TELETEXT

INTRODUCTION

Teletext is a method of broadcasting data via a TV signal. In its most widespread form, it is a system for transmitting textual information for display on the home TV receiver. The *pages* of text are selected by the viewer and displayed on the screen instead of the normal TV picture. Alternatively, text in *boxes* can be inserted into the TV picture for display as subtitles (captions). A wide range of information is available from most teletext services: news, weather, sports results, stock market prices, TV program schedules, program backup information, advertising, forthcoming events, travel information, leisure interests, and so on. The service is free to the end user, being funded from revenue raised by carrying advertisements or directly by the TV broadcaster or other organization.

The teletext information provider, who may be part of the broadcasting organization or an independent company, collects together the information to prepare hundreds of teletext pages and assembles them into a database. After conversion to a suitable format for transmission, the data are added to the TV signal and broadcast along with it. At the receiving end, the viewer has a TV set equipped with a teletext decoder. This decoder recovers the teletext signal, and according to the viewer's request entered via the remote control handset, stores the correct page and displays it on the screen. A service can also be received on a PC fitted with a suitable TV capture card.

Teletext transmissions are also used as a method of broadcasting commercial and professional data on a revenue-earning basis. The information is acquired and subsequently processed by application–specific equipment.

Teletext was invented in the United Kingdom in the early 1970s for use with 625 line analog TV systems. Later, other systems with different approaches were developed elsewhere (1). However, the original system, identified as system B in Reference 1, has emerged as the dominant teletext standard for analog TV. It is more generally known as *World System Teletext* (*WST*) and is referred to in this article simply as *teletext*. It has been very successful in some parts of the world, and well over 400 million teletext TV receivers have now been produced. In Europe, teletext is a standard feature of all new TV sets, and almost all analog TV broadcasters provide a teletext service. Many variants have been produced to cater to different languages and alphabets such as Arabic, Greek, and Chinese.

Teletext services are also available in many digital television broadcasts, using the same basic principles but different technical standards. The WST format can be still be used, but there are now several of more advanced open and proprietary standards offering greater display flexibility. Examples include the *MHEG-5 (Multimedia and Hypertext Experts Group)* (2) or *MHP (Multimedia Home Platform)* (3) standards. A comprehensive range of facilities for mixing text, still pictures, and video content is available, together with user interaction options. This combination of features is sometimes described as *interactive television*. The data for such services are transmitted in digital video broadcast packets using a carousel approach known as *DSM-CC* (4).

TELETEXT PRINCIPLES FOR ANALOG TELEVISION

Packets, Pages, and Services

Teletext information is inserted as digital data on otherwise unused lines in the vertical blanking interval (*VBI*) of an analog TV signal. A teletext *packet* occupies one VBI line and comprises 360 bits. In general, one packet represents one row of characters for a teletext *page*. The page display format is 40 characters wide by 24 rows high, so 24 teletext packets are needed to transmit one teletext page. As there is no return channel from the viewer to the broadcaster, all teletext pages are transmitted in sequence as a cycle. The viewer may have to wait for the page to be received if the decoder has insufficient memory to store the entire database. This is true for most decoders in current use.

A typical service can transmit about 20 pages/s, so an example 400-page database will take 20 s to transmit before the cycle is repeated. As page requests are made at random, the viewer might be lucky in getting instant access or unlucky in having to wait for the whole transmission cycle. So the average waiting time in the above example is 10 s. Higher performance decoders have storage for several pages, so more pages can be captured in advance; this gives a better chance of instant access when the viewer requests a new page.

The display format with its simple graphics is very efficient in conveying information with a small amount of data, at the same time being readable from a normal TV-viewing distance. Two examples of typical teletext pages are shown in Fig. 1.

Transmission Equipment

A typical arrangement at a TV broadcaster consists of a teletext inserter working with one or more editing terminals. The inserter contains memory for the teletext pages in transmission and provides facilities to insert them into the video signal. The editing terminals are used to compose the teletext pages and give instructions to the inserter as to which pages are to be included in the current transmission. Pages are created manually on the editing terminals, and systems often incorporate facilities to convert data feeds from remote systems to teletext pages automatically, such as stock market data or airline schedules. A block diagram of a complete analog teletext system is shown in Fig. 2.

Teletext data are added synchronously to the video feed before the usual modulator and transmitter using a *data bridge*. In a relay station, a *regenerator* is installed to maintain the quality of the teletext transmission. The regenerator receives the teletext signal, converts it back into a digital data stream, and reinserts clean data onto the outgoing video signal.

Subtitles are created by special equipment that provides an output to the teletext inserter synchronized to the TV program.

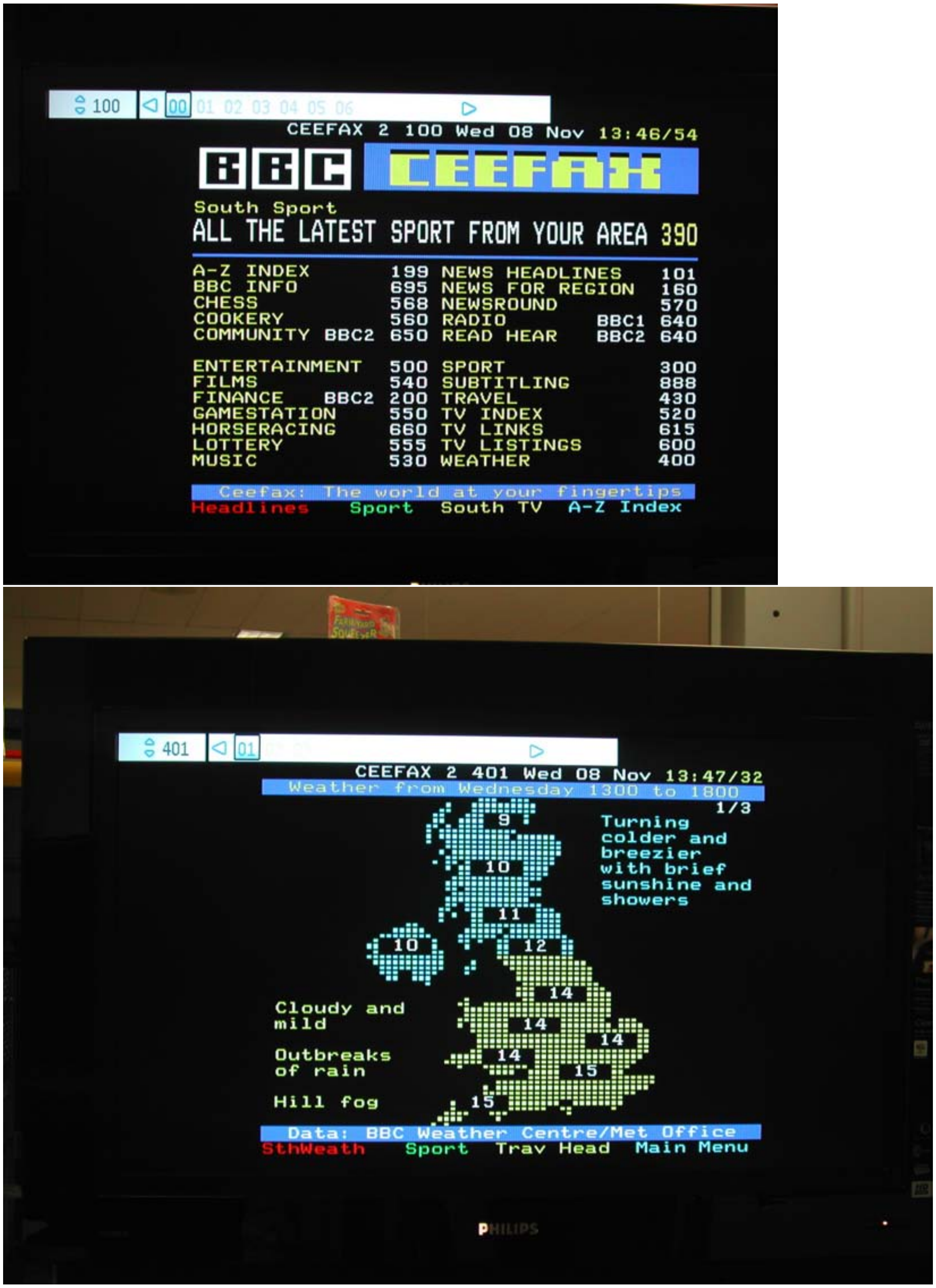


Figure 1. Typical teletext pages as displayed on a TV. (a) An example of an *Index* page that would be displayed when the viewer first switches the receiver into teletext mode. (b) An example of a page from the *Weather* section of a database, showing the low-resolution graphics of the original teletext system. (Pages reproduced courtesy of *BBC* Ceefax, London, U.K.)

Often, a broadcaster will provide analog and digital teletext services and make the same information available on the World Wide Web. To avoid unnecessary duplication of effort, the editorial content will usually be entered into a central database along with styling templates appropriate to each service. The pages will then be created automatically for each service and passed into the various distribution systems.

Decoders

On the receiving side, the necessary decoding functions are either built into special integrated circuits (ICs) or exist

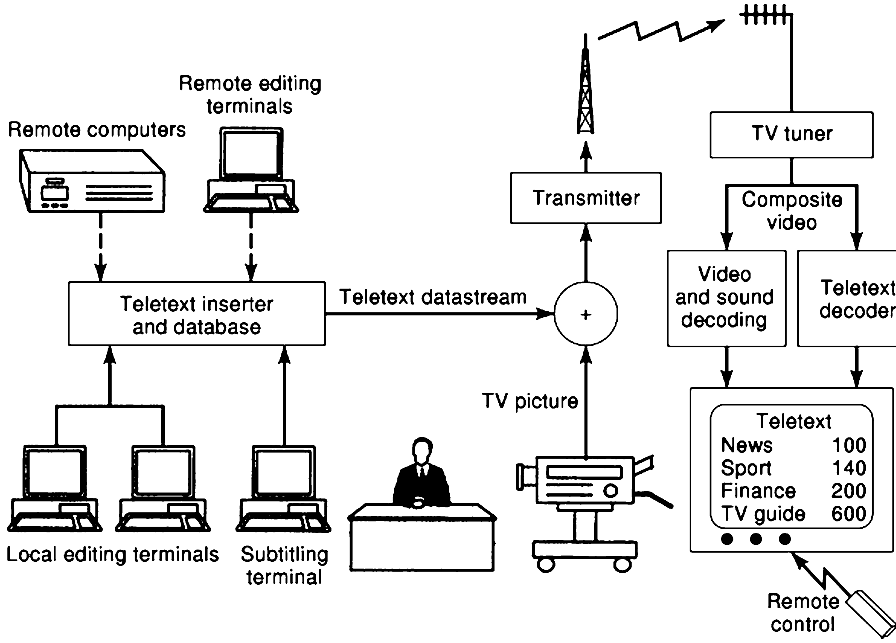


Figure 2. Complete analog teletext system, showing data origination, transmission, and reception.

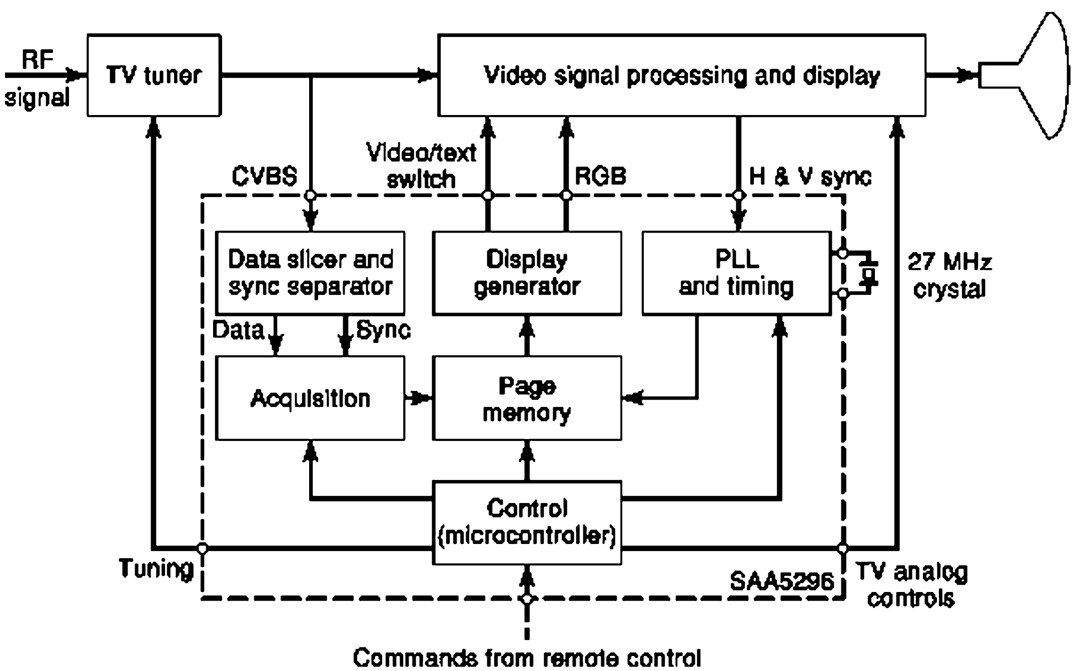


Figure 3. Block diagram of a teletext decoder, showing the main functions and interfaces to a TV receiver.

within more complex ICs performing other TV decoding tasks. A simplified block diagram of an analog teletext decoder within a TV receiver is shown in Fig. 3.

The data slicer recovers the digital teletext data from the baseband analog composite video signal (*CVBS*) provided by the tuner. This data stream is passed to the acquisition circuit, which compares the page number information with the requested page number coming from the control circuit, and when the correct page is found, it writes the data into the page memory. The memory is also addressed by the timing circuit, which reads out the data synchronized to the TV scanning circuits. In turn, the display generator converts the stored data to the text and graphics of the page, producing red, green, and blue (*RGB*) outputs, which go to the display via the TV's video circuits under the control of a Video/Text switching signal. Finally, the control circuit receives and stores the viewer's instructions from the remote control handset: the page requested, whether teletext or TV is to be displayed, and so on.

The first production teletext decoders in the mid-1970s required 10 to 15 ICs to perform the function. With dramatically improving IC technology over the years, in terms of

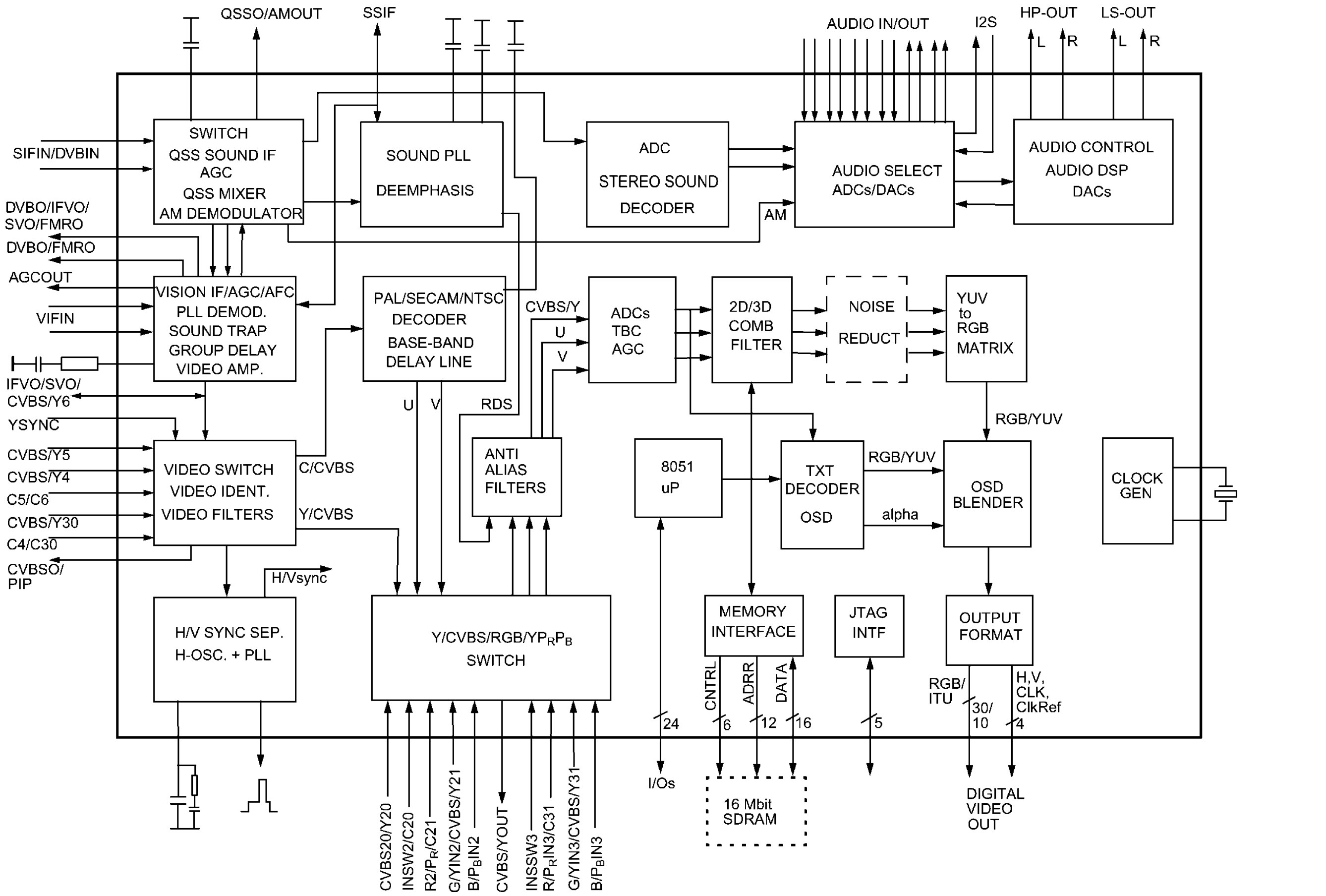


Figure 4. Block diagram of a highly integrated "one chip" TV IC incorporating a teletext decoder (TXT Decoder + OSD).

both logic density and increasing skill in mixed signal (analog and digital) techniques, the number of ICs required has reduced and performance and features have improved. A small fraction of an IC now suffices to perform the teletext decoding function. Consequently Teletext decoders are now integrated with other TV functions, so that one IC covers teletext, on-screen display, user interface, video signal processing, and control of the total system. In addition, some of the processing required is now done by software in the microcontroller. An example of such a highly integrated IC for an LCD TV is shown in Fig. 4. The high level of integration now possible with IC technology makes the provision of teletext functionality very cheap, and it is now a standard feature of even the smallest portable TV.

Teletext Evolution in Analog TV

There have been several developments since the first teletext services started in the mid-1970s. Many more languages are now covered, with support for accented letters (e.g., in German and Hungarian), special symbols (e.g., in Icelandic and Turkish), different alphabets (e.g., Arabic, Cyrillic), and ideographic symbols (e.g., Chinese) (5–7). Many decoder ICs now cover several languages and a wider geographical area than their predecessors, for example, most of Europe. Teletext is now broadcast in over 50 countries.

Methods of user access to pages have improved. The *Fastext* system provides color keys on the remote control associated with color prompts on the page, giving easy access to highlighted topics without using page numbers. The *TOP* (Table Of Pages) system allows menu selection of topics from the database. Multipage decoders provide faster (often instant) access to pages.

An adapted form of teletext has been used in video recorders to facilitate the recording of TV programs. Known as *Program Delivery Control* (*PDC*), this system allows cursor selection of items from a program schedule page and ensures correct timing of the recording. In addition, automatic setting of the timer display when first switching on, or to adapt to summer/winter clock time changes, can be provided via teletext.

Automatic tuning of new cable TV receivers can be provided using a teletext-based system known as *ACI (Automatic Channel Installation)*.

Teletext is also used for data broadcasting *(Datacasting)* to closed user groups as well as to the general public. Multimedia PCs and video cards often include teletext facilities together with TV reception.

Specifications for *enhanced teletext* services with better graphics and more colors (8), referred to as *Level 2.5* and *Level 3.5* services in Reference 9, and *electronic program guides* using teletext transmissions (10, 11), have also been defined. However, there are few broadcasts of these, because commercial attention is now mostly focused on developments for the environment of digital television.

TELETEXT SPECIFICATION FOR ANALOG TELEVISION

Display Format

The original teletext display format was developed to be as simple as possible to implement, with the assumption that the viewer might be at some distance from the screen. A basic teletext page has the following display characteristics:

- 24 rows, each of 40 non-proportionally spaced characters
- Limited character repertoire
- Very coarse graphics capability
- Character space attributes
- Black background outside the text area
- 7 full intensity colors, plus black
- One flash mode
- Conceal mode
- Double height character mode
- Subtitle mode

When the teletext specification was first drafted, it was felt prudent to center the display of the text as the purity and convergence of color cathode ray tubes toward the edges was not particularly good. As a result, the standard teletext display is characterized by a black border between the text and the edge of the visible display. A requirement for 24 rows of 40 characters dictated that each row would be 10 scan lines high (in 625 line systems), and each character position would be the equivalent of 1 μs wide. A fixed format was adopted, with a character cell containing either a character code or an attribute.

The standard was defined so that a basic teletext page would contain 960 characters and would occupy a maximum of 1 kbyte of memory. The 40 character positions across a display row have a one-to-one relationship to the 40 character or attribute bytes of the transmitted packet. A display generator can be constructed that interprets the data directly, which avoids the need for complex processing by the decoder. A typical code table is shown in Fig. 5.

Spacing Attributes. The first 32 entries, columns 0 and 1, in the code table of Fig. 4 select attributes that control the appearance (for example, color, size) of subsequent characters on that row. For example, the *Alpha Cyan* command is interpreted as “select cyan foreground color and use the alphanumeric character set.” The actions specified by an attribute persist for the rest of the row unless superseded by other control codes. The underlined attributes are the default conditions assumed at the start of each display row.

As each byte of transmitted data specifies either a character or an attribute code, and attributes are generally displayed as a space, limitations in the display effects can be achieved. In addition, some attributes take effect immediately (*Set-At*), whereas the action of others is delayed until the next character cell (*Set-After*). By way of example, assume it is required to set the foreground color to yellow and the background color to red. The start-of-row default is white characters on a black background. The sequence *Alpha Red, New Background, Alpha Yellow* has to occur prior to any text. It will be displayed as three spaces, with the red background starting at the cell occupied by the New Background command. Also, it is not possible to change the color of adjacent characters without an intervening gap. Thus, the control codes are referred to as *spacing attributes*.

Characters. The last 96 entries, columns 2 to 7, in the code table of Fig. 5 select character or graphics symbols. In effect, there are three overlapping sets of characters: Columns 2, 3, 6, and 7 each have three subcolumns, a, b and c.

1. Alphanumerics: For languages based on the Latin alphabet, this set consists of 83 ASCII characters plus 13 other characters classified as *national options*. The relevant positions are shown with a shaded background in Fig. 5, and the English national option set has been included. Other national option sets exist for major European languages, and typically, they include the most frequently used characters that have diacritical marks, for example, Á, ç, and ñ. The set required for the correct display of a page is specified as a parameter of the page. Character code tables for the Arabic, Cyrillic, Greek, Hebrew, and Thai alphabets also exist.
2. Contiguous mosaics: There are 64 graphical elements plus 32 alphanumeric characters (mainly the uppercase alphabetic characters). For each mosaic symbol, the normal display rectangle is organized as a coarse grid, 2 pixels wide and 3 elements high.
3. Separated mosaics: The contiguous mosaics are displayed in such a way that there is an area of background color around each of the coarse pixels.

The set in use is determined by the attributes encountered previously on the row. The characters in columns 4 and 5 are invariant, allowing uppercase text and graphics to appear side-by-side without the need for intervening spaces containing attributes for selecting alphanumerics or graphics. The alphanumeric set is selected as the default at the start of every row. The active pixels of a character are displayed in the current foreground color, with the remaining pixels appearing in the current background color.

TV Lines Available

Teletext data are usually restricted to lines in the VBI as the transmission normally accompanies a TV picture. The lines available in 625 line systems are 6 to 22 and 318 to 335. However, because of decoder limitations and the broadcasters' need for television signals to include test waveforms, not all available lines can be used in practice.

A marked increase in the overall data rate is possible if all the TV lines can be used (other than those containing field or equalizing pulses) when there is no need to broadcast a video picture. This is referred to as *full field* trans-

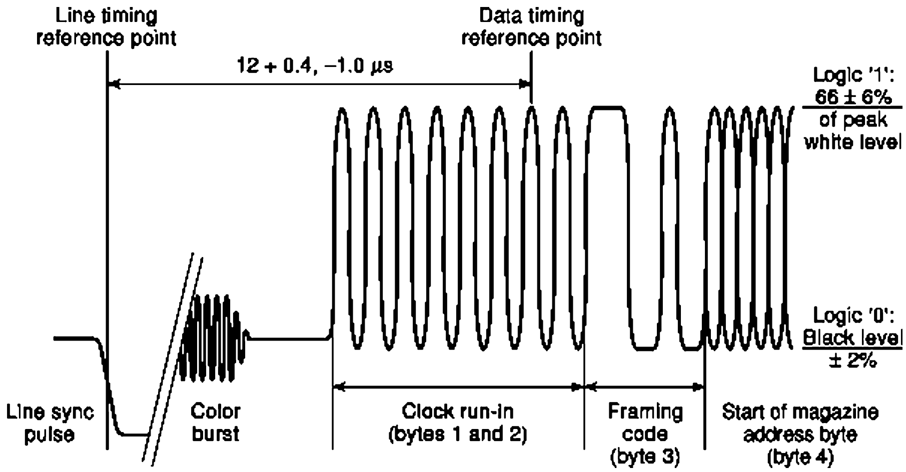


Figure 5. A typical teletext code table. The attributes in columns 0 and 1 marked with * have a *Set-At* function and take effect immediately; the remainder take effect from the following character cell (*Set-After*). Underlined attributes are the start-of-row default conditions. Shaded entries indicate the location of characters that are language dependent. The English national option set is shown.

mission and is used for certain specialist closed user group applications such as airport information systems and stock market dealing rooms.

Data Signals

A 625-line teletext system uses non-return-to-zero (*NRZ*) binary signalling at 6.9375 Mbits/s. This is 444 times the nominal television line frequency, and at approximately 70% of the theoretical maximum for a 5 MHz bandwidth channel, it represents a good engineering compromise between transmission speed and controllable decoding margins within the receiver. The signaling levels are shown in Fig. 6. In practice, overshoots occur because the transmission channel itself is bandlimited, which leads to an increase in the peak-to-peak amplitude of the data signal.

In an ideal data signal, the transmitted logic 1 appears as a raised-cosine pulse of 144 ns duration. This is achieved by passing the NRZ data signal through a phase-corrected shaping filter. To minimize intersymbol interference, the spectrum is substantially skew-symmetrical about a frequency corresponding to half the bit rate.

Packet Structure

A teletext data packet comprises synchronizing and address information and codes representing the data to be transmitted. There is a total of 45 eight-bit bytes in a 625-line packet. The first 5 bytes, the *preamble*, have a fixed structure and meaning, identifying the packet as teletext and defining its function.

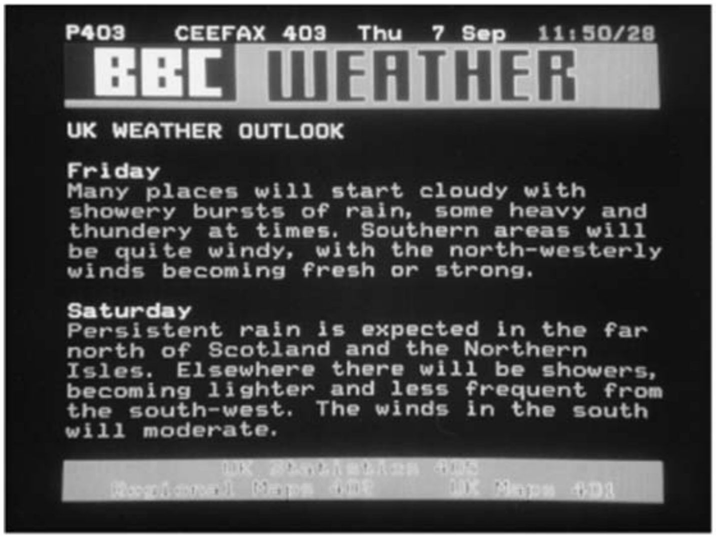
Preamble. The first two bytes of a packet form a *clock run-in* sequence of alternating bits to indicate the presence of a data line and to enable a decoder to synchronize to the bit stream, (Fig. 6). The third byte is a *framing code* and is used within the decoder to establish byte synchronization.

Bytes four and five of every packet contain address information. In each byte, four message bits are interleaved with four protection bits. This is a form of Hamming coding and is used to give some protection against transmission path errors. A decoder can correct a single bit error and identify double errors. Of the eight message bits, three are used as a data stream identifier, which allows up to eight separate *magazines* to be distinguished. The other five bits define the *packet address* (range 0 to 31).

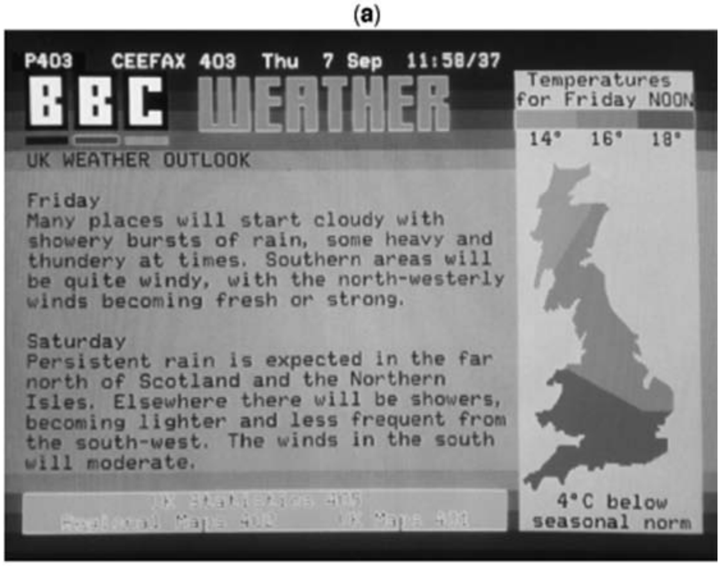
Packet Types and their Function. The remaining 40 bytes of a packet after the preamble contain data representing characters, display attributes, or application specific data. Additional address information appears in some packet types. The format and coding vary according to the packet address value specified by bytes 4 and 5 and, to some extent, the context and the application. Character data are usually odd parity encoded, but important control or address information is Hamming coded. In addition to the scheme mentioned above, a more transmission efficient Hamming protocol is also employed in some packet types, using 3 bytes to convey 18 message bits and 6 protection bits.

The common uses of each packet are listed below. Packets 0 to 28 belong to individual pages. Packets with addresses 24 to 28 carry supplementary information to improve decoder performance and provide display enhancements. Consequently, most are not intended for direct display and need to be processed by the decoder. Packets 29 to 31 have a standalone function.

- 0—Page header (see below).
- 1–23—Display data for standard pages.
- 24—Displays data for additional database navigation information.
- 25—Extends the data carrying capacity of a single page to 1k bytes.
- 26—Defines location-specific enhancements to the basic page, including the ability to insert characters that do not appear in the code table addressed by packets 0 to 23. For example, overwriting the default character "C" (implying "Copyright") at a specified position with the symbol (c).



(a)



(b)

Figure 6. Data timing and signal levels for a 625-line teletext packet.

- 27—Specifies in a machine-readable format page numbers that are in some way related to the received page. For example, the page numbers shown on an Index page.
- 28—Used in teletext services offering display enhanced versions of standard pages to define the character set and the set of colors to be used for that page. In commercial data services, it contains encryption and access-key data.
- 29—Similar functions to a packet 28, but the contents apply to all pages in the magazine rather than a single page.
- 30—Specific packets provide information about the TV channel and the current TV program to control the operation of VCRs.
- 31—Used for commercial data broadcasting applications, allowing the point-to-multipoint transmission of serial data streams.

Page-Format Transmissions

Fixed Format. A fixed format, synchronous system is used to transmit pages of information in WST, Which has been shown to be a very reliable and rugged approach (12) and, through helping to keep the decoder costs relatively low, has contributed to the overall success of teletext. Each packet with an address in the range 0 to 23 represents one row of text on the screen. Its vertical position is defined by the packet address alone, and it is not determined by data in previous or subsequent packets. Formatting commands such as *carriage return* and *back space* are not used. If the packet address becomes corrupted, a decoder will usually reject the packet completely rather than misplacing it within the displayed page. There will not be a knock-on effect on the rest of the page. The down side of this approach is that it still takes one complete packet to transmit a display row with just a single character in the first column. In the interests of transmission efficiency, it is not necessary to transmit a packet that contains no information, for example, an empty display row. The decoder is required to display a blank row in the absence of a packet.

Definition of a Page. The transmission of a given page begins with and includes the packet with an address of zero. Such packets are known as *page headers*. They are the most important of all packets as they contain unique information about the page not found in any other packet. Their contents include:

- The number of the page (typically in the range 100 to 899, but hexadecimal values up to 8FF can also be specified).
- Control data defining transmission parameters (for example, updated page, page out of numerical sequence).
- Control data defining display parameters (for example, subtitle page, character set options).
- Text for the top row of the display (usually the name of the service provider, page number, and date).
- A real-time clock.

The body of a page intended for display consists of one or more directly displayable packets in the range 1 to 23 and optional extension packets in the range 24 to 28. All packets have the same magazine number as used in the page header.

A page is terminated by and excludes the next page header packet having the same magazine address in *parallel transmission mode* or any magazine address in *serial transmission mode*. The two types of transmission mode are outlined below.

A Teletext Service

An analog teletext service contains pages from one or more magazines. A magazine consists of a set of one or more pages, each with the same magazine address value. The pages are normally transmitted in numerical order, but an out-of-sequence page can be marked as such using a control bit in the page header.

The magazines can be transmitted in numerical sequence (*serial mode*) or in an interleaved fashion (*parallel mode*). In serial transmission mode, the next packet to be transmitted is allocated to the next available VBI line, which implies a central database containing all the pages in the service. By contrast, in parallel transmission mode, each magazine is allocated to particular VBI lines, which allows contributions from more than one information provider to be combined easily to form one overall service. This can be implemented at a local transmitter to create a teletext database with national and regional components, for example.

Data broadcasting packets may also be present in the total service, but they are coded in such a way that they are ignored by page-format decoders.

SIGNAL DEGRADATION AND ERROR PROTECTION IN ANALOG TELETEXT SYSTEMS

A data broadcasting system has to be robust and take into account the possibility of data corruption. An analog teletext signal can be degraded in several ways during its journey from transmitter to receiver. This can give rise to errors in the displayed text or data. The following effects can occur:

- Limitation of the signal bandwidth.
- Distortion due to echoes, including both multipath reception and group delay errors.
- Airplane flutter.
- Random noise.
- Cochannel interference.

The effects of degradation of the teletext component of the TV waveform can be markedly different to those of the video. A short-term echo with a duration approximating the teletext bit period might produce an almost imperceptible ghost on the TV picture, whereas it can have an extremely destructive effect on the data signal, depending on the phase with which it arrives. Accordingly, owners of teletext receiving equipment are always advised to install a quality antenna to minimize the multipath components present in terrestrial signals.

Eye-height is often used as a figure of merit for transmitted data signals. With an ideal data signal, its value at any instant will be independent of adjacent pulses. However, when the signal passes through a linear network possessing somewhat arbitrary characteristics and subjected to the distortions listed above, this will no longer be the case. The signal will then suffer from intersymbol interference, and the voltage difference between the steady state values for logic 0 and logic 1 will be reduced. Eye-height is the minimum difference between the two logic levels expressed as a percentage of the data amplitude. Sampling occurs at the data rate at a position chosen to maximize the result. The consequence of too small an eye-height is that the teletext decoder may slice the data incorrectly. For a given eye-height, the number of bit errors that are made depends on the detailed bit pattern (i.e., the content of the data) and the nature of the echoes (13).

Most bytes are coded to allow a decoder to identify, and in some cases correct for, transmission path errors. Interested readers may refer to Reference 9 for precise bit-by-bit coding details. Unless raw data are transmitted, the chosen coding schemes ensure there are never more than 14 bit periods between data level transitions in the waveform, which simplifies the recovery of the bit-rate clock within the decoder.

With page-format transmissions, error integration is achieved over successive receptions of the page. If a packet is lost, the cyclical nature of the transmission should mean that it is captured during the next transmission of the page unless the quality of the signal is particularly poor. On first reception of a teletext page, a decoder is required to erase the old data from memory before writing in any new data. This process involves setting the display code for “space” at each location in the memory where the new page is to be acquired. The character data within a display packet is parity coded, and a decoder can only identify a single bit error. Should such an error occur, the decoder will not write in any new data at that location. If the error occurred during the first reception of the page, a space will be displayed at the affected location. If it happened during a subsequent acquisition, the character previously received would still be displayed, which amounts to a rudimentary form of error integration. Thus, with a marginal signal, the page may eventually become correct after a few receptions. A bit error rate (*BER*) of 1.3×10^{-4} corresponds to one missing character per page.

Double errors can occur at higher bit error rates, which can produce incorrect characters on the screen if the received byte passed the parity test. However, errors within the preamble are also likely, which results in the loss of complete packets.

More complex schemes incorporating cyclic redundancy checks (*CRC*s) and forward error correction (*FEC*) protocols are used in data broadcasting applications.

TELETEXT DECODERS: FUNCTIONS AND INTERFACES

The main functions of a teletext decoder were shown in Fig. 3. The operation of the decoder is described in more detail below.

Control Functions

All modern TVs use a microcontroller to perform the control functions: volume, brightness, color, contrast, tuning, mute, and so on. As the teletext decoder also requires control functions such as page selection, it is logical to use the same microcontroller for both purposes. As TVs have on-screen display of the channel number and analog settings, it makes sense to use the same character generator as the teletext decoder for such functions.

Typically the microcontroller for a standard analog TV is embedded in a single IC, which performs all video signal processing functions as well as teletext decoding, control, and on-screen display. Different versions of such ICs are made with different page memory and ROM sizes to allow product customization between different models or manufacturers by altering the software.

The microcontroller receives commands from the remote control handset via an infra-red link. As well as the normal TV functions, a teletext remote control has buttons for choosing TV or teletext mode. The number keys in teletext mode are used for selecting three digit page numbers, and often there are the four colored keys for easy selection of certain pages using additional navigation information (see below). A *HOLD* button stops pages being updated when it is desired to examine some information on a particular topic. This is useful for a sequence of *rolling* pages on the same page number where information is continuously changing every few seconds. For example, a weather page may alternate between details for today and tonight. A *SIZE* key allows the teletext display to be expanded vertically in two halves for easier reading if required. A *REVEAL* button permits the display of concealed text; this is used for quiz pages and puzzles to reveal the answers to the questions.

Some functions use the teletext decoder even when operating in TV mode. As the teletext transmission contains time information accurately updated every second, some TV remote controls also have a *TIME* button that enables the display of the time of day (hours, minutes, and seconds) in a box on the TV picture without having to select teletext. Station identification is often available from a channel-related teletext packet, which allows the name of the channel to be displayed in a box on the TV picture. This normally happens automatically for a few seconds after changing channels.

Although many teletext decoding and display functions are implemented in hardware, which is ultimately influenced by the microcontroller, certain processing functions such as the interpretation of additional navigation data are carried out by the microcontroller. Thus, it has access to the memory for reading the received data and for creating on-screen displays.

Data Slicing and Acquisition

The data slicer recovers the teletext data from the video signal. In simple terms, a slicing level is created, and the teletext signal above that level represents a logic 1, below the level being logic 0. Creation of the slicing level is not simple in practice, as the signal is subject to the various forms of distortion described earlier, and carefully designed algorithms are needed to get the best performance. High-performance data slicers contain circuitry to compensate for these effects.

The data slicer provides digital data and a data clock for the following digital circuitry, which converts the serial data stream into parallel format, performs the appropriate error checking and correction, and transfers the information to the acquisition circuit. A sync separator extracts the horizontal and vertical timing information from the video signal. It is used to define the timing window during which the teletext framing code is expected.

The acquisition circuit is used to find the appropriate pages by comparing the incoming data with the requests from the microcontroller. It searches for page headers, and if one is found with a page number matching a desired page, it causes all page data to be written into the page memory. This process applies to the page header itself and all following page-related data packets until the next (unwanted) page header is received, which terminates the reception of that page. Facilities are provided for the acquisition and storage of non-page-related data packets as appropriate.

Additional circuits provide for the time to be written to the memory from page header packets, deal with the various control bits in the page header, and clear the old data from the memory before writing in the new page. The page memory may have storage for several pages to give faster access; a typical device for a mid-price range receiver can store 10 pages. To speed up the acquisition process, several page comparator circuits are provided to search for more than one page simultaneously.

Timing and Synchronization

The timing signals within the teletext decoder are generated from a crystal oscillator and divided internally to the appropriate frequencies. As on-screen status displays and subtitles are viewed with the TV picture, it is necessary to synchronize the timing of the text display with the video. This synchronization is done using a phase locked loop (*PLL*) within the IC to track synchronization pulses (H) from the line timebase. In addition, field synchronization pulses (V) are taken from the field deflection circuit and are used to reset the vertical display timing counters.

For a full teletext display without a TV picture, a noninterlaced display is preferred, as it reduces display flicker that can be particularly apparent with 50 Hz TV systems. When a TV picture is present (for example, with subtitles), the normal interlaced timing is used.

Display Generation

The display generator reads data from the appropriate part of the page memory and converts it into characters and graphics. Characters are generated on a dot matrix, a common resolution being 12 dots wide and 10 dots high for one character cell. The character cell contains the symbol and the spaces between it and the adjacent cells, so a typical character occupies 10 dots wide by 7 dots high. The font shown in Fig. 5 has these characteristics.

Character patterns are stored in an on-chip ROM, which is a typical device containing four character set tables (e.g., Latin, Greek, Cyrillic, and Arabic alphabets) to cover a wide geographical area. In addition, some symbols are defined in the ROM by the TV set manufacturer for use in his on-screen menus.

The display generator responds to control characters, which change the size, select boxes, give concealed text, select alphanumerics or graphics, or change the color of the character or background. Also, facilities are provided for generating a cursor for use in on-screen menus.

The outputs of the display generator are the red, green, and blue (*RGB*) drive signals that go to the video processing circuit of the TV receiver. Although they are on–off type signals, their amplitude can usually be adjusted to suit the application. The insertion of the text display is under the control of the Video/Text switching signal. When this is high, the TV picture is blanked, allowing the RGB information to appear.

Additional video processing may be undertaken if necessary, e.g., to blend in multiple on-screen displays, or to provide the correct drive signals for an LCD display screen. Such functions are usually incorporated inside the IC with no external circuitry required.

DATABASE NAVIGATION AND ACCESS TIME IMPROVEMENTS

Early decoding systems assumed that a viewer would always key in a three-digit number to request a page and would be prepared to wait for 10 or 15 s for the page to arrive if the decoder could not store more than one page. As teletext gained popularity, databases grew in size, and it became more difficult to find the information of interest. Meanwhile, decoders gained some local processing capability and more memory but usually not enough to store the entire database. Viewers demanded improvements, and two methods for improving speed and ease of access emerged in the wake of the decoder advancements.

Some decoders use external (off chip) memory to store most of the database to give instant access to any page; however, for cost reasons, most teletext decoders have limited on-chip memory of a few pages. Systems have been designed to make optimum use of this limited memory, as described below.

The Fastext System

The objectives of the *Fastext* system are to reduce access time and to provide an easier method of page selection (9). The decoder is informed of pages the editor believes the viewer might select next having read the current page. For instance, on an index page, the page numbers could correspond to the page numbers shown on the display. Alternatively, a sequence of pages, for example, all the news stories, might be defined. The page number information (up to 6 numbers) is transmitted in a machine-readable format via a packet with an address of 27 appended to the basic page. On receiving the packet, a multi-page decoder can start immediately to acquire the pages specified up to the limit of its memory capacity. It is likely that by the time the viewer has read the current page and made his next request, the desired page will have been pre-captured and can be displayed immediately.

The second element of Fastext aids ease of access by enabling a single keystroke page selection. The editor appends an extra row of text to the bottom of the basic page for display only by Fastext compatible decoders. The display data are transmitted via a packet with an address of 24 and comprises four keywords, or prompts, each in a different color. The following example appears on the page shown in Fig. 1(a):

Headlines	Sport	South TV	A-Z Index
(in red)	(in green)	(in yellow)	(in cyan)

Each prompt is associated with one of the page numbers specified in packet 27. The remote control handset includes four colored keys that are in the same order as the on-screen prompts. In the example shown here, if the viewer wishes to read the *SouthTV* page, he only has to press the yellow button on his handset. The decoder will interpret relevant information from packet 27 and request the page. A multi-page decoder may have precaptured the page and can display it immediately.

The editor can also indicate the number of a relevant index page via packet 27. An additional dedicated key can be added to the handset to give the viewer direct access. For example, if the displayed page contained tennis information, then the *INDEX* key might link to the main index page for the *Sports* section.

Table of Pages

The Table of Pages (*TOP*) system enables the decoder to build on-screen menus to allow the viewer to select pages by theme or content (14). Pages within the teletext transmission are categorized according to specific themes (known as *blocks*) and subthemes (known as *groups*). The additional information, comprising titles and page numbers, is conveyed via special machine-readable pages from which the user menus are constructed by the decoder. Only packets in the range 0 to 23 are used, unlike the Fastext system. The display format is at the discretion of the TV manufacturer. The overall operation is likened to a card-file system. One box (block) might contain *News* pages, with the subdivisions (groups) *National, International, Economics,* and so on.

Knowledge of the structure of the database allows a decoder with additional page storage capacity to precapture the pages the viewer is likely to request, thus eliminating the access time. The additional information also indicates the page numbers in use. The viewer can be prompted immediately if he requests a page that is not being broadcast. The selection of pages is simplified by way of four additional colored keys on the remote control handset. Locally generated prompts, including the title of the next group in the current block and the title of the next block, are displayed in matching colors below the standard page.

ADDITIONAL FEATURES AND SERVICES IN ANALOG TV SYSTEMS

Teletext Subtitles

Subtitles are an important part of most teletext services. They are highly appreciated by the hearing-impaired community to understand the dialog of a TV program. Most subtitles are prepared in advance from recorded material using a special subtitle editing system. An operator types in the subtitles in the desired form, often using different colors for different characters, which aids understanding. These subtitles are then associated with precise times in the video material, the subtitling equipment responding to time codes from the video source. All this information is assembled as a database for the entire subtitled program. Other programs are subtitled in real time using stenography techniques or speech recognition systems.

At the time of transmission, the subtitling equipment ensures that the subtitles are accurately synchronized to the video signal. Subtitles are transmitted just like teletext pages, but they are inserted at the time required rather than in the regular sequence of normal teletext pages. If another page is interrupted by a subtitle, the transmission equipment arranges for it to be resumed when the subtitle has been transmitted.

A control bit in the page header is set to logic 1 to indicate that the page is a subtitle, which has the effect of switching on the TV picture for most of the screen and only allowing the display of text that is in *boxes*. The boxes are created using control characters *Start Box* and *End Box,* and during the boxes, the TV picture is blanked. Normally, the subtitles are transmitted as double height characters to aid legibility.

Closed Captioning and V-chip

The *closed captioning* system adopted in North America (15) uses similar techniques to teletext subtitles, but there are significant technical differences. The data rate is much lower, 500 kbits/s compared with 6.9 Mbits/s with, consequently, 2 bytes of character data per VBI line instead of 40. This rate allows it to be recorded on a standard VHS video recorder, and prerecorded VHS tapes with captions were common prior to the advent of the DVD (digital versatile disk). With the low data rate, the technique of preloading the caption data and then switching on the display is often used to get a fast, synchronized caption. Various display modes are possible, including scrolling and italics to have different styles of caption and facilitate understanding. A dedicated VBI line, line 21, is used to transmit the data. Legislation in the United States makes the provision of closed captioning decoders mandatory in new TVs.

The closed captioning system also provides the mechanism to classify the nature of the current TV program using the extended data services protocol which provides the parental control facility known as *V-chip* (16). The transmitted data interact with user settings to either enable or block the display of the TV program according to its content (sex, violence, etc.). This function, mandatory in new TVs in the United States, allows parents to exercise some control over the kinds of programs their children may watch.

VCR Programming and Start/Stop Control

An application of teletext to facilitate programming of video recorders is known as *Program Delivery Control* (*PDC*). This system uses teletext pages to carry TV program schedules with embedded control data (17). A PDC video recorder is equipped with a teletext decoder and special software.

To record a particular program, the user selects the schedule page, moves a cursor to the desired item, and presses a key to *record this*. All the necessary information about the channel, date and start time is loaded automatically into the VCR's memory. The embedded control data constitute a label that is unique to that program. In addition, PDC also broadcasts a real-time switching signal (as a dedicated teletext packet) containing the unique label of the current program. This signal is monitored by the VCR and is used to start and stop the recording rather than the usual timer. So if programs are running late, because of a news flash or sporting event overrunning, for example, it does not matter; the requested item will still be recorded in its entirety.

Special ICs have been made for the reception of the real-time switching signal, so that cheaper VCRs without full PDC can take advantage of it even if they are programmed conventionally (18). Personal video recorders (PVRs) and optical disk-based (DVD) video recorders can use the PDC data in the same way.

Data Broadcasting

Although teletext was primarily intended for a mass consumer market with display on a home TV, it has been shown to be suitable for other broadcast data applications. There are facilities within the data broadcasting specification (19) for transmitting data streams, not just pages. In 625-line systems, one VBI line can deliver 2 kbytes/s. Compression techniques applied to the source data can increase the effective amount of data carried per packet. In addition to unrestricted free access, services may be encrypted for closed user groups or premium services on subscription. The technique is sometimes known as *Datacasting*.

Applications include stock market price updates to PC terminals, remote printing of newspapers, horse racing information to betting shops, and chain stores updating their latest prices to their branches.

Automatic Channel Installation

Dozens of TV channels may be available on a cable TV network, and when a new TV or VCR is purchased, it is a tedious business to set up all the channel presets. To avoid this problem, the European TV and VCR manufacturers and cable operators have devised a system that performs the function automatically. Known as *Automatic Channel Installation* (*ACI*), the system relies on teletext technology (20).

Whenever an ACI-equipped TV or VCR is installed, it searches for a special teletext page. This ACI page lists all the available channels by name, their preset number, and frequency in megahertz for action by the ACI software. In this way, installation is made easy for the user, with all the required presets that change per channel being set automatically. The user just connects up the TV, presses an *INSTALL* button, and waits for the process to be completed in a matter of seconds.

Real-Time Clock Setting

The changeover twice a year between summer and winter clock times demands attention from users to reset all kinds of timer devices as well as clocks and watches. In particular, adjusting the timers of video recorders manually is inconvenient.

However teletext transmissions may include *real-time clock* data, contained in a version of packet 30 and typically transmitted every second. With suitable software, these data can be decoded and used to set the timers automatically to the correct time. This process is useful when the clocks change and when equipment is first bought and switched on.

In addition to relieving the users from having to perform a tedious task, the approach also maintains accuracy as the definition of time is produced from a synchronized data stream at the broadcaster, which compensates for any long-term drift in timing at the receiver.

Interactive Teletext

Over the years various forms of interactive teletext have been devised. At the simplest level, background information on a product or service is described on a teletext page, with a telephone number to ring for more details.

This process can be extended with a speech synthesizer on the telephone inviting the user to select a particular teletext page number. Then, an interactive dialogue can take place, with the teletext page being the downward channel from a central computer, dedicated to that particular user, and the touch tone dialer of the telephone being the upward channel.

The Fastext system can be used to provide a rudimentary interactivity with the user. The four color keys allow access links to four different pages, which can be independently set up from every page. By arranging the database structure appropriately, the broadcaster can set up multiple dialogue threads that are chosen by the user according to responses to color references in the text.

For example, a quiz can ask a question on a teletext page, with up to four multiple choice answers, such as:

> When was the Battle of Hastings? Press Red for 1492, Green for 1066, Yellow for 1914 or Blue for 1120.

If the user presses Red, this leads to a page saying:

> Incorrect. Not 1492! The battle of Hastings was fought in 1066. Press Red to continue

If the user pressed Green, however, this leads to another page saying:

> 1066 is correct, well done. The next question is.......

In this way the user can progress through the database of pages according to the responses given without any reference to page numbers. In fact, when this technique is used, page numbers incorporating at least one “hexadecimal” digit in the range A to F (e.g., page 1E2) are often used. This is to prevent these pages from being selected directly by number, as they would not make sense out of context.

Of course this approach is not genuinely interactive with the broadcaster. All possible answers are broadcast, and the transmitter has no knowledge of the threads being followed by the viewers. It just appears to be interactive to the individual viewer.

More comprehensive facilities for interactivity are specified in teletext for digital television, as described below.

OTHER TELETEXT STANDARDS FOR ANALOG TV

Most of this article so far has described the 625-line version of WST (system B in Reference 1) which evolved from the UK teletext standard, as this is the dominant teletext system in the analog television domain. Other teletext standards are outlined here briefly.

The 525-line WST standard (covered by system B in Reference 1) differs from its 625-line counterpart in its data rate because of the lower bandwidth (4.2 MHz) of 525-line channels. Each packet contains only 296 bits, transmitted at 5.727272 Mbits/s, and provides 32 bytes of data after the 5 bytes of preamble. Rather than restrict the display to 32 characters per row, the coding scheme was adapted so that some packets define the first 32 characters of a 40 character row, and others define four 8-byte groups to complete four rows.

As mentioned, the North American Closed Captioning system (15) uses a 500 kbits/s signal to deliver captioning and program information.

A variant of the 625-line WST system is broadcast in China (7). The Chinese character set consists of over 8000 symbols, and so the decoder combines the data bits from two adjacent bytes to select one character. A single Chinese character represents a whole word, and as it occupies an area equivalent to 6 Roman alphabet characters, the information content per page is comparable. It is also possible to transmit pixel information to create new symbols. Thus, the display generator requires RAM as well as 1 Mbyte of ROM for the fixed characters.

The Antiope system (system A in Reference 1) devised in France was an early competitor to WST in the 1970s. It was based on a concept of common data communication protocols that could be transmitted down a telephone line or broadcast with a TV signal. This made the decoders rather more expensive than WST, as more information processing was required—a significant cost in those days. Also, it was a variable format system, not as robust as WST in the presence of transmission errors. Although it was not successful in the broadcast environment, the telephone line protocols were used in the extensive Minitel system in France, with terminals providing access to all kinds of information. These are now superceded by standard Internet access.

Similar concepts were used in the Canadian Telidon system (system C in Reference 1) and the North American Basic Teletext System (*NABTS*) (21), but with a much more complex display protocol. These systems produce higher quality graphics than WST, but they require very significant data processing and better display circuitry. They were too expensive for the mass consumer market, but the protocols have been used for various forms of data broadcasting where the processing power is available or higher cost is acceptable. A variant of NABTS is transmitted in Korea, adapted to the Hangul writing system.

Japan has its own teletext system MOJI, adapted to the requirements of Japanese and Chinese symbols, with different data protocols to other systems. It has been developed from system D of Reference 1. It provides good quality graphics, but the decoders are expensive and the system was not successful commercially.

TELETEXT PRINCIPLES FOR DIGITAL TELEVISION

Within the last few years, digital television transmissions have started in various parts of the world, and many offer teletext services. The basic principles of teletext for digital television are the same as for analog television; however, the technical standards are completely different. This defference from the different environment of digital television and is influenced by the great advance in processing capability of decoder solutions in the 30 years since teletext for analog TV was devised.

Data transmission

Teletext data are added to the video signal, but instead of using different lines, it is time multiplexed at the packet level within the MPEG2 video transport stream, using a protocol known as DSM-CC OC (Digital Storage Media Command and Control Object Carousel) (Fig. 7).

DSM-CC OC can be thought of as a broadcast server. Teletext data consist of sets of files and directories. These are zipped up, labeled, and divided into parcels that are then sent over the unidirectional pipe in a continuously repeating carousel, which allows the receiver to reconstruct the original files and directories as it receives them.

Display Generation

Although it would be possible to use normal Internet standards such as HTML for display generation, the environment of a teletext receiver is different, and this consequently requires a different approach. The display must be readable from a significant distance as the viewer relaxes in a chair, in contrast to closer viewing of a PC screen.

No pointing device exists, merely a remote control. The screen is of a much lower resolution than a PC screen. Hence, accurate control is required for navigation between assets on the page along with pixel-accurate placement of those assets.

High-quality character rendering is now possible at low cost. A special font known as Tiresias has been developed for optimal clarity when rendering on a TV display, which is especially important for individuals with special visual needs.

In addition to alphanumeric character generation, a comprehensive range of facilities is available for all kinds of graphics and interactivity for teletext in digital television. The display standard, known as MHEG-5 (Multimedia Hypermedia Experts Group part 5), is a declarative (script) language. MHEG-5 contains various multimedia objects (or widgets) such as sliders and pushbuttons together with variables, events, timers, and token passing utilities. Effectively MHEG-5 acts in publishing multimedia applications in the way that HTML acts for publishing Web-based documents.

User Interactivity

The user has a standard remote control, similar to that provided for analog teletext TVs, which has several menu and text functions, together with “up-down-left-right,” select and four color keys, which are used in different ways to provide interaction functionality.

Normally the user will start to use teletext by pressing the text or red color key on the remote control device, which will make the teletext page visible to the viewer.

It has become commonplace in the United Kingdom for the opening page to contain a cutout showing scaled down video from the TV channel. This allows video to be watched at the same time as browsing the teletext, which is illustrated in Fig. 8.

In this example page, the column on the left allows scrolling up and down between subject areas. The page contains some text, e.g., “Press GREEN for shortcuts”, and a bitmap image (the BBCi logo). The red, green, yellow, and blue prompts at the base of the page are links that can be selected by pressing the corresponding color key on the remote control.

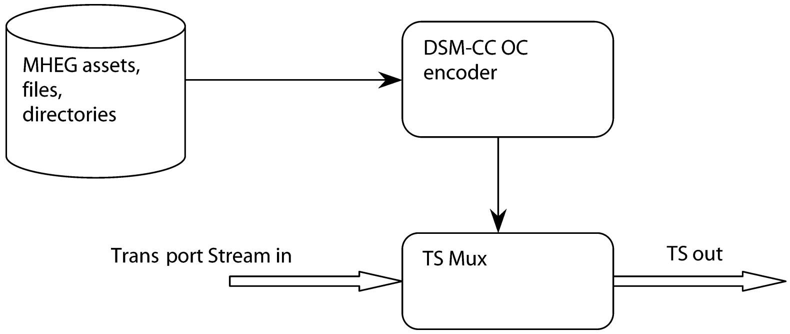


Figure 7. Insertion of digital teletext data in the transport stream using the DSM-CC object carousel.

Figure 8. Introduction Page for Digital Teletext (in practice the section shown as 'Video Plane' will contain a reduced-size version of the TV program video).

Hitting the select key while on a subject will drill down to the next level.

The user then presses the exit key to return to normal viewing.

TELETEXT SPECIFICATION FOR DIGITAL TELEVISION

Display Generation and User Interactivity

As mentioned, teletext for digital TV is based on the MHEG-5 language. The ISO 13522-5 specification (2) defines MHEG-5 or Multimedia Hypermedia Experts Group part 5. The U.K. profile (22) then fills in the gaps left by the ISO document to define implementation of digital teletext receivers in the United Kingdom. MHEG-5 is a declarative (script) language containing various multimedia objects (or widgets) such as sliders and pushbuttons together with variables, events, timers, and token passing utilities. Consequently, MHEG-5 performs a similar function to HTML in the PC/Web domain.

MHEG-5 is deliberately defined as a declarative language in order to keep the resources needed to decode it to a minimum. It consists of a predefined library of classes. Some are containers, such as a scene that contain items. The items can be visible such as a text box or a bitmap or slider; others are more functional such as a link object that is used for processing user input. The objects are defined in an MHEG-5 script, which can be authored in a text editor on a PC for instance.

The MHEG-5 decoder will load the script, from memory. It will parse the script ensuring it is syntactically correct (according to ISO 13522-5). It will then create each required object in the TV decoder's random access memory area (known as the heap). The objects will then await events such as user input, timers, or program related; at which time, they will process the events and update the display accordingly.

The following example illustrates the principles of an MHEG-5 application. The application can be observed in the screenshot below (Fig. 9).

This demonstration script consists of seven visible objects, the buttons on the left, the pictures at the top and bottom, and the picture on the right.

Each button is a link. A remote control can be used to move up and down between the links. Each time this is done, an event is created that causes the image in the large pane on the right to change.

The application consists of one MHEG-5 file called startup, a directory called weather, and five image files contained within that directory.

The source code to implement this simple example can be seen below, with annotations in the comments after the

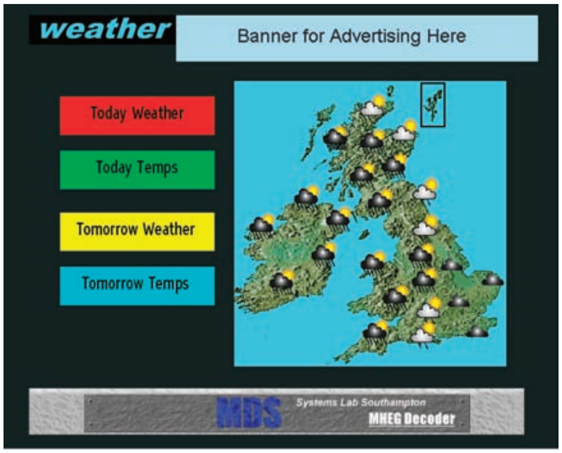


Figure 9. Example weather map page for digital teletext to illustrate the method of coding in MHEG-5.

// symbol.

```
:application ('startup' 0)
:onstartup (:transitionto (('startweatherscene' 0) ))
:textcolour "#010101"

:scene ( "startweatherscene" 0 ) // main scene container
:onstartup
(
:callactionslot (1000 2) // Highlight "Today Temp" button
)
:items // these are all the items in the scene
(
// set up whole screen background colour
:rectangle 104 // object is a rectangle with id 104
:origboxsize 720 576 :origposition 0 0
:origreflinecolour "transparent" // see video underneath
:origreffillcolour "#202828"

// navigation buttons
:pushbutton 200 // "Today Weather" pushbutton with object id 200
:origboxsize 200 50 // button is 200 by 50 pixels
:origposition 75 120 // draw at x=75, y=120
:buttonrefcolour "red" // make it red
:origlabel "Today Weather" // set button text

:pushbutton 201 // "Today Temps" pushbutton with object id
200
:origboxsize 200 50
:origposition 75 190
:buttonrefcolour "green"
:origlabel "Today Temps"

:pushbutton 202
:origboxsize 200 50
:origposition 75 270
:buttonrefcolour "yellow"
:origlabel "Tomorrow Weather"

:pushbutton 203
:origboxsize 200 50
:origposition 75 340
:buttonrefcolour "cyan"
:origlabel "Tomorrow Temps"


// add in the various images

:bitmap 320 // weather today image with object id 320
:initiallyactive true
:origcontent
:contentref (" /weather/wtoday.bmp") // the image file
:origboxsize 352 369
:origposition 300 100


:bitmap 330 // Footer banner with object id 330
:origcontent
:contentref (" /weather/Footer.bmp")
:origboxsize 640 60
:origposition 35 497


:bitmap 340 // Header banner with object id 340
:origcontent
:contentref (" /weather/header.bmp")
:origboxsize 189 38
:origposition 35 15


:bitmap 350 // Advert banner with object id 350
:origcontent
:contentref (" /weather/advert.gif")
:origboxsize 468 60
:origposition 225 15

// interactivity handling
:tokengroup 1000 //the tokengroup object defines interactivity
:movementtable // this defines movement around the page
(
// 1 2 3 4 item number in this token group
(1 1 2 3) // up key row
(2 3 4 4) // down key row
)
// Note: the matrix above defines the interactivity of the page.
// Each column refers to an action (see actionslots below) which is
// associated with a visible object. So the first column in this case
handles
// the "Today Weather" button, the second the "Today Temp" button,
and so // on.
// Each row represents a particular keypress. The first row in this
case
// being the "up" key, the second being the "down" key.
// Each matrix entry then contains a value. E.g. the first column,
second
// row contains a 2. This is the value of the item that is moved to
(i.e.
// receives the token) if the current object ( 1 ) receives the
// current action (down).
// For example, if "Today Weather" is the current object (i.e. is
// highlighted / has the token) then we are in the first column, and
if a
// down event is received (i.e. 2nd row) then the value 2 is given,
which
```

```
// means the second item ("Today Temp" button) is now highlighted
/ has the
// token.
// In reality, the action taken can be defined by the actionslots
below,
// but for the simplicity, only highlighting & un-highlighting are
described
// together with updating of the weather image.
:tokengroupitems
(
(200 :actionslots // process "Today Weather" button
(
(:sethighlightstatus ( 200 false ) ) // action 1
(:sethighlightstatus ( 200 true ) // action 2
:setdata
( 320 :NewRefContent(" /weather/wtoday.bmp") )
)
)
)
(201 :actionslots // process "Today Temp" button
(
(:sethighlightstatus ( 201 false ) )
(:sethighlightstatus ( 201 true ) :setdata ( 320 :NewRefCon-
tent(" /weather/ttoday.bmp"))
)
)
)
(202 :actionslots // process "Tomorrow Weather" button
(
(:sethighlightstatus ( 202 false ) )
(:sethighlightstatus ( 202 true ) :setdata ( 320
:NewRefContent(" /weather/wtom.bmp"))
)
)
)
(203 :actionslots // process "Tomorrow Temp" button
(
(:sethighlightstatus ( 203 false ) )
(:sethighlightstatus ( 203 true ) :setdata ( 320
:NewRefContent(" /weather/ttom.bmp"))
)
)
)
)
:notokenactionslots ( NULL NULL NULL)
// end of interactivity handling
// user input event handling
// up button handling

:link 80
:eventsource 0 // 0 specifies events from remote control
:eventtype userinput
:eventdata 1 // key code for "up"
:linkeffect
( :callactionslot (1000 1) // call slot 1 for
// tokengroup 1000 (un-highlight)
:move (1000 1) // send event 1 (row 1)
:callactionslot (1000 2) // call slot 2 for
// tokengroup 1000 (highlight)
// and change weather image
)

//down button handling

:link 90
:eventsource 0 :eventtype userinput
:eventdata 2 // key code for "down"
:linkeffect
( :callactionslot (1000 1)
:move (1000 2) // send event 2 (row 2)
:callactionslot (1000 2)
)

//select button handling
:link 91
:eventsource 0 :eventtype userinput
:eventdata 15 // keycode for "select" or "OK"
:linkeffect
( :callactionslot (1000 1))

)
:inputeventreg 2
:scenecs 720 576
```

The above example only uses some of the available keys. The DTG UK MHEG profile (22) specifies several groups of keys that must be present on the remote control. Of most importance to the teletext function are the cancel, text, red, green, yellow, and blue keys. These keys always available for exclusive use by the MHEG-5 decoder. The numerical keys (0 to 9) and navigation keys (up, down, left, right, select) are only available for teletext once the teletext mode has been entered.

Data Transmission

Digital Storage Media Command and Control, Object Carousel (DSM-CC OC) is the protocol used to broadcast the teletext data. This protocol is defined in ISO13818-6 (4).

Figure 10 illustrates the concepts of navigating an MPEG2 transport stream. The complete transport stream is represented as the largest (broadcast) pipe entering from the left. The transport stream consists of a sequence of packets of 188 bytes in length. Each 188 byte packet is labeled with a packet identifier, or PID. The packets with PID=0 contain the PAT (Program Allocation Table). The PAT signals where the services can be found in the transport stream multiplex. Each channel would be a service, e.g., Sky 1 or CNN or BBC 2.

Each service (and there are often six or seven in one multiplex) has a PMT (Program Map Table), which then further signals the PID values that carry audio, video, and teletext associated with that particular service.

The PMT will then carry a set of descriptors, one of which is called the databroadcast_id_descriptor. This descriptor carries the PID value for the stream carrying the DSM-CC Object Carousel starting point, which This is known as the DSI or Download Service Initiation table.

The DSI can then signal the location of one or more group identifiers, each of which has its own DII table (Download Info Indication). Each group contains a set of modules, and each module forms a part of a zip file. The modules are broadcast in a carousel. The receiver assembles the zip file from successively received download data blocks (DDBs). The zip file is then decompressed recovering the original files and directories of teletext data.

Figure 11 shows the structure, with the PMT Program Map Table linking to the DSI Download Service Initiation tables, which in turn refer to the relevant DII and DDB data blocks.

The data are repeated at intervals of typically 45 seconds, so that if the receiver misses a data block, it has to wait a maximum of 45 seconds for it to be re-broadcast in the carousel.

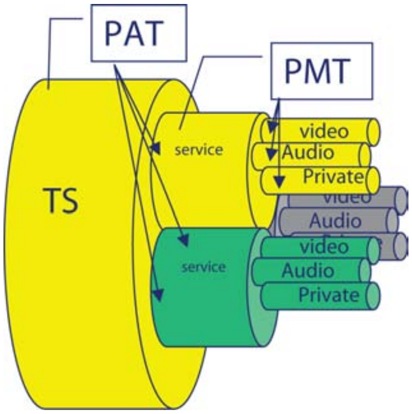


Figure 10. An MPEG2 transport stream (TS) showing the various components.

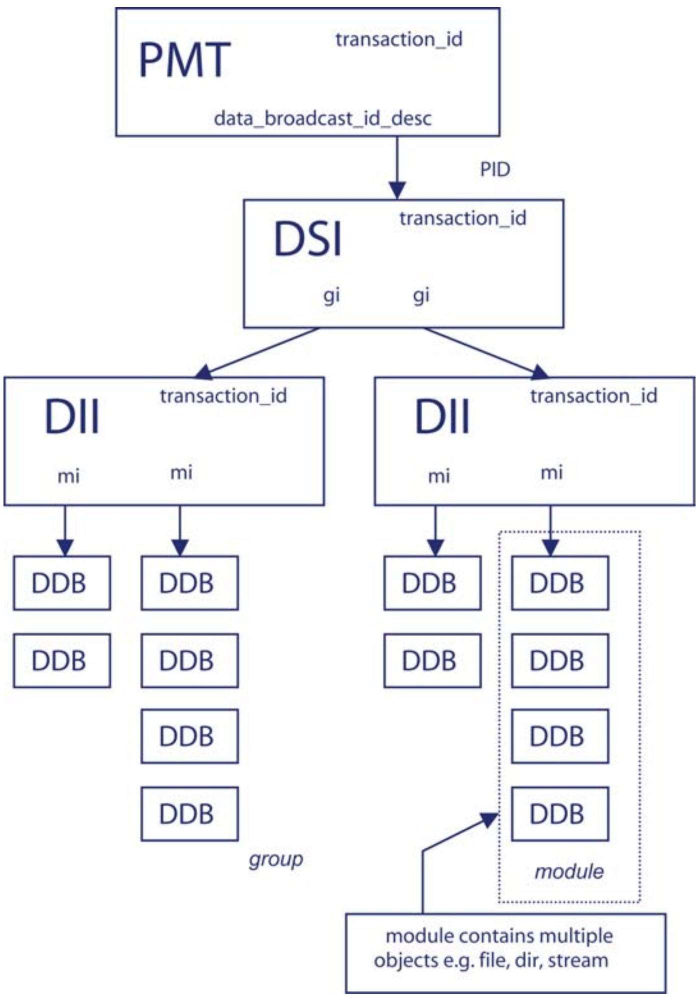


Figure 11. Structure of the data blocks carrying information to create a teletext page.

TELETEXT DECODERS FOR DIGITAL TELEVISION

A typical MHEG-5 decoder architecture is shown in Fig. 12.

The DSM-CC section acquires the teletext data from the broadcast stream. The MHEG-5 engine reads the data and decodes it, rendering the display to the screen using the on-board graphics libraries. The TV will normally run on a real-time operating system that gives access to the underlying hardware via a collection of drivers.

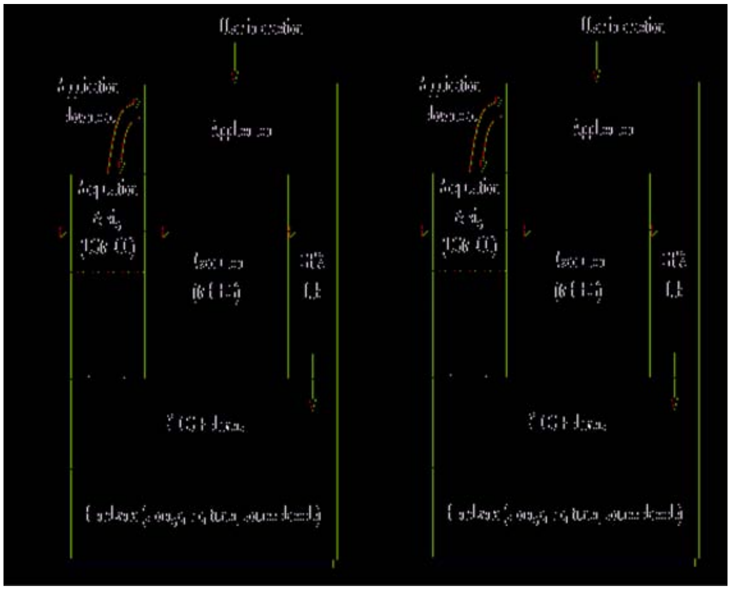


Figure 12. Architecture of a digital teletext decoder using DSM-CC and MHEG-5.

Figure 13. Example EPG for digital TV.

ADDITIONAL FEATURES AND SERVICES IN DIGITAL TV SYSTEMS

Subtitles

The European DVB (Digital Video Broadcasting) standard supports two styles of subtitling—character-based and bit-mapped. The character-based approach is simply the analog teletext method used in the digital domain as described below.

The bit-mapped approach (23) was developed specifically for use in DVB services and provides the broadcaster with many more presentation, alphabet, and language options. For example, analog teletext subtitles are always displayed within a box and restricted to the languages supported by the characters included in the ROM in the character generator. The DVB method allows transparent backgrounds behind the foreground text, and as the bit-maps are always downloaded, the display of any character from any alphabet or any symbol, e.g., , might precede the text to indicate that an actor is singing.

A DVB subtitle service provides a sequence of pages that are overlaid on the video image. A page is defined as containing one or more regions. Each region is a rectangular area with a set of attributes such as horizontal and vertical size, pixel depth, and background color. A region is used as the background structure into which graphical objects are placed. The use and positioning of objects within a region is defined separately for each region. Objects that occur more than once need only be transmitted once and then positioned multiple times. This approach provides full editorial freedom regarding the appearance and removal of objects and their position on the screen.

A graphical object may represent a character a word, a logo or icon, a line of text, or an entire sentence. Pixel data within objects are compressed using run-length coding. To ensure efficient use of the memory in the decoder, indexed pixel colors are defined for each region. Pixel depths of 2, 4, and 8 bits are supported, which allows up to 4, 16, or 256 different pixel codes to be used in each region. Each region

Figure 14. Example teletext pages in digital TV.

Figure 15. Example teletext pages in digital TV.

Figure 16. Example teletext pages in digital TV.

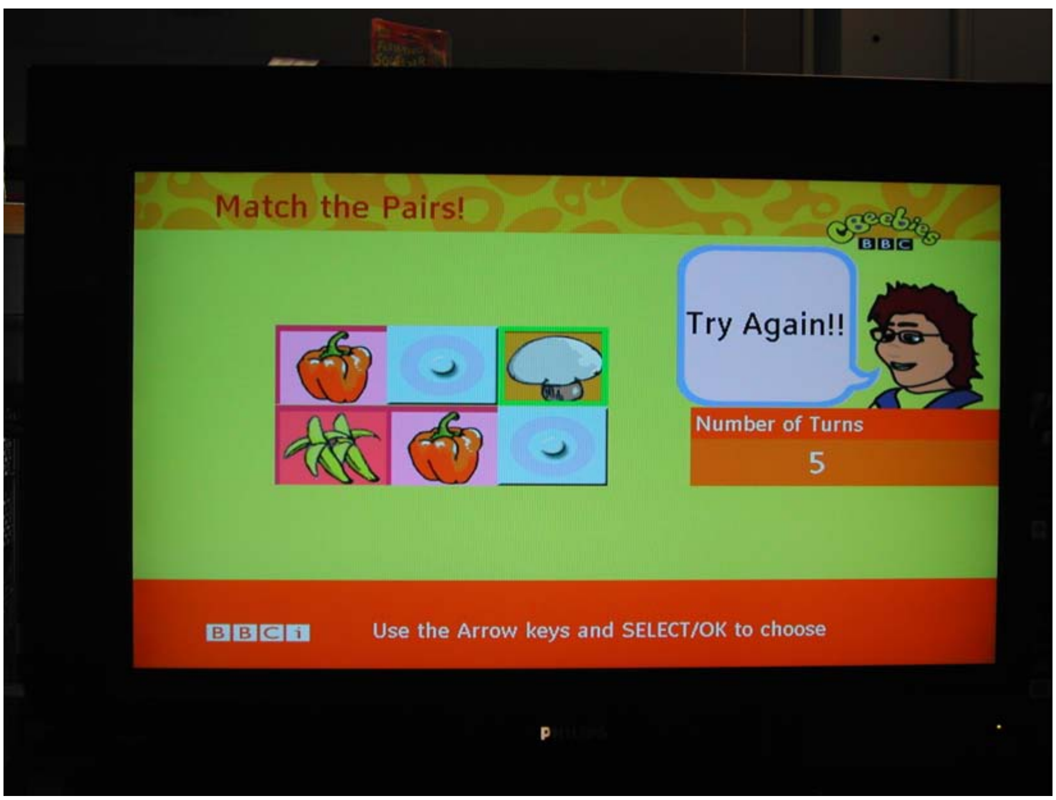


Figure 17. Example teletext pages in digital TV.

Figure 18. Example teletext pages in digital TV.

is associated with a single Color Look-Up Table (*CLUT*) to define the color and transparency for each pixel code. In most cases, one CLUT is sufficient to present correctly the colors of all objects in a region.

Subtitle streams intended for HDTV may include an optional data structure that explicitly defines the display size for which that stream has been created.

A DVB subtitle stream is carried in Program Elementary Stream (*PES*) packets, and the timing of their presentation is defined by the Presentation Time Stamp (*PTS*) in the PES header.

Separate specifications exist for DVD subtitling in Europe (23) and for Advanced Television (*ATV*) closed captioning in the United States (24).

Carrying "Analog" Teletext in Digital Television

If desired, a broadcaster may choose to convey WST "analog" teletext packets via DVB bitstreams (25). This process is intended for situations where a conventional analog TV receiver is connected to a digital set top box with minimal control and processing facilities, which can be done instead of, or in addition to, a full "digital" teletext service. All conventional "analog" teletext facilities are available, including subtitles.

Electronic Program Guides

Electronic Program Guide (EPG) data are also carried in the MPEG2 transport stream. An example EPG is shown in Fig. 13. It has a scrollable table of the available channels in the vertical direction. The table on the right can also scroll in a horizontal direction to view the future program schedule.

The EPG data are carried in the Program Specific Information (PSI) part of the MPEG2 transport stream, inside the EIT (Event Information Table). which is specified in References (26) and (27) with additional guidelines in Reference 28. The D-Book (29) defines the type and length of the fields that are used in the current EPG. For instance, the "Service Name" field in the EPG figure above is "BBC ONE" for the first entry.

EPGs typically carry schedule information for the next 7 to 14 days. They are of most use in personal video-recording devices, which allow a much simpler means of setting up a recording.

DIGITAL TELETEXT EVOLUTION

After the MHEG-5 standard was defined, efforts were made to extend it by adding "plug-ins" to the MHEG-5 scripts. Java emerged as the plug-in language of choice. Eventually the MHEG-5 framework was dropped in place of a fully-Java based solution known as Multimedia Home Platform or DVB-MHP. This is published as ETSI standard ETSI TS 101 812 (30). It facilitates greater features than MHEG-5 with the ability to host multiple applications and even games in the digital TV platform.

Recently the Globally Executable MHP (GEM) standard (3) has been adopted that forms a common base point for all major international non-proprietary interactive TV standards, ARIB, OCAP, ACAP, and MHP.

The advent of receivers with built-in hard disk drives, known as personal video recorders (PVRs), has necessitated another extension to MHP. This extension standardizes how the teletext is stored and retrieved alongside time-shifted audio/video content.

The widespread adoption of the MHP standards in public teletext services is still in its infancy; however, no doubt they will assume increasing importance in future years.

TELETEXT MARKET DEVELOPMENT

At the same time there has been a steady geographical expansion of teletext services. Almost all European countries have teletext services, and there is significant activity in the Middle East and Australasia. Worldwide, teletext is broadcast from some 50 countries.

With the start of digital television services in Europe, TVs and set top boxes equipped with digital teletext decoding are now being produced in quantity. So far over 30 million have been made, mostly using the MHEG-5 standard.

An established market provides significant opportunities for profitable advertising on teletext. For example, by 1990, over 10% of the U.K. population was accessing a commercial teletext service daily, exceeding the circulation of any national newspaper. It is a particularly useful medium for volatile products such as booking last-minute discount holidays, and it still has a significant market share in such areas despite the rise of the Internet as an information source.

Examples of typical teletext pages in the digital TV environment are shown in Figs. 14–18.

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