# THE DEVELOPMENT OF TELEMETRY SYSTEM IN CHINA

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## ABSTRACT

Telemetry as a research interest began to appear in the early days of this century. Since then it has gained great progress with its application fields growing all the time. This papper reviews briefly the history of telemetry introduces its state- of- the- art technology. The research activities and technological levels in this field inside China are included.

## KEY WORDS

Telemetry System, FDM TDM SDM

## INTRODUCTION

Telemetry in the United States began to evolve as a lochnology for research during World War II. The development of advanced aircraft technology and combat techniques proeuced the need for aradio telemetry. With peace, the research interests turned to jet aircraft. Now a widely used and important form telemtry is known as supervisory control and data acquisition system (SCADA). In China our group is devoted to telemetry for many years. We have learned a lot from advanced countries. In this paper, we look back the development of telemetry in the world at first. Then based on our research, we are going to introduce the development of telemetry in China.

## STATUS OF TELEMETRY IN THE WORLD

The telemetry systems all over the world have been developing drastically over these years. The European countries and the United States have established their own systems

respectively. In my opinion, the United States takes the lead in this field currently. So this paper focuses on the developments in US in recent 10 years, and the main points are as follows:

A. FDM--- an indispensible system brimming with full vigour.

Being the first-invented and first-utilized system, FDM has the advantage of flexibility and cost-effectiveness.

In 1944, the need arose for a four-chanel system to monitor performance of the Bumblebee experimental unmaned super-sonic ramjet. Princeton scientists used FM subcarrier for this job. Interestingly, they chose subcarrier center frequencies of 3.0, 3.9, 5. 4, and 7.35kHZ, with deviation of 7.5% on all subcarriers. These frequencies are our present IGIR PBW channels 8, 9, 10 and 11. They chose these frequencies to provide suitable guard bands between subcarriers; the deviation was chosen as the widest that could be handled with their subcarrier demodulators (discriminators).

The Applied Physics Laboratory at John Hopkins University was deeply invloved also in this telemetry system development; they were quite prominent in the first years of telemetry's evolution.

The newest development in FM is the "tunable digital multiplex discrimiantor", a device that replaces a bank of conventional discrimiantors, a tape speed reference discrimiantor, and a high-speed anolog multiplexer encoder.

Now, FDM covers about 20 percent of the entire market. The IRIG standard for telemetry, as revised in 1980, is IRIG 106-8. This document contains the use criteria for FDM which are as following:
DBW-25, CBW-A CBW-B, CBW-C.

The IRIG standard for telemetry, as revised in 1986, is IRIG 106-86. They are changed as follows PBW-25, CBW-A CBW-B, CBW-C, CBW-D, CBW-E, CBW-F, CBW-G. Still PBW is again updateded to PBW-27 in 1991, adding two channels whth central frequency of 690 Khz and 930 Khz respectively. All of these show that FDM is still occupying an important position with progress being made steadily.

B.PCM-- the main system with its dorminant role intensified.

At the present, 65 percent of the telemetry systems belongs to the category of PCM. With the integration of the computer technology, the new generation of telemetry computer systems is high under the way. It can be fairly safe to say that with the availability of faster computers and more sophisticated software, the performance of PCM will further be improved. To illustrate the tend, the following two figures are cited:

Responding to the need of higher data rates, manufacturers are offerring PCM ground stations at higher bits rates than ever before. The EMR 8300 series equipment from Fairchild Weston System Inc., for example, offers bit synchronibation to 33 megabits per second and end-to-end operation to 20 megabits per second.

The latest PCM ground station devices feature internal microprocessors, which enables the designer to offer command tranalation, self-diagnostics, and other featrues never before available.

C. Introduction of data randomizer and derandomizer

--There has always been a problem to deal with strings of 0's and l's in the data stream i. e. if there is a succession of 0's and 1 's, the bit synchronization will fail and therefore such case is not allowed. Fortunately, a new technique has been adopted to overcome this problem, the diagram of which is shown in Fig. 1.

D.The explicet proposition of idea "Success through telemetry"

Since telemetry has been incorporated into the field of armament (such as aeroplanes, missiles, satellites, etc) as well as communication, more and more people begin to feel that without the help of telemetry systems, there would not be any true success in most fields in the current society.

## STATUS OF TELEMETRY INSIDE CHINA

Before the open-to-the-outside-world policy was introduced, telemetry systems began to developed in China as early as

1958 independently. Now, with the efforts of all Chese researchers, the gap between the newest technology in th advanced countries and that in China has been reduced and further developments can be expected in the near future. In the descriptions below, the research activities at the author's lab are emphasized.

A. General status and history of teletry.

In 1958, the Chinese Acadamy of Sciences developed a 4 channel FM system, later a optical-electronical institute developed a 6 channel FM system. Still later, a mechanical institute made further improvements.

The research group at the Electronic Engineering Department of Electronic Engineering Department of Beijing University of Aeronautics &Astrnautics (BUAA) has been developing telemetry system all the time since early 1980s.

We have developed a series of laboratory prototypes in these years: 12 channel PBW FM system(l982), 23 channel PBW FM system (1984), PBW-24+CBW-B (1985), CBW-F, G (1986). Some of these models have been put into real use by several factories. Now we can fulfill all the use Criteria stated in the IRIG standare 106-86.

B. A major step forward in PCM technipue.

Being the main stream of telemetry system, our research group at BUAA have plunged a large part of our effort into the study of PCM Up to this year (1993) several key known-hows have been solved which include:

(l) Bit synchronizer

The telemetry bit synchronizer is typically a very flexible unit. It can accomodate a number of differing PCM codes, and can be optimized of performance in a variety of noise environments. In our lab, some synchronizer with bit rate ranging from 100bps to 4Mbps have been made. They are almost, if not absolutely, the best laboratory models in China.

(2) Frame synchronizer

The frame synchronizer adopts fixed stategy. It is baded upon separating the synchronization into three distinct operating modes: search, check and lock. Once minor frame synchronization is established, synchronization of subcommutate commutated can be accompished. Any PCM format with varying synchronization patterns can now be made up to 6.5Mbps, here in BUAA.

(3) PCM data simulator

A valuable addition to a telemetry system is a programmable simulator, which generate a PCM putput for system checkout. It is available also as one of the outputs to the bit synchronizer. Bit rates up to 10 Mbps are now realized by us.

(4) Data preprocesser

Telemetry data rates are increasing rapidly. The number of analysts per system is increasing, as are their data display requirements. Even though minicomputers are large and faster than ever before, they have not kept pace with the demands of telemetry users. In our expeiments, the DSP chip TMS320C25 is used to construct successfully a preprocessor with similar fuction of EMR 8571. Now, a 6.5M bps PCM telemetry system is available as a laboratory model.

C. The new telemtry system--SDM

Based on the traditional theory of orthogonal multiplex, the two telemetry systems FDM and TDM have long been advanced. Many people tend to think that they are the only two systems based on orthogonal functons. However, in 1980, we proposed a third one --aequency division multiples (SDM) based on Walsh frnctions which are also orthogonal and complite. In the paper the systim design measures taken to improve the accuracy and some new synchronization mathods we adopted were described. Since the choice of subcarriers is very important in designing a telemetry system, a table of recommended sequence values of the walsh functions for subcarriers of the telemetry system was presented.

Since the vebration signal in high frequency band is produced in many cases, it is necessary to build a system which can

measure this signal. The prequency response of each channel is 2000Hz. Since then, we continued to study SDM wystem and a new one basedon HAAR FUNCTION WAS INTRODUCED IN 1983. First, we discussed the way of buliding the Haar function generator. There are several ways to solve this problem.

Secondly, the mulivalue logic multiplier was described. The multiplier consists of three parts: operational amplifier, switching element and its control circuit.

Thirdly, according to the relationship between Haar waveforms and switching control wignal, we combined the multiplier with the generator as a whole which is called Haar function modulator.
The function of the mosulator is same as Haar function generator plus a number of multipliers, but the circuit of which is greatly simplified.

The experimental results showed that the new system is effective and as compared with Walsh system the Haar one seems to be a little better.

After years of research, we've discovered a new kind of orthogonal functions called Bridge funceions, Like a bridge (that's why it is so named), the Bridge functions have the every promise of being the basis for constructing another SDM system which was fulrilled and named as BAM- FM The Bridge funceions have the every promise of being the bases for constructingan entirely new kind of telenetry system, which has been named as sequency division multiplexing.

Since the Bridge functions are the mathematical basis of the new telemetry system, we will give a summary of the Bridge functions at first. We have successfully constructed an experimental prototype called BAM-FM system in our laboratory. The main ideas, block diagram, operational principles, and technical problens are discussed in the paper. All our work has proved that SDM has not only reserach interests, but also practical value.

## CONCLUSION

In all telemetry systems both inside and outside China have been well advanced in these years. Surely, they will play a much more important role in the future developments.

## RERERENCES


1. Zhang Qishan and Liu Zhongkan: Telenetry System Based on Walsh Functions ITC Proceedings Vol. XVI, 1980
2. Zhang Qishan and Zhang Minggrui: A Sepuency Division Multiplex System INC Proceedings, Vol. VXII, 1981
3. Ju Feng and Zhang Qishan : A Telemetry System Using Walsh Funct ions with Improvements in Accuracy ITC Proceedings Vol. XVIII 1982
4. Zhang Qishan and Li zhihua: A New Orthogonal Multiplex System ITC Proceedings, Vol. XVIII, 1982
5. Zhang Qishan and Li Zhihui:Copy Theory and Several Problems on Walsh Functions Proc. 1983, IEEE. Int. Symp. Electromagn. Compat.
6. Zhang Qishan and Zhang Wenguan: A Telemetry System Based on Haar Functions EMC Symposium 1983
7. Li Zhihua and ZHang Qishan: Introduction to Bridge Functions IEEE. EMC-25 No. 4, November, 1983
8. Li Zhihui and Zhang Qishan: Ordering of Walsh functios IEEE. Trans. On Eledtromagnetid, Compatibi1ity, Vol EMC-25, No. 2 May 1983
9. Shen Shituan Zhang Qishan : The Development of Haar Telemetry System ITC Prceedings Vol. XXI. 1985
10. Zhang Qishan: The Bridge Function Telemetry System ITC Proceedings Vol. XXVII.
11. Zhang Qishan: The Development and Tendency of Modern Telemetry Technology. ICAS- 92 proceedings