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DICE at ITN

Summary

Digital standards conversion began at ITN in 1973 when the first all-digital converter (525 NTSC to 625 PAL), built as a laboratory prototype by the Independent Broadcasting Authority, was delivered and installed. Later, in May 1975, ITN took delivery of a two-way DICE converter also designed and built by the IBA.

Much experience has been gained in the operation and maintenance of DICE in the course of running an international standards conversion facility service as well as use for ITN's own news requirements.

The quality of the converted picture is such that it would be very hard to improve upon it, and it causes one to question the quality of monitoring equipment.

Maintenance of this highly-complex device, employing digital techniques which are as yet unfamiliar to most television engineers, is aided by special testing jigs.

The DICE Digital Standards Converter, capable of converting in both directions between 525-line NTSC and 625-line PAL or SECAM, is now manufactured by Marconi Communication Systems Limited.

Introduction

Independent Television News Limited produces the national and international news programmes for all the commercial television companies in the United Kingdom. It is also a part-owner in UPITN, the international newsfilm agency.

ITN House is the facilities centre from which it broadcasts. These complementary roles of facilities company and specialist broadcaster provide a service to hirers that is unique in experience and equipment.

The facilities company, ITN House, not only operates and staffs television, sound and film equipment for the exclusive use of hirers but also draws on the wide range of equipment and experience of the broadcaster and the newsfilm agency and offers a complete television, film and sound service in London 365 days a year.

Digital standards conversion was first used operationally in early 1973, when a prototype one-way DICE was installed at ITN. Later, in 1975, the design having been finalized, a second DICE two-way converter arrived and, since then, all standards conversion at ITN between 525 and 625 and vice-versa has been digital.

The arrival of a DICE places new demands on both the maintenance engineer and on the existing analogue monitoring equipment. The ITN approach to some of these problems is described in later sections of this article.

History of standards conversion

Standards conversion is not a new process; it first became a necessity in the United Kingdom with the founding of the 'Eurovision Link' in 1954. At that time, the UK television system was entirely 405 lines, 50 fields per second, whilst on the continent of Europe both 625/50 and 819/50 were in use. Thus any interchange of programme material other than film for direct transmission meant that standards conversion was needed. Early standards converters were of the image transfer type and, of course, were monochrome only.

Since those first problems of system incompatibility, one might have thought that the television standards of the world would gradually be rationalized to possibly two systems, one for countries with 50Hz mains supply and one for 60Hz. However, that is far from what has happened, and all too frequently yet more variations have been introduced, not for technical reasons, but very often because of social and economic factors.

In 1966 ITN bought its first conversion equipment which was an image-transfer converter. Later, ITN owned and used various other converters like the BBC-designed analogue line store standards converter. The line store converters converted from 405/50 to 625/50 and vice-versa. This was the first all-electronic standards conversion equipment and it provided a great leap forward in terms of picture quality.

Such line store standards converters are still in service today providing 405 line monochrome signals to the remaining 405 line BBC and ITV transmitter networks. Considerable expertise is required from the maintenance staff in order to optimize the performance of these converters.

As an exercise in the use of digital techniques, in 1970/71 the Independent Broadcasting Authority (IBA) designed and built a digital line-store converter.[1]

The superior performance of this converter, achieved without the need for adjustment, confirmed the value of the digital approach. It gave the IBA engineers an appreciation of the technology that was later to be the basis of DICE.

It was not until the advent of videotape as the prime programme recording medium that broadcasters were faced with the need to convert between television systems with differing field rates. Once it became possible to store a programme on videotape, that tape could be flown across the Atlantic. Hence converters now had a new problem. The optical or image transfer

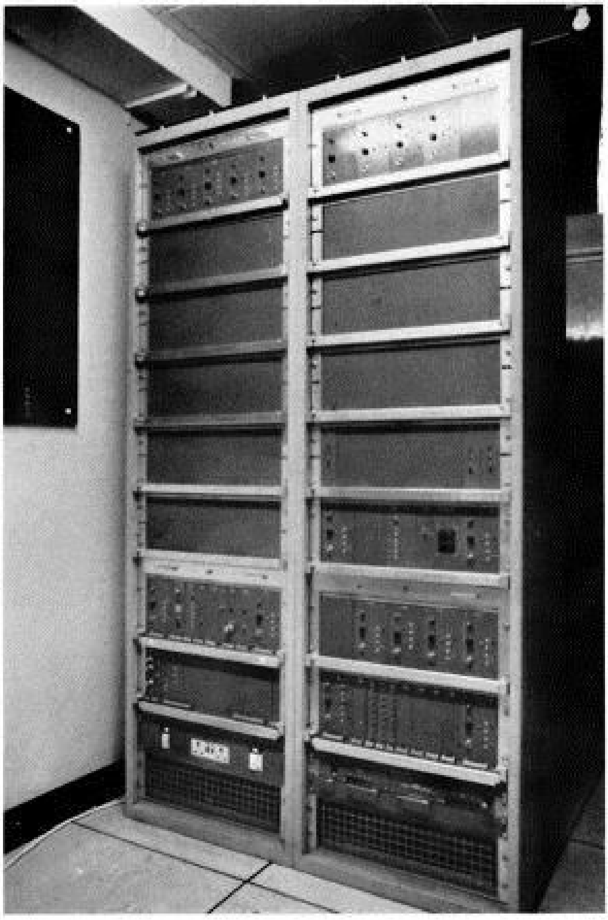

Figure 1. The first DICE installed at ITN

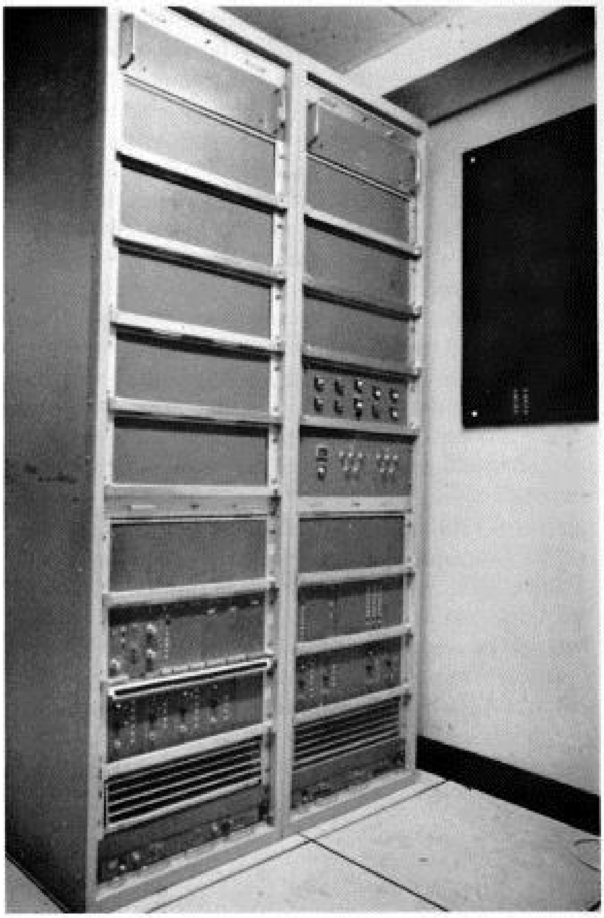

Figure 2. DICE, the latest two-way version

type of converter was readily adaptable to this, although its picture quality was far from ideal. In 1968 analogue colour-capable field rate standards converters were built and for a long time provided virtually the only means of converting between NTSC and PAL. ITN purchased this variety of machine in February 1970 and, for three years, it worked very hard both for ITN's news requirements and as a hireable facility for many TV stations around the world. There were certain inescapable problems with this device but these were mainly confined to signal-to-noise ratio and movement judder.

Finally, an all-digital converter was designed and built in the engineering laboratories of the Independent Broadcasting Authority.[2,3] This prototype of the now well-known DICE was a one-way (525 NTSC to 625 PAL) converter and this actual prototype was installed at ITN in February 1973 (figure 1). For the first time in the history of standards conversion a level of performance had been achieved whereby subjective assessment of picture quality revealed hardly any discernible differences between input and output.

The achievement of the IBA in achieving this triumph of engineering must be applauded, especially as a major part of the device employs the latest digital techniques never before applied to television.

Having gained enormous experience from building this first digital converter and also from operational experience gained at ITN, the IBA design team went into action again and produced a two-directional digital converter; 525/625 and 625/525 (figure 2). This converter can be arranged to convert either NTSC to PAL or NTSC to SECAM and conversely SECAM to NTSC or PAL to NTSC. This latest version of DICE is now manufactured and supplied by Marconi Communication Systems Ltd.

On completion, the two-way DICE was delivered to ITN in May 1975. Since that date ITN has provided an all-digital conversion service for its news programmes and for the many customers world-wide who come to ITN for its standards conversion service.

What is a DICE

DICE is an acronym for Digital Intercontinental Conversion Equipment. In brief, it is a predominantly digital television standards converter capable of converting either way between 525 NTSC and 625 PAL. It can also be arranged to handle SECAM as well as PAL or instead of PAL.

The input signal is treated in different ways according to the direction of conversion. If the input signal is 525 NTSC then it is immediately sampled at three times the NTSC subcarrier frequency to produce a stream of 8-bit parallel binary words coresponding to the amplitude of the waveform at each sample point. This data is then written alternately into each of two MOS shift register field stores.

Imagine an object moving across the screen from A to B. In 525 NTSC the object will be shown in 60 discrete positions every second but, after conversion, the same object must be seen to move in the same manner but now taking up only 50 discrete positions in moving from A to B.

In order to achieve this movement interpolation the information that has been written alternately into the two field stores is now read out simultaneously from them and is combined with suitable scaling factors. New television fields are thus produced at the correct repetition rate.

An analogous system of line interpolation is used to increase the number of lines per picture from 525 to 625.

A process of digital 'comb filtering' is employed to separate Y, I and Q information which is then fed to three digital-to-analogue converters. The base-band Y, I and Q signals are then re-coded to the output standard, i.e. PAL or SECAM.

For conversion from 625 standards to 525, the manner in which the signal is handled is somewhat different.

The input signal, whether it is PAL or SECAM, is first decoded into the base-band Red, Green and Blue components. These RGB signals are matrixed to form I and Q which, together with the input Y signal, are then passed to three analogue-to-digital converters. Y, I and Q are then digitized into three sets of parallel 8-bit words, which are multiplexed and fed into the line interpolation system.

Line interpolation is carried out before writing into the field stores because it reduces the size of store required by 20%. At this stage, the signal is really of the form 525 lines 50 fields per second. After line interpolation the data is written alternately into the two field stores and then read out at a time and speed dictated by the output reference synchronizing signals. Movement interpolation is then applied which manufactures the extra fields of information that are required to bring the 525/50 signal up to 525/60.

After this stage is reached all that remains to be attended to is the re-blanking of the signal and the digital-to-analogue conversion back to NTSC.

Operational experience of DICE

In earlier days of standards conversion quite considerable picture distortions were accepted because there was no alternative if the programme material was to be shown at all. Nowadays when the quality of conversion is nearly perfect, engineers and viewers alike are becoming very critical, and one wonders whether the output picture has in fact to be better than the input picture before standards converted programmes will be considered satisfactory! Now that the quality of conversions is so good there does seem to be a trend for people to expect identical input and output pictures. This is not possible, however, owing to the differing luminance bandwidth of the television standards.

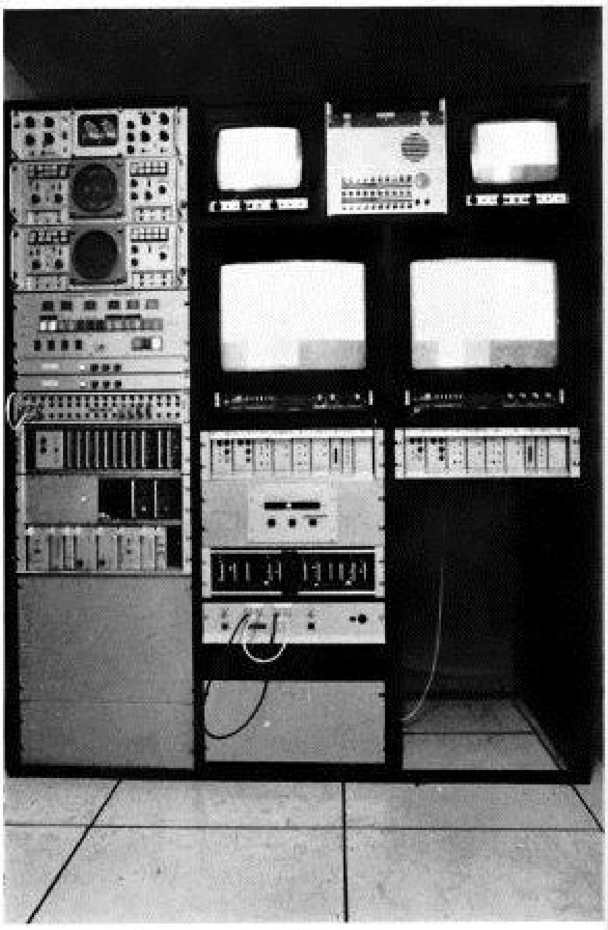

Figure 3. Monitoring equipment racks

The accuracy with which colour hue and saturation is converted is such that a new order of performance is required from the decoders which are used to display the input and output pictures. If the input and output hues are to remain within one or two j.n.d. of each other then the phase stability of the NTSC decoder must be better than 2° for all mains supply voltage and other environmental variations. This is indeed a tough test of a decoder and is only one of the parameters that needs careful attention. There is at first a very natural tendency to believe that any differences of hue, saturation, definition or ringing, etc., seen on the screen are attributable to the converter. Experience has shown that the level of distortion in DICE is so small that for any noted impairment one has first to ascertain to what degree it is being caused or worsened by ancillary equipment.

Apart from colour bars, a generally useful test signal for use with DICE is the monochrome sawtooth as it readily shows up typical digital defects. Because colour bars can be misleading, it is best to check DICE performance before on-air use with real picture signals.

There are no operational controls that have to be adjusted for best performance during conversion and, as such, it might be natural to regard the converter as a 'black box' which is to be inserted in series with the signal to be converted. Since normally no corrections can be applied, it might be argued that there is no need to have colour monitors permanently assigned to the input and output of DICE. This has not been the policy adopted at ITN and, in fact, a purpose-built monitoring rack has been installed in the converter area (figure 3). Customers converting prestigious programmes need convincing, under good viewing conditions, that DICE really does produce pictures as good as they have perhaps read about. The monitors therefore, take on a rather negative role – that of showing no errors.

Controls giving some adjustment of gain, lift, chroma and so on, can be switched in to deal with loss of quality of the input signal, but these are rarely used at ITN.

Another area where some problems have arisen is in waveform timing. Complaints have been made to ITN that the line-blanking interval on a series of conversions from 525 NTSC to 625 PAL had a duration of 15 microseconds (i.e. 3 microseconds too long). This turned out to be due to the original 525 material having a line-blanking interval of 14 microseconds instead of 11. DICE must of course assume that input blanking will be nominal and therefore begins converting at the nominal start of active picture. Thus, if the input blanking encroaches into active picture time, then the excess blanking will be converted and will appear as excessive output blanking. Hence careful attention must be paid to conformation with PAL, NTSC and SECAM system specifications at the input end of the converter. Unlike image-transfer converters there are no line-scan controls with which to stretch the picture to fill the screen.

Maintenance

The impact of digital television came with full force when the first DICE was delivered to ITN. Suddenly we had an extremely complex piece of equipment using almost entirely digital circuitry. More or less overnight it became one more of the many and diverse pieces of equipment that had to be maintained to very high standards with, if possible, zero down time!

One way of tackling the challenge of maintaining this largely new apparatus would have been to take onto the ITN staff a person with experience in this field. This was not the solution adopted and the existing engineers quickly came to terms with the new techniques. This was aided by some of the maintenance engineers attending informal training sessions at the IBA laboratories. Of course, some of the rack space occupied by DICE contains familiar analogue items: coders, decoders, input and output amplifiers, power supplies and so on.

The process of diagnosis, repair and test of many parts of DICE is aided by special test jigs. In particular, mention should be made of the Arithmetic Tester and the Store Board Tester. In the various interpolation processes that occur in DICE there are many digital adders, subtractors and multipliers. To test these manually would take many hours per unit and so the arithmetic testers were provided. In this tester, if rising or static binary numbers (A and B) are applied to the inputs of, say, an adder, the output would always represent A+B. In an 8-bit-wide system there would be 512 possible answers, and 65,536 possible answers for a multiplier. Obviously, it is just not feasible to test these units manually and so the output of such units is routed to a digital-to-analogue converter and then displayed on a monochrome picture monitor. Errors can quickly be spotted by observing any discontinuities in the various patterns produced (figure 4). The other major test jig is the Store Board Tester. This is a device that tests the shift register stores which make up the two fields of storage in the converter. The printed-circuit boards are simply plugged into the tester one at a time and various automatic tests are applied. LED indicators show which particular shift register or registers are not performing properly. It is interesting

Figure 4. The Arithmetic Tester in use

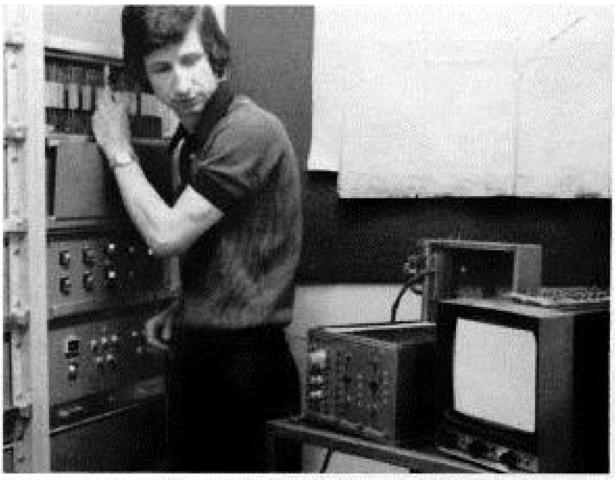

Figure 5. Using the Roving Digital-to-Analogue converter

to note that it has been found from time to time that the tester indicates a fault when, in fact, that particular store board works perfectly in the converter. However, a few days or weeks later that same printed-circuit board has actually failed. This shows the tremendous power of the test jigs and so allows for some preventative maintenance to be carried out.

A further useful aid in the investigation of fault conditions is the 'Roving DAC'. This is a digital-to-analogue converter connected to a video monitor. To use this device a circuit board is removed from the converter and the 'Roving DAC' input lead is inserted into the now vacant edge connector socket (figure 5). In this way the incoming data can be checked. Once again the power and speed of this method must be emphasized. It would be an awesome task to have to study an 18 Megabit-per-second data stream on an oscilloscope in the hope of recognizing an error.

Having traced the fault to a particular board a working spare is substituted. The fault can then be repaired under less trying conditions and in a slow, logical manner using conventional techniques such as voltmeters and oscilloscopes.

The process of fault finding and eventual repair is considerably aided by the truly excellent handbooks that are supplied with the converter. In a methodical manner the handbooks and circuit diagrams enable the engineer to trace and eliminate the working or non-working parts of the converter and so to gradually converge on a faulty board. This board is then replaced by a spare and the detailed diagram of that board then enables component-level maintenance to take place.

The converter has much in common with the digital computer, and, as a computor engineer would know, great care must be exercised when making tests and measurements on the working equipment. This perhaps goes without saying but it is particularly so in such a machine as this because the power supplies are capable of supplying large currents, i.e., 70 amps at 5 volts. If a short circuit were inadvertently put on the power rail of a circuit board the consequences could be very expensive!

For a television station with little or no digital equipment at present the business of running an efficient maintenance service on DICE could demand quite a large capital outlay on spare components and circuit boards. However, this is greatly eased in that the same types of boards are used in a number of positions. Further, the failure of some boards will not result in complete loss of programme but only a reduction in picture quality.

Although the down time of the standards converter is very small indeed a fault condition which occurs whilst converting some live event can be catastrophic. For this reason, ITN has purchased the necessary set of spare circuit boards. General components such as transistors, integrated circuits, etc., are, to a large extent, already held in the ITN technical stores.

Environment

At ITN the two digital converters are installed in a rather confined space which measures only 3m × 3m. A plan is shown in figure 6. Within this floor area also stands the monitoring rack. The area is air-conditioned and the normal ambient temperature around the converters is approximately 26°C. Maintaining a constant, moderately low temperature is of great importance in achieving a high reliability. Consequently it is the policy for DICE to remain switched on 24 hours a day. Ideally more room would have been allocated to the conversion area but space at ITN, being located in central London, is never very plentiful! A purpose-built maintenance bench is available nearby which houses the spare circuit boards in a specially designed upstand unit from the bench.

Conclusion

DICE provides a high-quality standards conversion facility that is easily integrated into any existing television station. As with any new equipment employing new techniques or components, adequate engineering ability and spares should be regarded as a high priority.

Acknowledgement

The author wishes to thank ITN for permission to write this article.

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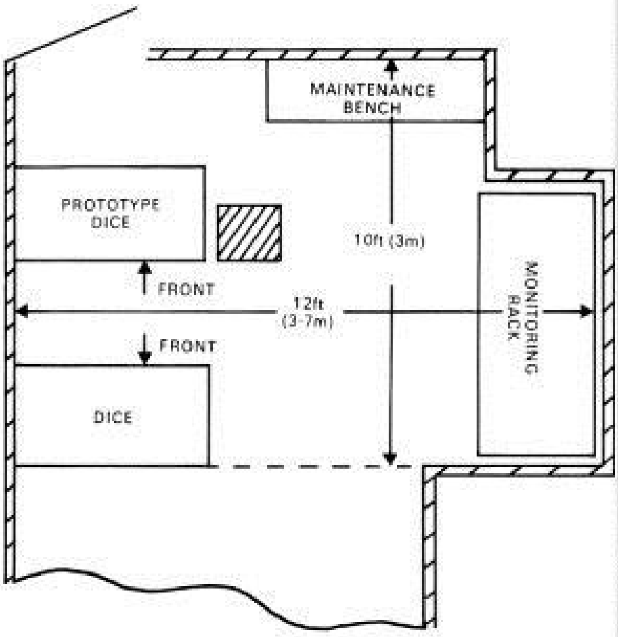

Figure 6. Floor plan