

APPLICATION NOTE

Outline Specification CPR120S, microcontroller for a Portable Radio system. V1.0

AN96020

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Abstract

CPR120 is a micro computer controlled Personal Radio system consisting of an FM, MW, LW and SW stereo radio and is battery-fed. It is based on a single microcontroller (P83CLx34) and the STR radio system TEA5757. (STR = Self Tuned Radio). This report gives an outline of the system describing system features and components.

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Outline Specification CPR120S, microcontroller for a Portable Radio system. V1.0 AN96020

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Summary

CPR120 is a micro computer controlled FM/MW/LW/SW radio system, (for battery-fed portable, personal radio systems), based on the TEA5757 STR radio system (STR = Self Tuned Radio), combined with a Tape deck.

CPR120S is the controlling microcontroller, it takes care of all radio functions as well as preset storage. The main features are listed below.

Tuner:

- Digital tuning for FM, MW, LW and SW band;
- Analog search next/previous station;
- Automatic analog fine tuning;
- Store and recall 5 presets per band;
- Frequency scan function;
- AST (Automatic Store Tuning) for FM and MW;

Tape:

- Tape play detection;

Clock and Timer:

- Clock function in standby;
- Switch-on timer function;
- Sleptimer up to 90 min;

Keys:

- Up to 9 local keys possible;

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REVISION HISTORY

Version	Remarks
Version 0.1	First release
Version 1.0	LW band changed; 12/24 Hour diode option removed; LCD diode option added and LCD layout changed; User interface diode option added.

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1. INTRODUCTION

CPR120 is a micro computer controlled Personal Radio system consisting of an FM, MW, LW and SW stereo radio. It is based on a single microcontroller (P83CLx34) and the STR radio system TEA5757. (STR = Self Tuned Radio).

The system contains functions such as search tuning, preset control, interface for a mechanical controlled tape deck (or an other external source), LCD display.

CPR120 will be used to built an application for a battery-fed powered portable, personal radio system.

2. BLOCK DIAGRAM OF THE SYSTEM

The basic block diagram of CPR120 with tape/external source interface is given in the figure below.

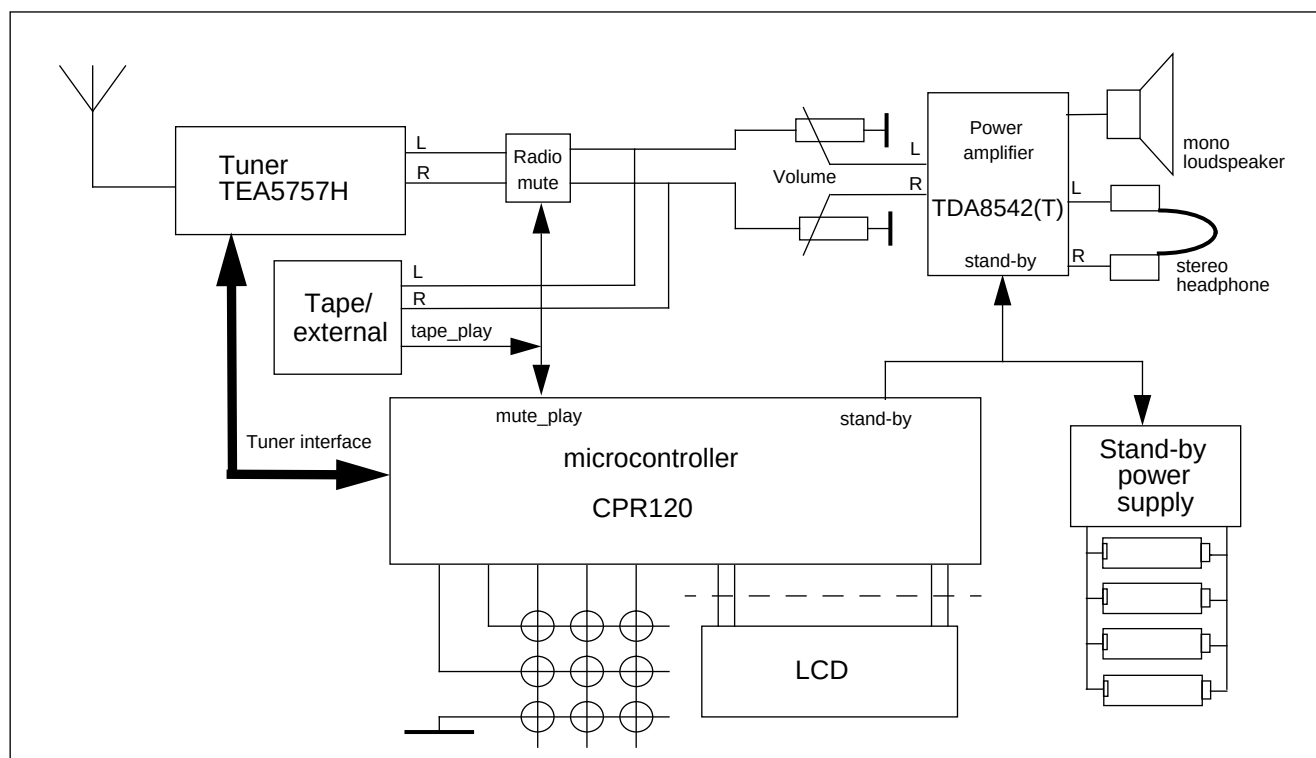


Fig.1 Block diagram of CPR120S with tape/external source interface.

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The figure below shows a basic radio only application.

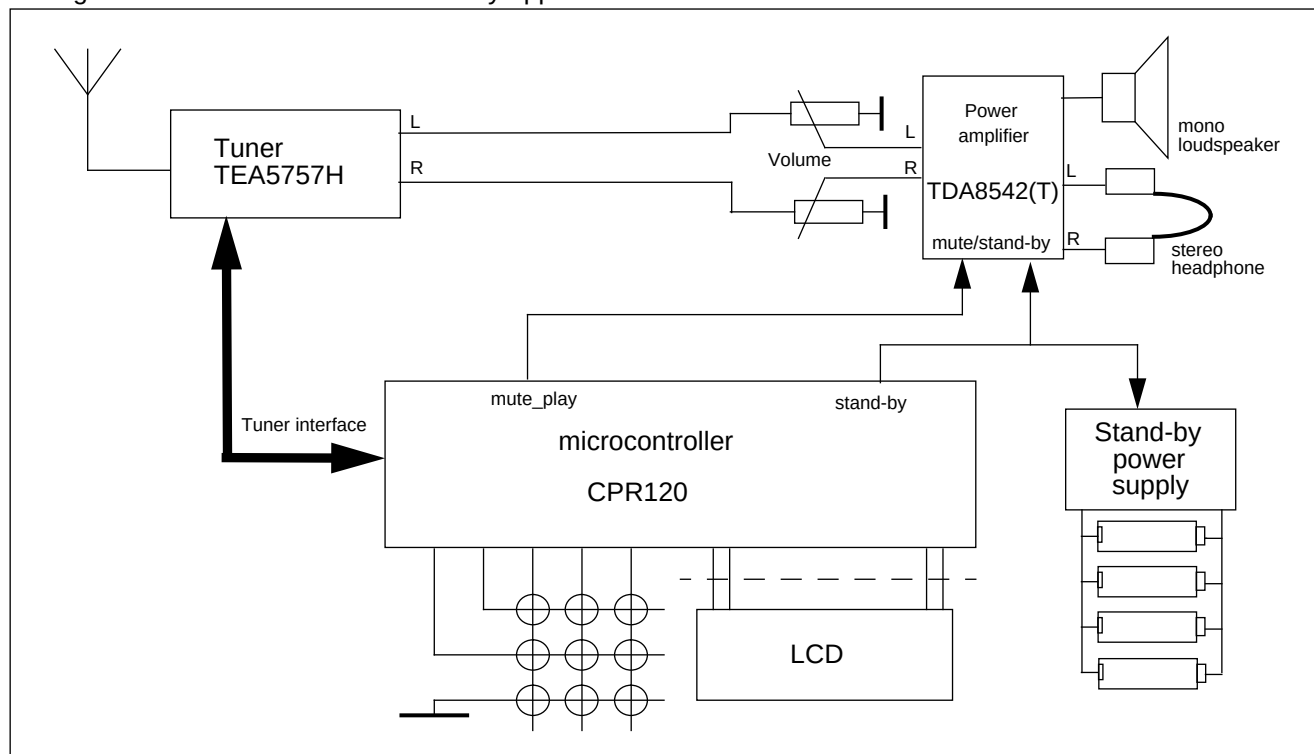


Fig.2 Block diagram of CPR120S in radio only application.

A short description of the key components is given below:

P83CLx34, CPR120S mask programmed microcontroller.

TEA5757H, AM/FM receiver including synthesizer and stereo decoder. The inherent Fuzzy Logic behaviour of STR (Self Tuned Radio), which mimics hand-tuning, yields a potentially fast yet reliable tuning operation. Search for next/previous station is fast, due to the analog solution. The search requires no IF-counter for stop detection.

TDA8542(T), A two channel audio power amplifier for an output power of $2 \times 1 \text{ W}$ in a 8Ω load at a 5V supply. The circuit contains two BTL amplifiers with a complementary PNP-NPN output stage and stand-by/mute logic.

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3. SHORT SPECIFICATION

Tuning

- Four bands FM, MW, LW and SW.
- Analog tuning principle with FLL backup system.
- User interface for tuning keys selectable by means of an option diode.
- Search up/down tuning with wrap around. Actual search is done by the TEA5757 IC, and the found frequency is read by the micro controller.
- Manual up/down tuning.
- Frequency scan up function, searching for the next station in the band and pausing 6 seconds before the next station is searched for.
- AST, Auto Store Tuning, searches and stores the 5 strongest stations in the selected band, only if the AST band is selected (FM or MW).
- Presets: 5 for FM, MW, LW and SW bands. (3 for the Japanese TV band).
- Preset up/down or preset 1 to preset 5 select keys.
- Saving last band and frequency of station at power off. (in stand-by mode)

Sound control

- Mute output to mute the headphones or power amplifier.

Clock functions

- Clock display function, also in stand-by mode.
- Switch-on timer function.
- Sleep timer function (90 -> 80 -> ... -> 10 -> off -> 90 min).

Display

- LCD configuration selectable by means of an option diode, normal (21 x 2 segments) or extended (19 x 3 segments)
- icons:
 - SLEEP, sleep timer enabled;
 - TIMER, switch-on timer enabled;
 - TUNED, the STR tuner is in-lock;
 - STEREO, stereo is detected in the FM band;
 - AST, AST band selected;
 - 1 digit (7 segments) for preset number display;
 - Normal LCD option:
 - FM, AM, MHz, kHz, used during radio mode;
 - 4.5 digits (7 segments) for frequency and time display;

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- Extended LCD option:
 - FM, MW, LW, SW, MHz, kHz, used during radio mode;
 - EXTERNAL, when the external tape (or CD) input is chosen;
 - MEMORY, when in preset programming mode;
 - 5, to display 5 kHz in the SW band;
 - 3.5 digits (7 segments) for frequency and time display;

Local control

- 9 local keys.

Switching on/off

- Momentarily or static power-on switch.
- Continuous mains power supply, to be able to save the RAM preset data and clock functions.
- Recall of last band, preset and frequency when switching on from stand-by.
- Display of clock functions in stand-by mode.
- First time power-on detection and defaults for presets and clock/timer settings.
- Output to control the power supply to use the timer functions.
- Input to detect the static power-on switch.

Tape/external function

- Tape play detection by means of the mute pin. (Or detection of the external input)

Options (Diode programmable)

- Area and band, 4 diodes allowing 16 implementations.
- Clock and timer-on function.
- LCD standard or extended.
- User interface for fast tuning up/down key handling.
- Static or momentary power switch.
- 5 preset select keys or preset up/down selection.

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4. TARGET CHARACTERISTICS OF THE RADIO

General			
Battery	DC 6V (4 x 1.5V)		
Current consumption	60 mA (Radio switched on, depending on the volume) < 0.1 mA (Radio switched off)		
Battery lifetime	> 8 hours (Radio switched on, depending on the volume)) > 200 days (Radio switched off, clock back-up)		
Output power (10% THD)	> 250 mW		
Speaker impedance	8 Ω		
Headphones impedance	2 x 32 Ω		
FM characteristics			
Tuning range	87.5 - 108 MHz		
I.F. frequency	10.7 MHz +/- 20 kHz		
Sensitivity	< 2 μV for 26 dB S/N		
I.F. rejection	> 50 dB		
Image rejection	> 40 dB		
Stereo separation 1kHz	> 25 dB		
S/N ratio	> 50 dB		
Search sensitivity	< 10 μV		
AM characteristics			
Frequency range	MW	522 - 1620 kHz	(9 kHz step)
		520 - 1710 kHz	(10 kHz step)
	LW	153 - 279 kHz	(3 kHz step)
	SW-A	5.9 - 17.9 MHz	(5 kHz step)
	SW-B ¹	2.3 - 6.2 MHz	(5 kHz step)
	SW-B	7.1 - 21.75 MHz	(5 kHz step)
I.F. frequency	450 kHz +/- 1 kHz		
Sensitivity	MW	< 1.5 mV/m at 26 dB	
	LW	< 2.5 mV/m at 26 dB	
	SW-A	80 - 160 μV	
	SW-B	80 - 160 μV	
Selectivity	MW	> 30 dB	
	LW	> 30 dB	
	SW-A	> 25 dB	
	SW-B	> 25 dB	
Search sensitivity	MW	< 30 μV	
	LW	t.b.f.	
	SW-A	t.b.f.	
	SW-B	t.b.f.	
I.F. rejection	t.b.f.		
Image rejection	t.b.f.		

1. With automatic band switching

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5. MICROCONTROLLER AND PIN ASSIGNMENTS

CPR120S is accommodated in a P83CLx34 microcontroller in a sdip-40 or qfp-44 package. The next figure shows the pinning.

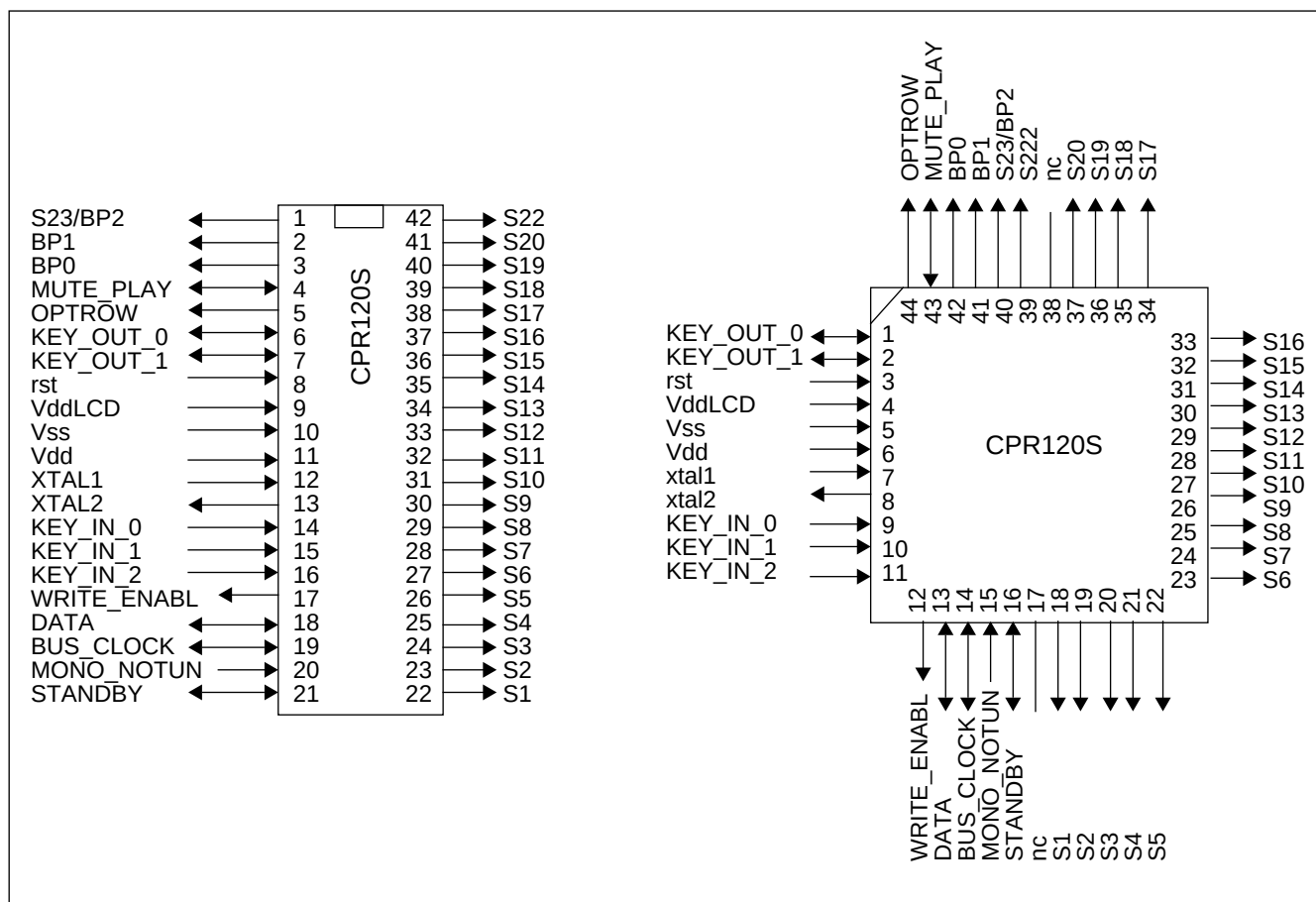


Fig.3 sdip-42 and qfp-44 package

The next table gives a description of all pins.

TABLE 1 Pinning

name	sdip	qfp	I/O	description
mute_play	4	43	I/O	Radio mute or tape play / external plug detection.
optrow	5	44	O	Option row output, connected to the cathodes of all option diodes.
key_out_0	6	1	I/O	Keyboard line 0 output. Option diode D0 input.
key_out_1	7	2	I/O	Keyboard line 1 output. Option diode D1 input.
key_in_0	14	9	I	Keyboard line 0 input. Option diode D2 input.
key_in_1	15	10	I	Keyboard line 1 input. Option diode D3 input.
key_in_2	16	11	I	Keyboard line 2 input. Option diode D4 input.
write_enabl	17	12	I/O	Write enable pin connected to the TEA5757. Option diode D6 input.

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TABLE 1 Pinning

name	sdip	qfp	I/O	description
data	18	13	I/O	Serial data pin connected to the TEA5757. Option diode D7 input.
bus_clock	19	14	I/O	Serial clock pin connected to the TEA5757. Option diode D5 input.
mono_notun	20	15	I	Stereo or in-tune detection connected to the TEA5757. Option diode D8 input.
standby	21	16	I/O	Power control pin to switch the power supply or to detect the static on/off switch.
rst	8	3		microcontroller reset pin.
vddlcd	9	4		LCD power supply (+).
vss	10	5		Ground.
vdd	11	6		Power supply (+5V).
xtal1	12	7		32 kHz oscillator input and output.
xtal2	13	8		
S23/BP2	1	40		Connected to LCD.
BP1	2	41		Connected to LCD.
BP0	3	42		Connected to LCD.
-	-	17		n.c.
S1	22	18		Connected to LCD.
S2	23	19		Connected to LCD.
S3	24	20		Connected to LCD.
S4	25	21		Connected to LCD.
S5	26	22		Connected to LCD.
S6	27	23		Connected to LCD.
S7	28	24		Connected to LCD.
S8	29	25		Connected to LCD.
S9	30	26		Connected to LCD.
S10	31	27		Connected to LCD.
S11	32	28		Connected to LCD.
S12	33	29		Connected to LCD.
S13	34	30		Connected to LCD.
S14	35	31		Connected to LCD.
S15	36	32		Connected to LCD.
S16	37	33		Connected to LCD.
S17	38	34		Connected to LCD.
S18	39	35		Connected to LCD.
S19	40	36		Connected to LCD.
S20	41	37		Connected to LCD.
-	-	38		n.c.
S22	42	39		Connected to LCD.

6. KEYBOARD

6.1 Keyboard layout

The keyboard is arranged as a 3x3-line matrix, up to 9 keys available. The bottom row of keys is connected to ground with one side.

For CPR120S, the allocation of the keys in the keyboard is fixed as shown in the figure below.

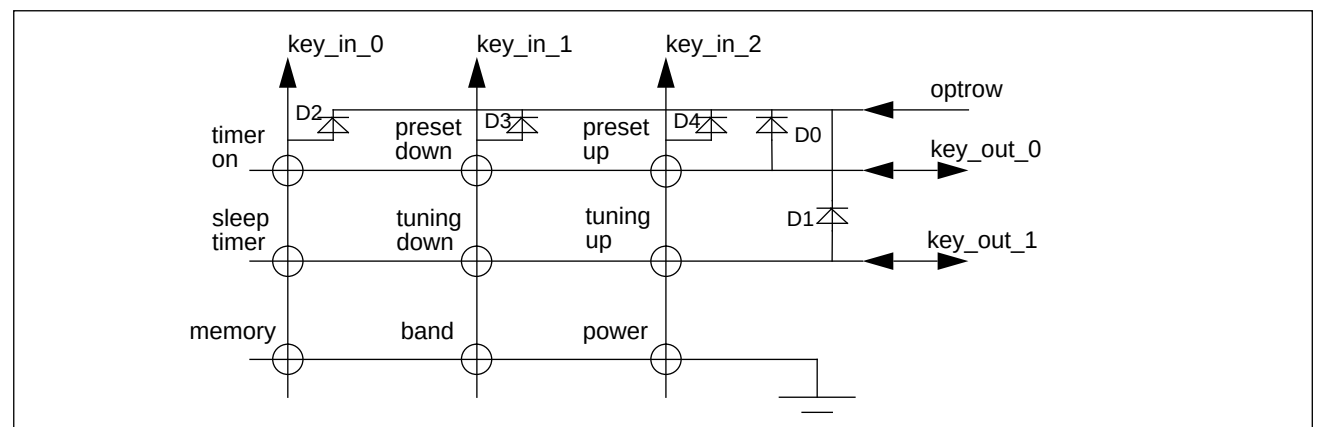


Fig.4 Standard CPR120S keyboard.

Optional 5 preset keys are used when no clock/timer functions are available and the static on/off switch is selected, see the figure below. (Option diodes D0, D1, D2 and D3 are not set).

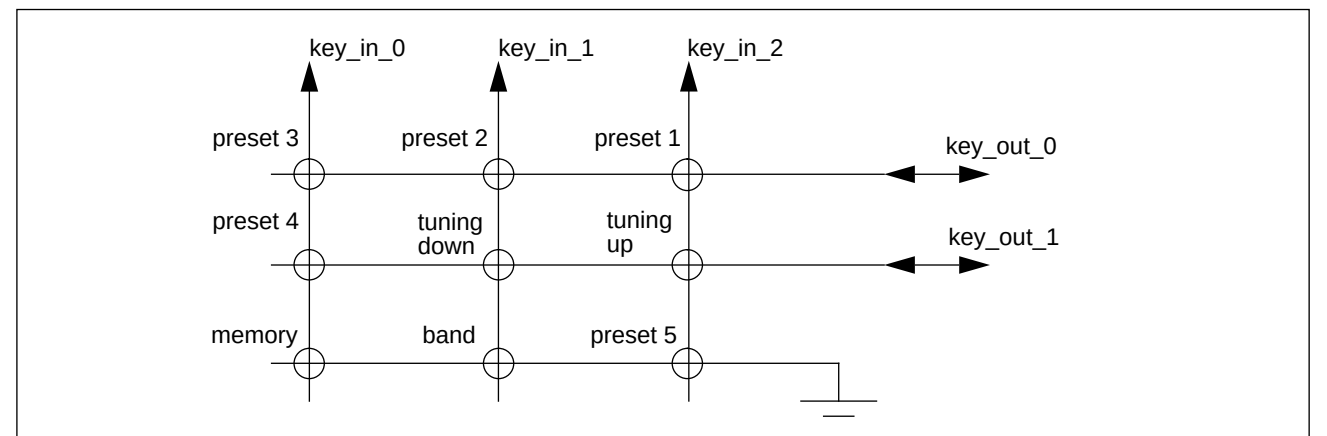


Fig.5 Optional CPR120S keyboard with 5 preset keys.

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6.2 Key table

The next table shows the basic functions of the keys in the various modes, radio, tape/external or clock/timer.

TABLE 2 Key functions

Key	Radio mode	Tape/external mode	Clock/timer mode
power	Switch on/off	Switch on/off	Switch on/off
memory	Preset store	-	Enter clock/timer adjust mode
sleep timer	Set sleep timer	Set sleep timer	Set sleep timer
timer on	Timer-on toggle	Timer-on toggle	Timer-on toggle
	Depending on the clock/timer option the next items are displayed: - clock (+clock setting); - timer-on (+timer-on setting for 6 sec); - radio or tape (=clock) display.	See left.	See left.
band	Select next band: FM>FM+AST; FM>FM+AST>MW>MW+AST; FM>FM+AST>MW>MW+AST>LW; FM>FM+AST>MW>MW+AST>SW; FM>FM+AST>MW>MW+AST>LW>SW; FM>FM+AST>FM-L>MW>MW+AST; FM>FM+AST>TV>MW>MW+AST; (next band selected depends on the area option).	-	Cancel clock/timer, select next band.
(AST)	Start AST search and programming (In preset store mode).	-	-
tuning up	Search/manual up.	-	-
	Start frequency scan (when pressed together with tuning down).	-	-
Set minute	-	-	Adjust hour up if in clock/timer adjust mode.
tuning down	Search/manual down.	-	-
	Start frequency scan (when pressed together with tuning down).	-	-
Set hour	-	-	Adjust minute up if in clock/timer adjust mode.
preset up	Select next preset	-	Cancel clock/timer, select next preset.
preset down	Select previous preset.	-	Cancel clock/timer, select previous preset.
preset 1 to 5	Select preset 1 to preset 5.	-	-

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7. OPTION DIODES

The option diodes are connected to the keyboard and the STR pins.

TABLE 3 Option diodes

Option Diode	Option
D0 ¹	Static or momentary power switch:
	Diode is set: momentary power switch, (enables sleep & timer-on function); Diode is not set: static power switch, (no sleep & no timer-on function).
D1	Select user interface for the Tuning up/down keys:
	Diode is set: fast user-interface (start search when key pressed and released within 0.5 sec, fast manual tuning when key is still pressed); Diode is not set: slow user-interface (first one manual tuning step, then auto repeat, start search when key is released).
D3 D2	Clock and timer enable/disable:
	0 0 ² = no clock and no timer; 0 1 = clock function only; 1 0 = clock and timer-on function.
D4	LCD selection:
	Diode is set: extended LCD (19 x 3 segments); Diode is not set: standard LCD, (21 x 2 segments).
D8 D7 D6 D5	Area options, see the frequency table.

1. Preset selection is done by means of 5 preset keys i.s.o. preset-up/down keys when the set is equipped with a static on/off switch and no clock and no timer functions (D0, D2 and D3 not set).
2. 0= diode is not preset. 1= diode is present.

The next table shows the various frequency band options.

TABLE 4 Frequency band options

area	option D8D7D6D5	band	start frequency	end frequency	step size	IF
Europe	0 0 0 0	FM	87.5 MHz	108 MHz	100 kHz	10.7 MHz
		MW	522 kHz	1620 kHz	9 kHz	450 kHz
Europe + LW	0 0 0 1	FM/MW + LW	153 kHz	279 kHz	3 kHz	450 kHz
Europe + SW-B	0 0 1 0	FM/MW + SW-B	2.3 MHz	21.75 MHz	5 kHz	450 kHz
Europe + LW, SW-A	0 0 1 1	FM/MW +				
		LW SW-A	153 kHz 5.9 MHz	279 kHz 17.9 MHz	3 kHz 5 kHz	450 kHz 450 kHz
USA	0 1 0 0	FM	87.5 MHz	108 MHz	100 kHz	10.7 MHz
		MW	520 kHz	1710 kHz	10 kHz	450 kHz

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TABLE 4 Frequency band options

area	option D8D7D6D5	band	start frequency	end frequency	step size	IF
Latin America	0 1 0 1	FM MW	87.5 MHz 520 kHz	108 MHz 1710 kHz	100 kHz 5 kHz	10.7 MHz 450 kHz
Latin America + SW-A	0 1 1 0	FM/MW + SW-A	5.9 MHz	17.9 MHz	5 kHz	450 kHz
Latin America + SW-B	0 1 1 1	FM/MW + SW-B	2.3 MHz	21.75 MHz	5 kHz	450 kHz
Near, Middle & Far East	1 0 0 0	FM MW	87.5 MHz 531 kHz	108 MHz 1719 kHz	100 kHz 9 kHz	10.7 MHz 450 kHz
Near, Middle & Far East + SW-A	1 0 0 1	FM/MW + SW-A	5.9 MHz	17.9 MHz	5 kHz	450 kHz
Near, Middle & Far East + SW-B	1 0 1 0	FM/MW + SW-B	2.3 MHz	21.75 MHz	5 kHz	450 kHz
East Europe	1 0 1 1	FM MW FM L	87.5 MHz 522 kHz 64 MHz	108 MHz 1620 kHz 74 MHz	100 kHz 9 kHz 50 kHz	10.7 MHz 450 kHz 10.7 MHz
South Africa	1 1 0 0	FM MW	87.5 MHz 531 kHz	108 MHz 1602 kHz	100 kHz 9 kHz	-10.7 MHz 450 kHz
Japan	1 1 0 1	FM MW TV ¹	76 MHz 522 kHz Ch1, 2, 3	91 MHz 1629 kHz	100 kHz 9 kHz	-10.7 MHz 450 kHz -10.7 MHz
FM only	1 1 1 0	FM	87.5 MHz	108 MHz	100 kHz	10.7 MHz

1. The Japanese TV band covers the sound of the TV channels Ch1 (=95.75 MHz), Ch2 (=101.75 MHz) and Ch3 (= 107.75 MHz). These are fixed into preset 1, 2 and 3, and can not be changed by the user. When the Japanese TV band is chosen only preset selection is allowed.

The table below shows how the SW bands are divided in the various sub-bands.

TABLE 5 SW Frequencies

SW-A	SW-B ¹
5.900 - 6.200	7.100 - 7.350
7.100 - 7.350	9.400 - 9.900
9.400 - 9.900	11.600 - 12.100
11.600 - 12.100	13.570 - 13.870
13.570 - 13.870	15.100 - 15.800
15.100 - 15.800	17.480 - 17.900
17.480 - 17.900	18.900 - 19.020
	21.450 - 21.750

1. The SW-B band is split up into 2 ranges, (2.3 - 6.2 MHz and 7.1 to 21.75 MHz), which are controlled by the bandswitch ports of the TEA5757.

8. LCD DISPLAY

The Liquid Crystal Display (LCD) is driven by the microcontroller. Two LCD options are available, a LCD with 2 backplanes (2 x 21 segments), and a LCD with 3 backplanes (3 x 19 segments).

The figure below shows the segments of the normal LCD.

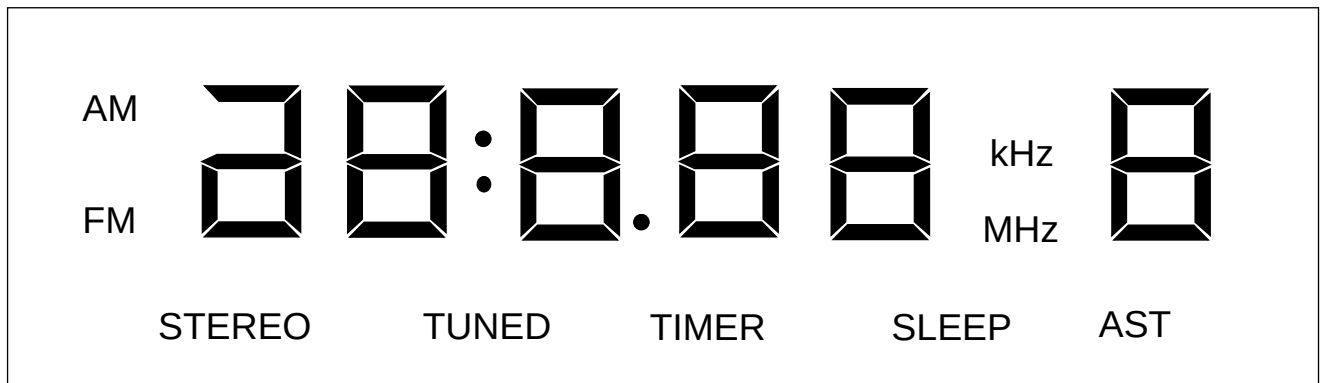


Fig.6 LCD display layout (Normal)

The figure below shows the segments of the extended LCD.

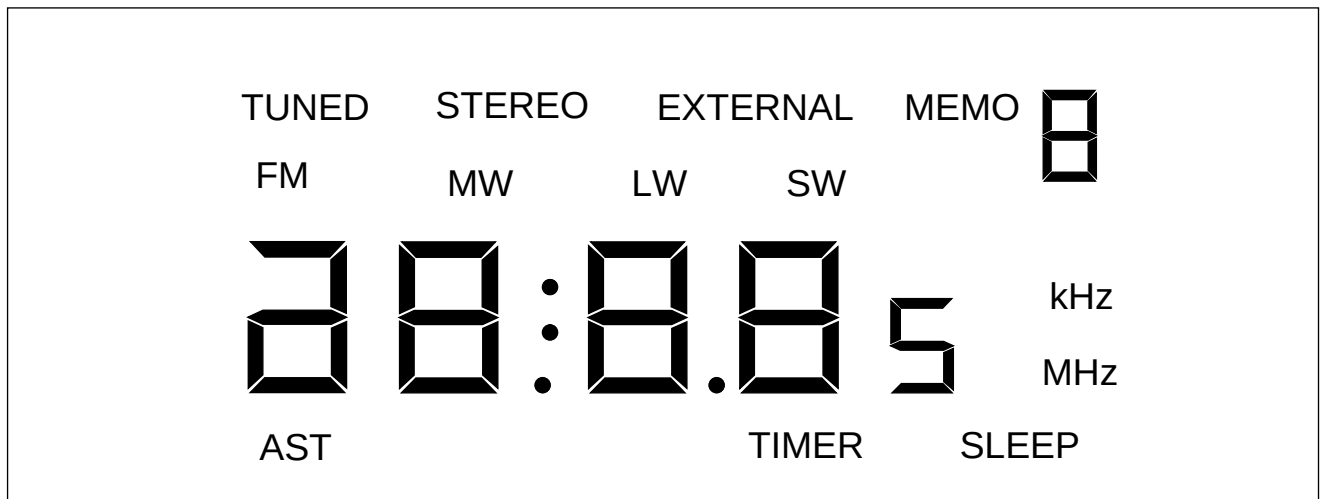


Fig.7 LCD display layout (Extended)