COMPUTER-CONTROLLED TELETEXT SYSTEM

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The experimental system described allows the loading into a personal computer of Teletext pages, including the ones that are not normally accessible on a domestic TV set equipped with a Teletext decoder.

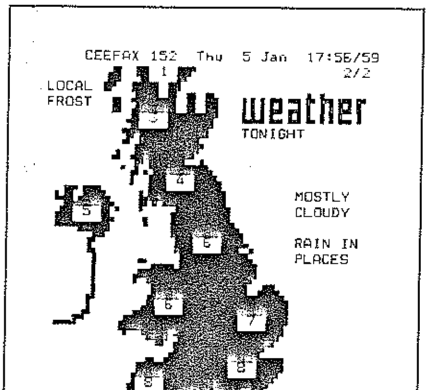
Teletext has been incorporated with television throughout Europe since the mid seventies, with the first published specification jointly issued in September 1976 by the BBC, IBA and BREMA. This initial specification permitted the production of domestic TV sets with Teletext. The specification has continued to develop over the years, and additional facilities have become available.

Teletext 'Level-2' provided multi-language text, and a wider range of display attributes that may be non-spacing. There is a wider range of colours and an extended mosaic pictorial set.

'Level-3' introduced dynamically redefined character sets (DRCS) permitting the display of non-Roman characters, for example Arabic or Chinese. Pictorial graphic characters may also be defined, allowing the composition of improved illustrations for the text compared with earlier levels.

'Level-4' includes full geometric graphics, and requires computing power to generate the display from a sequence of drawing instructions. This permits graphic displays as good as the highest resolution mode of the BBC-B computer. This level offers a colour palette of over 250,000 shades.

'Level-5' is full-definition still pictures, permitting an image of a better quality than achievable from a video camera. It has no losses due to modulating on to a carrier, and no noise added to the picture during transmission.



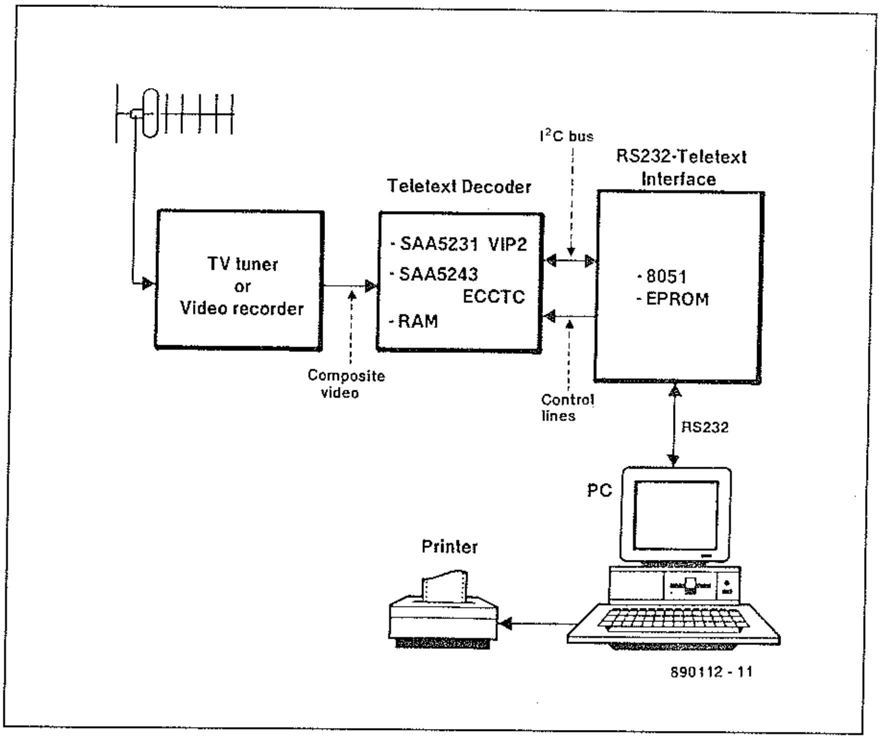


Fig. 1. Block diagram of the experimental system.

Also possible within the system at any level is Telesoftware, which is normally seen as a BASIC listing for BBC computers. It can however be machine code for any computer, and encrypted to limit access.

Levels 4 and 5 exist as specifications, although level 4 was transmitted by the IBA as long ago as 1981. There appear to be no TV sets able to handle these levels, and until the editors of CEEFAX and ORACLE use it, the extra cost would not be worth while. Given the TV producers' liking for computer graphics on everything from weather maps to pop videos, hopefully they will come very soon.

Hidden pages

The specification for Teletext is wider than apparent from the familiar remote control handset. Page numbers, for example, are chosen from a key pad with digits 0 to 9. A displayed page has 24 lines. Less known is the fact that the system can accept key numbers in hexadecimal. This means that page numbers such as 10F could be transmitted and never seen by a home TV set. This permits pages to be transmitted to specially equipped receivers only. The system can transmit 32 rows, 8 of which will not be displayed. Three of these are in fact defined: two are used to simplify and speed up related page selection, and the third carries system information including date, time, channel and, when permitted, a program definition field to enable video recorders to be switched automatically to recording by TV programme rather than time.

The key point is that the specifications and capabilities of Teletext are improving constantly, and an embedded design can not be altered to make use of these developments. In the case of hidden pages and rows, it may be that the originators do not

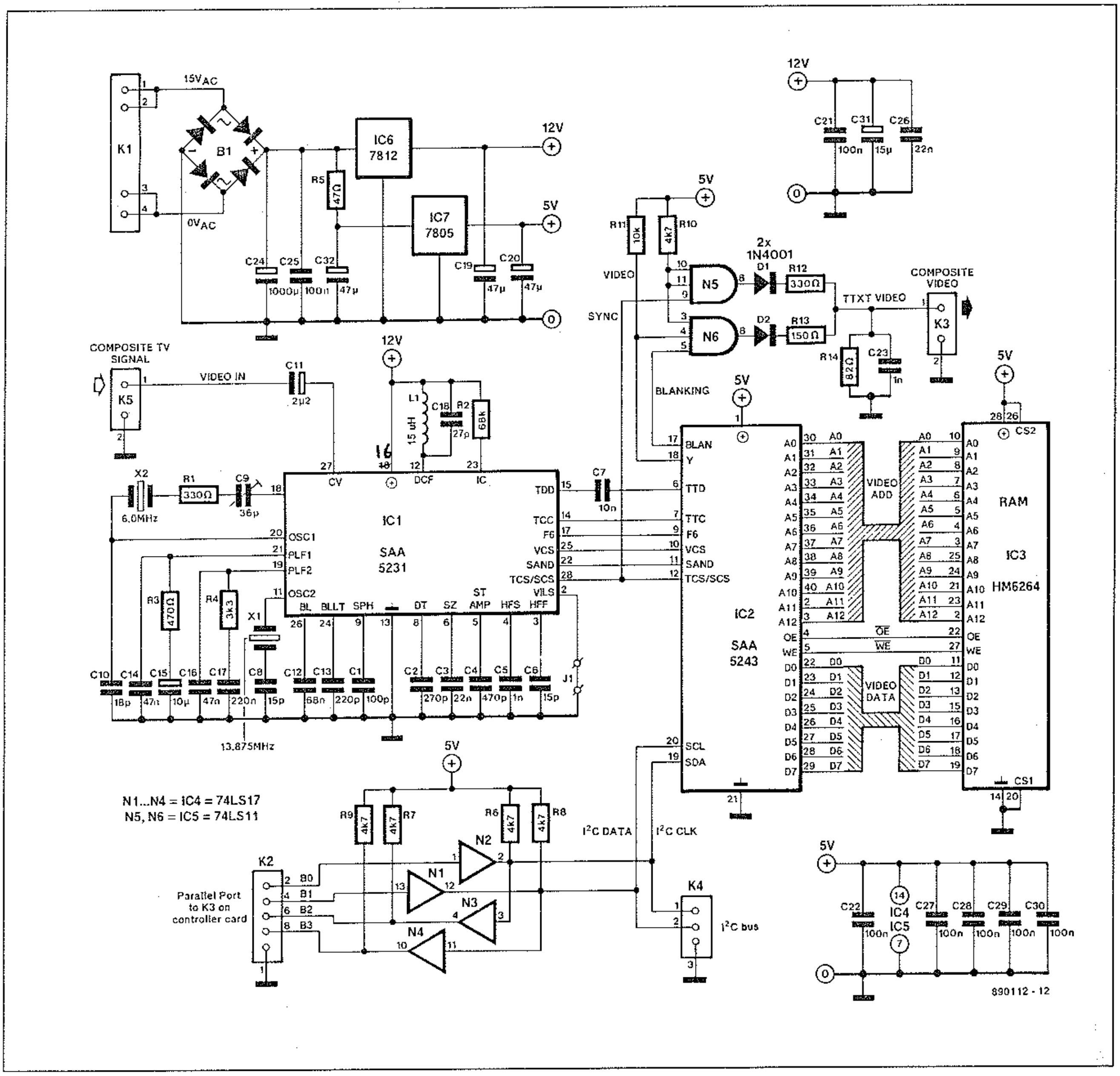


Fig. 2. Circuit diagram of the Teletext decoder card. The monochrome video output is optional, and intended for debugging purposes.

want to make the information generally available.

The Teletext decoder described here can access all definable pages and rows, and make them available to a personal computer (PC) for analysis. The design is split into three units, two of which will be described in detail in this article. These two units are a Teletext decoder and a data and control interface connected to a PC's RS232 port. The third unit in the proposed system is a TV tuner. The block diagram of the system is shown in Fig. 1.

The decoder

Philips Components (formerly Mullard in the UK) have long produced a family of ICs for Teletext, and most TV sets use them. The present decoder is based on two ICs from this family.

The first is the SAA5231 Video Interface Processor (VIP2), an analogue IC that requires quite a few passive components to be attached to make it work (see Fig. 1). The video processor takes a composite video signal from the TV set, and identifies those lines carrying Teletext information. These are subsequently transferred to the digital Teletext decoder IC SAA5243. The data clock is recovered from the Teletext data stream by the VIP2, and passed to the decoder IC. The 6 MHz clock that runs the system is also generated by the VIP2. The 13.875 MHz is divided by two and phase-locked to the Teletext data to become the data clock. Most of the resistors and capacitors around the VIP2 chip are required to extract and phase-control the Teletext data and clock.

The second IC, the SAA5243 ECCTC (Enhanced Computer-Controlled Teletext Chip), is the really clever one. It takes the stream of serial Teletext data, and analyses it. When a new page header arrives, the information is compared with that of the internal registers. If the new header identifies a requested page, it is stored to an area in the attached RAM. The decoder is capable of doing this for 4 unrelated pages, and holding the latest update of 4 Teletext pages at any one time.

The ECCTC also controls the display function of Teletext. Under the control of internal registers, one page in RAM is converted to a displayed page. The video signal is available as RGB TTL levels with separate sync and blanking. A monochrome signal is also available.

The third function of the ECCTC is the one that makes it the choice for this project: the SAA5243 is designed to work on a computer network, in this case the Philips I^{2}C bus. This is basically a two-wire networking system specifically designed for consumer electronics. Each I^{2}C bus compatible IC has a unique address built in, and a set of communication protocols to use. The IC monitors the network, and recognises when it is being talked to. In response to certain commands it interacts with the sending device on the bus.

In the present circuit there are only two devices on the I^{2}C bus: the decoder and the microprocessor. A connector is provided on the decoder board to make the connection to other I^{2}C devices possible if experimentation is desired.

The operation of the ECCTC chip and the I^{2}C bus is relatively complex. By contrast, the hardware required to implement the decoder chip in an I^{2}C environment is remarkably simple. The I^{2}C bus has strict protocols, and the timings must be adhered to. The ECCTC has several registers that have to be loaded correctly before anything will happen. At power-up there is little evidence of life from the device, and the display will not even have sync, let alone a default page of Teletext.

It is common for complex devices to be controlled via a piece of software called a *device driver*. With such a driver, the user has available a set of high-level commands that allow all the functions to be performed without the need of detailed knowledge of that particular function. A full discussion of the operation of the ECCTC and the I^{2}C bus is so detailed as to exceed the scope of this article. Software is available to drive the decoder card, and extract from the transmission any byte, row or page of Teletext. Readers wishing to know how this is done in detail are referred to the Application Notes mentioned at the end of this article.

The third essential IC is a 4-to-2 line converter that connects the Teletext decoder the I^{2}C network. The 4 lines go to the external processor that transmits data and clock up and down one pair, and receives data and clock back from the decoder.

A composite video output is available on the decoder board to display monochrome Teletext direct from the decoder. The video output is useful for debugging the system because switching between grabbed pages is instantaneous while transfer via the bus takes about 8 seconds. The few additional low-cost components needed to implement the video output seem worthwhile even if the facility is rarely used. They can be omitted, however, from the circuit without affecting the rest of the operation.

The composite video is taken from a Rediffusion tuner unit that can be used to drive the decoder card direct. The video output from a VCR should also prove all right. The decoder has a link that alters the input level required to drive the card. In the event of the source not supplying enough signal, a buffer may be required to connect the video source to the decoder card. Use of a tuner unit based on a SAW (*surface acoustic wave*) filter is well worth considering. Teletext is particularly sensitive to phase distortions, and SAW filters are a considerable improvement over L-C IF circuits.

The ECCTC chip has 8 channels, of which 4 are capable of grabbing a page of Teletext as it is received. The operator selects the channel to be current from 0 to 3. The required page for the current channel is selected, and that channel will continuously grab the updates for that page, even when the current channel is changed. The only exception occurs during page transfers to the host computer. The status line, row 25, must be examined to determine when the required page has been received. When a new page is requested, the old one is cleared, including the status line. This is then examined repeatedly until the new page received is signalled. The new page is then transferred in ASCII to the host computer, which has to do the graphics code conversion.

The use of the other 4 ECCTC channels is detailed below.

Downloading Teletext pages on a PC

The function of the controller card is to respond to instructions received on the RS232 link to a PC, and to return Teletext information to a host computer. All the timing and protocol requirements needed to transfer information on the I^{2}C bus are handled by an 8051-based controller card (Fig. 3).

Commands from the host computer are in the form of a single letter defining the requirement, followed by a qualifying number. Available commands are listed in Table 1. Page selection, for example, is made by the host PC sending the letter P followed by a 3-figure page number. The controller card then transmits the command to the Teletext decoder card. The controller repeatedly examines the status line in the decoder until the requested page is received. The page is subsequently transferred from decoder memory, via the RS232 interface, to the PC, which allows the page to be stored on disk, or to be printed.

Rhhh	examine row in hex
Ahh	examine row in text
Ch	channel select
Phhh	page select
D	display page
H	print page
F	file on disk
T	timed page
ESC	exit program

Table 1. Commands for the IBM PC control program.

The commands allow the full capabilities of the decoder to be available to the host PC, while keeping traffic on the RS232 interface to a minimum. To allow a wide variety of computers to be used, the bit rate has been set fairly low at 1200/s. This means that a page of Teletext takes about eight seconds to transfer. Pages are repeated roughly every 20 seconds on Teletext, so a selected page takes about 30 seconds to receive from request.

Channel selection allows 1 of the 8 channels to be selected as currently attached to the interface. The current channel is also the one used to form the on-card

Col.	0	1	2	3	4	5	6	7	8	9
B0	PU0	PT0	MU0	MT0	HU0	HT0	C7	C11	MAG0	0
B1	PU1	PT1	MU1	MT1	HU1	HT1	C8	C12	MAG1	0
B2	PU2	PT2	MU2	MT2	HU2	C5	C9	C13	MAG2	0
B3	PU3	PT3	C4	MT3	HU3	C6	C10	C14	0	0
B4	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	/FND	0
B5	0	0	0	0	0	0	0	0	0	S
B6	0	0	0	0	0	0	0	0	0	0
B7	0	0	0	0	0	0	0	0	0	0

PU	units
PT	tens
MAG	magazine
MU	minute units
MT	minute tens
HU	hours units
HT	hours tens
C4–C14	transmitted control bits
S	page is being looked for
/FND	page has been found
ERR	transmission error in byte

Table 2. Row 25: status line format codes.

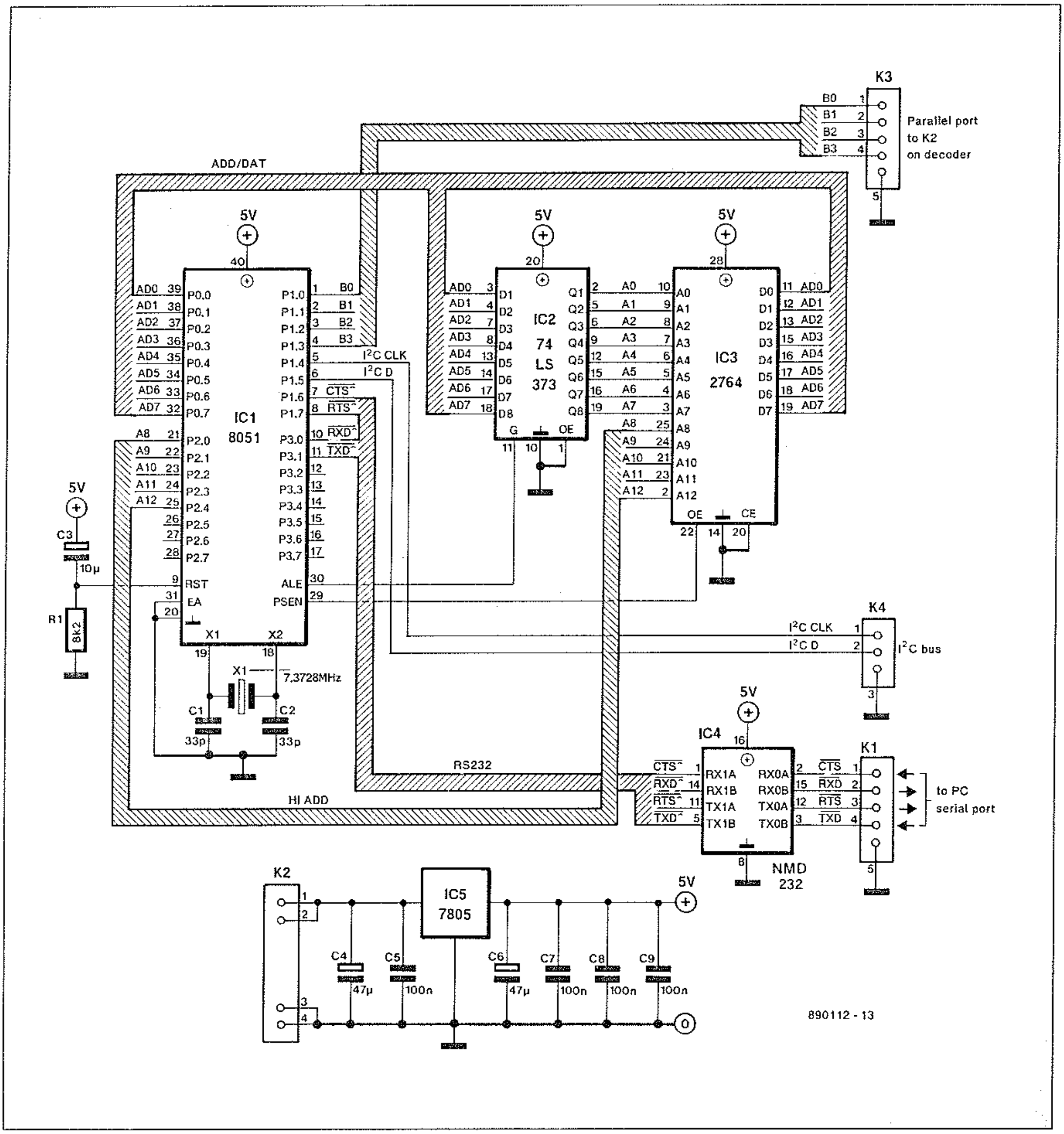


Fig. 3. Circuit diagram of the PC interface card that holds the 8051 controller, EPROM with firmware, and the RS232 level convertor chip.

monochrome display, if used. As already discussed, ECCTC channels 0 through 3 are Teletext pages of the form seen on the TV screen. Channels 4 through 7 are extensions of the first 4 pages. Commands such as D (display) and H (hard copy; print) use the currently selected channel as the source of data. Page selection can only be achieved for channels 0 through 3.

The controller transfers pages as blocks of 24 rows of 40 characters. The embedded commands of Teletext are removed, and the 7-bit code is extended to 8 bits to allow for direct representation of graphics.

The choice of graphic characters to use may pose a problem in that there is no standard for Teletext graphics. The author used an Okidata-80 as well as an Epson MX-80F/T printer. Both of these have a character set that includes all Teletext shapes. Unfortunately, the codes are different for each printer. The IBM clone used was fitted with a Hercules type monochrome display adapter. This has very few graphic characters, so only an approximation of Teletext shapes is possible. To allow the use of two printers, the control card has the option of two translations of the Teletext page. Each will result in a print-out that is an accurate black-and-white copy on the appropriate printer. The display has only 6 graphic characters that are similar enough to use. Since there are 64 Teletext graphics characters, the host computer translates the graphics character into 1 of the 6 which is most appropriate. The resultant displayed page is in fact better than one would expect. Since the quality of this display is a function of the host computer configuration, users should be able to write their own graphics translation routines to maximize the fidelity of the representation. The commands that transfer text do so with all colour information removed. If the computer is capable of colour, the hex transfer command must be used to ensure that the decoder supplies unaltered data for translation into a format suitable for the display used. An accurate monochrome display is always available from the decoder card. Pages saved to disk are in the printer format, and can be printed out at any time for an exact copy.

Users who have other printers will need to make modifications to permit a true copy. Provided the printer is capable of producing the Teletext graphics set, one of the approaches will work. If the graphics of the printer are ROM-based, the character codes supplied by the RS232 interface card must be translated into appropriate printer codes. This will be a one-to-one translation carried out with the aid of a look-up table which a number of PC communications programs, such as Procomm, have available. If the printer is a type with a RAM-based character set, such as the Epson FX-80 or compatible, the best approach is to reprogram it to emulate an Epson MX-80F/T.

Since the purpose of the present decoder is to permit examination of the data without pre-conceptions, and allow non-ASCII data to be read, two other transfer modes are available.

The first of these allows transfers of a specified row in ASCII with graphics modified as with the full-page mode. The other transfers a specified row in hexadecimal format as it appears in memory, allowing the host PC to process a page of unmodified data.

These two options can be demonstrated quickly by examining channel 4: three lines will contain data; one has plain ASCII text, one Hamming-modified numbers relating to the ASCII text, and the third contains plain hexadecimal data containing status infirmation on the transmission, including time, date and channel.

PC interface card

The RS232 interface and controller card shown in Fig. 3 is based on the 8051 microcontroller from Intel. The 128 bytes of internal RAM are sufficient to hold all information for control and temporarily program data. An external EPROM addressed by a latch Type 74LS373 holds the machine code that forms the control program. The UART (universal asynchronous receiver/transmitter) in the 8051 coupled to Newport Components' single 5 V RS232 interface chip Type NM232CD result in a simple, yet reliable, RS232 link. The NM232CD has an on-board ±15 V converter.

Practical use of the system

Having built the decoder and the interface, you are in a position to get more out of Teletext than from a standard television-based system. The ability to save

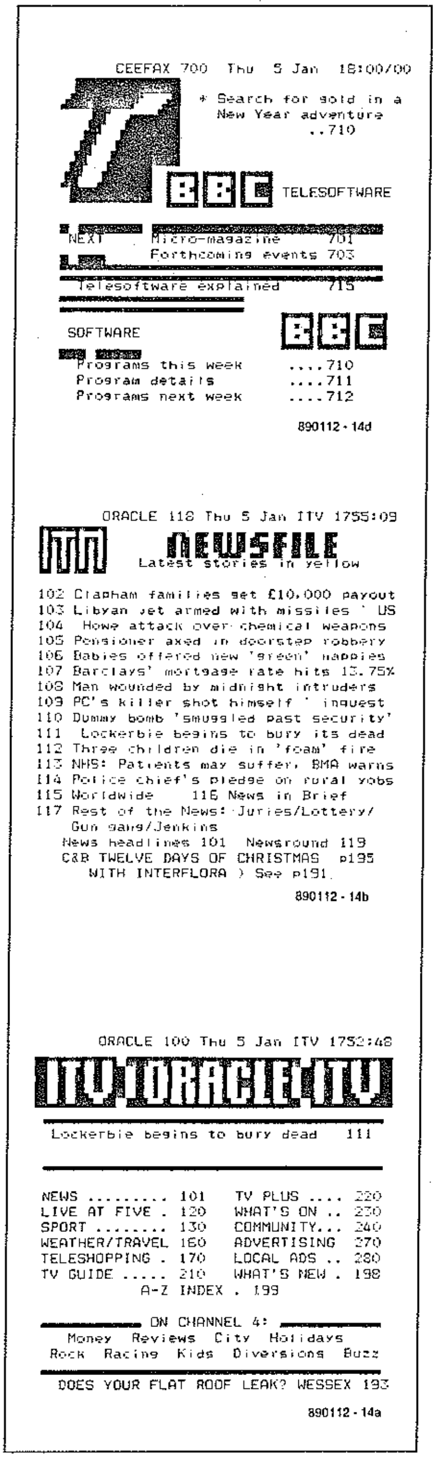


Fig. 4. Some more sample print-outs of Teletext pages downloaded with the proposed system.

pages to disk and edit them creates the ability to build up a database. All weather charts, for instance, over a certain period could be collected if meteorology is a hobby.

The BBC transmits computer programs via Teletext, and these are available with the present system. Once pages can be transferred to disk, it becomes possible to save an entire magazine. One on disk, access to pages is much faster than waiting for the page to come up in the transmission. This is particularly true if a sub-page is requested. A sub-page can be specified by selecting the required page, and setting the time-page option to the sub-page number, i.e., timed page 0003 for sub-page 3 to display this only.

For a first challenge of beating the hiders of information, users may like to consider the Televox page, currently on page 777 of ITV on HTV and presumably elsewhere. This is an interactive page where a subscriber can control the display of information via voice control on the telephone. On first entry to the service, the user is given a timed page number to set his Teletext to. Then information is sent as a timed page transmission, immediately followed by a blank screen on a non-timed page. The effect is that if the timed page is not set, the pages appear for only a fraction of a second and can not, therefore, be read. The odds of guessing the correct page are small, and as subscribers log on and off it changes.

For further reading:

1. *Broadcast Teletext Specification*, September 1986. BBC, IBA, BREMA.
2. *Level-4 Enhanced UK Teletext*. R.H. Vivian, IBA UK.
3. *Enhanced Computer-Controlled Teletext Circuit SAA5243*. Philips Components Technical Publication 255.
4. *World System Teletext Specification*.

The software developed by the author may be ordered through the Readers' Services under order number ESS113. A 5¼-inch 360 KByte MS-DOS formatted floppy disk is supplied, containing:

- the control program for IBM PCs and compatibles equipped with an RS232 port;
- the contents of EPROM IC_3 on the RS232 interface card. The code is provided in the form of a file in Intel-hex format.

Details on ordering the package are given on the Readers' Services page elsewhere in this issue. We regret that no PCB artwork has been designed for the present project.

Note: the SAA5231, SAA5243 and the 13.875 MHz quartz crystal used for building this project should be available as spare parts from authorized Philips Components Service Centres.