Fig.25 SAA2501H digital broadcast decoder

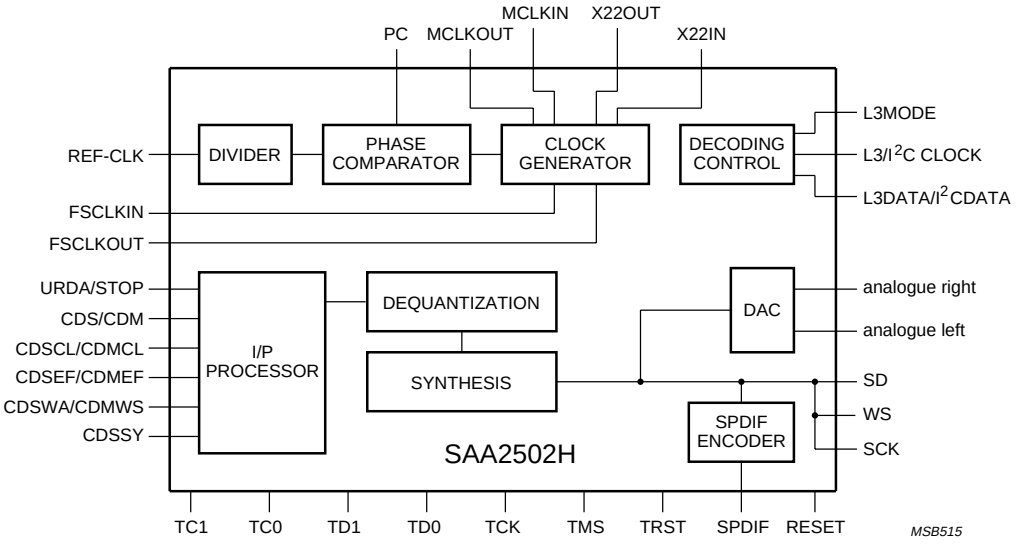


Fig.26 SAA2502H MPEG-1/2- compatible audio decoder

23. DIGITAL SIGNAL PROCESSING ICs

Our digital signal processing (DSP) ICs comprise the SAA7740H DSP IC, the SAA7710T Dolby Pro Logic DSP, and two DACs with DSP features: the TDA1546T and TDA1548T.

SAA7040H Digital Audio Processing IC

This is a very flexible function-specific 4-channel DSP for audio signals. In the general mode, it can provide listening environment enhancements such as equalization, concert hall-effects, reverberation, surround sound/ karaoke processing, and digital volume/balance control.

In the dual/quad filter modes, the IC can also be reconfigured as a dual or quad digital filter with programmable frequency characteristics.

A stereo expansion mode provides stereo digital filtering, 5-band graphic equalization and complex stereo expansion for headphone out-of-head and incredible stereo applications.

Function parameters, correction coefficients and a number of configurations can be downloaded to the IC via an I^2C-bus interface.

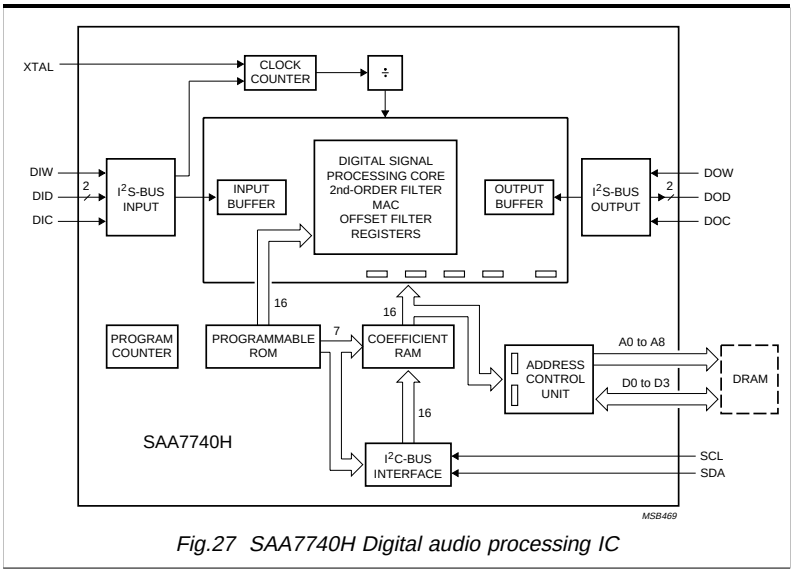


Fig.27 SAA7740H Digital audio processing IC

Table 37 SAA7740H data

Characteristic	SAA7740H
typical crystal frequency	16.9344 MHz
supply voltage (V_S)	4.5 to 5.5 V
total supply current (f_c = 16.9344 Mhz)	145 mA
total power dissipation (f_c = 16.9344 Mhz)	700 mW
operating temperature range	−40 to +85 °C
package	QFP64

Features

- two digital audio inputs and outputs in the I^2S format
- independent input and output interfaces
- slave input and output interfaces
- I^2C microcontroller interface
- DC filtering at the inputs
- one programmable 2nd-order digital filter unit
- 5-band parametric equalizer with selectable centre freq., slope and boost/cut gain settings of ±12 dB
- External delay-line processing for delays of up to 1 s
- Reverberation with selectable reverberation time (up to 5 s) and energy
- Three different surround sound programs to obtain a spatial effect with four loudspeakers
- Passive Dolby surround sound processing, with addition of an external dynamic noise reduction IC
- stereo width control from mono to stereo to spatial stereo
- stereo listening environment acoustic effects (e.g. concert hall) with 8 coefficients and 8 delayed taps per channel
- digital volume and balance control
- Soft-controlled soft mute/de-mute via the microcontroller interface.

SAA7710T Dolby Pro Logic surround sound circuit

This is a high-quality audio-performance add-on digital signal processor. It comprises all the necessary features on chip for complete Dolby Surround Pro Logic sound.

In addition, the device also incorporates 3- and 5-band parametric equalizers, and tone and volume controls. These features can be used to replicate surround sound as an alternative to Dolby Pro Logic, or when the input is non-Dolby surround coded.

Features

- adaptive matrix
- 7 kHz low-pass filters
- adjustable delay for surround channel
- modified Dolby B noise reduction
- noise sequencer
- output volume control
- automatic balance and master level control with DC-offset filter
- hall and matrix surround sound functions
- Either:
  - 3-band parametric equalizer on main channels left, centre, right (f_s = 44.1 kHz), or
  - 5-band parametric equalizer on main channels left, centre, right (f_s = 32 kHz), or
  - tone control (bass/treble) on all four output channels (f_s = 44.1 kHz)
- optional clock divider for crystal oscillator
- I^2C-bus mode control

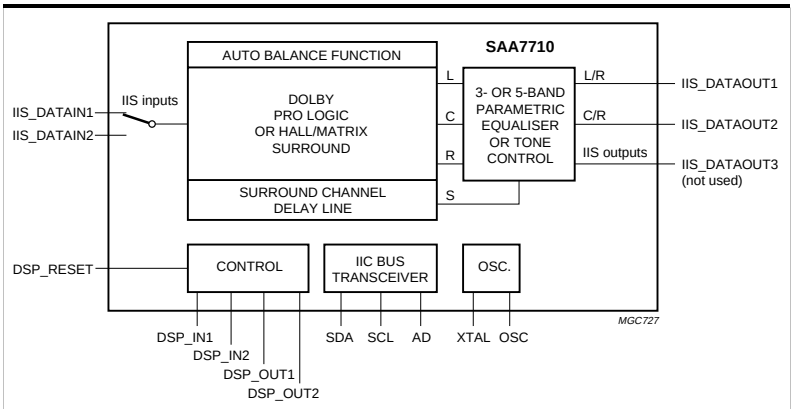


Fig.28 SAA7710T Dolby Pro Logic surround sound IC

Table 38 SAA7710T data

Characteristic	SAA7710T
supply voltage (V_S)	4.5 to 5.5 V
on-chip delay line (f_s = 44.1 khz)	≤45 mA
4-channel active surround sound	20 to 20 000 Hz
stereo I^2C digital input channels	2
stereo I^2C digital output channels	2
package	SO32

TDA1546T and TDA1548T Bitstream/CC filter-DACs

These filter-DACs feature a unique combination of bitstream and continuous calibration techniques. The DAC functions as a bitstream converter for low-level signals, and as a dynamic continuous calibration converter for large signals. This technique results in low power consumption, a small chip and simple application.

These DACs include up-sampling filtering and noise-shaping. The combination of high oversampling up to $16f_s$, second-order noise-shaping and continuous calibration ensures that only simple 1st-order analog post-filtering is required.

These DACs accept input in I^2S format or Japanese format with word lengths of 16, 18 and 20 bits. Four cascaded filters increase the oversampling rate to ×16. A sample-and-hold function increases the oversampling rate in normal speed mode to ×96 ($f_{sys} = 384f_s$) or ×128 ($f_{sys} = 256f_s$) or to ×48 ($f_{sys} = 256f_s$) or ×64 ($f_{sys} = 384f_s$). A 2nd-order noise shaper converts this oversampled data into a bitstream.

The DACs incorporate special data encoding. This ensures an extremely high signal-to-noise ratio, superior dynamic range, and immunity to process variations and component ageing.

Table 39 TDA1546T and TDA1548T data

Characteristic	TDA1546T	TDA1548T
single supply voltage	3.8 to 5.5 V	2.7 to 4 V
power dissipation	265 mW	50 mW
typ. THD + N at full-scale (0 dB)	−88(0.004) dB(%)	−85(.0056) dB(%)
typ. THD + N at −60 dB (A-weighting)	−44(0.6) dB(%)	−35(1.179) dB(%)
Typical signal-to-noise-ratio (A-weighting)	108 dB	95 dB
Full-scale output voltage (RMS value)	1.5 V	0.7 V
Selectable system clock	256, 384 $\times f_s$	256, 384, 64 $\times f_s$
× oversampling:		
normal speed ($f_{sys} = 256f_s$)	128	128
normal speed ($f_{sys} = 384f_s$)	96	96
double speed ($f_{sys} = 256f_s$)	64	64
double speed ($f_{sys} = 384f_s$)	48	48
Serial input format	I^2S, “S” $1f_s$, 16, 18 or 20-bit	I^2S, “S” $1f_s$, 16, 18 or 20-bit
package	SO28	SO28

Two on-chip operational amplifiers convert the DAC output currents into voltages. Externally-connected capacitors perform the required 1st-order post filtering. No further filtering is required.

The unique combination of bitstream and continuous-calibration techniques, together with a high degree of analog and digital integration, results in a single-filter DAC with 18-bit dynamic range, high linearity, and simple, low-cost application.

Common features

- simple application
- continuous calibration DAC combined with the bitstream technique
- cascaded 4-stage digital filter incorporating 2-stage FIR filter, linear interpolator and sample and hold
- DSP features (digital volume and tone control)
- master or slave mode clock system
- smoothed transitions before and after muting (soft mute)
- noise shaper
- no zero crossing distortion.

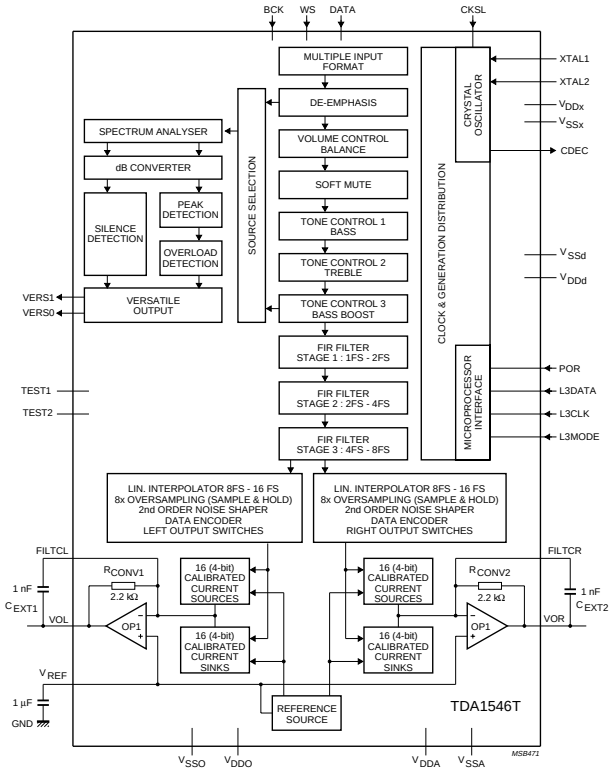


Fig.29 TDA1546T bitstream/continuous calibration filter-DAC

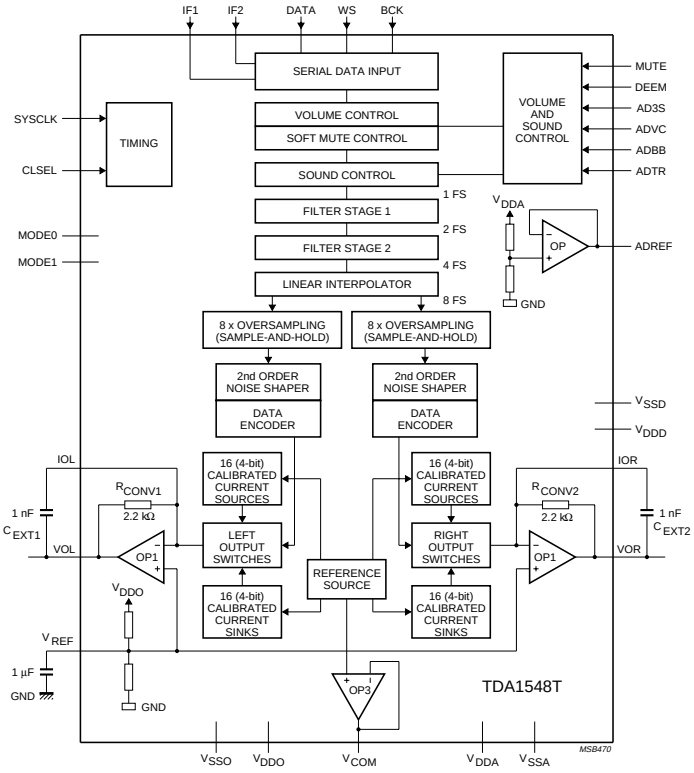


Fig.30 TDA1548T bitstream/continuous calibration filter-DAC

24. AUDIO CONTROL ICs

Philips' audio control ICs incorporate stereo pairs of resistive voltage dividers connected to multi-input op-amps, the tail currents of which are either DC controlled via potentiometers, or digitally controlled via the I^{2}C-bus to adjust volume level, stereo balance, bass level, treble level and fader/output selection. The advantages of this principle are very wide dynamic range combined with low noise and distortion. The low noise and low distortion figures have resulted in approval for use with cassette players with Dolby B and C noise reduction.

Some of the ICs include a fader control which is independent of the volume control which permits sound distribution adjustment between two pairs of audio power amplifiers. And some include a source selector (e.g. for FM, AM or cassette player inputs).

Audio control ICs with I^{2}C-bus control

Our sounds fader control ICs comprise five I^{2}C-bus controlled ICs: TEA6320(T)/21/22T/23T/30T.

Common features

- bass and treble control
- balance control
- interface for equalizer
- mute switch via I^{2}C-bus
- mute switch via IC pin
- maximum gain 20 dB
- THD = 0.05%.

Table 40 Comparison stereo audio control circuits with I^{2}C-bus control (measured with an 8.5 V supply)

Type number		TEA6320(T)	TEA6321	TEA6322T	TEA6323T	TEA6330T
interface for noise reduction circuits		✓	✓	✓	✓	
mute control at audio signal zero crossing		✓	✓	✓	✓	
loudness with bass and treble setting						✓
loudness control combined with volume setting		✓	✓	✓	✓	
stereo (mono) inputs		4 (1)	4 (1)	4 (1)	4 (1)	1 (0)
differential inputs				✓	✓	
supply voltage	V	7.5 to 9.5	7.5 to 9.5	7.5 to 9.5	7.5 to 9.5	7 to 10
max. input (output) signal	V	2 (2)	2 (2)	2 (2)	2 (2)	2 (1.1)
min. output load resistance	kΩ	2	2	2	2	10
stereo volume 1 control:						
range	dB	51	51	51	51	86
step resolution	dB	1	1	1	1	2
L/R & F/R channel volume control:						
range	dB	55	55	55	55	
step resolution	dB	1	1	1	1	
total volume control range	dB	106	106	106	106	86
loudness control:						
bass boost	dB	17	17	17	17	
treble boost	dB	4.5	4.5	4.5	4.5	
fader control range	dB					30
bass control:						
range	dB	±15	±18	±15	±18	±15
step resolution	dB	1.5	1.8	1.5	1.8	3
treble control:						
range	dB	±12	±12	±12	±12	±12
step resolution	dB	1.5	1.5	1.5	1.5	3
channel separation	dB	96	96	80	80	90
ripple rejection	dB	76	76	76	76	70
input isolation	dB	105	105	105	105	
signal-to-noise ratio	dB	105	105	105	105	98
package		SDIL32, SO32	SO32	VSO40	VSO40	SO20

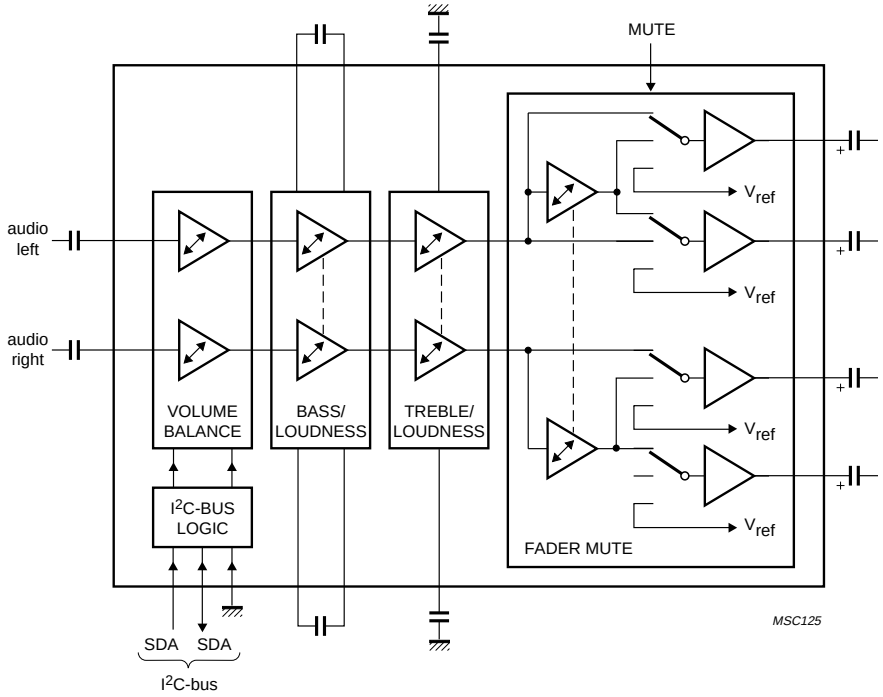
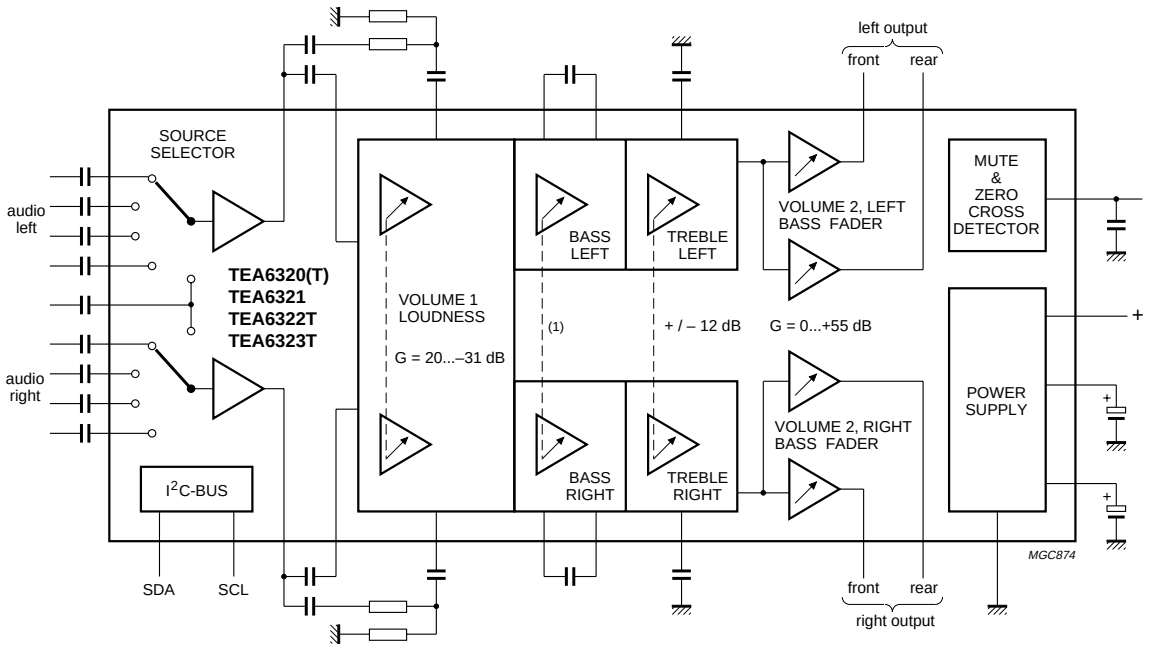


Fig.31 TEA6330T sound fader control circuit



(1) Bass gain = +/–15 dB for TEA6320(T)/22T and +/–18 dB for TEA6321/23T (with T-filter network)

Fig.32 TEA6320(T)/21/22T/23T sound fader control circuit

Audio equalizer circuit with I²C-bus control

The TEA6360(T) is a highly-integrated 5-band stereo equalizer with an I²C-bus controlled tone processor for music centres and car radio. It incorporates 5 stereo pairs of constant-bandwidth boost/cut bandpass filter sections, each centred on a different audio frequency. It also has a built-in I²C-bus interface for receiving filter setting commands from a microcontroller. Each stereo pair of filters has a linear frequency response setting and can be simultaneously controlled in 5 steps of centre frequency boost or cut. The IC is optimized for a frequency boost/cut of 12 dB in five 2.4 dB steps. The frequency response of the filters can be controlled with constant or variable Q-factor.

Each filter section consists of a bridged-T RC network (notch filter) connected in the input or feedback path of an internal operational amplifier. To allow free choice of the centre frequency, maximum gain and Q-factor, the reactive components of each filter section (2 capacitors and one resistor) are external. These can be standard surface-mount types.

In the complete equalizer, 5 filter sections are directly connected in series for each stereo channel. Since the overall DC gain of the circuit is 0 dB irrespective of the filter settings, offset voltages are not amplified. Because the entire circuit is DC-coupled, has a wide input signal swing (2.1 V to V_S - 1 V) and a typical offset of zero, components for DC decoupling and reference voltages are not necessary.

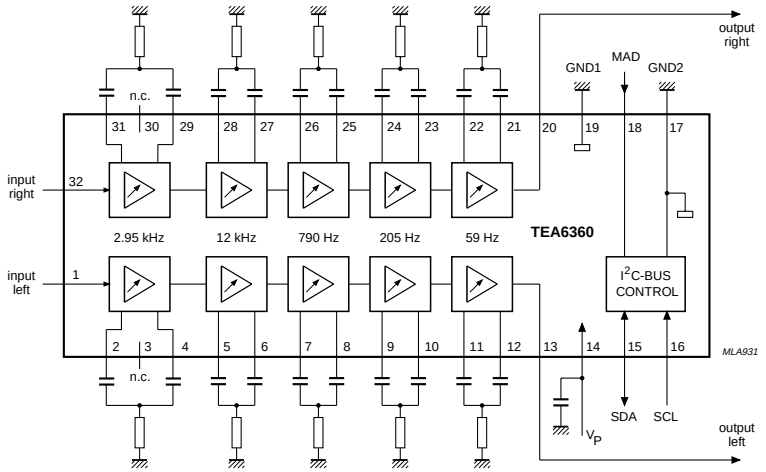


Fig.33 The TEA6360(T) 5-band stereo equalizer

Table 41 TEA6360(T) data (measured with an 8.5 V supply)

Characteristic	Value
supply voltage (V_S)	7 to 13.2 V
supply current	24.5 mA
max. input signal	2.1 V
max. output signal	1.1 V
frequency response (−1 dB, linear)	0 to 20 kHz
channel separation	75 dB
total harmonic distortion	0.2 %
ripple rejection	60 dB
signal-to-noise ratio	93 dB
package	DIL32 (SOT232)/ SO32 (SOT287)

Features

- 5 filters per channel
- centre frequency, bandwidth and maximum boost/cut defined by external components
- variable or constant Q-factor via I²C software
- I²C control for all functions
- defeat mode for linear frequency response and optimum noise performance
- all stages DC coupled
- 120 dB crosstalk attenuation between I²C-bus inputs and audio outputs
- 2 different programmable module addresses.

Audio control circuits without I²C-bus control

Both the TDA1524A and TDA1526 are ICs designed as an active stereo tone/volume control for mains-fed equipment. They include functions for bass and treble control, volume control with built-in contour (can be switched off) and balance. All these functions can be controlled by DC voltages (remote control) or by single linear potentiometers. The TDA1524A is also suitable for car radios with Dolby noise reduction systems.

Common features

- loudness with bass (and treble) setting
- bass and treble control
- balance control
- mute switch via IC pin.

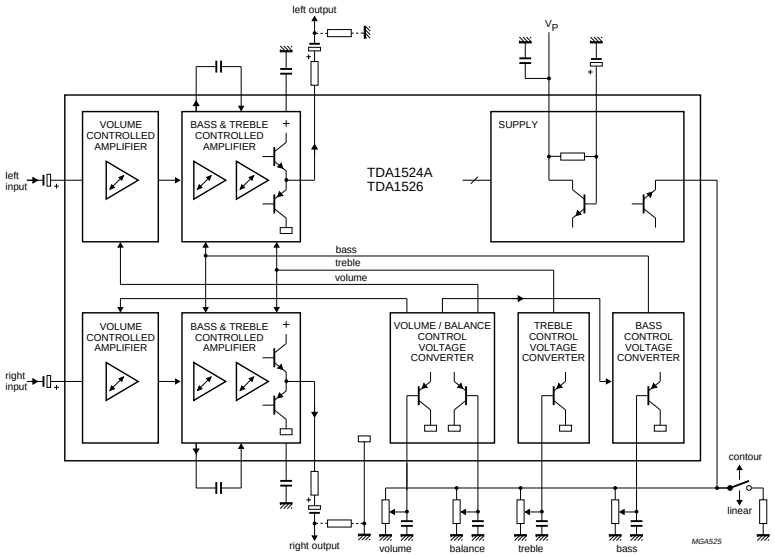


Fig.34 The TDA1524A and TDA1526 stereo audio control circuit

Table 42 TDA1524A and TDA1526 data (measured with an 8.5 V supply)

Characteristic	TDA1524A	TDA1526
supply voltage (V_S)	7.5 to 16.5 V	7.5 to 16.5 V
max. gain	21.5 dB	21.5 dB
max. input signal	2.4 V	2 V
max. output signal	2 V	2 V
min. output load resistance	4.7 kΩ	4.7 kΩ
stereo volume control range	100 dB	100 dB
fader control range	30 dB	30 dB
bass control range	−19 to +17 dB	−15 to +17 dB
treble control range	±15 dB	±15 dB
channel separation	60 dB	60 dB
total harmonic distortion	0.3 %	0.5 %
ripple rejection	50 dB	50 dB
signal-to-noise ratio	85 dB	90 dB
package	DIL18 (SOT102)	DIL18 (SOT102)

25. DISCRETE SEMICONDUCTORS FOR RADIO/AUDIO

Table 43 n-channel JFETs for the RF input stages of AM tuners

Type number	$\lvert Y_{fs} \rvert$ (mS)	I_{DSS} (mA)		$-V_{(P)GS}$			Case
	min.	min.	max.	min.	max.	typ.	
J109	−	40	−	2	6	−	TO-92
J110	−	10	−	0.5	4.0	−	
BF245A-C	3.0	2	25	0.25	8.0	−	
BF256A-C	4.5	3	18	0.5	7.5	−	
BF247A	8	30	80	0.6	14.5	−	
J309	10	12	30	1.0	4.0	6	
J310	10	24	60	2	6.5	6	
BF851A-C	12	2	25	0.2	2	1.5	
BSR58	−	8	80	0.8	4.0	−	SOT23
PMBFJ110	−	10	−	0.5	4.0	−	
BF545A-C	3	2	25	0.4	7.8	−	
BF556A-C	4.5	3	18	0.5	7.5	40	
PMBFJ309	10	12	30	1.0	4.0	6	
BF861A-C	12	2	25	0.2	2	1.5	

Table 44 MOSFETs for AM/FM tuners

Type number	C_{ig1-s} (pF) typ.	$\lvert Y_{fs} \rvert$ (mS) typ.	$V_{(P)G1-S}$ (V) min.	$V_{(P)G2-S}$ (V) min.	F (dB) typ.	Case
BF908(WR)	3.1	43	-2	−1.5	0.6 at 200 MHz 1.5 at 800 MHz	SOT143 (SOT342R)
BF992	4.0	25	−1.3	−1.1	1.2 at 200 MHz	SOT-143
BF998	2.1	24	−2.5	−2.0	1.0 at 800 MHz 0.6 at 200 MHz	SOT-143
BF1100(WR)	2.2	28	-1.5	−1.5	2 at 800 MHz	SOT143 (SOT343R)

Table 45 Varicap diodes for AM tuning

Type number	V_{RM} (V)	C_d (pF)	at $V_{(1)}$ (V)	C_d (pF)	at $V_{(2)}$ (V)	C_d ratio at V_1/V_2	r_s (Ω) max.	f (MHz)	C (pF)	Matched	Case
BB112	12	440-540	1.0	17-29	8.5	>18	<1.5	0.5	$C_{1\ V}$	<3%	SOD-69
BB130	32	450-550	1.0	12-21	28	>23	<2.0	1.0	$C_{1\ V}$	<3%	SOD-69
BB212	12	500-620	0.5	<22	8.0	>22.5	<2.5	0.5	500	<3.5%	TO-92

Table 46 Varicap diodes for FM tuning

Type number	V_{RM} (V)	C_d (pF)	at $V_{(1)}$ (V)	C_d (pF)	at $V_{(2)}$ (V)	C_d ratio at V_1/V_2	r_s (Ω) max.	f (MHz)	C (pF)	Matched	Case
BB135	30	17.5-21	0.5	1.7-2.1	28	8.9-12	<0.75	470	9	no	SOD-323
BB204	30	37-42	3.0	14	30	2.5-2.8	<0.4	100	38	no	TO-92
BB804	20	42-47.5	2.0	26	8	1.65-1.75	0.2	100	38	no	SOT-23

CUSTOMER SUPPORT

During the more than twenty years that Philips has been supplying ICs to meet the needs of radio/audio manufacturers, we've built an unrivalled reputation for keeping our customers at the forefront of circuit design and innovation. This reputation wasn't earned solely by providing integrated circuits to meet the industry's needs, but also by offering extensive applications and design-in support in many countries.

An important part of our customer support package is our comprehensive and regularly updated descriptive publications and data handbooks.

Another important item is an IICRADIO I^2C-bus control program (available on 3.5 inch disk). This program allows engineers to evaluate, analyze and test Philips' radio/audio ICs which have an I^2C-bus interface, without knowledge of the internal software structure of the circuits.

All that's needed to run the program is an IBM or compatible PC with MS-DOS or PC-DOS and at least 1 Mb of RAM. An I^2C-bus interface board must be connected between the I^2C-bus of the board under test and the CENTRONICS parallel printer port of the PC.

The program incorporates a database for IC control data and a set of easy to use dedicated or universal menus for controlling the ICs. All the menus are self-explanatory and the desired functions can be accessed with a single keystroke. The dedicated menus show all the control functions of the associated IC divided into logical groups. All data communication on the I^2C-bus is subjected to error checking and, if errors occur, they're displayed on the PC screen as simple, easily understood messages.

Table 47 Documentation relating to radio/hi-fi ICs

Title	Ordering code	Publication type
Audio amplifier ICs designer's guide	9398 706 66011	brochure
Audio data converters and misc. digital audio IC's designer's guide	9397 750 00151	brochure
Car radio designer's guide	9397 750 00149	brochure
CD designer's guide	9397 750 00356	brochure
I^2C-bus control programs for consumer applications	9398 362 90011	brochure
Integrated Audio Amplifier... ... from 60 mW to 100 W	9398 706 92011	brochure
Philips DCC Key Modules	3122 321 52272	brochure
R(B)DS radio PC-card using OM5604	9397 750 00262	brochure
Remote control ICs and RC-5 command tables	9398 393 39911	brochure
TDA1561Q high-efficiency audio amplifier	9398 707 24011	brochure
The I^2C-bus and how to use it (including specifications)	9398 393 40011	brochure
TV designer's guide	9397 750 00148	brochure
IC01a - Semiconductors for radio and audio systems	9398 652 61011	data book
IC01b - Semiconductors for radio and audio systems	9398 652 62011	data book
IC11 - General purpose/linear ICs	9398 182 10011	data book
IC12 - I^2C peripherals	9397 750 00306	data book
IC14 - 8048-based 8-bit microcontrollers	9398 177 00011	data book
IC20 - 80C51-based 8-bit microcontrollers	9397 750 00013	data book
SC07 - Small-signal field-effect transistors	9397 750 00085	data book
CPR120S outline specification (version 1.0)	AN96020	application note
CCA210S outline specification (version 1.0)	AN96017	application note
CCA210 user manual (version 1.0)	ERA/UM96001	user manual
CCR910S RDS decoder user manual	AT/RA3490	user manual

Title	Ordering code	Publication type
CCR910S RDS decoder outline specification	9398 076 4001	lab. report
CCR911S RDS decoder functional specifications	HAT/AN92012	lab. report
CCR912S RDS decoder user manual	HAT/AN92021	user manual
CCR921 R(B)DS decoder out line specifications	AN95048	application note
CCR921 R(B)DS decoder user manual (version 1.0)	AN95066	user manual
HiFi7000 CD audio system user manual (version 1.0)	SAU/UM95018	user manual
HiFi7000 CD player system outline specification (version 1.2)	AN95109	application note
Influence of the audio frequency modulation on the RDS data reception	HAT/AN92023	application note
Quartz crystal oscillator for SAA6579T	HAS/AN93001	application note
SAA2500/SAA2501 MPEG Audio Decoders user manual (version 1.0)	AN95014	user manual
SAA6579T RDS demodulator application report	HAT/AN92001	application note
SAA7740H design engineering software user guide	NBA/AN9403	user manual
SAA7740H digital audio processor IC for consumer applications	NBA/AN9410	lab. report
SAA7740H game management user guide	NBA/AN9407	user manual
Smart radio user manual (version 1.0)	AN95108	user manual
TDA1548T(Z) low voltage, low power headphone filter DAC (version 1.1)	NBA/AN9507	lab. report
TDA1551Q/54Q/55Q/58Q audio power amplifiers for car radio	NBA/AN9202	lab. report
TDA1552Q/53(A)Q, TDA1556Q and TDA1557Q double BTL amplifiers	NBA/AN9013	lab. report
TDA1560Q power lifting amplifier	NBA/AN9206	lab. report
TDA2613: economic 6 W hi-fi audio amplifier for mains-fed applications	NBA/AN8902	lab. report
TDA2614: economic 6.5 W hi-fi audio amplifier for mains-fed applications	NBA/AN9110	lab. report
TDA2616: 12 W stereo hi-fi audio amplifier	NBA/AN9205	lab. report
TDA7052/53: 1 W componentless BTL mono/stereo audio amplifiers	NBA8907	lab. report
TDA7052A: 1 W BTL mono audio amplifier	NBA/AN9207	lab. report
TDA7056: 3 W mono BTL audio amplifier	NBA/AN9004	lab. report
TDA7056A: 3 W BTL mono audio amplifier with DC volume control	NBA/AN9208	lab. report
TDA7057: 3 W componentless BTL stereo audio amplifier	NBA/AN9009	lab. report
TDA7088T: FM one chip receiver	HBA9101	lab. report
TEA5710: the next step in AM/FM reception	NBA/AN9201	lab. report
TEA5711/12: AM/FM-stereo ICs for manual & digital tuning	NBA/AN9307	lab. report
TEA5757: FM/MW/LW radio receiver	AN95006	lab. report
TEA5757H: PC-control	ERA95012.0	lab. report
TEA57xx family self tuned single-chip AM/FM receivers	AN94082	lab. report
TEA6320(T) audio control IC in combination with TEA6360(T) equalizer IC	AN95101	lab. report
TEA6320T audio control IC measurement results	AN95082	lab. report
TEA632x family: audio control ICs	AN95054	lab. report
TSA6060 fast PLL synthesizer for all radios	ZE/21/02/94	lab. report

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