512 ACE – a 512 2Mbit/s port automatic cross-connection equipment

D.J. Binnington

Summary The 512 2Mbit/s port, automatic cross-connection equipment (512 ACE) is currently being developed to complement the successful Marconi U4200 series of 128 2Mbit/s port ACEs already installed by British Telecom in the UK and by other major telecommunication authorities around the world.

The ACE equipment replaces existing hard-wired digital distribution frames (DDF) and their associated multiplex equipment at cross-connect sites, and is a major enchancement to private-circuit digital networks. Together with their associated remote control equipment (RCE), the ACEs provide a radical improvement in circuit provisioning and maintenance.

The 512 ACE is a further major enhancement which can be used in situations where the capacity of a single 128-port ACE is insufficient to meet the immediate or future demand for circuits. It is also a more practical and cost-effective means of providing extra capacity than the alternative way of using co-sited and interconnected 128-port ACEs. This also results in minimum demands for accommodation and power.

This article discusses some of the design considerations which arose during the development, and details the implementation of the 512 ACE as the Marconi U4203 series equipment. An introduction is also given to some of the existing and future enhancements to be made available, which may be added as sub-equipments to the basic 512 ACE.

Introduction

Within the last few years there has been a rapid increase in the use of private-circuit digital networks by customers of British Telecom and other major telecommunication authorities around the world. The progressive introduction of British Telecom's KiloStream service in the UK, and the later inclusion of the automatic cross-connection equipment (ACE), have previously been described.[1, 2, 3] The steady increase in the volume of traffic has highlighted the need for larger ACE-type switching equipments and spurred the development of a number of sub-equipments to further enhance the basic facilities.

Switches with a capacity greater than 128 2Mbit/s ports have already been constructed for British Telecom by interconnecting a number of co-located 128-port ACEs together. However, the interconnections between each of the ACEs reduces the total potential traffic capacity and results in the switch being inherently blocking for some connections. In order to reduce the blocking effect without significantly reducing the capacity, the number of interconnections required between ACEs needs to be carefully minimized. This does mean, however, that some of the flexibility of ACE is lost and may also result in difficulties as the network grows, since the interconnections can only be realistically minimized during the system planning stage.

The demand for single ACE equipments with a capacity larger than 128 ports has existed for some time but, until recently, the development of larger switches in a single equipment could not be justified. Studies have now shown, however, that with the current state of semiconductor switch technology, an ACE can be produced that will be large enough for the majority of users and yet still be competitive in the relatively low numbers required.

The optimum size of the switch depends on a number of factors, but market research has shown that switches of up to 512 ports will be of most benefit to the majority of users. Marconi has, therefore, concentrated on the development of a 512 2Mbit/s port ACE by extending its 128-port ACE technology and using as many common parts as possible. The following paragraphs discuss some of the technical design considerations made during the current development and then go on to describe the eventual implementation of the 512 2Mbit/s port ACE as the Marconi U4203 series of equipment.

D. J. Binnington

David Binnington joined Line Division of the Marconi Company at Writtle in 1972. He initially worked on 24-channel PCM equipment and was later involved in the development of several projects including 30-channel PCM, Supergroup Codec, Hypergroup Codec and R111 Multiplexer. In 1980 he was involved in the development of the equipment for British Telecom's KiloStream service and then in 1983 was engaged in the study and resulting development of the 128-port ACE. In 1984 he was appointed senior development engineer and is currently the project leader responsible for the development of the 512-port ACE.

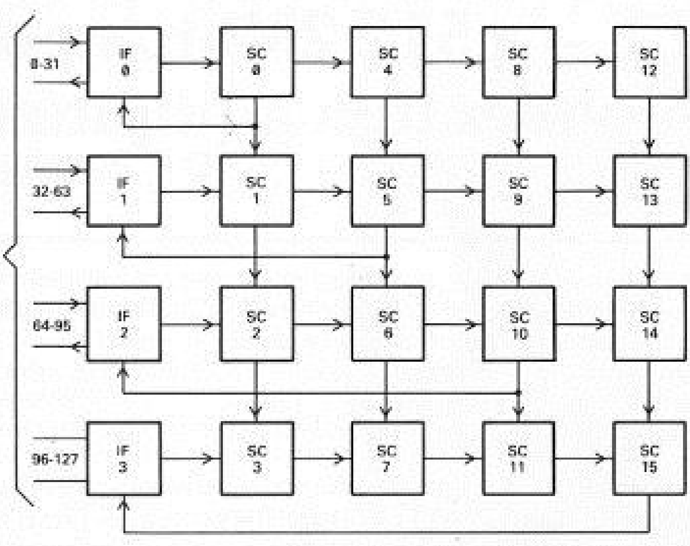

Fig. 1. 128-port, non-blocking switch plane

Overview of the 128-port ACE switch array

In order to appreciate the design considerations required in the development of the 512 ACE, it is necessary to give a brief overview of the current 128 ACE equipment.

The most obvious difference between the 128 ACE and the 512 ACE, apart from the number of ports, is the size and type of switch array required, and it is this that will be discussed since it is central to the development of the 512 ACE.

The 128-port ACE switch array is shown in the simplified schematic diagram of figure 1. This is constructed as a single-stage, square array, using a total of 16 switch cards. Each switch card is a 32 × 32 port array and contains 16 space and time, cross-point switches, known as digital switch modules (DSM), built into a 4 × 4 array. Each DSM is a single VLSI-circuit, 8×8-port, unilateral switch which has the capability to switch any input port and timeslot to any output port and timeslot. If the timeslot switching aspect is ignored for now, and the DSM is treated as a simple space switch array, then each one contains the equivalent of 64 cross-points.

The total number of cross-points required in the 128 ACE is simply the number of input ports, N, multiplied by the number of output ports, M. In this case, the array is square with N = M, therefore N^2, gives a total of 16384 cross-points or 256 DSMs for the 128 ports. This number of cross-points is larger than would be absolutely necessary just to provide the switching function, but it is not unreasonable since it meets all the basic requirements and is strictly non-blocking for a number of circuit configurations. These include point-to-point, point-to-multipoint and wideband, multi-timeslot (N×64kbit/s) circuits, with bit sequence and timeslot integrity being maintained for the latter. This type of square switch array has a number of advantages, including a simple control system and an expansion capability from 32 ports in 32 port steps, up to the maximum of 128 ports, in a relatively simple manner.

The basic rule for expansion is that a square array must always be maintained for all sizes of the switch. This is ensured by adding switch cards, to produce square arrays of 1, 4, 9 or 16 cards, as required, with one switch interface card being added at each of these size steps.

512 ACE using a single-stage switch

It would appear that a switch for 512-port ACE could be achieved by simply increasing the size of the 128-port switch array. However, one major problem with the single stage, single switch design is that it quickly becomes uneconomic as the number of ports required is increased. For a 256-port switch array, 65536 cross-points or 1024 DSMs would be required and for 512 ports, some 262144 cross-points or 4096 DSMs would be necessary. Apart from the high cost and the semiconductor switch technology currently available, just interconnecting this number of DSMs would be a problem, since this would involve some 256 switch cards of the present ACE type for each switch array.

For a given size of switch, the cost per port is an important factor and so, for a large single-stage switch, the cost of the cross-points required is prohibitive compared to the cost of the common equipment necessary to control it. This cost tends to remain fairly static as the switch size is increased and therefore the number of cross-points used in any design needs to be minimized.

Multi-stage switching

The solution to the single-stage switch problem is to use a multi-stage switch plane consisting of a number of smaller switch arrays interconnected in such a way as to provide the same switching function as the simple single-stage switch, but with a lower number of cross-points. Unfortunately, a small penalty must be paid for this method, in that the control system is more complex, both in software and hardware, although the advantages considerably outweigh the disadvantages.

Multi-stage switches have been extensively studied for many years and the general principles are well known, but unfortunately there is no single optimum solution for a particular switch size or configuration. In considering the design for the 512 ACE switch plane, a number of factors had to be taken into account, not least that the switch plane should be strictly non-blocking for 64kbit/s point-to-point connections and that the interface to the line shelves should be the same or similar to that of the 128-port switch, thereby allowing some common parts to be used.

Designs using three and five stages were considered, but the design chosen is shown in figure 2.

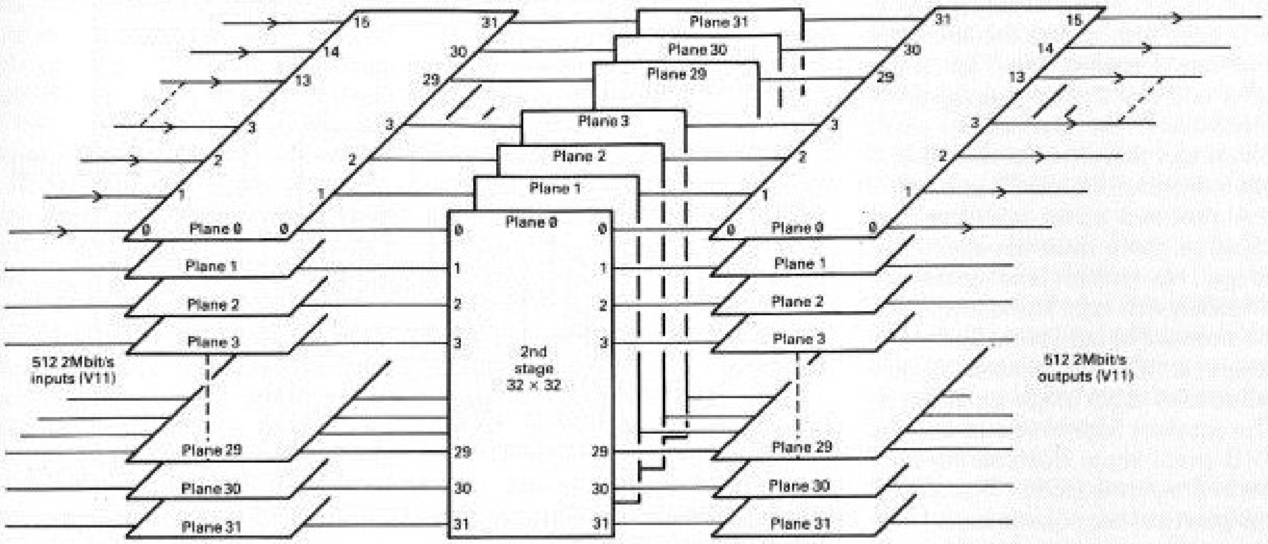

Fig. 2. 512-port, 3-stage non-blocking switch plane.

This is based on the strictly non-blocking principles of Clos[4] and consists of a symmetrical structure of three stages each consisting of a number of smaller switch arrays.

The two outer stages are essentially space switches which are reconfigured for every timeslot, i.e, in both stages each input timeslot can be switched individually to any free output port, but without a displacement in time. The inner stage is a conventional time-and-space switch.

Number of cross-points required

Ignoring the timeslot switching aspect for now, the minimum total number of cross-points, C(3), required to produce the switch plane can be determined by the general formula:

$$C(3) = (n+m-1)(N+M+NM/nm)$$

where n=the number of inputs per input stage array, m=the number of outputs per output stage array and N and M are the total number of inputs and outputs of the switch plane respectively.

In this case where N=M and n=m this gives:

$$C(3)=(2n-1)(2N+N^2/n^2)$$

From this we find that C(3) is at a minimum when n is approximately 15.5. Then taking the nearest integer, each 1st stage array must have 16 inputs and each 3rd stage array must have 16 outputs. Each of the outer stage arrays must additionally have one link with each of the 2nd stage arrays.

Number of 2nd stage arrays

The number of 2nd stage arrays, k, must be sufficient to avoid blocking under the worst case traffic conditions. If we assume that the switch is almost fully occupied such that only one more connection can be made between the outer stages, then the worst case occurs when $n-1$ 2nd stage arrays are busy with links to the 1st stage and $m-1$ 2nd stage arrays are busy with links to the 3rd stage. If the switch is to be non-blocking then the final connection between the 1st and 3rd stages can be made only if an additional 2nd stage array is available. The minimum number of 2nd stage arrays, k, required to avoid blocking, is therefore $(n-1)+(m-1)+1$ or $n+m-1$. In this case where n and m are both 16, the minimum number of 2nd stage arrays is 31.

From a practical point of view it is far more convenient to use a figure of 32 to maintain the symmetry of the switch. This rounding up results in a larger number of cross-points than would strictly be necessary, 65536 compared to 63488, but the extra array does provide some redundancy. This additional, normally redundant capacity, can be of use for instance where multi-point or N×64k circuits are required and contiguous timeslots have to be maintained.

Total number of switches

For 512-port ACE we therefore require 32 16×32 switches for the 1st stage, 32 32×32 switches for the 2nd stage and 32 32×16 switches for the 3rd stage. When considering timeslot switching in this arrangement, it is sufficient to carry this out only in the centre stage, indeed this is an essential requirement to minimize the circuit delay and for the simple handling of N×64kbit/s circuits. This suggests that the outer stages could be implemented using dedicated space switching arrays. However, in the interests of reducing development costs and maintaining a common control strategy, all switch arrays will be constructed using the DSM as the basic building block. The whole switch plane shown in figure 2 requires a total of 1024 8×8 DSMs.

Expansion

The whole switch plane must be capable of expansion from a sensible minimum to the full 512 ports in a similar manner to the current 128 ACE. The outer stages do not present a problem since the individual array sizes of 16 inputs and 16 outputs conveniently match the number of ports served by a current ACE line shelf. This allows the line shelf interface circuitry, one 1st stage array and one 3rd stage array to be constructed on the same card, which can therefore be fitted on a one-card-per-line shelf basis.

A problem arises with the 2nd stage, as there must always be 32 arrays, no matter how small the overall switch size. The size and not the number of individual 2nd stage arrays is directly related to the number of outer stage cards fitted. The smallest logical size of array is 8×8 ports since this can be performed by one DSM. This size is not practical because at least 16 of these devices can be fitted onto a single card.

The answer is to use 16×16 arrays, comprised of four DSMs each, and to put four of these arrays on one card. A total of eight cards is then required to provide the 32 arrays. This gives the minimum practical size of the 2nd stage switch as 16×16 ports which can therefore serve up to 16 line shelves or 256 ports. The 16×16 arrays can be grown only by adding three more 16×16 arrays to produce a square 32×32 array. In practical terms this requires 24 more cards of the same type to be fitted.

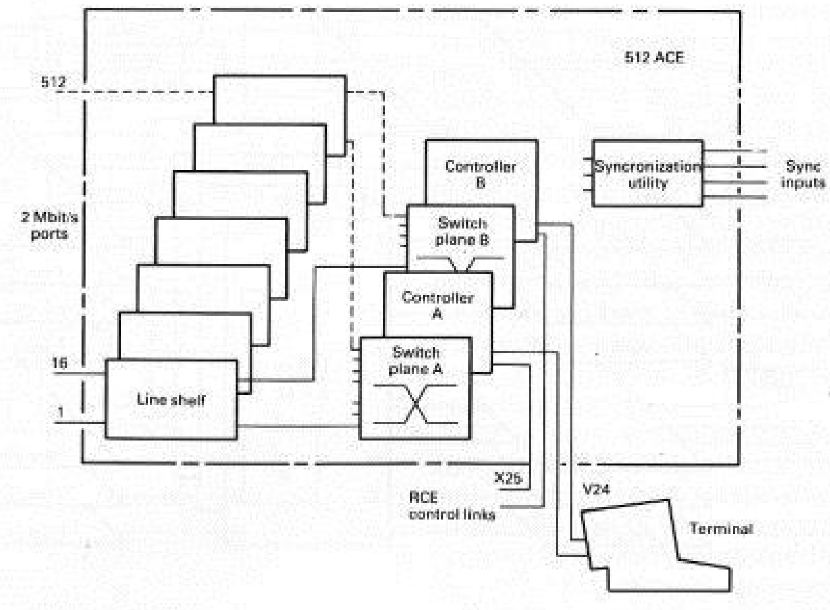

Fig. 3. 512 ACE schematic diagram

Cable duct	LR5	Cable duct	LR4	LR3	CE1	CE0	LR0	Cable duct	LR1	Cable duct	LR2
	Power A		Power A	Power A	Controller A	Sync A	Power A		Power A		Power A
	Power B		Power B	Power B	Controller B	Sync B	Power B		Power B		Power B
	Lines 496-511		Lines 400-415						Lines 144-159		Lines 240-256
	Lines 480-495		Lines 384-399	Lines 304-319	Switch A Outer 0	Switch A Inner 1	Lines 48-63		Lines 128-143		Lines 224-239
	Lines 464-479		Lines 368-383	Lines 288-303	Switch A Inner 0	Switch A Outer 1	Lines 32-47		Lines 112-127		Lines 208-223
	Lines 448-463		Lines 352-367	Lines 272-287	Switch B Outer 0	Switch B Inner 1	Lines 16-31		Lines 96-111		Lines 192-207
	Lines 432-447		Lines 336-351	Lines 256-271	Switch B Inner 0	Switch B Outer 1	Lines 0-15		Lines 80-95		Lines 176-191
	Lines 416-431		Lines 320-355						Lines 64-79		Lines 160-175

Fig. 4. 512 ACE rack layout

512 ACE implementation

General

It would appear that, apart from the quantity required, the line terminations, power supplies, synchronization utility and the controllers could remain essentially the same for the 512 ACE as for the 128 ACE. This is only partially true as will be discussed later.

The basic requirement to keep the equipment as small as possible has been met mainly by the use of multi-layer printed-circuit boards and surface-mount technology in the switch planes.

Figure 3 gives a simplified schematic diagram and figure 4 shows the rack layout for a fully equipped 512 ACE. The full size 512 ACE requires eight 2.2m British Telecom Transmission Equipment Practice, TEP-1(E), racks. The equipment can be sub-equipped if required with the minimum size being three racks, consisting of two common equipment racks and one line rack. This minimal size switch can be constructed and grown from 16 ports upwards, although the smaller sizes are unlikely to be cost effective, since a minimum number of switch cards is required in the centre stages of each switch plane. A more logical initial size is likely to be between 128 ports and 256 ports.

All shelves, apart from the power and controller shelves, are fitted with a control and interface card which interfaces with the controller shelves over a dual port asynchronous link. This allows the controllers to configure the shelves and to request alarm status and monitoring information to be sent back which, after further processing, is passed to the RCE. The whole equipment is powered from a nominal −50V battery via a number of dc-dc switching converter power units.

Common equipment racks

Two common equipment racks house the two 8VU shelf synchronization utility, the two 8VU controller shelves and the duplicated switchplanes housed in four 24VU shelves.

Synchronization utility

The synchronization utility is similar to that used on 128 ACE and consists of two interlinked but separable shelves to facilitate maintenance in service. The utility can be fed with up to four timing sources, any one of which can be used to frequency lock the internal oscillators.

The four timing sources can be any combination of traffic or non-traffic HDB3 2Mbit/s signals or 2 MHz synchronization interface (SI) signals. Each of the four sources is fed to a separate line monitor card which monitors the signal to ensure that it is a valid synchronization source and then extracts the 2048 kHz clock. The recovered clocks from these sources are fed to each of the two oscillator cards operating in a worker-standby mode.

Both oscillator cards generate their own 8192kHz clock from a stable oven-controlled oscillator and can either be in a free-running mode or frequency locked to one of the selected input timing sources. The oscillator card selected as worker is frequency locked to the selected input timing source and the standby card is frequency locked to the worker. Since the two oscillator cards are always locked together, a no-break change-over can be ensured in the event of one of the oscillators failing.

The oscillator cards automatically select which one of the four timing sources is to be used as a synchronizing source and, in the event of all sources failing, the oscillator will free-run in 'memory mode' at a frequency established just prior to the failure.

The 8192kHz clocks are fed to three distribution cards, where the clock from the worker card is used to derive 4096kHz and 100Hz timing signals. The distribution of the timing signals differs from that used in the 128 ACE in that these are now distributed as separate pairs from the distribution area to each of the equipment shelves on a multi-drop scheme. The triplication of the clocks from the distribution cards and subsequent majority voting on the destination cards ensures full security of the timing sources.

A common control interface and display card is provided for the monitoring and display of alarm status for both of the shelves in the utility.

Controllers

The duplicated controller shelves differ from those used on 128 ACE in that they are of a new design based on the 68000 microprocessor family of devices, rather than on the Z80A previously used. Each shelf contains a single-board computer, an input/output extension board, an alarm interface board and a power supply. Future expansion is provided for with extra card positions for one input/output board and up to two memory expansion boards.

Communication to each of the equipment shelves is different from the single-control-port-per-shelf polling system used on the 128 ACE. Each controller shelf now has a number of RS485 asynchronous duplex serial ports which are connected to the line, synchronization and switch shelves by means of a number of multi-drop links. Each shelf has a unique address and communicates to the controller only when instructed to do so.

V28 synchronous, duplex serial ports are provided for inter-controller communication in the normal 'master/slave' mode and also for communicating via an X25 network link to the RCE. V28 asynchronous duplex serial ports are provided for communicating with a local terminal.

Records of operational data, including the cross-connection map, are retained in non-volatile memory in both controllers and this is checked and maintained from the RCE. The master controller ensures that the slave memory is kept updated such that, in the event of the master failing, the slave can take immediate control. The controller operating in the slave mode may be taken out of service for maintenance. In the event of both controllers failing, switch cross-connections already made are retained by the switchplane memory.

Switchplanes

Duplicated switchplanes with their own separate 5V power supplies are used in a worker/standby mode to ensure security of operation in the event of a power unit failure or other fault which may result in the loss of traffic. If this should occur on

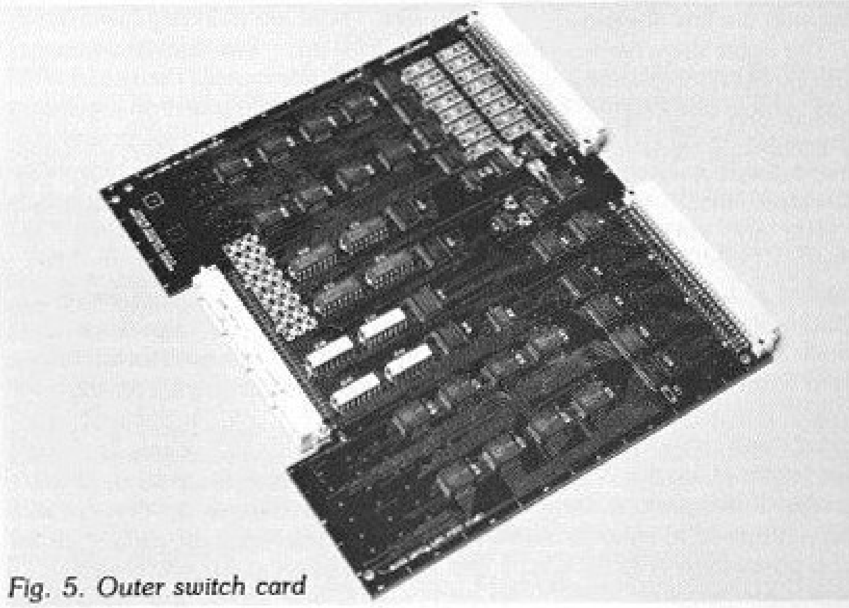

Fig. 5. Outer switch card

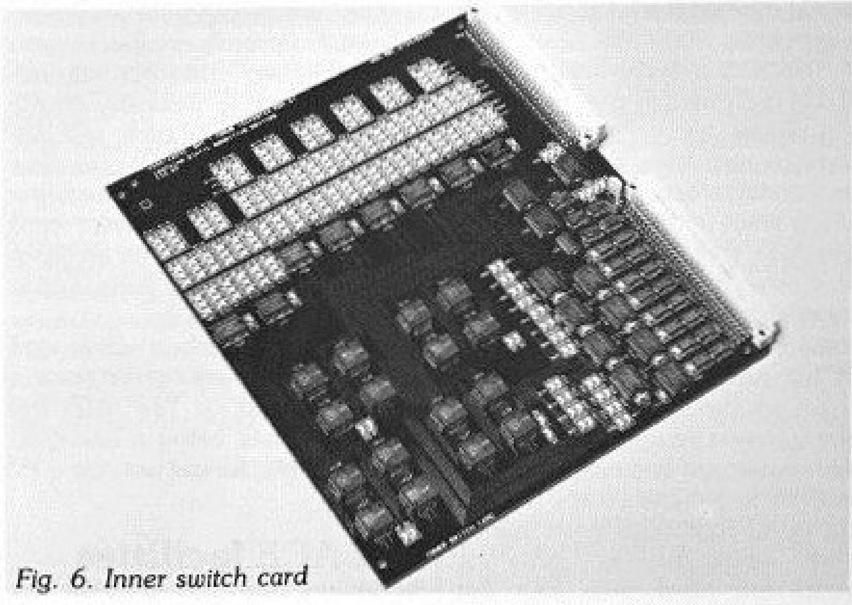

Fig. 6. Inner switch card

the worker switchplane, the traffic is automatically routed via the standby switchplane. Either switchplane can be used in the master mode and the standby can be taken out of service for maintenance.

The switchplane is divided into halves, each consisting of a 24VU shelf with a multi-layer backplane, one in each of the common equipment racks. Each shelf contains half of each of the three stages in the whole switchplane.

Two types of switch cards are used, both constructed using multilayer printed-circuit boards and surface-mounted components. The outer stage card (figure 5) contains the 1st and 3rd stage circuits and the inner stage card (figure 6) contains the 2nd stage circuits. In addition, the outer stage switch cards perform the bothway conversion of 16 2Mbit/s TTL level signals to balanced V11 signals for interfacing with the line shelves.

The outer stage card contains 16 8x8 DSMs connected as two separate arrays, one of 16x32 lines and the other of 32x16 lines. One of these cards is required for every line shelf fitted.

The inner stage switch card also has 16 DSMs but these are connected as four arrays, each one of 16x16 lines. When fitted to the shelf the separate arrays on each card form one quarter of a larger 32x32 line array, thus a total of 32 inner stage cards in the two shelves are required for the 32 32x32 line arrays. If the switchplane is to be sub-equipped to cater for less than 256 ports, then only 32 16x16 line arrays are required, which can be accommodated on a total of only eight cards.

Two switch timing cards are fitted in each shelf to supply the timing signals and buffer the control data to and from the inner and outer stages and also to provide clock status information. A control interface card performs the interface between the controller and the switch timing cards.

Line racks

A full size 512 ACE requires six 2.2m line racks, three either side of the common equipment racks. The four outermost line racks are fitted with six line shelves each, catering for up to 96 2Mbit/s ports in each rack, whilst the two innermost racks are fitted with four line shelves each, catering for up to 64 2Mbit/s ports in each rack. Cable ducts are provided to give access to the 2 Mbit/s termination areas on each line shelf.

Two power shelves are fitted in each line rack, with up to six power supplies in each, providing dual +7V supplies in a 'worker/standby' mode, thereby ensuring a secure supply to each line shelf.

Power shelves

The power shelf is similar to the 128 ACE power shelf but has provision for up to six power supply units. The power units now provide +7V rather than +9V, and one is required for each line shelf fitted to the line rack.

The appropriate power unit output from each of the power shelves is diode OR'ed on each line card, clock interface card and switch test card to provide secure +7V supplies. These are then regulated down to +5V using low drop, series regulators on each card. The use of +7V power units and low drop regulators ensures a lower overall power dissipation, enabling up to two more line shelves to be fitted to each rack compared to the 128 ACE.

Line shelves

The line shelves are similar to those used on 128 ACE but have dual 9600 kbit/s ports connected to the controller and separate timing connectors for the triplicated synchronizing clocks. Each line shelf can accommodate up to 16 2Mbit/s line cards. Access to the 2Mbit/s ports is provided on each shelf by means of co-axial connectors.

The line cards are of a new design and incorporate a number of new features to enable them to meet differing customer requirements, including flexibility in the use of spare bits and cyclic redundancy checking (CRC-4). Because of the greater delay through the three-stage switch, software controllable timing has been incorporated to allow the card to be used in single-stage 128 ACEs.

The clock interface cards and switch test cards are new editions of the cards used on 128 ACE, the only difference being a low-drop +5V regulator for use with the +7V supply.

512 ACE facilities

In general, the 512 ACE has the same facilities as the 128 ACE equipment, but with a greater capacity. It can be used to replace, wholly or partially, a conventional manual cross-connect site and can also be part of a remotely controlled network using an RCE.

Monitoring and reporting of circuit alarm status and remote testing of circuits are all incorporated within the equipment software. The 512 ACE equipment has the capability of terminating up to 512 2Mbit/s digital bearers in accordance with CCITT Recommendation G703. At the most basic level it can automatically cross-connect any 64 kbit/s channels within and between bearers, although subsystem enhancements such as remote alarm concentration and signalling data switching require the allocation of some of these channels, i.e, TimeSlot 0 (TS0) and TimeSlot 16 (TS16) respectively.

The switch provides full availability and is strictly non-blocking for all single 64 kbit/s channels. The capability to configure unidirectional, multi-point circuits (broadcast type) and wideband (n x 64 kbit/s) circuits, subject to some rules regarding timeslot sequencing, is also provided. In both these cases, some blocking of future multi-point or (n x 64 kbit/s) circuits may occur, depending upon the usage made of these facilities. The blocking may be overcome by suitable rearrangement of the existing switch connections to enable free multiple paths to be found.

Future facilities

Only the basic 512 ACE equipment has been described and this does not include some of the facilities currently available on the 128 ACE equipment, although these may be fitted as sub-equipments as required. In some cases these are included in the 512 ACE and use the same control and timing facilities, whilst in others the equipment can either be co-located or remotely sited from the 512 ACE.

Remote alarm concentration

This provides the facility to concentrate and process the alarm and spare bit information contained within the TimeSlot 0 bits of incoming 2Mbit/s ports. Access is also provided to make use of the spare bits in the outgoing Timeslot 0s.

Sub-rate switching

This provides the facility to switch low-rate data of 8 kbit/s, 16 kbit/s or 32 kbit/s. Typically this would be used to aggregate two 32 kbit/s adaptive differential PCM (ADPCM) channels into one 64 kbit/s channel.

X50 switching

This provides switching for CCITT Rec. X50, Division 3 data and may either be co-located or remotely sited from the 512 ACE.

Audio conferencing bridge

This allows voice-band or audio conferencing for up to 31 users in any combination.

2Mbit/s multi-junction equipment (MJE)

This provides point-to-point duplex connections between a main terminal and a number of tributary terminals on remote customer sites and under customer control. The main terminal is used to poll around tributaries providing data rates of 12 kbit/s, 24 kbit/s and 48 kbit/s in a structured data format. Similar facilities can be provided for data structured to CCITT Rec. X50.

Conclusions

The 512 ACE design is a major enhancement to digital data networks and provides a cost-effective and radical improvement in circuit provisioning and network maintenance. It occupies less than one twentieth of the floor space that is normally required by standard manual DDFs and multiplexers, and allows a far more flexible service to be provided. The 512 ACE may be included in the same networks and share the same RCE facilities as the 128 ACE.

Acknowledgements

The author would like to thank his colleagues in Marconi Communication Systems who have made contributions or helped in other ways in the preparation of this article.

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RESUMEN

El equipo de interconexión automática 512 de acceso de 2Mbit/s (512 ACE) está siendo dessarollado actualmente para complementar la serie U4200 Marconi de gran éxito de los ACE 128 de acceso de 2Mbit/s ya instalados por British Telecom en el Reino Unido y por otras compañías importantes de telecommunicaciones en todo el mundo.

El equipo ACE sustituye los existentes distribuidores digitales alámbricos (DDF) y su correspondiente equipo de multiplexaje y sitios de interconexión, y es una importante mejora de las redes digitales de circuitos privados. Junto con su correspondiente equipo de control remoto (RCE), los ACE proveen una mejora radical en la provisión de circuitos y mantenimiento de las redes.

El 512 ACE es aún una mejora mayor y peude usarse en situaciones en que la capacidad de un solo ACE de acceso 128 es insuficiente para satisfacer la demanda inmediata o futura de circuitos. También es más práctico y económico como medio para proveer capacidad extra que la alternativa de usar los ACE de acceso 128 en el mismo sitio e interconectados. Además ofrece demandas mínimas de alojamiento y potencia.

El presente artículo trata de algunas consideraciones de diseño que surgieron durante el desarollo, y detalla la realización del 512 ACE y del equipo de la serie U4203 de Marconi. También se ofrece una introducción a las mejoras existentes y futuras que van a estar disponibles, y que podrán ser adicionales subequipos del 512 ACE básico.

ZUSAMMENFASSUNG

Die automatische Querververbindungseinrichtung (ACE) mit 512 2Mbit/s-Anschluß (512 ACE) wird zur Zeit entwickelt, um die bereits von British Telecom in Großbritannien und anderen großen Telefonbehörden der ganzen Welt eingebauten ACE mit 128 2Mbit/s Anschluß zu vervollständigen.

Die ACE-Einrichtung ersetzt bestehende fest verdrahtete digitale Verteilerrahmen und dazugehörige Multiplexgeräte an Querverbindungsplätzen und stellt eine größere Erweiterung privater Digitalnetze dar. Mit den dazugehörigen Fernsteuerausrüstungen (RCE) bieten die ACE eine radikale Verbesserung bei der Leitungserstellung sowie bei Wartung der Netze.

Die Einrichtung 512 ACE ist eine größere Erweiterung, die sich für Anwendungen eignet, bei denen die Leistung einer 128-Anschluß-ACE nicht ausreicht, um den jetzigen oder künftigen Bedarf an Leitungen zu decken. Weiterhin handelt es sich um eine praktischere und kostengünstigere Lösung des Problems zusätzlicher Leistungsforderungen als der Ausweg über am gleichen Ort vorgesehene und angeschlossene ACE mit 128 Anschlüssen. Auch lassen sich Platz- und Strombedarf damit senken.

Dieser Aufsatz erörtert einige der Konstruktionsprobleme, die bei der Entwicklung auftraten und beschreibt die Implementierung der Einrichtung 512 ACE als Marconi-Gerät der Reihe U4203. Einige bestehende und künftige Erweiterungen, die noch zur Verfügung gestellt werden und als Nebengeräte den Grundeinrichtungen 512 ACE zugefügt werden können, sind hier auch vorgestellt.

RÉSUMÉ

Le matériel ayant 512 entrées de 2Mbit/s, à interconnexion automatique (512 ACE) est actuellement en cours d'être mis au point pour compléter la série U4200 à grand succès de Marconi de matériel ayant 128 entrées de 2Mbit/s déjà installé par British Telecom au Royaume-Uni et par d'autres services officiels importants de télécommunications autour du monde.

Le matériel ACE remplace les répartiteurs numériques câbles existants (DDF) et leur matériel de multiplexage connexe aux emplacements d'interconnexion, et il constitue une amélioration importante aux réseaux numériques de circuits privés. Conjointement avec leur matériel connexe de commande à distance (RCE), les équipements ACE assurent une amélioration radicale dans la mise en oeuvre de circuits et l'entretien de réseaux.

Le 512 ACE est une amélioration complémentaire importante qui peut être utilisée dans des situations où la capacité d'un matériel ACE simple à 128 entrées n'est pas suffisante pour répondre a a demande immédiate ou future en mati´ére de circuits. Il constitue également un moyen plus pratique et plus rentable d'assurer une capacité supplémentaire par rapport à l'autre moyen d'utiliser des équipements ACE à 128 entrées cositués et interconnectés. Cela aboutit également à un minimum de demandes pour une prise en charge et pour de la puissance.

Cet article met en question quelques unes des considérations d'étude qui furent soulevées pendant la mise au point, et il indique en détails la mise en oeuvre du matériel ACE 512 comme le matériel de la série U4203 de Marconi. Un avant-propos est également mis sur pied à propos de quelques unes des améliorations existantes et futures qui seront rendues disponibles, et qui peuvent être ajoutées en tant que sous-équipements au matériel ACE 512 de base.