Mullard

Technical publication

Computer Controlled Teletext (CCT)

INTRODUCTION

During the last few years, teletext has firmly established itself in the domestic tv market. A major factor in this rapid expansion has been the proven performance of the first-generation teletext decoders. As the price of the decoder board falls and its features improve, the size of the market is expected to rise still further. The next generation of decoders, known as Computer Controlled Teletext, CCT, offers a range of improved facilities and is now available.

The UK teletext signal conforming to the orignal BBC/IBA/BREMA specification of 1976 is known as Level 1 teletext. This is the first in a series of downward-compatible teletext Levels from 1 to 5. Each level has improved features in relation to the preceding level; for example, pastel colours and more advanced graphics. To obtain downward compatibility, 'extension packets' or ' ghost rows' (invisible to first-generation teletext decoders) will be transmitted in association with the normal data. The extension packets will contain the extra information required for the higher teletext levels (Ref.1).

There are two basic categories of functions performed in a teletext decoder. Firstly, there are the standard functions fixed by the broadcast specifications which are always performed in the same way; for example, data slicing and sync generation. The second category consists of functions that are liable to differ significantly between different customers and applications, for example the displayed language.

The second-generation decoder distinguishes between these two basic categories to allow, in a very cost-effective manner, much more flexibility in the facilities offered. The fixed functions are performed by dedicated circuitry in the ICs. The variable functions are performed in software by an associated control microcomputer. This controls the European computer-controlled teletext chip, type SAA5240, referred to as the EURO CCT. (EURO, European, indicates that this IC is for 625-line operation.)

The EURO CCT based decoder is shown in Fig.1. This example has storage for eight pages. It makes use of the rapid advances in fabrication technology made since the first-generation teletext decoders were designed. It combines the functions and improves on the performance of several chips used in the original decoders. A new Video Input Processor (VIP2, SAA5230) improves the performance of the decoder under poor signal conditions. The

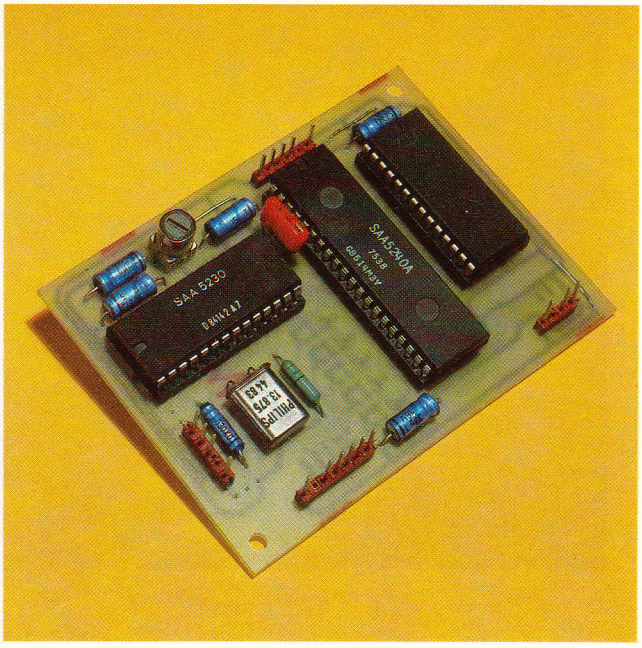


Fig.1 The EURO CCT based decoder (8 page).

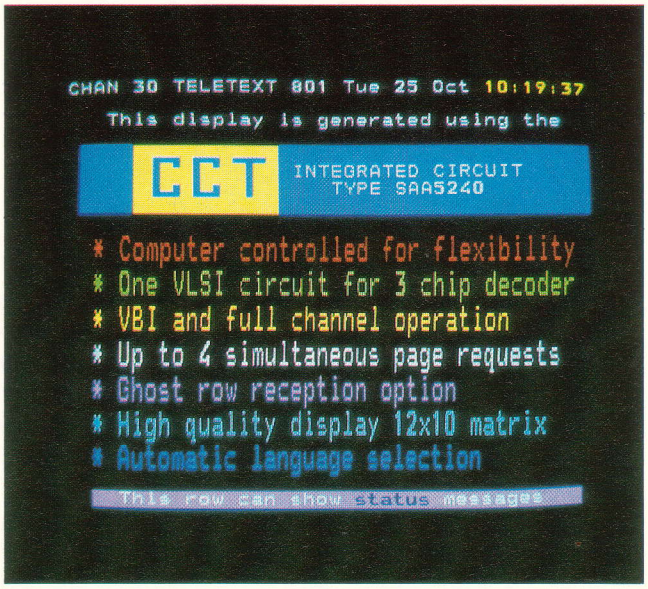
control microprocessor with associated memory uses the I^2C (Inter-IC) serial data transfer bus (Ref. 2).

The system has improved display characteristics, providing a non-interlaced display from an interlaced tv transmission to reduce flicker. Also, a major improvement in character shape is achieved by using a 12 X 10 dot resolution ROM in place of the original 5 X 9 type.

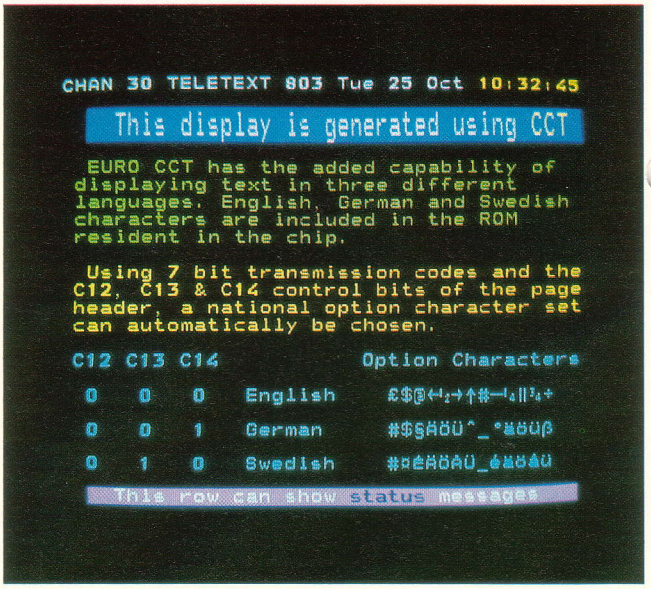
The EURO CCT is basically a Level 1 decoder with some enhanced features. One of these features is the ability to capture the data required for all the planned levels, although in its standard form it cannot display the extra information. It does permit, however, facilities like linked pages, automatic display language switching, programme service rows and telesoftware to be used when sufficient additional resources are built into the decoder. This usually means extra software in the control microcomputer.

Another feature of this type of second-generation decoder which may become important is the ability to capture data in full-channel mode, that is with teletext data on all tv lines. This allows a high data transfer rate, (approximately 600 pages/second) on a dedicated channel such as satellite or cable tv or even on simple data distribution networks.

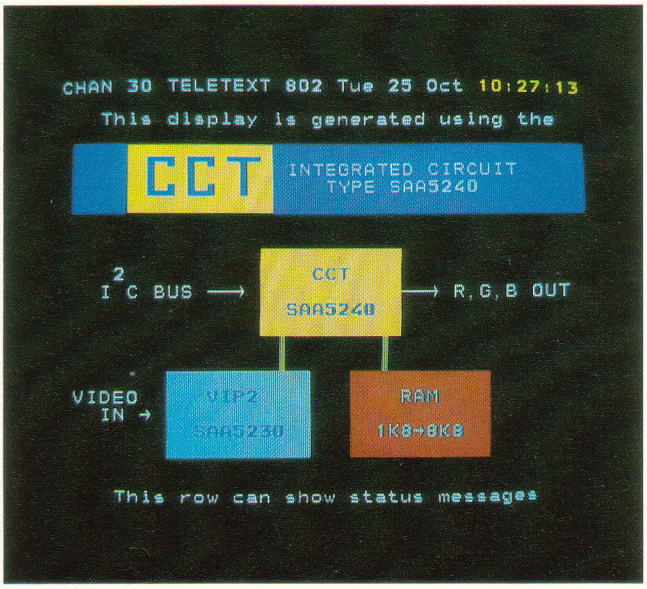
From the user's point of view, access time to the



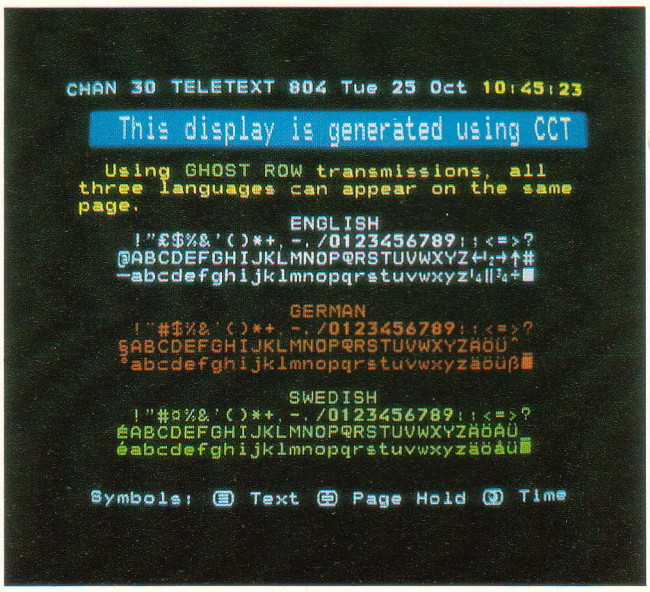
(a)



(c)



(b)



(d)

Fig.2 Sample EURO CCT generated teletext pages:
a) General text display
b) EURO CCT block diagram
c and d) Multiple language options

required page is of prime importance; in this respect the ability of the EURO CCT to search for up to four pages simultaneously is a real advantage. Also, helpful status messages can be generated locally and displayed on a separate row either above or below the main text.

Some of the EURO CCT features are illustrated in Fig.2 which shows four simulated pages displayed on a domestic receiver. In Fig.2a, the major advantages of the system are listed in double-height characters using the standard high-resolution dot display. The status row is available for locally generated messages and is shown beneath the main text. Fig.2b shows a basic block diagram of the EURO CCT based decoder. Fig.2c illustrates the fact that up to three different languages can be displayed using the same EURO CCT chip (previously a change of TROM was necessary to change language). In this case English, German, and Swedish are shown. However, a mask programmed device variant can be used to provide any three latin-based languages. The language is normally automatically selected by the control bits in the page header. More than one language can be displayed on a single page, however, using ghost row transmissions, as shown in Fig.2d.

A EURO CCT based teletext decoder can be built on a single-sided printed circuit board, and indeed many setmakers may decide to incorporate the decoder into the main tv board to reduce costs. EURO CCT allows more complex and sophisticated systems to be custom built by adding extra resources (hardware and software) while maintaining a low cost for the simple basic decoder.

FIRST-GENERATION LSI TELETEXT DECODER

The block diagram of the first-generation LSI teletext decoder with remote-control handset is shown in Fig.3. It consists of 12 ICs including two for the infrared user-control link normally positioned separately from the main decoder board. The basic decoder functions are performed by:

- VIP (Video Input Processor) SAA5030 – a bipolar linear device which provides serial data and clock derived from the incoming video signal. It also arranges timing synchronisation for the rest of the decoder.
- TAC (Teletext data Acquisition and Control) SAA5040 – a digital NMOS device which arranges the capture of the requested page into memory. It is also concerned with the overall decoder control and writing user status into memory.
- RAM–1K8 bytes of memory for page storage with standard LSTTL circuits to provide an interface.

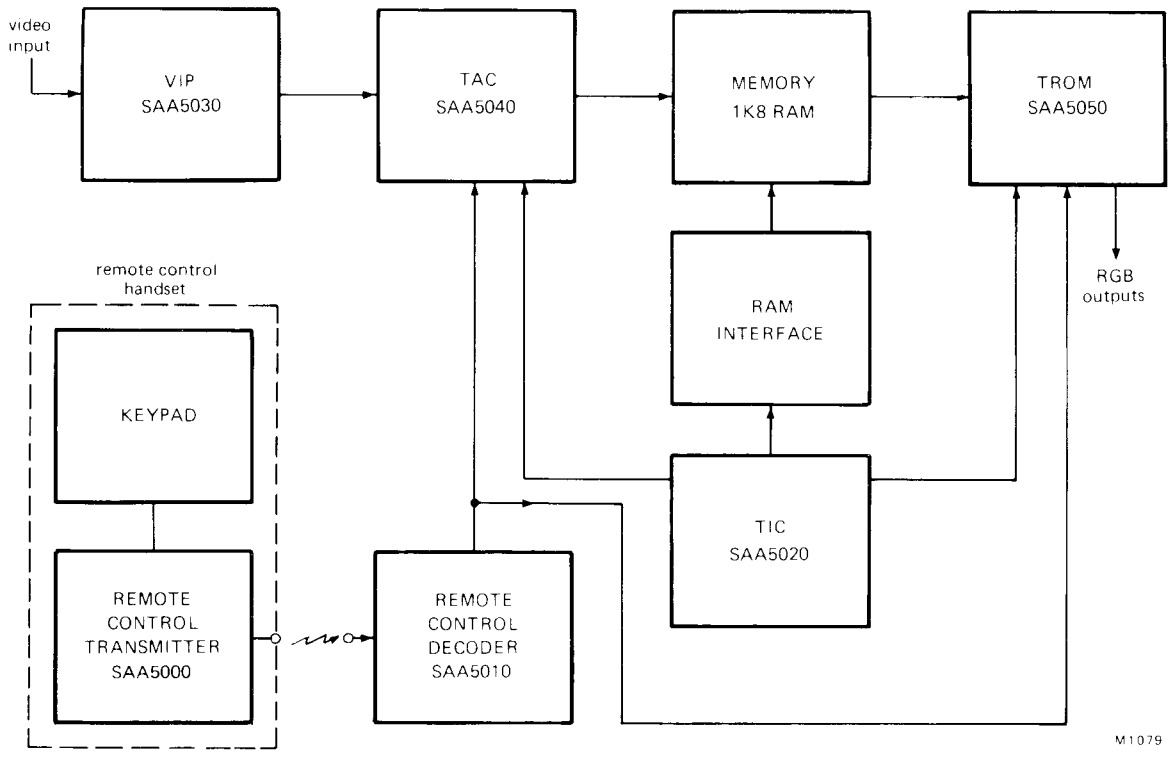


Fig.3 First-generation LSI teletext decoder

- TROM (Teletext Read Only Memory) SAA5050 – an NMOS device containing a ROM for generating characters from a dot matrix and other control functions.
- TIC (TIming Chain) SAA5020 – an NMOS device providing timing and addressing signals for the whole decoder.

These components are mounted on a single decoder board that has sold in millions but is currently being replaced by the new EURO CCT based decoder.

EUROPEAN COMPUTER CONTROLLED TELETEXT (EURO CCT) BASED DECODER

A block diagram of the EURO CCT based decoder is shown in Fig.4. The video processing functions are performed by the VIP2, basically an updated VIP1, although the two are not compatible. The EURO CCT effectively replaces seven ICs in the first-generation teletext decoder (TAC, TIC, TROM, and four TTL interfaces). It does not include, though, the remote-control command processing and status functions, formerly carried out in TAC. These are now required to be programmable and are therefore performed in the control microcomputer.

Standard static RAM is connected to the EURO CCT as page memory. For a single-page decoder 1K8 bytes are required but up to 8K8 bytes may be used giving up to eight stored pages.

The control microcomputer is used to decode the remote-control pulses from the infrared receiver. It also controls the operation of the decoder and provides status messages. Depending on the particular application, the microcomputer may also control other tv functions, for example tuning.

The interface between the microcomputer and the EURO CCT is the standard I^2C bus. Although most data flow is from the microcomputer to the EURO CCT, the bus is bidirectional so that, for example, data in the page memory may be read by the microcomputer.

Vido Input Processor VIP2, SAA5230

The bipolar linear IC VIP2, type SAA5230, performs most of the functions of the VIP1, type SAA5030, as shown in Fig.5. However, each function has been redesigned to improve performance and build on the operating experience gained with VIP1. In particular, the data extraction function has been designed to avoid the use of any critical components and it can be easily adapted to operate at different data rates. There are two VIP1 functions, field sync integrator and signal quality detector, which are not included in VIP2. These functions are now performed digitally inside the EURO CCT chip.

The data detector of VIP2 finds the slicing level for extracting the teletext data and compares it with the video to obtain sliced data. The slicing level can adapt itself to variations in data amplitude and to low-frequency disturbances such as co-channel interference, while remaining relatively unaffected by echoes, data content, or noise. An additional feature is that high-frequency losses in the signal are compensated if necessary to obtain a greater eye opening and to ensure better data reception.

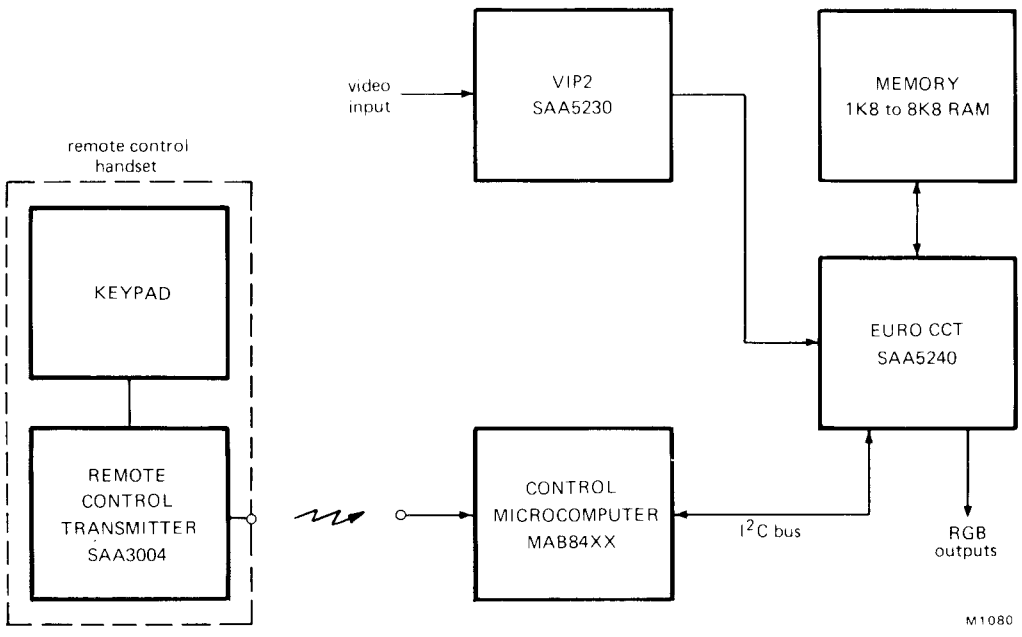


Fig.4 Block diagram of the EURO CCT based decoder

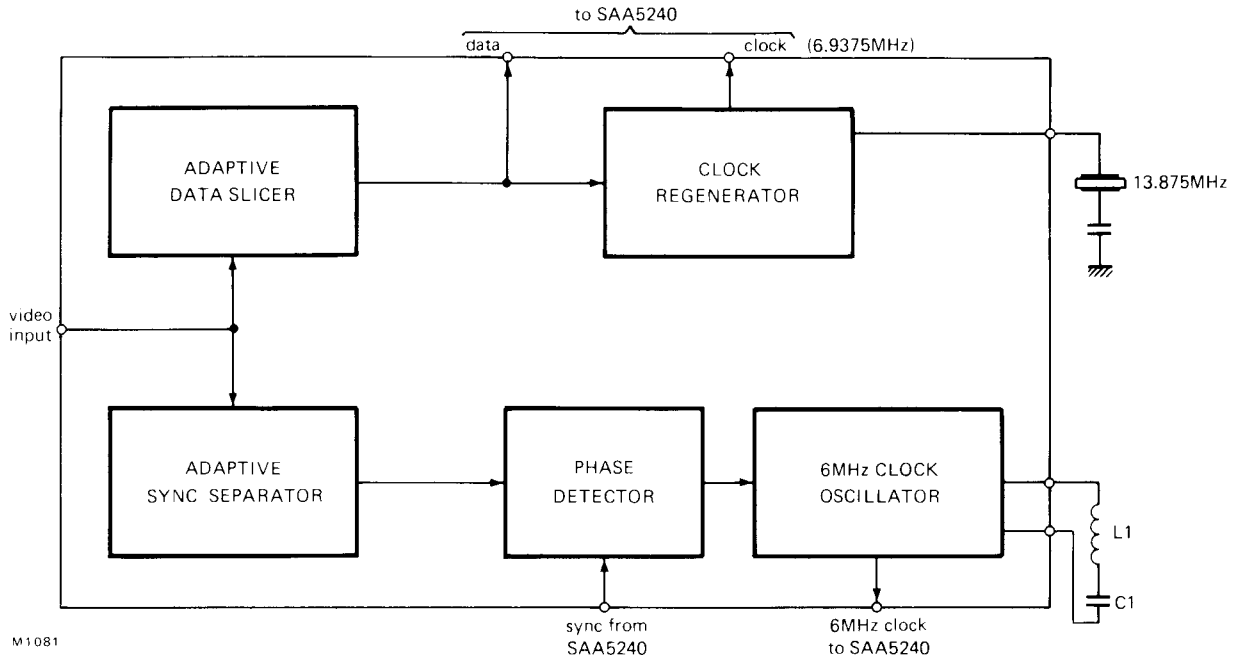


Fig.5 Video Input Processor VIP2 type SAA5230 block diagram

The clock regenerator takes in sliced data and generates a clock in synchronism. It uses a continuous clock, derived from a free-running crystal oscillator, whose phase is shifted in a feedback loop until it is at the optimum point for latching the data. A PLL is not used as it would take too long to lock up; the present circuit will find the correct clock phase before the end of the run-in. This type of regenerator achieves less jitter than a tuned coil, with no critically adjusted components and no possibility of missed clock cycles causing a loss of bit synchronisation.

The VIP2 contains a 6 MHz VCO which is the clock for the character display. This clock is part of a PLL required to synchronise the characters to the video; the PLL has been designed to allow the display to be locked to a VCR for status messages, etc. The chip includes a wide range adaptive sync separator for this PLL. The separated sync is also taken to the EURO CCT to perform field synchronisation of the display.

EURO CCT IC, SAA5240

A simplified block diagram of the 40-pin EURO CCT IC is shown in Fig.6. It contains five major functions: timing chain, character generator, data acquisition, memory interface, and I^2C interface and control.

Serial data and clock signals from VIP2 are input through the TTD and TTC pins, and the appropriate data is captured by the data acquisition function. It is then passed to the RAM via the memory interface and supplied to the character generator, which in turn provides RGB drive outputs for the video stages of the receiver or monitor. Outputs are also provided for blanking and contrast reduction of the tv picture (BLAN and $\overline{COR}$), together with a monochrome text signal for driving a printer (Y).

Timing chain

Timing signals for the whole circuit are provided by the timing chain function, which operates from a 6 MHz clock F6 from VIP2. Line synchronisation with the incoming signal is performed by a phase-locked oscillator in VIP2, which is provided with a reference signal SAND from the EURO CCT. A composite sync waveform, VCS from VIP2, provides field synchronisation for the acquisition timing and also the display timing when interlaced display is selected. The display timing circuit generates a composite sync waveform, $\overline{TCS}$, which is used to drive the display timebases via VIP2; alternatively this pin can act as an input for a composite sync waveform to 'slave' the display timing circuits. In summary, the main features of the timing chain include:

- Operates from external clock, VIP2.
- Display format – 625 lines/25 rows/10 lines per row.
- Can generate interlaced or non-interlaced composite sync.
- User-selected double-height is available.
- Line counter for acquisition is independent of display.
- Software control of data entry period; that is either normal field flyback (lines 6 to 22), or all lines (full channel).

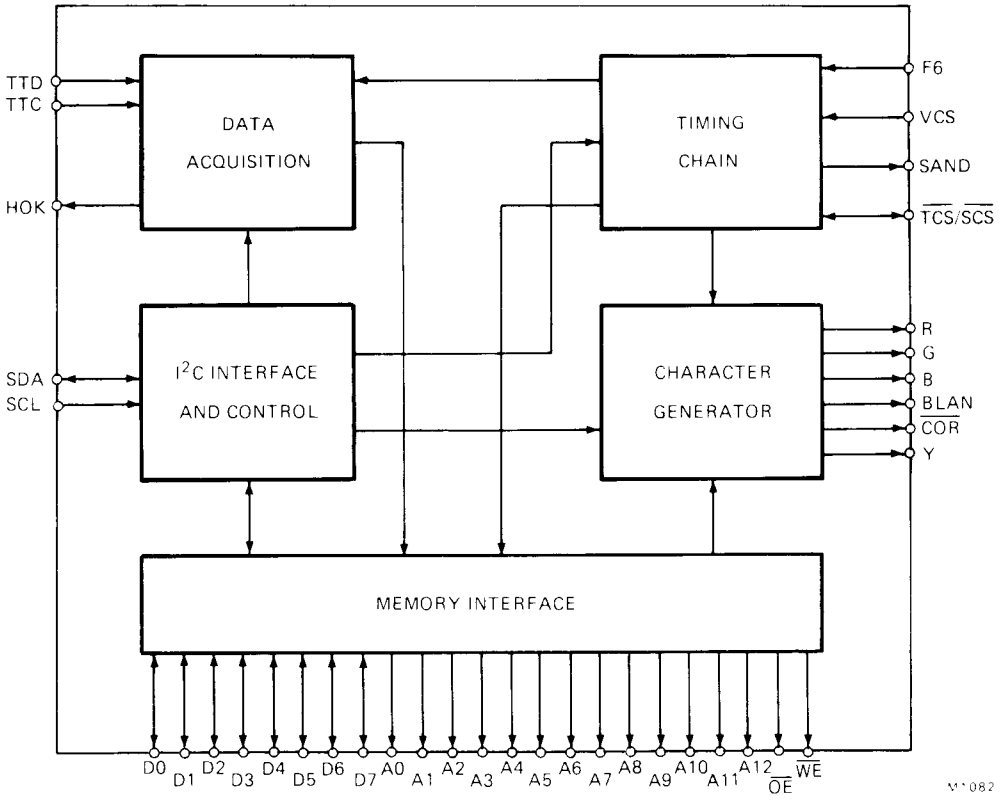


Fig.6 EURO CCT type SAA5240 block diagram

- Internal field sync integrator.
- Internal signal quality detector.
- Interfaces with VIP2 (SAA5230) but not VIP1 (SAA5030).

Character generator

The ROM in the EURO CCT contains 128 characters, each stored as a matrix of 12 dots horizontally and 10 dots vertically, leading to better display appearance and greater legibility than was previously the case. The 128 characters are selected by character address decoding and the ten lines by ROM line address decoding. The ROM is accessed once per microsecond providing 12 outputs corresponding to the 12 dots in each line of a character. A 64 μs rate signal from the timing chain clocks the lines per row counter, which normally divides by ten (except when double-height is selected). The counter output is used to select the appropriate line of 12 dots in the ROM.

The outputs from the character generator are R, G, B, BLAN, $\overline{\text{COR}}$, and Y, as shown in Fig.6. The Y output is active for the character foreground only, regardless of colours, and does not contain the flashing function. Blanking signals for the tv picture are supplied through the BLAN pin being combined dot, box, and full-screen blanking. All the character generator output pins have the open-drain configuration, making many different interfacing arrangements possible.

The main features of the character generator are:

- Display is based on 12 X 10 dot matrix.
- Interlaced or non-interlaced under software control.
- Serial attributes only.
- 128 alphanumeric characters.
- 3 national character sets (initially English, German, and Swedish; see Figs.2c and 2d.)
- 6 location auxiliary character set.
- RGB and Y outputs open-drain (true polarity).
- BLAN (blanking) and $\overline{\text{COR}}$ (contrast reduction) outputs are open-drain.
- Y output foreground colour only.
- Flashing is inhibited from Y output (for printers).
- BLAN output is combined character, box, and full-screen blanking.
- $\overline{\text{COR}}$ output allows contrast reduction for superimpose or boxes (software controlled).
- Double-height characters inhibited in row 23.
- User-selected double-height under software control. Large characters are then displayed quadruple-height.
- Separate status row, always available for software-generated messages. This may be displayed at the top or bottom of the screen, (under software control).

- Status row is always in single height.
- Decoding for black foreground colour is provided.
- Internal cursor inverts background and foreground colours. It may be made to flash using a software loop in the control microcomputer.

Data acquisition

The data acquisition section is enabled by a signal from the timing chain during lines 6 to 22 inclusive in field flyback mode or all lines in full channel mode. Serial data from the VIP2, type SAA5230, at 6.9375 MHz is applied to the TTD (TeleText Data) pin via an external coupling capacitor. TTC (TeleText Clock) is used to shift the teletext data into the EURO CCT from the VIP2. The serial data stream is converted to 8-bit wide parallel data bytes, and a byte counter keeps track of the incoming data and allocates it to the correct function.

The EURO CCT acquisition section is capable of searching for, storing in memory and constantly updating four pages simultaneously. In general the system operates as if there were four entirely different acquisition circuits. In non-ghost row mode, up to eight pages may be stored although only four at a time may be kept updated.

With first-generation teletext decoders there are two methods of requesting a page – normal and timed. The former requires three digits and ignores the sub-code whilst the latter requires all seven digits to be specified. The EURO CCT includes a much more flexible option – the 'don't care' facility. This method allows pages to be acquired when the full numbering allocation and transmission sequence is not known in advance.

The major features of the acquisition section are listed below:

- Accepts UK standard teletext transmission.
- Automatic switching of character sets by C12, C13, and C14 bits of the page header (see Figs.2c and 7).
- Extension packets can be accepted for processing by the microcomputer (up to 24 rows per page). 2K8 bytes of memory are used per page, hence there is a maximum of 4 pages in this mode.
- All transmitted control bits and addresses can be read by the microcomputer (after hardware Hamming checks), for any stored page.
- Up to 4 simultaneous page requests are allowed in either field-flyback or full-channel mode.
- Software selection of field-flyback or full-channel data operation.
- 'Don't care' facility is available on magazine, page, and sub-code digits.
- In field-flyback mode, automatic clearing of old page on first reception and clearing when page header bit C4 is set.
- In full-channel mode, the clear functions are not available so pages should be transmitted non-row-adaptively.
- Central part of the page header rolls, in green, when the page in the display chapter is being looked for.
- Broadcast (rolling) time is always directed to the display memory.
- 8-bit data reception option on all rows (for example, telesoftware), or normal 7-bits plus parity (under software control).
- Output indicating valid data line (for echo equaliser interface).
- Acquisition function may be switched off under software control.

Memory interface

The memory interface has 8 parallel data input/outputs (D0 to D7) and 13 address outputs (A0 to A12) which interface up to 8K bytes of static RAM. Control signals $\overline{OE}$ (Output Enable) and $\overline{WE}$ (Write Enable) are also provided. The RAM cycle is 500 ns, with in general one write and one read cycle every microsecond. In summary, the major features of the memory interface include:

- Interfaces up to 8K RAM providing up to 8 stored pages in normal mode or 4 stored pages in ghost row mode.
- 500 ns memory cycle time.
- Timings for static RAMs only, 200 ns access time is sufficient.
- I^2C bus can address any RAM location for reading and writing.
- Address converter from row or column to 10 bits is included and addresses all 1024 locations.
- All memory automatically cleared to 'space' on power-on.
- Separate address counters for display, data acquisition, and I^2C bus. I^2C bus address counters allow incrementing and presetting.
- RAM locations not used for display or data acquisition purposes are available for use by the control microcomputer.
- All RAM accesses (display, acquistion and I^2C bus) are synchronous with system clock.
- All pages can be cleared, one at a time, under software control.

I^2C bus interface and control

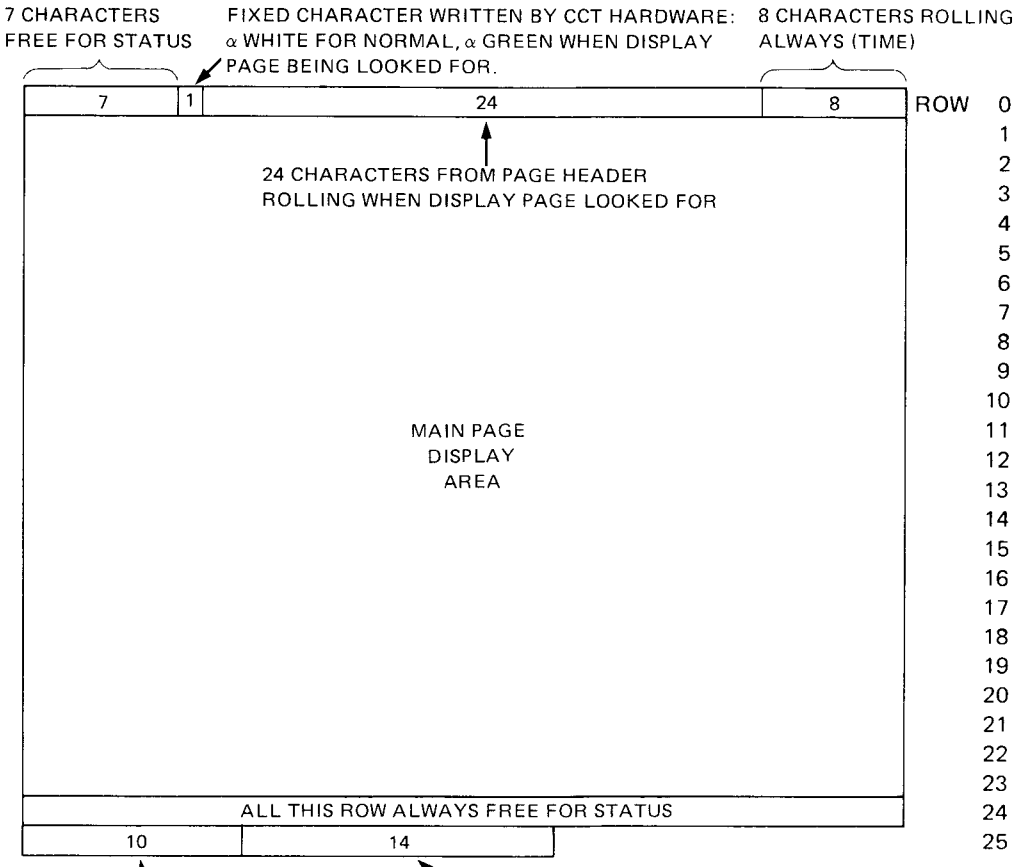
The I^2C bus and control section provides the means of controlling the variable functions of the EURO CCT, either directly using mode-register bits or indirectly via the memory devices. The I^2C bus slave transceiver accepts commands from the microcomputer via the SDA and SCL (serial data and clock) pins. The main features are:

- Standard I^2C bus slave transceiver.
- Operates from 0 to 100 kHz.
- Acknowledge function is performed.
- Position registers auto-increment after certain commands or may be directly addressed.
- Auto-increment between certain command registers as well as direct addressing.
- All RAM locations are accessible via the I^2C bus for reading and writing.

EURO CCT memory organisation and register maps

Fig.7 shows the organisation of a page memory. The EURO CCT provides an additional row compared with first-generation decoders bringing the display format up to 40 characters by 25 rows. Rows 0 to 23 form the teletext page as broadcast and row 24 is the extra row available for user-generated status messages.

The first 10 bytes of row 25 contain control data relating to the received page and this is detailed in the



D0	PU0	PT0	MU0	MT0	HU0	HT0	C7	C11	MAG0	0
D1	PU1	PT1	MU1	MT1	HU1	HT1	C8	C12	MAG1	0
D2	PU2	PT2	MU2	MT2	HU2	C5	C9	C13	MAG2	0
D3	PU3	PT3	MU3	C4	HU3	C6	C10	C14	0	0
D4	HAM.ER.	HAM.ER.	HAM.ER.	HAM.ER.	HAM.ER.	HAM.ER.	HAM.ER.	HAM.ER.	$\overline{\text{FOUND}}$	0
D5	0	0	0	0	0	0	0	0	0	PBLF
D6	0	0	0	0	0	0	0	0	0	0
D7	0	0	0	0	0	0	0	0	0	0
COLUMN	0	1	2	3	4	5	6	7	8	9

Fig.7 EURO CCT decoder page display and memory organisation

expanded section at the bottom of Fig.7. Seven digits are used to identify a page: magazine (page hundreds), page tens, page units, hours tens, hours units, minutes tens, and minutes units. (The names of the last four digits are from an obsolete application as time coded information.) Bits C4 to C14 are used to control various display facilities; see Fig.2c for an example.

The abbreviations are:

MAG	magazine	page number
PU	page units	
PT	page tens	
MU	minutes units	page sub-code
MT	minutes tens	
HU	hours units	
HT	hours tens	
$\overline{\text{FOUND}}$	LOW for page has been found	
PBLF	page is being looked for	
HAM.ER.	Hamming error in corresponding byte	

The remaining 14 bytes in row 24 are unused and are free for use by the microcomputer, if required.

Row 0 is for the page header. The first seven columns (0 to 6) are free for status messages. The eighth is an alpha-numerics white or green control character, written automatically by EURO CCT to give a green rolling header when a page is being looked for. The last eight characters are for rolling time.

Fig.8 shows the mode registers in the EURO CCT, R1 to R11; Register R11, for accessing external memory, can be written or read; all the others can only be written. Some of the following abbreviations are used:

(R1) Mode

T0, T1	interlace/non interlace 312/313 line control
TCS ON	text composite sync or direct sync select
$\overline{\text{DEW}}$/FULL FIELD	field-flyback or full-channel mode
$\overline{7+P}$/8 bit	7 bits with parity checking or 8-bit mode

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0	
T_A	$\overline{7+P}$/ 8 BIT	$\overline{\text{ACQ.}}$ ON/OFF	GHOST ROW ENABLE	$\overline{\text{DEW}}$/ FULL FIELD	TCS ON	T_1	T_0	R1 MODE
–	BANK SELECT A_2	ACQ. CCT A_1	ACQ. CCT A_0	T_B	START COLUMN SC_2	START COLUMN SC_1	START COLUMN SC_0	R2 PAGE REQUEST ADDRESS
–	–	–	PRD_4	PRD_3	PRD_2	PRD_1	PRD_0	R3 PAGE REQUEST DATA
–	–	–	–	–	A_2	A_1	A_0	R4 DISPLAY CHAPTER
BKGND OUT	BKGND IN	COR OUT	COR IN	TEXT OUT	TEXT IN	PON OUT	PON IN	R5 DISPLAY CONTROL (NORMAL)
BKGND OUT	BKGND IN	COR OUT	COR IN	TEXT OUT	TEXT IN	PON OUT	PON IN	R6 DISPLAY CONTROL (NEWSFLASH/SUBTITLE)
STATUS ROW $\overline{\text{BTM}}$/TOP	CURSOR ON	$\overline{\text{CONCEAL}}$/ REVEAL	$\overline{\text{TOP}}$/ BOTTOM	$\overline{\text{SINGLE}}$/ DOUBLE HEIGHT	BOX ON 24	BOX ON 1-23	BOX ON 0	R7 DISPLAY MODE
–	–	–	-	CLEAR MEMORY	A_2	A_1	A_0	R8 ACTIVE CHAPTER
–	–	–	R_4	R_3	R_2	R_1	R_0	R9 ACTIVE ROW
–	–	C_5	C_4	C_3	C_2	C_1	C_0	R10 ACTIVE COLUMN
D_7 (R/W)	D_6 (R/W)	D_5 (R/W)	D_4 (R/W)	D_3 (R/W)	D_2 (R/W)	D_1 (R/W)	D_0 (R/W)	R11 ACTIVE DATA

– bit does not exist.

T_A and T_B must be 0 for normal operation.
All registers are write only, except R11 (Read/Write).
All bits in registers R1 to R10 are cleared to 0 on power-up except bits D0 and D1 of registers R5 and R6 which are set to 1.

All memory is cleared to 'space' (00100000) on power-up, except row 0 column 1 chapter 0, which is 'alpha white' (00000111) as the acquisition circuit is on.

Fig.8 EURO CCT register map

(R2) Page request address

start column	column for acquisition data
ACQ CCT	which of 4 page requests
bank select	one of two banks of 4 page requests (one at a time)

(R4) Display chapter

determines which of 8 pages is displayed

(R5, R6) Display control for normal and newsflash/subtitle

PON	Picture on
TEXT	Text on
COR	Contrast reduction on
BKGND	Background colour on

These functions have IN and OUT referring to inside and outside the boxing function respectively.

(R7) Display mode

BOX ON 0	boxing function allowed on row 0 etc.
STATUS ROW	Row 25 displayed below or above main text
$\overline{\text{BTM}}$/TOP	

COLUMN	D_4	D_3	D_2	D_1	D_0
0	DO CARE MAG	$\overline{\text{HOLD}}$	MAG2	MAG1	MAG0
1	DO CARE PAGE TENS	PT3	PT2	PT1	PT0
2	DO CARE PAGE UNITS	PU3	PU2	PU1	PU0
3	DO CARE HOURS TENS	X	X	HT1	HT0
4	DO CARE HOURS UNITS	HU3	HU2	HU1	HU0
5	DO CARE MINUTES TENS	X	MT2	MT1	MT0
6	DO CARE MINUTES UNITS	MU3	MU2	MU1	MU0

X bit not used

Fig.9 EURO CCT page requests register (R3) map

(R8 to R11) Active chapter, row, column, and data information written to or read from page memory via the I^2C bus.

The arrows shown on the right of the register map indicate that the register auto-increments to the next one on the following I^2C transmission byte.

Register R3 (for page requests) is shown in detail in Fig.9. Abbreviations are as in Fig.7 except for DO CARE bits. When the DO CARE bit is set to 1 this means the corresponding digit is to be taken into account for page requests. If the DO CARE bit is set to zero the digit is ignored. This allows, for example, 'normal' or 'timed page' selection.

If HOLD is set LOW, the page is held and not updated.

There are four groups of data shown in Fig.9, one for each acquisition circuit (four simultaneous page requests). Columns auto-increment on successive I^2C transmission bytes.

SYSTEM CONFIGURATIONS

Single-page CCT decoder

The single-page CCT decoder, shown in Fig.10, is designed to work with the TDA3560 PAL decoder circuit but is typical of the system configuration. (The components for the remote-control link are not shown.)

The video input from the receiver demodulator is coupled to the CV (Composite Video) pin on VIP2. The data slicing function in VIP2 generates serial data TTD and data clock TTC which are passed to EURO CCT. The composite sync part of CV is output as VCS, and its line component is compared with SAND to provide the phase-locked 6 MHz system clock, F6. The $\overline{\text{TCS}}$ output from EURO CCT is passed through VIP2 to the STTV pin, which provides the sync signal to the tv receiver timebases. Positive or negative sync may be chosen depending on the connection of the load resistor. The $\overline{\text{TCS}}$ output of EURO CCT may be switched off under I^2C bus command; when this happens VIP2 automatically provides composite video output on the STTV pin for synchronising a normal tv picture.

Interfacing of the EURO CCT to the page memory is straightforward. A single-page display requires 1K byte of memory so only ten address lines (A0 to A9) are required. Eight data lines (D0 to D7) and two control lines (output enable, $\overline{\text{OE}}$ and write enable, $\overline{\text{WE}}$) complete the interface.

The output red, green, and blue signals (R,G,B) from EURO CCT are buffered by emitter-followers, and the upper voltage levels are clamped by the diodes to a value which depends on the contrast control of the tv reciever. This allows text amplitude to follow picture contrast under a common control.

The blanking output (BLAN) is similarly buffered to

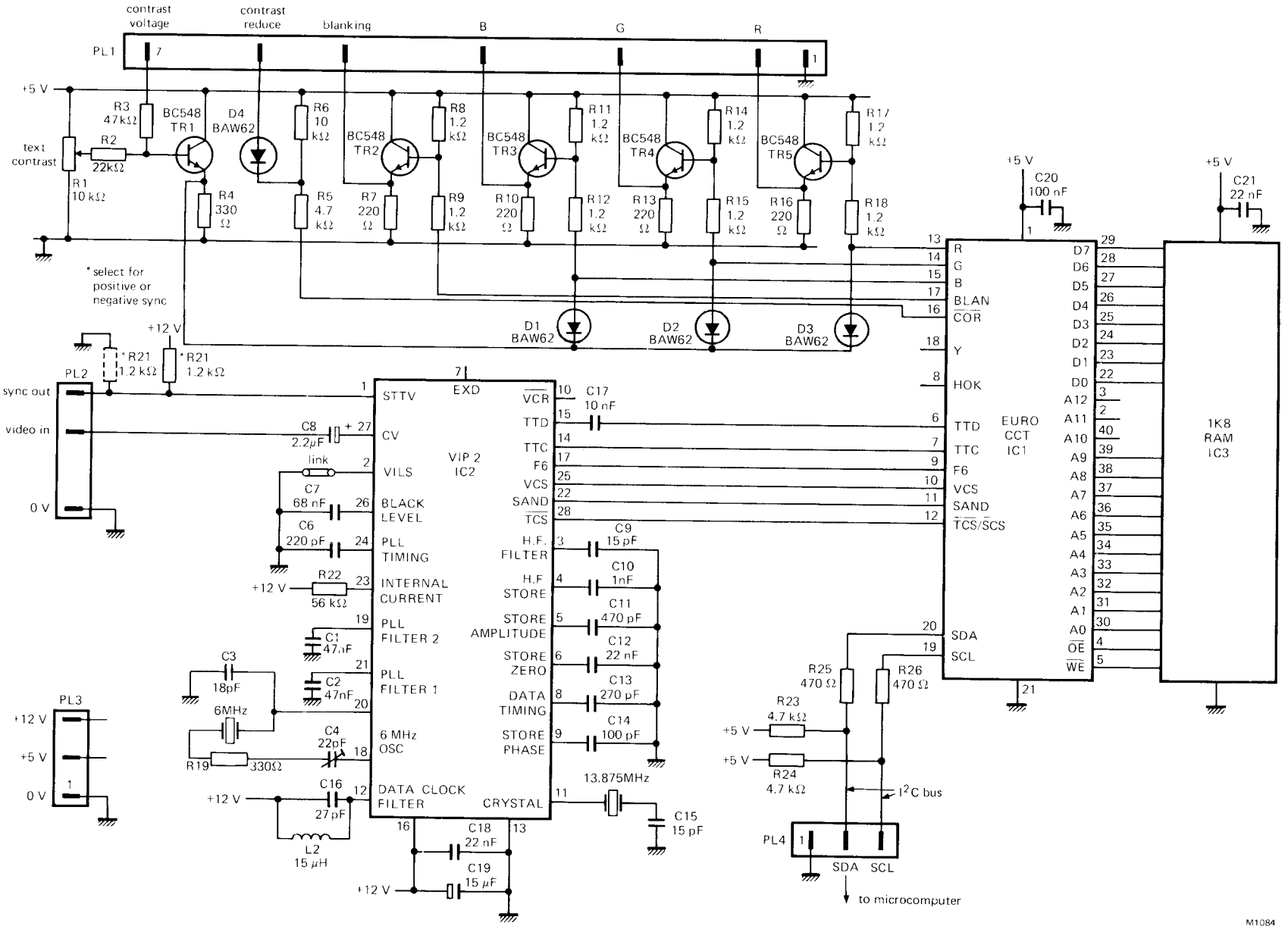


Fig.10 EURO CCT based single-page decoder circuit diagram

give a switching signal for picture video. The BLAN pin of EURO CCT provides full screen, box, and dot blanking combined, so there is no need for the external OR-ing arrangements required in first-generation LSI decoders.

When the contrast-reduce function is activated, the $\overline{COR}$ pin goes LOW. A suitable potential divider and diode arrangement can reduce the contrast voltage in the receiver by a preset amount. This can be used for more readable mixed displays or subtitles in reduced-contrast boxes, for example.

Suitable decoupling capacitors complete the single-page EURO CCT decoder shown in Fig.10. The system may be realised on a single-sided printed circuit board, about 100 mm square.

In the decoder shown in Fig.10, the control microcomputer and software will depend on the facilities required and the type of remote control to be used. As an example, consider a decoder required to work with the first-generation remote control (SAA5000/SAA5010 series), to give similar performance to the first-generation decoders. This could be provided by an MAB8420 microcomputer using the 2K bytes of ROM provided on-chip.

This example assumes that the software is written in a modular form for ease of understanding and flexibility of use. Some extra facilities can be provided within the available 2K bytes of software; for example status messages on arrival of a page, hold and update, don't care digit page requests, toggled height commands, etc. If the software modules are not required to be general, to be used for a particular model only as opposed to a range of decoders, software more dedicated to the application can be written. In this case it would probably be more economic in ROM utilisation, allowing more facilities to be provided with the same microcomputer.

General control variation

Various EURO CCT based control configurations are possible; one of the simpler ones is shown in Fig.11a. In addition to performing its normal CCT functions, the single microcomputer is used to decode user commands from the remote-control unit. It can also be used to control directly all display analogues and receiver tuning.

The examples shown are based on the MAB8400 series of microcomputers. Available in a range of program-memory sizes, they are particularly convenient to use in this kind of system because of the hardware serial bus interface provided on-chip. This greatly facilitates interfacing with the I^2C bus and the microcomputer can be programmed to act as a master or slave transmitter or receiver. The I^2C bus itself is a sophisticated interface which can support bi-directional data flow, multi-transmitter operation, and data acknowledge with data transfer rates up to 100 kHz.

In Fig.11b, a modular structure is used, with one microcomputer to perform the remote-control decoding and tuning system drive functions and a second microcomputer dedicated to teletext decoder control. The system can be extended to provide, for example, viewdata, VCR, or cable decoding functions, simply by connecting extra hardware to the common I^2C bus (provided the existing system has sufficient resources, for example an adequate number of spare keys).

Generally, the I^2C bus allows great flexibility in the design of systems and is convenient where sub-systems are physically some distance apart. In addition, an increasing number of special-purpose devices are being made with I^2C bus interfaces on-chip. Examples are the PCD8571 128 X 8 bit static CMOS RAM, the PCB8573 clock/calendar chip, the SAB3035 (CITAC) tuning and analogue control chip, and the SAA1300 tuner switching circuit. Using these components it is possible to build sophisticated systems for all kinds of applications up to the limit of cost and the designer's imagination.

Multipage decoders

Almost all teletext decoders that have been manufactured so far have been for single page use. The EURO CCT based decoder is capable of searching for and storing up to four pages simultaneously (including extension packets). Extra software as well as more memory space (1K byte per page for normal use, 2K bytes per page in ghost-row mode) is required to deal with multipage requests. In fact, the circuit diagram is almost identical to that for single-page acquisition (Fig.10). The only addition necessary is that some or all of the three unused EURO CCT address lines (A10, A11, and A12) need to be connected to the enlarged memory. Up to 8K bytes of memory may be used.

By using a software command it is possible to switch the EURO CCT based decoder into ghost-row mode. This mode allows for greater 'user-friendliness' especially with the linked pages facility.

Linked pages are those that the user is most likely to select next from their current position in the database. The Broadcaster previously identifies these associated page numbers which can be transmitted using packet 27. A EURO CCT based decoder can be made to capture these associated pages, using suitable control software. In this way, the apparent page access time can be reduced, as those pages which have been identified as being most likely to be required next can be captured while the current page is being read. (Captured pages are, of course, immediately available when user selected). Further, the technique can be used in combination with packet 24 transmissions which give page selection information for display in the EURO CCT status row. This information can be in the form of coloured keywords associated with corresponding coloured buttons on the user's keypad, minimising the need for three-digit

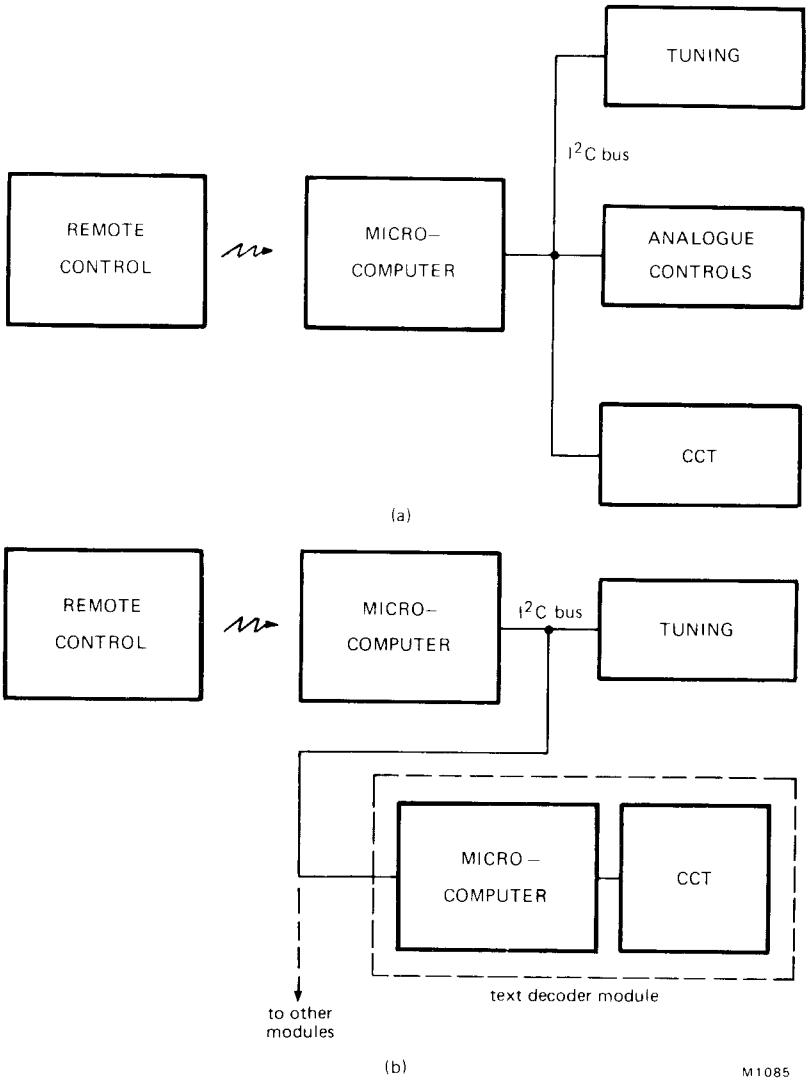


Fig.11 EURO CCT control variation:
a) using a single microcomputer
b) using a separate microcomputer for CCT functions only

page number dialling. Such a combination gives a fast access, easy to use data retrieval method known as 'full features teletext' or 'turbotext'.

Full-channel decoders

The EURO CCT has the ability to handle teletext on all tv lines, for use with cable transmissions. This full-channel decoder is achieved by software command, the hardware being the same as that required for normal field-flyback mode. However, page clearing has to be handled in a slightly different manner.

When a page is first received, the EURO CCT usually arranges for the old data in memory to be cleared. There is no problem in field-flyback mode as most of the field period is available for the clear function. However, in full-channel mode wanted data may be coming in at the same time, thus inhibiting the clearing function. There are two ways around this difficulty.

Firstly, the database can be arranged to transmit non-row-adaptively, so that blank rows are always transmitted. There is then no need to clear the page as new data will overwrite the old. Alternatively, the page can be cleared by a command from the control software when a new page is requested, so that new data is received into an already blank memory. If the database is very large, it is possible to arrange a second page of memory to display the old page

until the new one has been received, thus avoiding a blank screen for the transmission cycle time.

Viewdata

The display standards of wired text systems are currently in transition to a higher level than Level 1 teletext, with more sophisticated graphics, pastel colours, etc. However, the Level 1 display available since the inception of the UK Prestel service is adequate for many applications at the lower cost end of the market and for these users the EURO CCT is an ideal display device.

For most viewdata systems the data rate is relatively low (for example 1200 baud) and this is easily transferred down the I^2C bus into the EURO CCT. In this way interfacing complexity is minimised. The EURO CCT also contains features which facilitate the handling of the information, for example page clear command, automatic address increment, and cursor display.

A viewdata-only decoder is shown in Fig.12. This consists of an MAB8440 microcomputer performing the decoding, connected to the SAA5070 (LUCY) device and Line Terminating Unit (LTU) which interface the telephone line. The PCD8571 remembers the required numbers for the autodialler and autoidentification.

It is possible to have both teletext and viewdata decoders in the same receiver. The modular receiver architecture of Fig.11b is very suitable for this application.

Telesoftware

The basic concept of telesoftware – transmitting computer programs via teletext – embraces a large variety of equipment and system configurations. If the application involves simple processing of alphanumeric data, for example financial calculations, then the EURO CCT display facilities and transfer of data via the I^2C bus would be adequate. This type of system could be built into a tv receiver as a more complex type of teletext decoder with an additional microcomputer and perhaps more memory. Telesoftware protocols use the linked-page facility to handle long programs and so the EURO CCT would be operated in ghost-row mode. If the remote-control keypad buttons were sufficient for the application, a telesoftware add-on unit could be constructed for use with the modular tv system of Fig.11b.

For some applications a more sophisticated graphics display may be required. In these situations the EURO CCT would be used as the telesoftware acquisition system, with a suitable form of interface to transfer the data to, for example, a home computer. It is also possible to use EURO CCT in '8-bit' mode (that is with normal parity checking disabled), allowing sophisticated error-correctable or scrambled-data streams to be dealt with for special applications.

The telesoftware technique could also be applied to page selection methods in sophisticated teletext decoders. This would allow a pseudo-interactive viewdata-like control scheme, by making the displayed page number depend on YES/NO questions or selections. In view of the database size, this would be most applicable to full-channel data systems.

Other telesoftware applications may not need an alphanumeric display, for example a credit card verifier, with invalid card numbers transmitted by teletext. For these applications, the EURO CCT could still be a suitable acqusition-only device in view of its multipage and ghost-row capabilities.

It is also possible with the EURO CCT to request pages in hexadecimal, not just BCD digits. This is necessary for the acquisition of telesoftware and higher levels of teletext. Using the full hexadecimal range there are 4 194 304 combinations of page and sub-code numbers.

Other configurations

Although it is anticipated that the great majority of EURO CCT applications will have the device built into the same equipment as the display, it is also possible to use add-on units plugged into the standard tv aerial socket. Tuner, i.f., and demodulator stages are required for the decoder input, together with a colour encoder and modulator for the output.

A printer for hard copies of the teletext pages may be included in a sophisticated receiver or connected separately as a decoder peripheral. There are two main ways of interfacing a printer. The first is to provide a real-time scanning dot stream from the Y output of the EURO CCT with a suitable interface buffer in the printer itself. Alternatively, character data can be read out of the display memory via the I^2C bus and transferred to the printer, which in this case must have its own character generation system.

The same technique of reading character data through the I^2C bus can also be applied to bulk storage of data, for example using a tape recorder. The I^2C bus data is processed (and compressed if necessary) by a microcomputer which drives a suitable modem function, for example part of LUCY SAA5070.

The configurations briefly mentioned here are examples of the very many arrangements made possible by this extremely versatile device.

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1) World System Teletext Specification, June 1985.
2) 'I^2C bus and compatible components for flexible control systems', Mullard Technical Publication 625446XX, 1985.

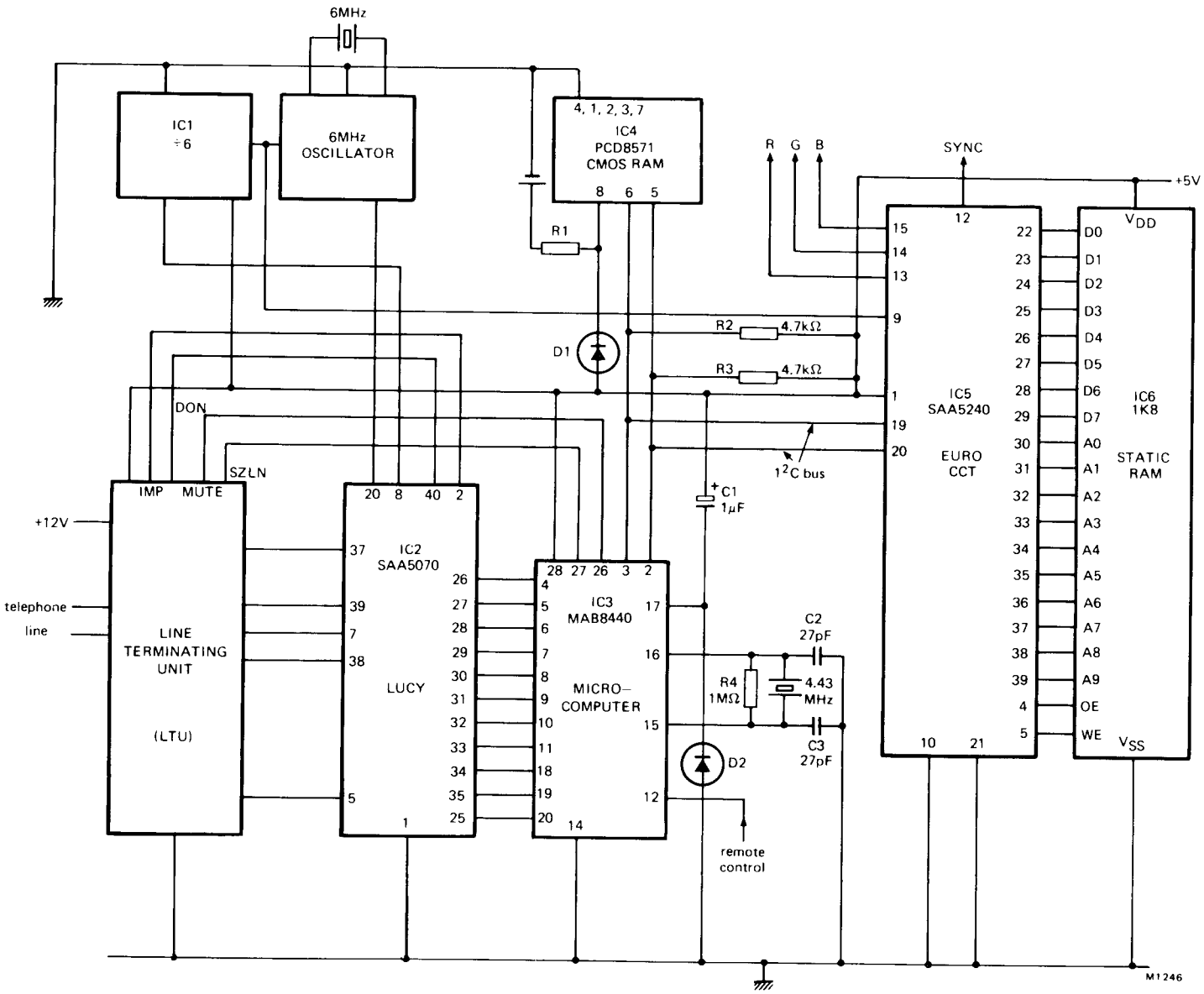


Fig.12 Viewdata decoder circuit diagram.
(RGB interface components not shown.)

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