VIDEOTAPE RECORDING

Theory and Practice

Third edition

JOSEPH F. ROBINSON

Revised by

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Preface

The object of this book is to review the practice and underlying theory of videotape recording. For the reader with a basic engineering knowledge and some experience in television, the main body of the text should be practical, readable and informative, although owing to the complexity of the subject some effort is required toward the end of each chapter. For the student or engineer requiring a more precise treatment the complex analysis is included as an appendix. This should not deter the less academic reader, who should find plenty of information in the rest of the text.

The terminology used has been, where possible, that defined by the SMPTE, although in some cases a choice between two or more common terms has had to be made. A complete glossary, which contains most of the various terms used in VTR, is included at the end of the book. Trade terms, which have been avoided in the text, are also defined here.

The book fully explains the difference in VTR practice owing to the differing television line standards used throughout the world. This covers the 525 line 60 fields per second, NTSC colour, of the American continent and Asia, and the 625 lines 50 fields per second, PAL and SECAM colour of Europe, Russia, Africa and Australasia.

The choice of units was a difficult one, as most mechanical design work on VTR was based on the foot, pound, second (FPS) system, making dimensions in these units whole numbers or neat fractions of whole numbers. Today, however, there is an international drive to standardise on the metric system.

The metre, kilogramme, second (MKS), system of units has, therefore, been adopted, with the exception of mechanical dimensions where the FPS system is used with its metric equivalent in brackets.

The book is designed to be a useful reference work for the VTR engineer, because, where possible, the various standard formats have been described and analysed. These include the Broadcast Quadruplex 2 in wide, B and C 1 in wide, IVC alpha 1 in wide, VCR ½ in wide cassette, EIAJ ½ in wide, VHS ½ in wide, Betamax ½ in wide, VCC ½ in wide and LVR. Each chapter is well referenced and bibliographed for further reading.

Introduction

The achievement of magnetic recording has a long history of arduous struggle, inspiration, deep theoretical analysis and lucky breaks. Its evolution has been motivated by war and economic gain. Its progress can be followed for over 70 years in three main continents of the world, Europe, America and Asia. Sometimes the major steps were as a result of theoretical research but more often the theory followed the practical demonstration. The development did not result from international co-operation but as a result of an international engineering requirement to store or record information. The milestones in this development can be seen in Denmark, United States of America, Germany, United Kingdom, Holland and Japan.

Evidence of experiments in magnetic recording exists as early as 1880 but the first practical demonstration was given by Valdemar Poulson in 1898 when he patented, in Denmark, the Telegraphone.[1] The device used a continuous steel wire as the recording medium and produced a noisy, distorted low output signal. This poor performance did not deter Poulson and a colleague Pederson from forming the American Telegraphone Company in 1903 and later, in 1906, they patented d.c. bias, which improved the distortion and increased the output although the signal/noise ratio was still poor.

Apart from developments in electronic amplification very little improvement was made until the late 1920's when two major advances on opposite sides of the Atlantic created the improvements which, although not fully exploited until after the war, led to high quality recording and playback as we understand it today:

1. Research work in the US Navy by Carlson and Carpenter culminated in the first patent for the use of a.c. bias.[2] This improved the distortion and the signal/noise ratio on existing wire recorders considerably.
2. In 1928, Pfleumer[3] patented a method of coating and using paper tape

covered with magnetic powder. This idea of a tape was to overcome several problems associated with wire recorders, in particular that of the wire twisting and the difficulty of coupling the flux from the wire to the pick-up head. With improvements in tape oxide[4] and the increased use of plastics instead of paper, magnetic tape consisting of ferric oxide on a plastic base was to provide the future magnetic recording medium exclusively for at least 40 years. In 1935 the AEG Company in Germany demonstrated the Magnetophone[5] at the German Annual Radio Fair. It was this recorder that laid down the basic principles that are in use up to the present day. Many improvements have been made but the layout and concept is almost identical with that of modern 1/4 in reel-to-reel recorders.

In parallel with plastic covered tape, the use of steel tape was developed in the United Kingdom by the Marconi company with the Marconi-Stille[6] and in Germany with the Blattnerphone.[7] Such devices were limited by the recording medium itself where large reels over 60 cm in diameter containing 3000 metres of tungsten-steel tape lasted a little over 30 minutes. During World War II Germany developed the plastic tape medium while the Allies concentrated on wire and steel tape. In 1946 it was obvious which had advanced the most.

Further improvements in tape and heads brought the tape speed on high quality audio recorders from 30 inches per second down to 7½, 3¾, and even 1⅞ i.p.s., giving satisfactory performance. Since 1947 recorders based on the Magnetophone design have been produced in almost every industrialised country of the world. Audio cassettes now provide a quality superior to any recording device known before World War II with a packing density that enables a man to store in his pocket more information than it would have been possible for him to lift using steel-tape as the recording medium.

In the early 1950's the need to record measurement signals used in medical, physical, mechanical and electronic research led to recorders of similar design to audio recorders but with a much higher frequency response, multi-track facilities and a tighter specification on tape speed. The response of such machines can now exceed 3MHz with speeds up to 120 i.p.s.

It was thought that the answer to video recording was an extension of this stationary head and fast tape speed principle and in 1954 RCA demonstrated a longitudinal track recorder[8] operating at a speed of 360 i.p.s. It did not have the full bandwidth capabilities and three main problems were evident:

1. The quantity of tape used and the size of the spools became intolerable for any reasonable length of recording.
2. It was difficult to control the tape speed, in particular fluctuations in tape speed, to within the limits required for a television signal. A time-base error of ± 1 microsecond can be severe on a television signal and this would require the tape to be in the correct position at the correct time to within one millionth of a second.
3. The bandwidth of a video signal is at least 18 octaves and the theoretical limit for any tape system is 10 octaves, irrespective of head-to-tape speed.