P. J. Watkins, B.Sc. (Hons.)

Microprocessor control for Arion

Summary

The main signal processing and control elements of the Marconi Arion shipborne satellite terminal have been implemented by the use of a microprocessor.

The process of performing functions in software that were traditionally carried out by purpose-built hardware gives a terminal design that is inherently flexible, and which can be readily modified to take account of system evolution or to achieve compatibility between differing systems. It is expected to be suitable for future satellite systems including INMARSAT.

The placing of system specific functions in software also permits the use of standardized boards giving reduced production costs.

Introduction

Arion, the ship terminal for satellite communication, is typical of the increasing sophistication found in modern communication systems, where a simple user interface masks a complex system engineering.

When the development of a ship terminal was first considered it was felt that the control and access functions would be implemented in conventional hard-wired logic. It soon became apparent, however, that the specification was still evolving and that there was also the aspect of being able to work to undefined future satellite systems. Some kind of flexible approach was obviously required.

With the advent of the 8080 and 6800 microprocessors it was felt that microprocessors were now sufficiently powerful to be useful in communications products and a range of standard boards was produced.

It was decided that the 8080 would have sufficient processing capability to accept data from the radio equipment with minimal conditioning and it would be possible to carry out all the digital processing in software.

To indicate the type of functions that can be performed in software the functional aspects of the MARISAT control system will be described followed by the way in which they were implemented.

The MARISAT control system

Overall control of the MARISAT system is vested in the shore station. A ship may only take or make a call once it has made the correct responses to the station and then only on a channel selected by the shore station.

In the forward (shore-ship) direction the shore station transmits a continuous 1200bit/s carrier, time divided into a 0.29 second frame. Six frames combine to make a 1.74 second multiframe. The start of each frame is indicated by a unique word, every sixth word being complemented to locate the start of the multiframe. Following the unique word is a terminal address field which may contain a unique terminal address or one of a number of selective or general broadcast addresses. The address field is succeeded by assignment and control information used to establish and clear a channel. The complete address and data fields are protected by a (63, 57) BCH error detecting code. The remainder of the frame contains twenty-two telegraph channels, each channel consisting of two 6 bit characters representing CCITT No. 2 alphabet characters or signalling characters.

In the return direction two types of transmission are provided for, both at the same 4,800 bit rate. One channel is reserved for random access request data bursts, others being allocated for time divided telegraph bursts. The request transmissions from the ship is also protected by a (63, 39) BCH code.

In normal operation the terminal has first to acquire the satellite and lock onto the forward carrier. Once a steady pattern of unique words is detected the terminal can begin the continuous decode of the assignment channel to ascertain if it is being addressed. It is also then in a position to request a channel if required.

Figure 1 gives a diagrammatic representation of the functional blocks required to implement the control and access equipment of a MARISAT terminal. Detectors search for the unique and complimentary unique words. Once one is found the following assignment and telegraph data can be demultiplexed.

The assignment data is error checked and if satisfactory is processed by the channel controller. This checks to see if the terminal is being addressed and if the following data is consistent with the current state of the terminal. If the checks pass, then the channel controller will take the appropriate action. This may involve tuning the terminal to receive a new call, enabling the appropriate modems and displaying the new status.

The telegraph channel demultiplexer selects one channel as specified by the channel controller and extracts the characters. Signalling characters are sent to the channel controller and printing characters to the teleprinter interface for subsequent transmission to the teleprinter.

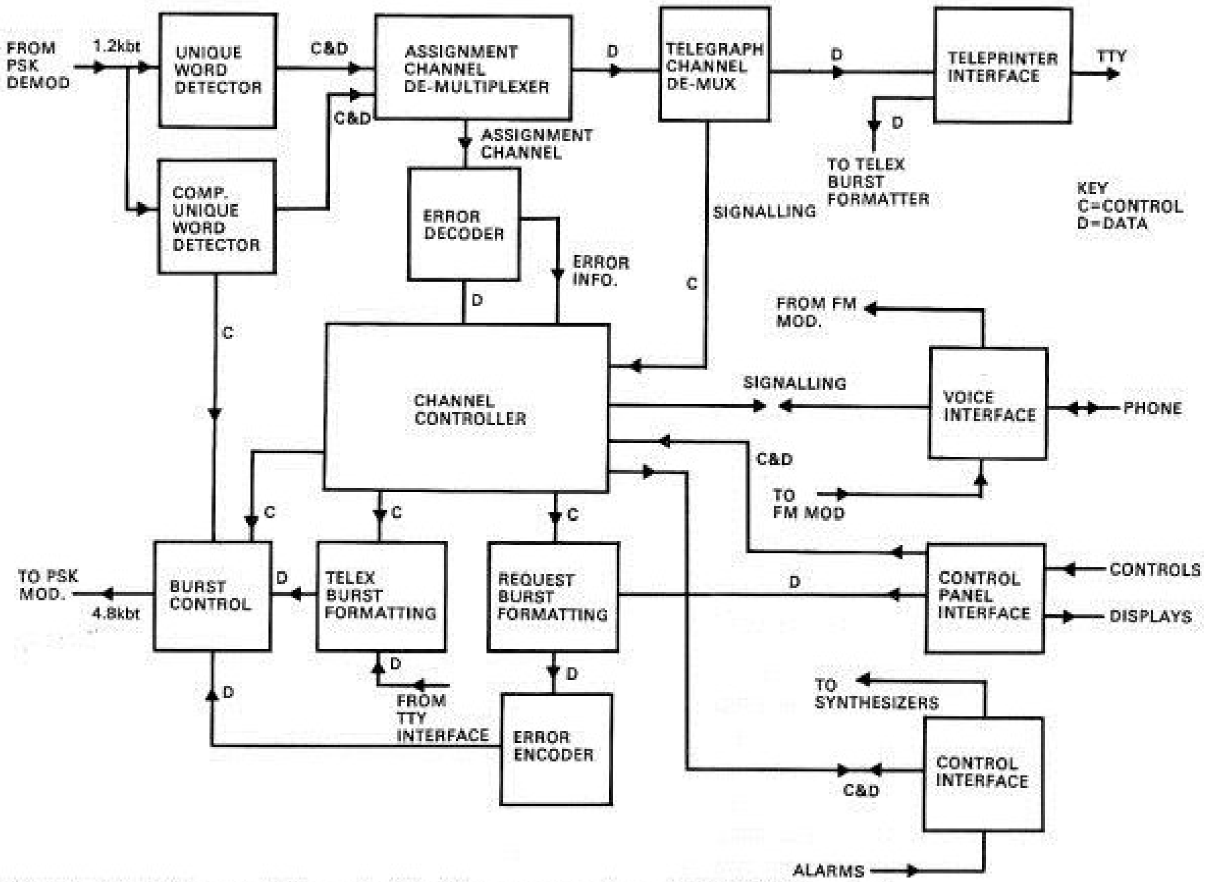

Figure 1. Block diagram of the control functions necessary for a MARISAT terminal

Data for transmission in the return direction is formatted according to type. Request data is extracted from the control panel and must be error encoded before transmission. Telegraph data is sent from the teleprinter interface, with signalling characters being inserted by the channel controller. The burst controller decides the transmission time of the burst, using information supplied by the channel controller. For the timing of telegraph bursts the start time for the multiframe is also required and is supplied by the complementary unique word detector.

The channel controller also has inputs from other interfaces. The voice interface monitors and inserts the in-band voice signalling and registers the handset on/off hook and ringing states.

The control panel interface provides the request burst data, telegraph clearing control and status displays.

The control interface is the means by which the channel controller monitors and sets the communications equipment.

Microprocessor implementation

In any microprocessor system there will be a number of interfaces between the processor and the outside world. The establishment of this hardware/software interface is one of the first design considerations and will have a major impact of the final equipment, cost and versatility. Performing too many functions in hardware will lead to reduced flexibility and greater product cost, conversely expecting the software to carry out an excessive number of tasks can give inadequate performance and result in over complex programs which are expensive to produce and difficult to maintain.

The chosen microprocessor works on 8 bit parallel data and it is usually convenient to present information to it in this form. Data is received serially from both the radio equipment and the teleprinter and, while it is possible to detect serial elements in software by sampling techniques, this usually results in an unacceptable overhead. A standard board therefore provides the necessary serial to parallel conversion for the teleprinter and a special serial interface was developed for connections to the phase shift keying (p.s.k) demodulator.

In the forward direction the arrival of each individual bit from the p.s.k demodulator is detected by the serial interface and causes an interrupt to be raised to the processor. The bit is staticized and may be read by the processor at any time up to the arrival of the next bit when it will be overwritten. This represents an interrupt rate of 0.833ms.

For transmission of request and telegraph data in the return direction a processor controllable, parallel to serial converter (serializer), is provided. This permits

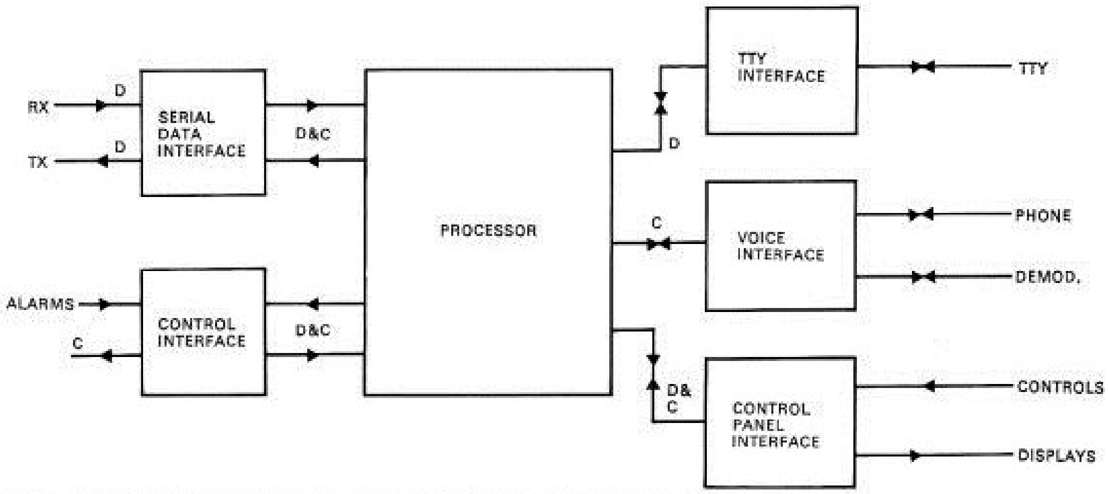

Figure 2. Simplification of Figure 1 achieved by the use of the microprocessor

the transmission of variable length bytes and eases the software task of packing up the data prior to sending. An interrupt is only raised when the complete byte has been sent, thus reducing the processor workload.

A parallel read/write interface connects the processor to the operator's control panel and provides for the illumination of displays, the sensing of switches, sounding of bells, etc. These inputs and outputs are standardized, thus the meanings attached to them are only dependent on the software.

An additional, essentially parallel, interface provides the control drives to the frequency synthesizers and the selection of the various modems and companders.

Only one simple analog interface is required. This provides for the detection and generation of the voice supervisory tones and provides the detectors required for transmitter power monitoring. Independent of the processor, it also generates the various ringing and warning tones used on voice calls.

Application of software techniques enables the block diagram of functions as shown in figure 1 to be reduced to that shown in figure 2.

Software

The program performs two basic types of function. One is the hardwared logic simulation where the software carries out such routine functions as unique word detection, BCH encoding and decoding, event timing, teleprinter input/output, etc. The other type of function is that of decision making where the program has to decide from both hardware and software status indications whether certain terminal or operator actions are valid and what is the correct alternative in a particular choice of actions.

The software executes in basic synchronism with the data being received from the assignment channel and performs the same cycle starting with the unique word and finishing with the last telegraph channel. This avoids decisions in the program as to what action is required whenever a change of state occurs.

The processor reads in the data from the forward channel one bit at a time. This is necessary to give the required counting accuracy for timing the transmitted telegraph bursts in the return direction.

The terminal can be in one of two basic modes, in or out of synchronism. The in-sync condition is the normal operating mode, loss of synchronism only occurring during loss of carrier or returning. According to the mode, the software will either search for the unique or complementary unique word or confirm its presence at the expected point in the frame. Once the presence of the unique word is established, the remainder of the assignment data is entered and processed. The BCH coding is checked by the software at this point.

The address field is compared with the internally preset address and with the various broadcast addresses. If a match is found, the message type is checked against the current terminal software status, and any inconsistent type rejected. The message type 'Unconditional Release' will reset the terminal regardless of its status.

Following the detection of a valid message type, the channel type is processed. In the case of, say, a voice call the processor will place the terminal in the correct mode for the initial reception of the call. The voice synthesizer settings will be computed from the channel number data, the transmitter and s.f tone detector enabled and the appropriate status displayed on the control panel.

If a duplex or shore-to-ship simplex telegraph call is set, the processor will count in the characters of the twenty-two telex channels and save the two characters of the selected channel. Non-signalling characters are placed in a software buffer. An independent routine will service this buffer to output the characters to the teleprinter. Signalling conditions are persistance checked by counting the signalling characters. When sufficient of the same type have been received to indicate a change of state, the software call status will be used to determine the necessary action.

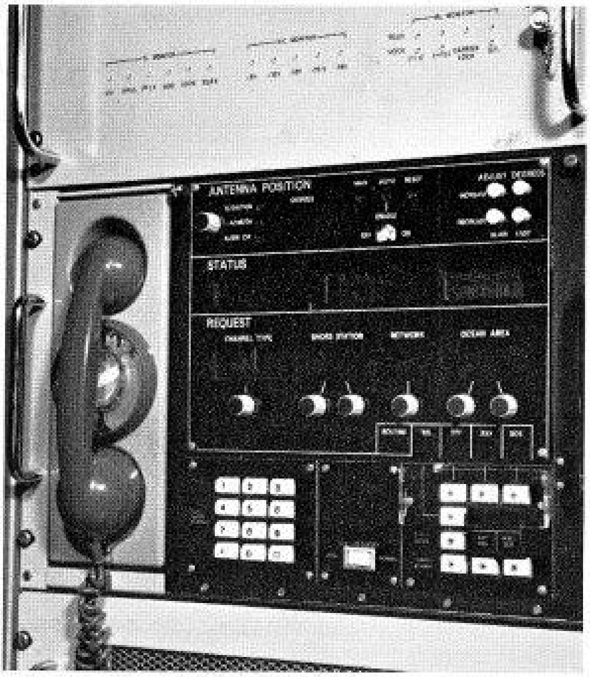

Figure 3. Control panel of the ARION below-decks equipment

Characters received from the terminals teleprinter are placed in a twelve character software buffer. When the interrupt routine detects that the output bit count has been reached, the buffer is frozen and the first byte is written to the output serializer. The buffer will then be emptied byte by byte in response to interrupts from the serializer. The teleprinter works in full duplex mode, local reflection being provided by the processor. This enables the terminal to break into 'off-line' work when a new telegraph call is received and to inhibit reflection when telegraph character transmission is not possible.

The terminal is required to time the period between request message transmissions and to time the duration of the transmission of the supervisory tone, at the end of a voice call. The processor obtains a sense of time by counting the 0.29 second frames. The specified tolerance on the above times is such that this technique is suitable without recourse to external timing hardware.

The state of certain hardware items (*e.g.* handset on/off condition, supervisory tone detector, various alarm conditions) is brought to an interface board where they are regularly scanned and acted upon by the processor. If the processor finds the action request bit set, indicating that the terminal operator requires a request burst transmission, the control panel switch settings are read and checked against the current software status. If the request data is consistent and no request inhibit time-out is running, the control panel settings are reformatted into a software buffer. BCH encoding is performed by a separate software routine. The transmitter is tuned to the request frequency and transmission of the data is performed in a similar manner to the telegraph burst.

The radio unit serial interface is the only interrupting peripheral. The rest of the devices are serviced by a 'software scan' process when the processor is idle. This has the advantage that a device can be ignored at a particular point in a program sequence if data from it would be invalid or confusing.

Fault finding

One of the advantages of a software controlled terminal is the ease by which the basic functions can be modified to assist fault diagnosis. As well as a set of basic test routines contained within the main programs it is also possible to load additional test programs via the reader on the terminal's teleprinter. The tests start with a minimum amount of hardware involving just the processor, the control panel and its interface. Once this combination has been established as functioning, the tests may be widened to include other interfaces.

Software development

In addition to the production of standard hardware, a number of software development tools have been produced. These include editors, a CORAL compiler, loaders, simulators and online testing aids.

To assist the final testing of the program in the absence of a satellite, a shore station simulator was built. This was constructed from a number of standard microprocessor boards and a special purpose serial interface. The unit is controlled from a teleprinter and generates the assignment channel data, any field of which can be altered by teleprinter command. It will also search for transmissions from the ship terminal and display any data received. As well as being a development aid it also serves as production test equipment for the complete channel assignment unit.

Conclusion

Providing that sufficient expertise is available or can be acquired, considerable advantages can result from the use of a microprocessor in equipment of this type. The use of standard boards across a range of products has obvious advantages, and development times will in general be reduced. Functional modifications can be easily introduced both during production and in the field. Production testing is eased as software functions do not require proving, it being sufficient to show that the program board has been correctly loaded.

The above is an account of the design philosophy adopted in the development of the Marconi 'Arion' Ship Terminal for operation into the MARISAT system.

Acknowledgement

The author wishes to thank the Engineering Director of Marconi Communication Systems Limited for permission to publish this article.