ELSEVIER

JOE CIESZYNSKI

CLOSED CIRCUIT TELEVISION

SECOND EDITION

Newnes

Closed Circuit Television

Closed Circuit Television

Second edition

Joe Cieszynski
IEng MIEE (elec) Cert. Ed. CGI

ELSEVIER

AMSTERDAM • BOSTON • HEIDELBERG • LONDON • NEW YORK • OXFORD
PARIS • SAN DIEGO • SAN FRANCISCO • SINGAPORE • SYDNEY • TOKYO
Newnes is an imprint of Elsevier

Newnes

Newnes
An imprint of Elsevier
Linacre House, Jordan Hill, Oxford OX2 8DP
200 Wheeler Road, Burlington, MA 01803

First published 2001
Reprinted 2002
Second edition 2004

British Library Cataloguing in Publication Data
A catalogue record for this book is available from the British Library

ISBN 0 7506 5728 6

Typeset by Replika Press Pvt Ltd, India
Printed and bound in Great Britain

Contents

Preface

In the preface to the first edition I wrote that closed circuit television (CCTV) was a growth industry, and that the growth was very much a result of the impact of new technology. As I write this preface to the second edition of *Closed Circuit Television*, this situation has not changed. Technology has continued to advance, bringing with it the possibility of much clearer images even in conditions where a few years ago it would have been impossible to film. Add to this the advances in digital recording, high speed data transmission and biometric recognition and alarm systems, and we have the ability to design and install CCTV systems that just a few years ago were the stuff of science fiction.

However, like any high tech installation, these systems will only function correctly if they are properly specified, installed and maintained. Consequently a CCTV engineer needs to be conversant with modern electrical, electronics, digital and microprocessor principles, electrical installation practice, health and safety issues and telecommunications and broadband technology, in addition to having an in-depth knowledge of CCTV principles and technology.

This book has been written to provide the latter in the above list – a knowledge of CCTV principles and technology. Like the first edition, it uses the City & Guilds/SITO Knowledge of Security and Emergency Alarm Systems syllabus (course 1851) as its basis, making it suitable reading for trainees studying towards this qualification or for those who are working towards an NVQ level II or III in CCTV installation and maintenance. However, to cater for those who are already practising in the industry but who wish to further their technical knowledge and understanding, this second edition includes discussion of such topics as digital video signal compression, digital tape and hard disk recording, and CAT5 structured cabling.

This second edition includes two completely new chapters covering lighting and ancillary equipment. Furthermore, where the first edition was devoted primarily to the UK PAL television system, having noted that the book was being purchased in somewhat large numbers across the Atlantic in the USA, it was felt only right that this new edition should incorporate NTSC television standards.

It is my hope and wish that trainees and engineers alike will find this a useful handbook and aid towards their personal development.

Joe Cieszynski

Acknowledgements

I would personally wish to thank all of those who have helped in the production of this book by providing information and/or support. I should mention Andrew Holmes of Data Compliance Ltd, David Grant of ACT Meters, Gar Ning of NG Systems, Martin Kane, Simon Nash of Pelco UK Ltd and Simon Liddy and Steve Pilling of PAC International Ltd.

There are some people who I would like to thank in particular: Ian Fowler of Norbain SD Ltd for his patient proofreading of parts of the book, and for the many times that he made himself available to discuss aspects of theory and technology; David, Hannah, John and Ruth my four (grown-up) children for their patience with me during what, at times, appeared to be the endless writing stage; and Linda my wife for her much-appreciated support.

1 The CCTV industry

The term 'closed circuit' refers to the fact that the system is self-contained, the signals only being accessible by equipment within the system. This is in contrast to 'broadcast television', where the signals may be accessed by anyone with the correct receiving equipment.

The initial development of television took place during the 1930s, and a number of test transmissions were carried out in Europe and America. In the UK these were from the Crystal Palace transmitter in London. The outbreak of the Second World War brought an abrupt end to much of the television development, although interestingly transmissions continued to be made from occupied Paris using an experimental system operating from the Eiffel Tower; the German propaganda machine was very interested in this new form of media.

Ironically, the war was to give television the boost it needed in terms of technology development because in the UK it seemed like every scientist who knew anything about radio transmission and signals was pressed into the accelerated development programme for radar and radio. Following the war many of these men found themselves in great demand from companies eager to renew the development of television.

Early black and white pictures were of poor resolution, however the success of the medium meant that the money became available to develop new and better equipment, and to experiment with new ideas. At the same time the idea of using cameras and monitors as a means of monitoring an area began to take a hold. However, owing to the high cost of equipment, these early CCTV systems were restricted to specialized activity, and to organizations that had the money to invest in such security. These systems were of limited use because an operator had to be watching the screen constantly; there was no means of recording video images in the 1950s, and motion detection connected to some form of alarm was the stuff of James Bond (only even he did not arrive until the 1960s!).

Throughout the 1960s and 1970s CCTV technology progressed slowly, following in the footsteps of the broadcast industry which had the money to finance new developments. The main stumbling block lay in the camera technology which depended completely on vacuum tubes as a pick-up device. Tubes are large, require high voltages to operate, are generally useless in low light conditions (although special types were developed – for a price), and are expensive. Furthermore, an early colour camera required three of these tubes. For this reason throughout these years CCTV remained on the whole a low resolution, monochrome system which was very expensive.

By the 1980s camera technology was improving, and the cost of a reasonable colour camera fell to a sum that was affordable to smaller businesses and organizations. Also, VHS had arrived. This had quite an impact on the industry because for the first time it was possible to record CCTV images on equipment that cost well below £1000. Prior to this, CCTV could be recorded on monochrome reel-to-reel machines, however these were expensive and were not exactly user-friendly.

From the mid 1980s onwards television technology advanced in quantum leaps. New developments such as the CMOS microchip and charge coupled device (CCD) chip brought about an increase in equipment capability and greatly improved picture quality, whilst at the same time equipment prices plummeted. Manufacturers such as Panasonic and Sony developed digital video recording machines, and although these were intended primarily for use in the broadcast industry (at £50 000 for a basic model the CCTV industry was not in a hurry to include one with every installation!), they paved the way for digital video signal processing in lower resolution CCTV and domestic video products.

Up until recently, CCTV has had to rely on its big brother the broadcast industry to develop new technologies, and then wait for these technologies to be downgraded so that they become affordable to customers who cannot afford to pay £30 000 per camera and £1000 per monitor. However, the technology explosion that we are currently seeing is changing this. PC technology is rapidly changing our traditional ideas of viewing and recording video and sound, and much of this hardware is inexpensive. Also, whereas in the early years the CCTV industry relied largely on the traditional broadcast and domestic television equipment manufacturers to design the equipment, there are now a number of established manufacturers that are dedicated to CCTV equipment design and production. These manufacturers are already taking both hardware and concepts from other electronics industries and integrating them to develop CCTV equipment that not only produces high quality pictures but is versatile, designed to allow easy system expansion, user-friendly, and can be controlled from anywhere on the planet without having to sacrifice one of its most valuable assets – which is that it is a closed circuit system.

The role of CCTV

So often CCTV is seen as a security tool. Well of course it is, however it also plays equally important roles in the areas of monitoring and control. For example, motorway camera systems are invaluable for monitoring the flow of traffic, enabling police, motoring organizations and local radio to be used to warn drivers of problems, and thus control situations. And in the case of a police chase, control room operators can assist the police in directing their resources. The same of course applies to town centre CCTV systems.

CCTV has become an invaluable tool for organizations involved in anything to do with security, crowd control, traffic control, etc. Yet on the other hand the proliferation of cameras in every public place is ringing alarm bells among those who are mindful of George Orwell's book *Nineteen Eighty-Four*. Indeed, in the wrong hands, or in the hands of the sort of police state depicted in that book, CCTV could be used for all manner of subversive activity. In fact the latest technology has gone beyond the predictions of Mr Orwell. Face recognition systems which generate an alarm as soon as it appears in a camera view have been developed, as have systems that track a person automatically once they have been detected. Other equipment which can see through a disguise by using parameters that make up a human, such as scull dimensions and relative positions of extreme features (nose, ears, etc.), or the way that a person walks, is likewise under development. At the time of writing all such systems are still somewhat experimental and are by no means perfected, however with the current rate of technological advancement we can only be a few years away from this equipment being installed as standard in systems in town centres, department stores, night clubs and anywhere else where the authorities would like early recognition of 'undesirables'.

To help control the use of CCTV in the UK the changes made to the Data Protection Act in 1998 meant that images from CCTV systems were now included. Unlike the earlier 1984 Act, this has serious implications for the *owners* of CCTV systems as it makes them legally responsible for the management, operation and control of the system and, perhaps more importantly, the recorded material or 'data' produced by their system. The Data Protection Act 1998 requires that all non-domestic CCTV systems are registered with the Information Commissioner. Clear signs must be erected in areas covered by CCTV warning people that they are being monitored and/or recorded. The signs must state the name of the 'data controller' of the system and have contact details. When registering a system, the data controller must state its specific uses and the length of time that material will be retained. Recorded material must be stored in a secure fashion and must not be passed into the public domain unless it is deemed to be in the public interest or in the interests of criminal investigations (i.e. the display of images on police-orientated programmes).

On 2 October 1998 the Human Rights Act became effective in the UK. The emphasis on the rights to privacy (among other things) has strong implications for CCTV used by 'public authorities' as defined by the Act, and system designers and installers should take note of these implications. Cameras that are capable of targeting private dwellings or grounds (even if that is not their real intention) may be found to be in contravention of the rights of the people living there. As such, those people may take legal action to have the cameras disabled or removed – an expensive undertaking for the owner or, perhaps, the installing company who specified the camera system and/or locations.

In relation to CCTV, the intention of both the Data Protection and Human Rights Acts is to ensure that CCTV is itself properly managed, monitored and policed, thus protecting against it becoming a law unto itself in the future.

The arguments surrounding the uses and abuses of CCTV will no doubt continue, however it is a well-proven fact that CCTV has made a huge positive impact on the lives of people who live under its watchful eye. It has been proven time and again that both people and their possessions are more secure where CCTV is in operation, that people are much safer in crowded public places because the crowd can be better monitored and controlled, and possessions and premises are more secure because they can be watched 24 hours per day.

The CCTV industry

Despite what we have said about CCTV being used for operations other than security, it can never fully escape its potential for security applications because, whatever its intended use, if the police or any other public security organization suspect that vital evidence may have been captured on a system, they will inspect the recorded material. This applies all the way down to a member of the public who, whilst innocently using a camcorder, captures either an incident or something relating to an incident. For this reason it is perhaps not surprising to hear that the CCTV industry is largely regulated and monitored by the same people and organizations that monitor the security industry as a whole.

The British Security Industry Association (BSIA) Ltd is the only UK trade association for the security industry that requires its members to undergo independent inspection to ensure they meet relevant standards. The association has over 500 members and represents thirteen different sectors of the industry. There are 50 CCTV companies in membership, representing approximately 75% of the UK turnover for this sector. The BSIA's primary role is to promote and encourage high standards of products and services throughout the industry for the benefit of customers. This includes working with its members to produce codes of practice, which regularly go on to become full British/European standards. The BSIA also lobbies government on legislation that may impact on the industry and actively liaises with other relevant organizations, for example the Office of the Information Commissioner (in relation to the Data Protection Act) and the Police Scientific Development Branch. The BSIA also provides an invaluable service in producing technical literature and training materials for its members and their customers.

Inspectorate bodies are charged with the role of policing the installation companies, making sure that they are conforming to the Codes of Practice. Of course, a company has to agree to place itself under the canopy of an Inspectorate, but in doing so it is able to advertise this fact and gives it immediate recognition with insurance companies and police authorities.

To become an approved installer a company must submit to a rigorous inspection by its elected Inspectorate. This inspection includes not only the quality of the physical installation, but every part of the organization. Typically, the inspector will wish to see how documentation relating to every stage of an installation is processed and stored, how maintenance and service records are kept, how material and equipment is ordered, etc. In addition the inspector will wish to see evidence that the organization has sufficient personnel, vehicles and equipment to meet maintenance requirements and breakdown response times.

In some cases the organization is expected to obtain BS EN ISO 9002 quality assurance (QA) accreditation within two years of becoming an approved installer. At the time of writing there is no specific requirement that engineers working for an approved installation company hold a National Vocational Qualification (NVQ) in security and emergency systems engineering, however this may well become the case in the future.

Another significant body is the Security Industry Training Organization (SITO Ltd). SITO is responsible for the development of training standards for the security industry, and is recognized and approved by the DfES for this function. During recent years SITO has worked to develop NVQs as well as other awards for all sectors of the security industry, and in relation to CCTV engineering have developed awards to NVQ levels II and III. These awards are jointly accredited by SITO and City & Guilds.

City & Guilds are an established and recognized examinations body. With regard to the security industry, apart from awarding certificates to successful NVQ candidates, the City & Guilds appoint the external verifiers whose role it is to check that NVQ assessment centres, be these colleges, training organizations or installing companies, are carrying out the assessments to the recognized standards.

The City & Guilds also offer the Underpinning Knowledge test papers (course 1851) for the four disciplines relating to security and emergency system engineering; these being CCTV, intruder alarm, access control and fire alarm systems. These awards are intended to contribute towards the underpinning knowledge testing for the NVQ level III award, although a candidate may elect to sit these tests without pursuing an NVQ. It must be stressed, however, that the 1851 award is not an alternative qualification to an NVQ, and a person holding only the 1851 certificates would not be deemed to be qualified until they have proven their competence in security system engineering.

The Home Office department of the Police Scientific Development Branch (PSDB) play a most significant role in CCTV. For many years the CCTV industry had no set means of measuring the performance of its systems in terms of picture quality, resolution and the size of images as they appear on a monitor screen. This meant that in the absence of any benchmarks to work to, each surveyor or installer would simply do what they considered best. This situation was not only unsatisfactory for the industry, potential customers were in a position where they had no way of knowing what they could expect from a system and, once installed, had no real redress if they were unhappy, because there was nothing for them to measure the system performance against.

The PSDB set about devising practical methods of defining and measuring such things as picture resolution and image size and, for example, in 1989 introduced the Rotakin method of testing the resolution and size of displayed images (see Chapter 12). They have also developed methods of analysing and documenting the needs of customers prior to designing a CCTV system. This is known as an Operational Requirement (OR).

CCTV is currently a growth industry. It has proven its effectiveness beyond all doubt, and the availability of high quality, versatile equipment at a relatively low cost has resulted in a huge demand for systems of all sizes. Within the industry there is a genuine need for engineers who truly understand the technology they are dealing with, and who have the level of underpinning knowledge in both CCTV and electronics principles that will enable them to learn and understand new technologies as they appear.

2 Signal transmission

A CCTV video signal contains a wide range of a.c. components with frequencies between 0–5.5MHz, in addition to a d.c. component, and problems occur when engineers consider a video signal in the same terms as a low voltage d.c. or low frequency mains supply. However, when you consider that domestic medium wave radio is transmitted around 1MHz, then it becomes clear that the 0–5.5MHz video signal is going to behave in a similar manner to radio signals.

In this chapter we shall examine the peculiar way in which radio frequency signals behave when they are passed along cables, and therefore explain the need for special cables when transmitting video signals.

CCTV signals

An electronically produced square wave signal is actually built up from a sinusoidal wave (known as the fundamental) and an infinite number of odd harmonics (odd multiples of the fundamental frequency). This basic idea is illustrated in Figure 2.1 where it can be seen that the addition of

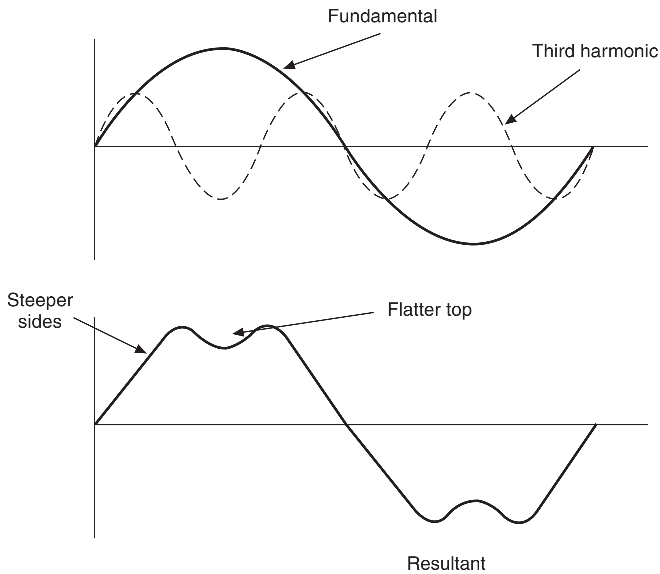

Figure 2.1 *Effect of the addition of odd harmonics to a sinusoidal waveshape*