Application Note

Outline Specification of High-End RDS/EON Car Radio System
CCR520S V2.5

Report No: AN96007

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Radio Data System
Radio Broadcast Data System
EON
CCR520S
P83CE528
Clock function

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This Outline Specification is valid for CCR520S software release V2.5.

Modifications with respect to the application note "Outline Specification of Computer Controlled Car Radio System CCR520S V2.0", report number AN95033:

1. NVM Initialization added.
2. Clock with synchronisation to RDS added

Modifications with respect to the application note "Outline Specification of Computer Controlled Car Radio System CCR520S V1.5", report number ERA/AN93008:

1. USA option added for RBDS and USA band limits / tuning grid.
2. Allow AF-switching to Supra-regional transmitters for RDS.
3. PTY functionality.
4. During AST running frequency is not displayed anymore.
5. The TA / PTY Alarm volume level is programmable.
6. Improved RDS decoding and AF switching behaviour especially with respect to multipath.
7. Improved EON preset update.
SUMMARY:

CCR520 is a computer controlled high-end AM/FM car radio system with RDS/RBDS decoding. It is based on a single 8051 family microcontroller (P83CE528) and various I²C-bus controlled peripherals.

The system contains functions such as PLL tuning, IF control, stereo decoding, RDS/RBDS+EON decoding, IAC, sound switching, sound fader control, LCD display, cassette interface, external audio input jack, clock function and a detachable front.

Radio control and RDS/RBDS+EON processing are combined in a single microcontroller.

"The purchase of Philips' complete set of Integrated Circuits as specified in this Outline Specification for manufacture of a radio system conforming the relevant specification as herein given, secures immunity from suit on unauthorized use of those Philips' patent rights, which specifically relate to automatic broadcast station storage (AST) and/or radio data system (RDS) features."

Purchase of Philips' I²C components conveys a license under the Philips' I²C patent to use the components in the I²C-system provided the system conforms to the I²C specifications defined by Philips.

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1 INTRODUCTION

CCR520S is a computer controlled system based on a P83CE528 microcontroller. It controls a high-end AM/FM car radio with RDS (Radio Data System) or RBDS (Radio Broadcast Data System) and EON (Enhanced Other Networks information) and various I²C-bus controlled peripherals.

The main features are:
- Radio control and RDS/RBDS decoding in a single microcontroller.
- Bands: FM, MW, LW. (Factory selectable FM only / LW disable)
- Tuning: manual, automatic (search and scan), Automatic Store Tuning (AST), selectable tuning grid and band limits for different parts of the world (Europe/USA option).
- Presets: 18 FM, 12 MW, 6 LW.
- External audio jack for e.g. CD player.
- Controls power stabilizer IC.
- PLL frequency synthesizer.
- Sound control: volume, bass, treble, balance, fader, loudness and mute via I²C-bus or potentiometers.
- RDS/RBDS functions:
  - PS Programme Service name display and storage in Non Volatile Memory;
  - PTY Programme Type display and searching;
  - TP/TA Traffic Announcements break-in;
  - AF/PI Alternative Frequency follow and storage in Non Volatile Memory;
  - EON Enhanced Other Networks traffic announcements and update of preset AF lists in NVM.
  - TIME Time information extraction for clock function.
- Security code:
  - enable/disable by the user;
  - preprogrammable in the factory by means of a service mode.
- Non Volatile Memory for: programme presets;
  - RDS/RBDS information;
  - System status.
- LCD display with 120 or 144 segments.
- Keyboard optionally detachable with up to 27 key functions.
- Clock function

NOTE: RBDS is an extension of the European RDS system. Every reference in this document to RDS is also valid for the RBDS system, unless specified otherwise.
2 BASIC HARDWARE CONFIGURATION

The basic configuration of the computer controlled car radio system CCR520 is given in the figures below.

Figure 1  Block diagram of CCR520 with fixed keyboard
Figure 2  Block diagram of CCR520 with detachable keyboard
The CCR520 concept requires the next IC’s to be present in the system:

- **TDA1574(T)** Performs all the FM front-end functions, except the R.F. pre-amplifier stage. Incorporates an FM/IF pre-amplifier.

- **TEA6200** AM tuner, up-conversion system. Does not need an aerial tuned circuit. I.F. frequency 10.7 MHz. No alignments needed.

- **TEA6100** Integrated FM/IF system including a digital AM/FM tuning interface for microcomputer controlled radios with an I²C-bus.

- **TSA6057(T)** PLL synthesizer with separate prescalers for AM and FM and loop filter outputs. I²C-bus controlled.

- **TDA1591(T)** System combination of adjustment free PLL stereo decoder with de-emphasis control and an Interference Absorption Circuit (IAC) with low component count. Specially designed for car radios.

- **TEA6330T or TDA1526** I²C-bus (TEA6330) or potentiometer (TDA1526) controlled AF pre-amplifier for car and home receivers. Includes volume, bass, treble, balance, fader (TEA6330) control and mute (TEA6330).

- **CCR520S** The microcontroller, based on a P83CE528EFB. It is a 8051 derivative with an 8-bit CPU, 32 Kbytes ROM, 512 bytes RAM and four 8-bits I/O ports in a 44-pin QFP package.

- **TDA3602** Supply voltage stabilizer in SIL package with three output voltages (2 x 5V and 8.5V). Two outputs are switchable by external controls.

- **TDA1552Q** Class-B audio power amplifiers in SIL plastic package with 4 identical amplifiers.

  - **TDA1554Q** The TDA1552Q can deliver 2 x 22 W in BTL configuration, the TDA1554Q can deliver either 4 x 11 W or 2 X 22 W.

- **SAA6579(T)** RDS demodulator with onboard 57 kHz bandpass filter and a digital demodulator. Outputs a digital data signal and a clock signal for further processing.

- **PCF8566T/PCF8576T** LCD display drivers that interface to almost any liquid crystal display (LCD) having low multiplex rates. They generate the drive signals for any static or multiplexed LCD with up to four backplanes and up to 24 (PCF8566) or 40 (PCF8676) segment lines and can easily be cascaded for larger LCD applications. I²C-bus controlled.

- **PCF8582/94E-2P/T** 256/512 byte 5V electrically erasable programmable read only memories (EEPROM) that can be 100,000 times re-written.

- **PCF8574(T)** Detachable Keyboard Scanner. I²C-bus controlled.

- **TDA8579(T)** Differential Line Amplifier for external input.
3 SHORT SPECIFICATION

Tuning:  - Frequency bands:

Optionally the following frequency bands are used:

<table>
<thead>
<tr>
<th>Band</th>
<th>Lower Frequency</th>
<th>Upper Frequency</th>
<th>Step Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>FM</td>
<td>87.50 MHz</td>
<td>108.00 MHz</td>
<td>50 / 100 kHz</td>
</tr>
<tr>
<td>MW</td>
<td>531 kHz</td>
<td>1629 kHz</td>
<td>1 / 9 kHz</td>
</tr>
<tr>
<td>LW</td>
<td>144 kHz</td>
<td>288 kHz</td>
<td>1 kHz</td>
</tr>
<tr>
<td>FM</td>
<td>87.90 MHz</td>
<td>107.90 MHz</td>
<td>100 / 200 kHz</td>
</tr>
<tr>
<td>AM</td>
<td>530 kHz</td>
<td>1710 kHz</td>
<td>1 / 10 kHz</td>
</tr>
</tbody>
</table>

- PLL tuning principle.
- Manual tuning up / down.
  Initially slow pace / fine grid. After 2.5 sec. fast pace / coarse grid.
- Local/DX switch.
  The local/DX feature controls the search sensitivity. If the FM tuner has a tuner attenuator, the local/DX switch controls the attenuator during search. If not, it controls the signal level threshold during search. Default after switching on is always DX mode.
- Automatic search tuning up / down.
  Sensitivity is controlled by local/DX. If after one complete band sweep in local mode no station is found, the radio switches automatically to DX. Automatic muting and display of running frequency.
- Frequency scan.
  Continuous automatic search tuning, pausing for 6 seconds on every station.
- AST (Automatic Store Tuning) for FM and MW band.
  AST switches to FM-AST or MW-AST band, searches for the 6 strongest transmitters and stores them in the AST programme preset memory. In FM, duplication of PI codes will be avoided.
- Programme preset memory.
  For each band (FM1, FM2, MW, LW, FM-AST and MW-AST) 6 programme presets and a "manual" frequency are stored. In FM, additional RDS information is stored: PI code (Programme Identification), PS-name (Programme Service), AF list (Alternative Frequencies) and AF follow mode on/off.
  Whenever another band is selected, the radio reverts to the last frequency tuned to in the new band. (This can be either a preset frequency or a manually tuned frequency).
- Programme preset up / down control.
  Programme presets can be recalled/stored by two key control (up and down) or by 6 separate preset keys.
- **AF follow mode.**
  If AF follow mode is on, the set will regularly measure the signal strength on alternative frequencies and compare it with the current station. If an alternative frequency offers better quality, the radio will switch over, and update the alternative frequency list. The measuring scheme is designed to cause minimum noticeable disturbance for the listener. The interval time between two measurements depends on the signal quality.

- **Intelligent preset programme recall.**
  If an FM programme preset with a known PI code is recalled, the primary frequency and all alternative frequencies stored in NVM are examined. The frequency with the highest signal strength that broadcasts the correct PI code will be selected. Only when the programme is not found on one of the AFs, a search is started after 6 seconds for a station with the proper PI code.

- **TA mode.**
  In TA mode the radio only searches for traffic stations. These are stations that may transmit (EON) traffic announcements. The radio will automatically start a search when switching TA mode on and the current station is not a traffic station.

- **PTY search mode.**
  In PTY search mode the radio only searches for transmitters that transmit a user-selected PTY code. Dependent on the factory option USA/Europe the RBDS PTY-table or the RDS PTY-table is used.

- **Last status memory:** frequency, PI code, PS Name, AF lists and AF follow mode on/off status are stored in memory for each preset in each band. This status is recalled during preset switch, band switch and switch on.

**RDS:**

- Bit, block and group synchronisation (inclusive RBDS E-block detection).

- **Data decoding and collection of:**
  - PI, Programme Identification code;
  - AF, Alternative Frequencies;
  - TP, Traffic Programme;
  - TA, Traffic Announcement;
  - PS, Programme Service name;
  - PTY, Programme TYpe;
  - EON, Enhanced Other Networks information;
  - TIME, Time information.

- **AF follow mode using PI and AF** (see also Tuning).

- Display of the Programme Service name in 8 alpha-numeric characters (PS name).

- Display of AF, TP, TA, PTY and regional mode status.
- Regional mode on/off switching. When regional mode is on, the radio will, during AF switching, only switch over to stations with exactly the same PI-code or Supra-regional code. When regional mode is off, the radio will also switch over to stations broadcasting regional variants of the original PI-code. (so called "generic" or "family" PI-codes). For USA application (RBDS) the regional function will only work for PI codes above B000_{hex}. PI codes below B000_{hex} don't have regional variants. (AF-switching is only allowed to stations with exactly the same PI code).

- Break-in of traffic announcements and PTY alarm messages when the radio is muted or in Cassette / External mode.

**EON:**
- Temporally switch to an other station if EON information indicates a traffic announcement on that other station even when the radio is muted or in Cassette / External mode.
- Update lists of alternative frequencies of other stations stored in preset memory with information received via EON.

**Detachable front:**
- Optionally, the keyboard and the LCD display unit can be placed on a detachable front, controlled by a 2nd I2C bus. Only 5 contacts are required to connect the detachable front (6 if it hosts also the power key). No extra hardware is required to detect its presence.

**Control:**
- Up to 27 local control keys on either a fixed, a detachable keyboard or a combination.

**Clock:**
- A twenty four hour clock can be displayed if RDS time information has been received.

**Display:**
- 120 Segment LCD or 144 Segment LCD with Umlaut (ü) and Accent (á) characters, 1:3 multiplexed.

- 8 Alphanumeric characters + decimal point are used for display of:
  - Band and frequency (Example: "FM 103.50")
  - Indication "BALANCE", "FADER", "TREBLE", "BASS" and their position (either analog bar or digital)
  - The security code being entered
  - RDS programme service name (PS) in 8 alphanumeric characters
  - RDS programme type (PTY)
  - "MUTE", in case the user mutes the radio, cassette or external
  - Cassette mode function such as "PLAY ->", "CAS WIND", etc.
  - Clock display can be: " 08.12" or "   --.--" if not yet synchronised to RDS clock.

- 7 Segment display for the current programme preset number.
- 8 Icons for display of:
  - STEREO On when stereo pilot signal is detected, off when forced mono is selected or no stereo pilot signal is detected.
  - AST On when AST band selected.
  - AF On when AF follow mode is enabled (see also Tuning). Flashes if no RDS data received.
  - TA On in TA mode and flashing during a traffic announcement in progress.
  - TP On when a traffic station is received, flashing when the station is not a traffic station and TA mode is on.
  - PTY On when PTY code received, flashing during PTY search.
  - DOLBY On in cassette mode when dolby selected.
  - ME/CR On in cassette mode when ME/CR selected.

Non Volatile Memory:

Either 256 or 512 bytes. The amount of memory determines the maximum number of alternative frequencies to be stored per preset (5/9 AF’s for 256/512 bytes EEPROM).

The next information is stored in NVM:

- Checksum to verify whether an EEPROM has been initialized or not. If a not initialized EEPROM has been detected default values will be stored to insure reasonable settings for e.g. the audio control values.

- System status e.g.: band, audio source (radio / cassette / external).

- User programmable options.

- For each band (FM1, FM2, FM-AST, MW1, MW-AST, LW): six preset frequencies and one non-preset frequency, last used preset.

- For each stored FM frequency:
  - PI-code
  - PS Name (512 byte EEPROM only)
  - AF List (9 AF’s maximum, 5 AF’s for 256 byte EEPROM)
  - AF follow mode on/off.

- Audio controls: volume, bass, treble, fader, balance and loudness.

- Four digit security code (0000 - 9999).
  - Security code can be preprogrammed with the keyboard by means of a service mode, or a preprogrammed EEPROM has to be used.
  - Security code can not be changed by the user. The security code can be enabled or disabled by the user; enable/disable status is stored in NVM.
  - If enabled, the security code must be entered each time the main supply line has been interrupted or the radio has been removed from the retrack.
External audio input:

- Automatically switches to external audio source when a connector is inserted.
- External/radio mode key.
- Optional source switching to cassette mode (cassette is in) or always to radio mode (option diode D6 is in) when the external plug is removed.

Sound:

- Volume, balance, fader, treble and bass control with vol-up/down keys.
- Analog control select key to cycle through balance, fader, treble and bass.
- Mute key
- Automatic muting during tuning and AST search (silent tuning).
- Break-in of traffic announcements (in TA mode) and PTY-alarm messages when the radio is muted or in cassette / external mode. The volume level during a TA / PTY message can be installed to one of 5 fixed by means of the user programmable options.
- Loudness switching.
- Sound settings are stored at switch-off and recalled at switch-on.
- "Bleep" tone to confirm user actions such as storing a programme preset, entering AST mode, etc.
- Mono / stereo function.
- Output pins for mute, loudness and traffic announcement, for use with conventional audio control circuitry.

Power-amplifier:

- Conventional power-amplifiers can be used such as two TDA1552Q (4 x 22 Watt), one TDA1554Q (4 x 11 Watt (2 Ω load) or 6 Watt (4 Ω load)) or one TDA1552Q (2 x 22 Watt (4 Ω load)) in a BTL stereo configuration.

Options:

- Diode programmable
- Detachable front
- No LW band
- FM only
- No security code
- Static on/off switch
- Method of source switching
- Application area of the radio (USA/Europe)
User programmable
- 2 / 4 Loudspeakers
- Loudness on/off
- Bar / digital sound control display
- TA / PTY Alarm volume level
- Security code enable/disable

Automatically detected
- Digital sound control chip or conventional controls
- 120 / 144 segment LCD display
- 256 or 512 bytes EEPROM
- Loudness
- Local/DX FM Tuner Control
- AMS )
- Dolby ) Cassette deck functions
- ME/CR )

Power connections:
- Continuous power supply input. Normally connected directly to the car battery. All supply power is drawn from this input.
- Ignition key input. Normally connected to the accessory contact of the ignition switch. Used for switching the radio on/off by the ignition key. This input is also used when the static on/off switch option is chosen instead of the momentary on/off key. In this case the static on/off switch button is connected to the ignition key input.

Switching-on/off:
- Recall of last system status (e.g.: frequency, band, sound control settings, RDS status and last selected audio source).
- Switch on by:
  - Power key, can be static or momentary.
  - Ignition contact (after the set was switched off by turning the ignition off).
- Switch off by:
  - Power key, can be static or momentary.
  - Ignition contact.
  - Removal of detachable keyboard.
  - Opening of the security contact.
  - Wrong security code entered (after 30 to 40 seconds).
- When switched on while the ignition contact is (and remains) off, the set will automatically switch off after 60 minutes.
- The radio will switch on again when switched off due to a power dip during engine start.
Cassette: - Automatically switches to cassette mode after insertion of a cassette
- Interfaces with a mechanically controlled cassette deck
- Play/wind mode detection
- Play direction detection for auto-reverse cassette decks
- Radio reception during wind mode
- Cassette/Radio mode key
- Metal/Chromium tape on/off key
- DOLBY system on/off key
- AMS (Auto Music Search) on/off key
- Optional source switching to external mode (cd plug is in) or always to radio mode (option diode D6 is in) when the cassette is ejected.
4 TARGET CHARACTERISTICS OF THE RADIO

General

Supply voltage range 10.2 to 16 V
Quiescent current, power off 2 mA (typ.)
power on 520 mA (typ.)
Operating ambient temperature -30 to 75 °C
FM frequency range
 Europe 87.5 to 108 MHz
 USA 87.9 to 107.9 MHz
AM frequency range
 Europe 144 to 288 kHz (LW)
 531 to 1629 kHz (MW)
 USA 530 to 1710 kHz (MW)
IF-frequency (AM and FM) 10.7 MHz

FM characteristics

\[ V_{\text{supply}} = 14.4 \, \text{V}, \]
\[ T_{\text{amb}} = 25 \, ^\circ \text{C}, \]
\[ f_0 = 98 \, \text{MHz}, \]
\[ f_{\text{dev}} = 22.5 \, \text{kHz}, \]
\[ f_{\text{mod}} = 1 \, \text{kHz} \]

Signal generator
Radio aerial
input (150 Ohm)

Figure 3 Dummy aerial to test the FM mode

Aerial input voltage (Vin), for -3 dB limiting (f_{mod} = 400 Hz)
for (S+N)/N = 26 dB 10 µV
for 10 dB crosstalk (stereo) 3 µV
150 µV

Signal-to-noise ratio over most of the signal range 60 dB
RF signal handling capability for THD < 2% at 75kHz dev. > 2 V

AF output over most of the signal range
measured at pin 11 of IF module TEA6100. 150 mV
AM suppression over most of the signal range > 50 dB
Total Harmonic Distortion over most of the signal range. 75 kHz dev. 0.5 % (typ.)

Adjacent signal selectivity (two signal method) S_{200} > 44 dB
IF bandwidth 3dB bandwidth 160 kHz
IF suppression > 85 dB

Search sensitivity Vin > 20 µV
RDS sensitivity:
Traffic Announcement Vin > 14 µV
PSservice Name Vin > 16 µV
IF counter resolution 6.4 kHz
Frequency grid
Search Tuning Europe 100 kHz
Manual Tuning USA 50 kHz

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AM characteristics

\[ V_{\text{supply}} = 14.4 \text{ V}, \]
\[ T_{\text{amb}} = 25 \, ^\circ\text{C}, \]
\[ f_0 = 999 \text{ kHz}, \]
\[ m = 0.3, \]
\[ f_{\text{mod}} = 1 \text{ kHz unless otherwise specified.} \]
Dummy aerial as shown in Figure 4.

![Diagram of dummy aerial](image)

**Figure 4** Dummy aerial to test the AM mode

Aerial input voltage (Vin),
for \( (S+N)/N = 26 \text{ dB} \)
MW 45 \( \mu \text{V} \)
LW 70 \( \mu \text{V} \)

Signal-to-noise ratio for Vin = 1 mV
> 45 dB

AGC range Vin/500 mW for 10 dB variation of AF output
90 dB

RF signal handling capability for THD < 10 % at \( m = 0.8 \)
1.4 V

Total Harmonic Distortion over most of the
AGC range, \( m = 0.8, f_{\text{mod}} = 400 \text{ Hz} \)
< 2 %

Total bandwidth B 3dB
5 kHz

Fidelity ( -3 dB )
30 Hz - 2 kHz

IF suppression tuned frequency 1400 kHz, Vin = 20 \( \mu \text{V} \)
62 dB

Image rejection tuned frequency 1400 kHz, Vin = 20 \( \mu \text{V} \)
76 dB

IF selectivity
\[ S_9 \]
36 dB
\[ S_{20} \]
66 dB

IF counter resolution
500 Hz

Frequency grid,
LW (search and manual tuning) 1 kHz
MW (search tuning) Europe 9 kHz
MW (manual tuning) 1 kHz
MW (search tuning) USA 10 kHz
MW (manual tuning) 1 kHz

Search sensitivity Vin
> 45 \( \mu \text{V} \)

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5 MICROCONTROLLER AND PIN ASSIGNMENTS

CCR520S is based on a P83CE528 microcontroller. It is single-chip microcontroller, manufactured in an advanced CMOS process and is a derivative of the 80C51 microcontroller family.

The pin assignments for CCR520S are given in Figure 5 and Figure 7. Figure 6 and Figure 8 show the keyboard configurations for the fixed and detachable front respectively.

Figure 5 Pinning of CCR520S for fixed front

Figure 6 Keyboard configuration for fixed front
**Figure 7** Pinning of CCR520S for detachable front

**Figure 8** Keyboard configuration for detachable front

When the detachable keyboard option is chosen it is not necessary to use all the keys in the small fixed keyboard. At least the power key should be mounted when is chosen for the momentary on/off key. (Static on/off switch option disabled)
The following table gives a short description of all pins.

<table>
<thead>
<tr>
<th>PIN</th>
<th>NAME</th>
<th>I/O</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>EXSTAT</td>
<td>I/O</td>
<td>Status of external audio jack</td>
</tr>
<tr>
<td>2</td>
<td>SCL</td>
<td>I/O</td>
<td>I2C Bus Clock line</td>
</tr>
<tr>
<td>3</td>
<td>SDA</td>
<td>I/O</td>
<td>I2C Bus Data line</td>
</tr>
<tr>
<td>4</td>
<td>RESET</td>
<td>I</td>
<td>Device reset</td>
</tr>
<tr>
<td>5</td>
<td>CMECR</td>
<td>I/O</td>
<td>Cassette ME/CR select</td>
</tr>
<tr>
<td>6+16+28+39</td>
<td>Vss</td>
<td></td>
<td>GROUND</td>
</tr>
<tr>
<td>7</td>
<td>PILOT</td>
<td>I/O</td>
<td>Stereo indication / mono/stereo control</td>
</tr>
<tr>
<td>8</td>
<td>RDSCLK</td>
<td>I</td>
<td>RDS Clock from RDS demodulator</td>
</tr>
<tr>
<td>9</td>
<td>SECUR</td>
<td>I</td>
<td>Security contact</td>
</tr>
<tr>
<td>10</td>
<td>BLPTST</td>
<td>I/O</td>
<td>Bleep output / Test input (service mode)</td>
</tr>
<tr>
<td>11</td>
<td>CDOLBY</td>
<td>I/O</td>
<td>Cassette doby select</td>
</tr>
<tr>
<td>12</td>
<td>RDSDAT</td>
<td>I</td>
<td>RDS Data from RDS demodulator</td>
</tr>
<tr>
<td>13</td>
<td>EXMUTE</td>
<td>I/O</td>
<td>Mute external audio source</td>
</tr>
<tr>
<td>14</td>
<td>XTAL2</td>
<td>O</td>
<td>Oscillator output</td>
</tr>
<tr>
<td>15</td>
<td>XTAL1</td>
<td>I</td>
<td>Oscillator input</td>
</tr>
<tr>
<td>17+38</td>
<td>Vdd</td>
<td>I/O</td>
<td>+ 5 V supply voltage</td>
</tr>
<tr>
<td>18</td>
<td>KEYB0</td>
<td>I/O</td>
<td>Keyboard matrix line 0</td>
</tr>
<tr>
<td>19</td>
<td>KEYB1</td>
<td>I/O</td>
<td>Keyboard matrix line 1</td>
</tr>
<tr>
<td>20</td>
<td>KEYB2</td>
<td>I/O</td>
<td>Keyboard matrix line 2</td>
</tr>
<tr>
<td>21</td>
<td>KEYB3</td>
<td>I/O</td>
<td>Keyboard matrix line 3 / AMS select</td>
</tr>
<tr>
<td>22</td>
<td>KEYB4</td>
<td>I/O</td>
<td>Keyboard matrix line 4</td>
</tr>
<tr>
<td>23</td>
<td>KEYB5</td>
<td>I/O</td>
<td>Keyboard matrix line 5 / detach. I2C Data</td>
</tr>
<tr>
<td>24</td>
<td>KEYB6</td>
<td>I/O</td>
<td>Keyboard matrix line 6 / detach. I2C Clock</td>
</tr>
<tr>
<td>25</td>
<td>HOLD</td>
<td>I</td>
<td>Power supply OK in</td>
</tr>
<tr>
<td>26</td>
<td>/PSEN</td>
<td>O</td>
<td>Program Store Enable (n.c.)</td>
</tr>
<tr>
<td>27</td>
<td>ALE</td>
<td>O</td>
<td>Address Latch Enable (n.c.) (disabled)</td>
</tr>
<tr>
<td>29</td>
<td>/EA</td>
<td>I</td>
<td>External Access (connect pull-up)</td>
</tr>
<tr>
<td>30</td>
<td>ON</td>
<td>O</td>
<td>Power supply on control</td>
</tr>
<tr>
<td>31</td>
<td>TA</td>
<td>O</td>
<td>Traffic announcement in progress</td>
</tr>
<tr>
<td>32</td>
<td>CMUTE</td>
<td>O</td>
<td>Cassette mute</td>
</tr>
<tr>
<td>33</td>
<td>RMUTE</td>
<td>O</td>
<td>Radio mute</td>
</tr>
<tr>
<td>34</td>
<td>CDIR</td>
<td>I</td>
<td>Cassette direction (forward/reverse)</td>
</tr>
<tr>
<td>35</td>
<td>CINDRV</td>
<td>I</td>
<td>Cassette In drive</td>
</tr>
<tr>
<td>36</td>
<td>IGN</td>
<td>I</td>
<td>Ignition contact status or static on/off switch</td>
</tr>
<tr>
<td>37</td>
<td>CPLYWD</td>
<td>I</td>
<td>Cassette play/wind mode</td>
</tr>
<tr>
<td>40</td>
<td>OPTROW</td>
<td>O</td>
<td>Option row output</td>
</tr>
<tr>
<td>41</td>
<td>LO/DX</td>
<td>I/O</td>
<td>Local / DX control</td>
</tr>
<tr>
<td>42</td>
<td>LOUDN</td>
<td>I/O</td>
<td>Loudness</td>
</tr>
<tr>
<td>43</td>
<td>AUMUTE</td>
<td>O</td>
<td>General audio mute</td>
</tr>
<tr>
<td>44</td>
<td>CENABL</td>
<td>O</td>
<td>Cassette enable</td>
</tr>
</tbody>
</table>

Philips Semiconductors Application Note AN96007
6 KEYBOARD

The keyboard consists of a 7-line triangular matrix connected to the microcontroller or the I/O expander PCF8574. The following table lists the available keys.

<table>
<thead>
<tr>
<th>NAME</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>P 1</td>
<td>Preset-1</td>
</tr>
<tr>
<td>P 2</td>
<td>Preset-2</td>
</tr>
<tr>
<td>P 3</td>
<td>Preset-3</td>
</tr>
<tr>
<td>P 4 / AMS</td>
<td>Preset-4 / Auto Music Search on/off (cassette)</td>
</tr>
<tr>
<td>P 5 / ME/CR</td>
<td>Preset-5 / Metal/Chromium on/off (cassette)</td>
</tr>
<tr>
<td>P 6 / dolby</td>
<td>Preset-6 / dolby on/off (cassette)</td>
</tr>
<tr>
<td>POWER</td>
<td>Power on/off (momentary on/off key)</td>
</tr>
<tr>
<td>VOL-UP</td>
<td>Analog sound setting up</td>
</tr>
<tr>
<td>VOL-DOWN</td>
<td>Analog sound setting down</td>
</tr>
<tr>
<td>SELECT</td>
<td>Select analog function for update</td>
</tr>
<tr>
<td>MUTE</td>
<td>Mute on/off</td>
</tr>
<tr>
<td>FREQ-UP</td>
<td>Manual / search tuning upward</td>
</tr>
<tr>
<td>FREQ-DOWN</td>
<td>Manual / search tuning downward</td>
</tr>
<tr>
<td>AUTO/MANUAL</td>
<td>Switch between manual / search tuning</td>
</tr>
<tr>
<td>BAND</td>
<td>Cycle through bands</td>
</tr>
<tr>
<td>AST</td>
<td>Automatic search tuning band select and programming</td>
</tr>
<tr>
<td>AF / REG</td>
<td>RDS AF follow mode on/off / regional mode on/off</td>
</tr>
<tr>
<td>TA</td>
<td>RDS traffic information mode on/off</td>
</tr>
<tr>
<td>PTY</td>
<td>Display current PTY / enter PTY search mode</td>
</tr>
<tr>
<td>LOUD / RESET</td>
<td>Loudness on/off / Sound settings reset</td>
</tr>
<tr>
<td>MODE</td>
<td>Radio / cassette / external selection (/when pressed long, display clock)</td>
</tr>
<tr>
<td>LOCAL / DX</td>
<td>Local / DX selection</td>
</tr>
<tr>
<td>STEREO</td>
<td>Suppress/enable stereo mode</td>
</tr>
<tr>
<td>PRE-UP / ME/CR</td>
<td>Programme preset up / Metal/Chromium on/off (cassette)</td>
</tr>
<tr>
<td>PRE-DOWN / dolby</td>
<td>Programme preset down / Dolby on/off (cassette)</td>
</tr>
<tr>
<td>SCAN</td>
<td>Automatic frequency scan</td>
</tr>
<tr>
<td>DISPLAY</td>
<td>Select display (Clock display / PTY / frequency / PS name)</td>
</tr>
</tbody>
</table>
7 OPTION DIODES

<table>
<thead>
<tr>
<th>Diode</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1</td>
<td>Detachable front</td>
</tr>
<tr>
<td>D2</td>
<td>FM Only</td>
</tr>
<tr>
<td>D3</td>
<td>No LW band</td>
</tr>
<tr>
<td>D4</td>
<td>No security</td>
</tr>
<tr>
<td>D5</td>
<td>Static on/off switch</td>
</tr>
<tr>
<td>D6</td>
<td>Method of source switching</td>
</tr>
<tr>
<td>D7</td>
<td>USA Application</td>
</tr>
</tbody>
</table>

Figure 9  Location of option diodes

8 LCD DISPLAY

The Liquid Crystal Display (LCD) is driven by either one PCF8576 or two PCF8566’s. Figure 10 shows all the segments of the display. To support the RDS programme service name (PS) feature, the display is equipped with 8 alpha numeric characters. With 13 segments per character, display is possible of all required RDS characters (capitals only); with 16 segments per character, umlauts and the accent can be displayed as well.

Both displays operate in 1:3 multiplex mode.

Figure 10  Liquid Crystal Display (LCD) layout