

1708179

by Thomas Wood

FILE	15329_THOMAS_WOOD_1708179_177752_1303423498.DOCX (728.37K)		
TIME SUBMITTED	02-MAY-2020 11:09AM (UTC+0100)	WORD COUNT	2809
SUBMISSION ID	125925303	CHARACTER COUNT	14803

Course: HND Electrical and Electronic Engineering

Module: SGEE5005 Signals and Digital Comms

Assignment: Digital Communication

Name: Thomas Oliver Wood

University number: 1708179

Date submitted: 02/05/2020

Word count: 2289

Contents

1. Executive Summary.....	4
2. Research into digital communication systems and techniques (2000)	5
2.1 The essential components of a digital communication system	5
2.1.1 Sources	5
2.1.2 Input Transducers	5
2.1.3 Transmitter	5
2.1.4 Communication Channel.....	6
2.1.5 Receiver.....	6
2.1.6 Output Transducer	6
2.2 An evaluation of methods of error checking and error correction.....	7
2.2.1 Parity	7
2.2.2 CRC	7
2.2.3 CSMA/CD	8
2.3 The origins of the UK Telephone Network.....	10
2.4 The development of Synchronous Digital Hierarchy (SDH)	11
2.5 A comparison of SDH frame composition and data rates.....	12
3. Conclusions	14
4. Reference list and bibliography	15
5. Annexe for diagrams, data sheets, results tables etc	16

Figure Table

Figure 1 - Digital Communication System (Li, n.d.)	5
Figure 2 - Parity-bit added to existing byte data	7
Figure 3 - CRC Error Detection (Anon., n.d.)	8
Figure 4 - CSMA/CD (Middleton, 2016)	9
Figure 5 - PDH	10
Figure 6 - SDH Bit Rate	11
Figure 7 - SDH Frame Structure	12
 Table 1 - Frame Structures.....	 13

1. Executive Summary

This report includes extensive research tasks that concentrate on the digital transmission of data. This includes the most important components that are required within a digital communications system, methods of error detection within transmitted data and extensive research into SDH and PDH.

The history of the UK's telecommunication system has been researched and certain interesting developments have been commented upon.

This report is a non-bias report that allows for conclusions to be drawn from the research only. This therefore makes the conclusions drawn more interesting as some may not be true but it shows how certain theories can be perceived.

Y
o
u
n
e
e
d
to
c
o
v
er
al
l
s
e

ct
io
n
s
a
n
d
gi
v
e
a
n
o
v
er
vi
e
w
of
th
e
e
nt

2. Research into digital communication systems and techniques (2000)

2.1 The essential components of a digital communication system

In order for digital communication to take place an array of different components are used within a methodical order. The most basic digital communication system must include the following essential components (Figure 1);

- Sources
- Input Transducers
- Transmitter
- Communication Channel
- Receiver
- Output Transducer

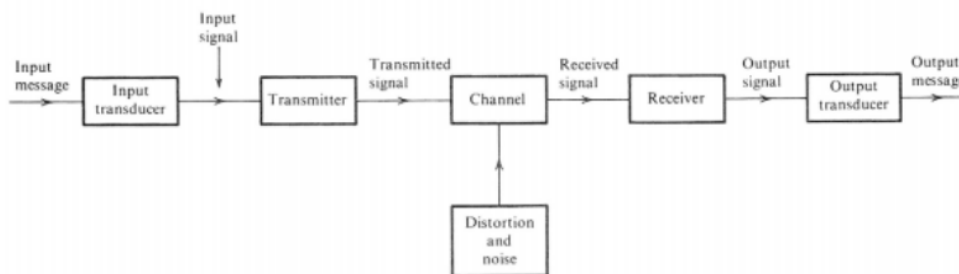


Figure 1 - Digital Communication System (Li, n.d.)

2.1.1 Sources

The source is the input signal to the system. There is a substantial amount of different sources both electric and non-electric, an example of a few possible sources are, Audio Files (such as MP3), Human Voice and Emails.

2.1.2 Input Transducers

“The source is converted by an input transducer into an electrical waveform referred to as the baseband signal or message signal.” (Li, n.d.). As Li states the source is converted by an input transducer; without this process non-electric signals could not be transmitted over great distance. Input transducers themselves are more commonly referred to as sensors and include microphone, camera and keyboard.

2.1.3 Transmitter

Once the baseband signal has been produced efficient transmission of the signal must be achieved. In order to prepare the signal accordingly a transmitter is used. The transmitter itself is a circuit of components (listed); noise filter, ADC, encoder, modulator and signal amplifier. Each of these components assist in improving the efficiency of the transmission.

2.1.4 Communication Channel

“The channel is a medium through which the transmitter output is sent” (Li, n.d.), Li explains that the channel isn’t like a TV channel but instead the medium of the transmitted signal. This medium is most often a coaxial cable or optical fibre. This medium is regarded as guided as the cable is fixed between the transmitter and the receiver. The medium can also be unguided and this is true within radio transmission, within RF transmission the medium is the air and therefore there is no physical link between the transmitter and the receiver.

2.1.5 Receiver

Once the signal has been transmitted, the receiver (in theory) does the polar opposite to the transmitter in order to re-gain the original baseband signal developed from the input transducer. The receiver itself is a circuit built from the following components; noise filter, DAC, decoder, demodulator and signal amplifier.

2.1.6 Output Transducer

The output transducer is simply an output device that is used to represent the input signal. It can either convert the digital data back into the analogue input (if applicable), or the digital conversion can be used to represent the input. Examples of output transducer are; speakers, computer screens and lighting.

2.2 An evaluation of methods of error checking and error correction

Error checking and correction is the process in which the reliability of retrieved data is ensured. Kay explains this in easily; “we need to know that what arrives on the other end is identical to what we sent.” (Kay, n.d.). Therefore methods are used in order to detect any potential error between the sent data and the received data and correction methods then would simultaneously to correct any errors found. There are several of these methods that are discussed below.

2.2.1 Parity

Currently the best known developed method of error detection is parity. This method utilises an extra bit; this extra bit is added to every existing byte of data and is either assigned a value of 1 or 0 (Figure 2). The receiver analyses each bit, locates the parity bit's and then ensures they are in the state they were assigned. If there is a change in the state of the parity bit then it is known that at least one byte has changed.

The value of the parity bit depend on whether the method of; even parity or odd parity is chosen. In even parity an even amount of ones would assign the parity bit 0 (as seen within left hand byte of Figure 2), however within odd parity the very same principle is reversed and therefore an even amount of ones assigns the parity 1 (seen within the right hand byte of Figure 2).

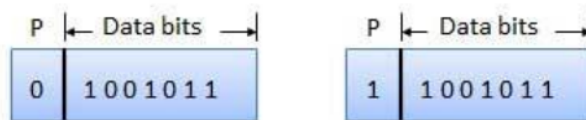


Figure 2 - Parity-bit added to existing byte data

The receiver can then detect errors by using the above theory to see if any data bytes have become corrupted.

2.2.2 CRC

Cyclic Redundancy Check or CRC, is an error detection technique “widely used in digital networks, such as LANs and WANs, as well as in some storage devices.” (Grami, 2015). This technique is simple to implement and is most useful in detecting packet errors. This technique works through the use of a divisor; this divisor is a pre-determined binary number that is exactly divisible for the data unit. Therefore, after transmission the receiver will divide the data unit received by the divisor included and if no error has taken place the remainder will be 0. Anything other than a remainder of 0 and the data has become corrupt and therefore should not be accepted.

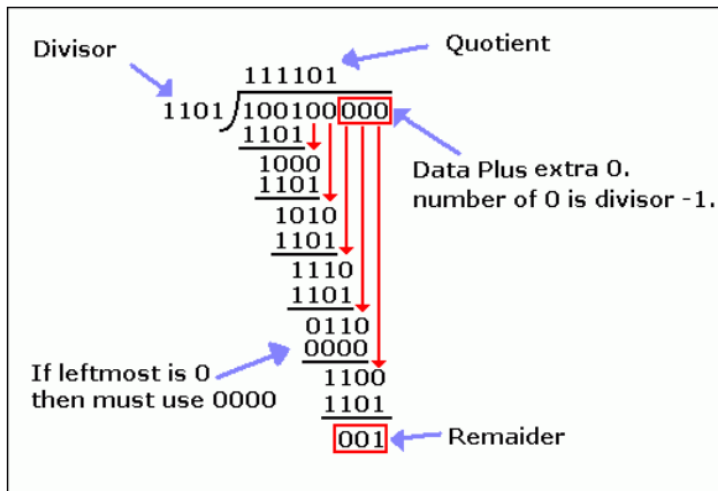


Figure 3 - CRC Error Detection (Anon., n.d.)

A visual representation of how the CRC method works can be seen within Figure 3. It can be seen that first of all the sent data has had additional 0's appended to it, the amount of 0's added is determined by the size of the divisor; the number of 0's appended is always one less than the size of the divisor. Simple binary division is then utilised to give the remainder. It should also be noted that if the data's leftmost figure is 0 then a divisor of 0000 is to be used. This particular example shows corrupted data being received this is known as the remainder is not 0.

2.2.3 CSMA/CD

CSMA/CD or Carrier Sense Multiple Access/Collision Detection (Figure 4) is a protocol that is utilised within networks that are exchanging data, most commonly these networks utilise Ethernet. In simple terms this protocol attempts to prevent collisions of data. With this protocol every device upon the network is given the same priority for sending signals therefore no devices have priority (this is Multiple Access). "Carrier sense describes how an Ethernet interface on a network device listens to the cable before transmitting." (Orebaugh, 2004), Orebaugh explains that before transmitting a signal a network interface will listen for signals upon the cable to ensure no other devices are currently transmitting. If no signal is heard the data can be transmitted however the interface continues to listen to ensure no other device attempts to transmit as well. This process ultimately will prevent possible collisions of data.

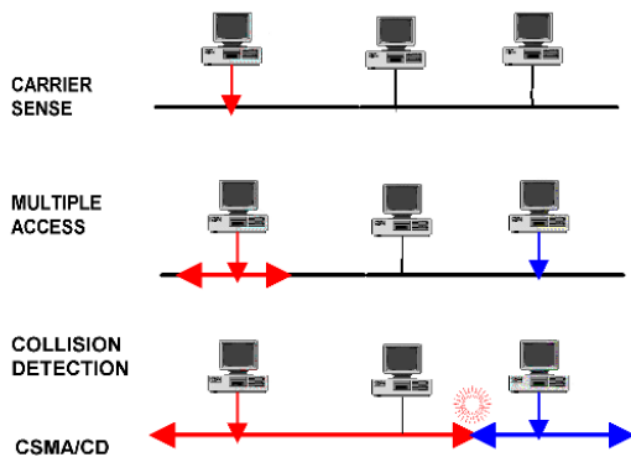


Figure 4 - CSMA/CD (Middleton, 2016)

However, if a collision does occur this can be detected by the Ethernet interface, a “special jamming signal” (Chen, 2004) is sent to every device upon the network. The transmitting device will then wait a random amount of time before re-transmitting the data. This process is commonly known as random backoff. Through the implementation of CSMA/CD a networks performance can be enhanced by increasing the interfaces from half-duplex mode to full-duplex.

2.3 The origins of the UK Telephone Network

The first demonstration of long-distance telephony within the UK was seen within 1878. This was between the inventor of the telephone (Alexander Graham Bell) and Queen Victoria. This network consisted of one single earth return wire from London to Southampton. However, it wasn't until 1890 before the growth of the telephone network. This first network consisted of around 12,000 telegraph offices and were all linked through the use of iron or steel wire overheads. However, in 1892 the material of the wire was upgraded to copper due to the process of hard drawn copper being used.

In the 1960's a "UK Trunk Task Force (UKTTF)" (Ward, 2006), underwent the modelling of the future network system; it was concluded that in order to improve efficiency and lower cost the implementation of digital transmission and switching would be required. Following these findings by 1980 the coaxial UK network system had begun to take shape. It was decided by BT that the existing line code being used was no longer suitable for the coaxial cable and therefore upgraded to 6B4T, the carrier cable network comprised of two cables one for both directions of transmission.

Each cable comprised of 24 pairs, and hence there were 24 channels multiplexed at predominately 64 kHz. This was the introduction of PDH, and therefore the digitalisation of the pre-existing analogue transmission network. PDH makes use of multiplexers and de-multiplexers in order to increase the swiftness of transmission of data (Figure 5). By using multiplexers large amounts of data is combined into one and therefore reduces the traffic.

PDH Levels and Bit Rates			
Carrier level	North America	Europe	Japan
Voice/data channel	64 kbps (DS0)	64 kbps (E0)	64 kbps
First level	1.544 Mbps (DS1) 24 channels	2.048 Mbps (E1) 32 channels	1.544 Mbps 24 channels
Intermediate level	3.152 Mbps (DS1C) 48 channels	N/A	N/A
Second level	6.312 Mbps (DS2) 96 channels	8.448 Mbps (E2) 128 channels	6.312 Mbps 96 channels or 7.786 Mbps 120 channels
Third level	44.736 Mbps (DS3) 672 channels	34.368 Mbps (E3) 512 channels	32.064 Mbps 480 channels
Fourth level	274.176 Mbps (DS4) 4032 channels	139.264 Mbps (E4) 2048 channels	97.728 Mbps 1440 channels
Fifth level	400.352 Mbps (DS5) 5760 channels	565.148 Mbps (E5) 8192 channels	565.148 Mbps 8192 channels

Figure 5 - PDH

2.4 The development of Synchronous Digital Hierarchy (SDH)

Since the discovery of SDH the overall performance of telecommunications has been revolutionized, in addition to the performance the cost has also been reduced with the introduction of optical fibers. As demand from network providers and their customers began repeatedly grow there was the need to find a solution that provided a more “sophisticated service that would allow larger bandwidth, better performance monitoring facilities and greater network flexibility” (Consortium, 1994).

This demand sparked the creation of new standards that would allow for a one single-world multiplexing standard to be formed. It was noted that the solution should be synchronous and based upon byte interleaving. By doing this the switching capabilities are very flexible both above and below the primary bit rates. Ultimately these requirements were realised from the development of SDH.

SDH functions through the use of multiplexers, within the multiplexing process “payloads are layered into lower-order and higher order virtual containers” (Consortium, 1994) each of these VC’s have a range of overhead functions equipped that allow for management and error monitoring. Again this shows the service-base network that SDH provides. The basic operation of SDH is to transmit a light signal using LED’s upon a fiber optic cable.

The eventual standardised bit rates for SDH can be seen within Figure 6. SDH is based upon multiples of 155.520 Mbit/s.

Synchronous Hierarchy, SDH		
SDH	Digital Bit Rate	SDH Capacity
STM-0	51.840 Mb/s	21 E1s
STM-1	155.520 Mb/s	63 E1s or 1 E4
STM-4	622.080 Mb/s	252 E1s or 4 E4s
STM-16	2488.320 Mb/s (2.5 Gb/s)	1008 E1s or 16 E4s
STM-64	9953.280Mb/s(9.953 Gb/s)	4032 E1s or 64 E4s

Figure 6 - SDH Bit Rate

The basic units of SDH is STM (Synchronous Transport Module), it is known that SDH is synchronous as the higher rate is always an exact multiple of the lower rate.

2.5 A comparison of SDH frame composition and data rates

The transmission format of SDH is known to be STM, with the most common being STM-1. The data is transported as frames; these frames are constructed into 9 rows and 270 columns. These frames are known as a STM frame. The first 9 columns of the frame is for the “sectional overhead and pointer” (Tambe, 2011). This is known as the overhead of the frame.

This leaves a further 261 columns (270-9=261) that consist of actual data. This actual data is held by VC's or virtual containers. This is known as the payload of the frame. The frame structure can be seen within Figure 7.

RSOH and MSOH are the overheads of the frame and stand for; RSOH regenerator section overhead and MSOH multiplex section overhead.

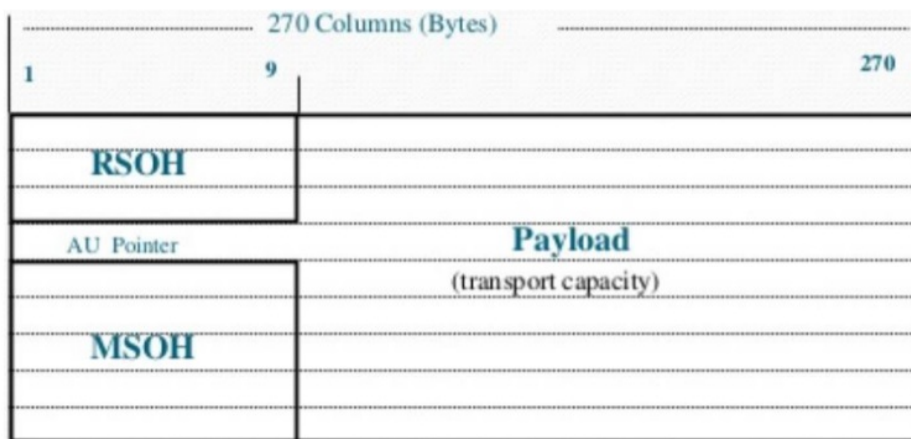


Figure 7 - SDH Frame Structure

The frame is transmitted row by row which means that 270 columns are transmitted at a time. This is shown below;

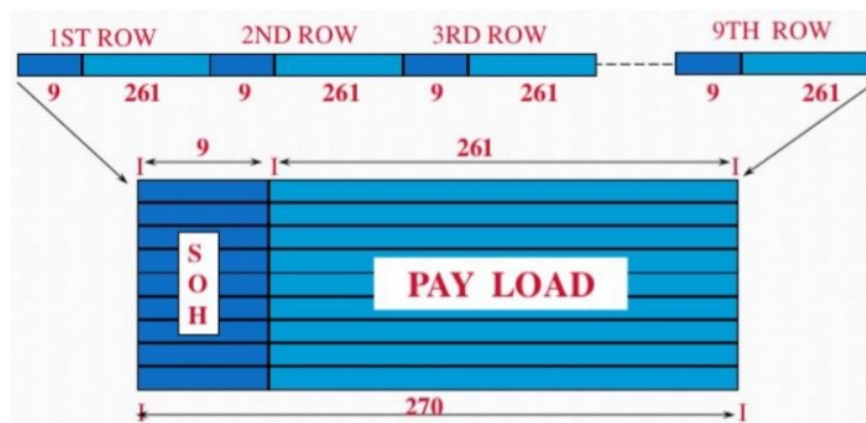


Figure 6 shows the bit rates of SDH at different STM. Due to the hierarchy being synchronous it can be concluded that the bit rate of STM-N = N x 155.520 Mbit/s. This equation is proven below;

Columns within frame = 270

Bytes = 9 x 270 = 2,430

Bits = 8 x 2,430 = 19,440

Bits/s = 19,440 x 8,000 = 155,520,000 or 155.520 Mbit/s

This bit rate is STM-1.

As commented upon earlier SDH is synchronous therefore it can be concluded that the frame structure for STM-2 has the same proportion as STM-1 however the total bits is 4 times the amount. Therefore, the frame composition of STM-2 would have an overhead of 36 columns and a pay load 1044. This process is further proven in the table developed within Table 1,

SDH	Overhead	Payload	Total Columns	Number of Bytes	Number of Bits	Bit Rate (Bit/s)
STM-1	9	261	270	2430	19440	155520000
STM-4	36	1044	1080	9720	77760	622080000
STM-16	144	4176	4320	38880	311040	2488320000
STM-64	576	16704	17280	155520	1244160	9953280000

Table 1 - Frame Structures

3. Conclusions

In conclusion although this report was to conduct research into digital communication systems the most frequent finding from research was that digital communication systems are far more efficient than analogue communication systems, this is due to the speed and large amount of data that can be transmitted within digital systems.

Within 2.1 research into the key components within a digital communications system was carried out. it was found that there were only 6 key components, however some of these were circuits made up of even more components. In all it was surprising how simple the system seems from the components needed.

Section 2.2 sees research carried out into certain error detection. Even after a small amount of research it was clear that parity bit was the most common form of error detection, this is due to its simplicity not its performance. This is concluded because although parity bit is good at detecting errors actually pinpointing the error within the data is where it struggles compared to other error detection methods such as CRC.

Section 2.3 caused the most research within the report, this was due to a lot of different sources completely contradicting each other's dates for certain developments of the UK telecommunication system. Therefore, it was decided that only the dates that were frequently mentioned within different sources will be commented upon. In conclusion these dates clearly show the digital breakthrough within the 1980's to be the most important breakthrough since the invention of the telephone.

In conclusion the understanding of SDH has been furthered within sections 2.4 and 2.5. This is concluded as the bit rates and frame structure for the transmission of SDH have been investigated and understood. Furthermore, the history of the creation and implementation of SDH has been researched. Ultimately it has been understood that although PDH is known as the major breakthrough in digital telecommunications, SDH certainly can be concluded to be a major breakthrough itself. A contributing factor to this conclusion is the fact that SDH has been adopted globally and therefore the communications globally will become far more efficient. 2.5 A comparison of SDH frame composition and data rates

Ultimately this report has allowed for a lot of interesting research and has identified how complicated the telecommunications system within the UK has been over past years.

4. Reference list and bibliography

Anon., n.d. *Tripod*. [Online]

Available at: <http://t4planet.tripod.com/cyclicredundancycheck.htm>

[Accessed 18 April 2020].

Chen, W.-K., 2004. *The Electrical Engineering Handbook*. s.l.:Academic Press.

Consortium, T. I. E., 1994. *Columbia EDU*. [Online]

Available at: http://www.ee.columbia.edu/~bbathula/courses/HPCN/chap04_part-2.pdf

[Accessed 24 April 2020].

Grami, A., 2015. *Digital Communications*. 1st ed. s.l.:Elsevier India.

Kay, R., n.d. *Computer World*. [Online]

Available at: <https://www.computerworld.com/article/2568133/error-checking-and-correction.html>

[Accessed 8 April 2020].

Li, T., n.d. [Online]

Available at: <https://www.egr.msu.edu/~tongli/teaching/ece865/Introduction>

[Accessed 8 April 2020].

Middleton, A., 2016. *Wordpress*. [Online]

Available at: <https://asmiddleton.wordpress.com/2016/03/06/protocols/>

[Accessed 24 April 2020].

Orebaugh, A., 2004. *Ethereal Packet Sniffing*. s.l.:Syngress.

Tambe, S. R., 2011. [Online]

Available at: <https://www.slideshare.net/SamadhanTambe/sdh-frame-structure>

[Accessed 24 April 2020].

Ward, K., 2006. *The itp*. [Online]

Available at: https://www.theitp.org/knowledge_hub/historic/Short_History

[Accessed 24 April 2020].

5. Annexe for diagrams, data sheets, results tables etc

FINAL GRADE

GENERAL COMMENTS

Instructor

62/100

PAGE 1

PAGE 2

PAGE 3

PAGE 4

Text Comment. You need to cover all sections and give an overview of the entire report.

PAGE 5

PAGE 6

PAGE 7

PAGE 8

PAGE 9

PAGE 10

PAGE 11

PAGE 12

PAGE 13

PAGE 14

PAGE 15

PAGE 16

THOMAS WOOD**0****RESEARCH-INFORMED LITERATURE**

There was very good evidence of further reading and research from credible and reliable sources. Your interpretation and understanding of the additional research was good and demonstrated a very good underlying appreciation of the subject. Your references were appropriate to the task and applied with few errors or inconsistencies. Your reference list was of an appropriate length for this assignment.

14/20**KNOWLEDGE AND UNDERSTANDING**

The knowledge and understanding of the subject demonstrated by this assignment was reasonably extensive. There were very few gaps in your knowledge of the basic principles and your understanding of the higher level concepts was demonstrated to a limited degree. You have demonstrated some critical understanding of the main concepts and expanded your knowledge beyond that contained in the course notes, however your explanations need to be more detailed and written with a greater emphasis on critical evaluation rather than description.

20/40

ANALYSIS



Your analysis of the task was generally very good, both in class and as shown in this assignment. You have demonstrated sound critical analysis skills and your approach to the task was logical. You carried out a detailed evaluation of the results and included a good conclusion relating the practical results to researched theory. The conclusions demonstrated very good cognitive skills and the ability to interpret quantitative and qualitative data without error.

20/30

PRACTICAL APPLICATION AND DEP.



N/A

SKILLS FOR PROFESSIONAL PRAC.



In this assignment you have demonstrated skills in working individually and also collaboratively. Your written report was written in a professional and confident style, however you still need to be more efficient with your word count. The report was very well presented, with excellent diagrams in appropriate places, good sentence/paragraph structure and clear calculations.

8/10