數位視訊傳輸技術

Digital Transmission for Speech & Video

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Reference:

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[2] Bernard Sklar, ***Digital Communication fundamentals and Applications***, 2^{nd} ed., Prentice Hall, 2001.

[3] Simon Haykin, ***Communication Systems***, 4^{th} ed., John Wiley & Sons, 2001

[4] John G. Proakis and Masoud Salehi, ***Contemporary Communication Systems using Matlab***, Brooks/Cole, 2000.

[5] Stephen G. Wilson, ***Digital Modulation and Coding***, Prentice Hall, 1996.

Overview of Digital Transmission

What is Digital Transmission for?

1. Source: a sequence of real valued samples as its message such as voice, imagine.
2. Channel: a physical mechanism that accepts an input signal and produces an output signal.
3. Modulation technology
4. Coding technology

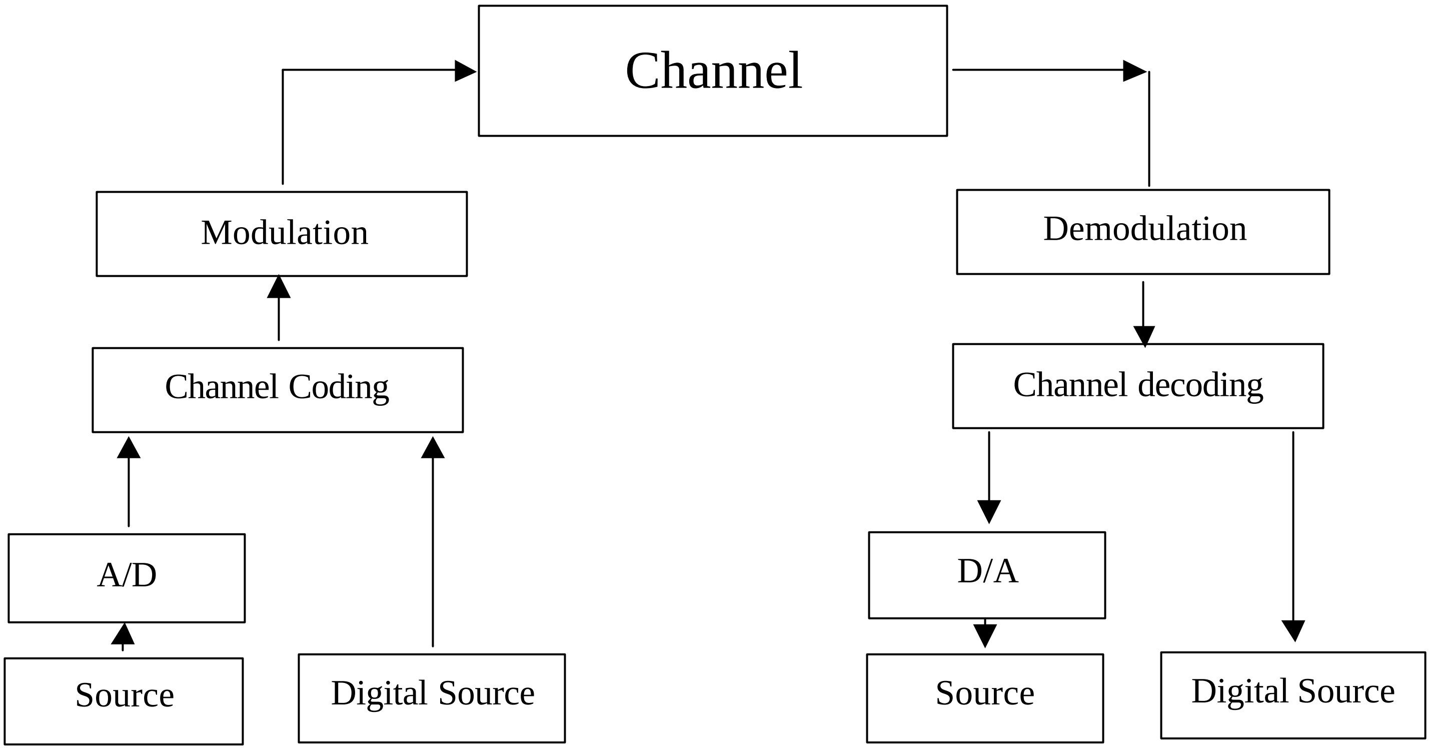

Fig. 1 Digital Transmission Pathway

Channel:

1 voice channel	64Kbps
T1 (24 v.c.)	1.544 Mbps
T2 (4 T1)	6.312 Mbps
T3 (7 T2)	44.74 Mbps
Optical Fiber	1.2, 1.7, 2.3 Gbps
Free space	

Citizens Band radio service(CB) :

CH	MHz(AM)	CH	MHz(AM)	CH	MHz(AM)	CH	MHz(AM)
1	26.965	11	27.085	21	27.215	31	27.315
2	26.975	12	27.105	22	27.225	32	27.325
3	26.985	13	27.115	23	27.235	33	27.335
4	27.005	14	27.125	24	27.245	34	27.345
5	27.015	15	27.135	25	27.255	35	27.355
6	27.025	16	27.155	26	27.265	36	27.365
7	27.035	17	27.165	27	27.275	37	27.375
8	27.055	18	27.175	28	27.285	38	27.385
9	27.065	19	27.185	29	27.295	39	27.395
10	27.075	20	27.205	30	27.305	40	27.405

Frequency Spectrum:

Name	Frequency	Function
VLF (Very Low Frequency)	3-30Khz	Navigation,Sonar **航海,航空,聲納**
LF (Low Frequency)	30-300Khz	Radio Bacons,Navigation **電報,航海,航空**
MF (Medium Frequency)	300-3000Khz	AM Radio,Coast Guard **調幅收音機,海洋守衛**
HF (High Frequency)	3-30Mhz	Telegraph **電訊,電報機**
VHF (Very High Frequency)	30-300Mhz	TV,FM Radio,Paging **電視,調頻收音機,呼叫器**
UHF (Ultra High Frequency)	300-3000Mhz	AMPS(800),GSM(900,1800,1900) Aviation(960),Satellite **行動電話,航空飛行器,衛星**
SHF (Super High Frequency)	3-30Ghz	Rader,Satellite **雷達,衛星**
EHF (Extreme High Frequency)	30-300Ghz	Satellite,Areospace **衛星,宇宙航空**

Cable TV Channel Assignment:

CH	Video CH	Audio CH	CH	Video CH	Audio CH
1	73.250	77.750	16	133.250	137.750
2	55.250	59.750	17	139.250	143.750
3	61.250	65.750	18	145.250	149.750
4	77.250	71.750	19	151.250	155.750
5	77.250	81.750	20	157.250	161.750
6	83.250	87.750	21	163.250	167.750
7	175.250	179.750	22	169.250	173.750
8	181.250	185.750	23	217.250	221.750
9	187.250	191.750	24	223.250	227.750
10	193.250	197.750	25	229.250	233.750
11	199.250	203.750	26	235.250	239.750
12	205.250	209.750	27	241.250	245.750
13	211.250	215.750	28	247.250	251.750
14	121.250	125.750	29	253.250	257.750
15	127.250	131.750	30	259.250	263.750

第三代行動通信業務各執照所使用頻率之頻寬及頻段如下：

一、執照A：2 x 15MHz(1920~1935MHz;2110~2125MHz) + 5MHz(1915~1920MHz)

二、執照B：2 x 10MHz(1935~1945MHz;2125~2135MHz) + 5MHz(2010~2015MHz)

三、執照C：2 x 15MHz(1945~1960MHz;2135~2150MHz) + 5MHz(2015~2020MHz)

四、執照D：2 x 15MHz(1960~1975MHz;2150~2165MHz) + 5MHz(2020~2025MHz)

五、執照E：2 x 20MHz(825~845MHz;870~890MHz)

Bandwidth :

voice (Analog)	4K Hz
Music (AM)	10K Hz
Music (FM)	200K Hz
TV	6M Hz
CATV	20M Hz
HDTV	1G bps
Compressed HDTV	20M bps

Baseband Transmission

Waveform representation:

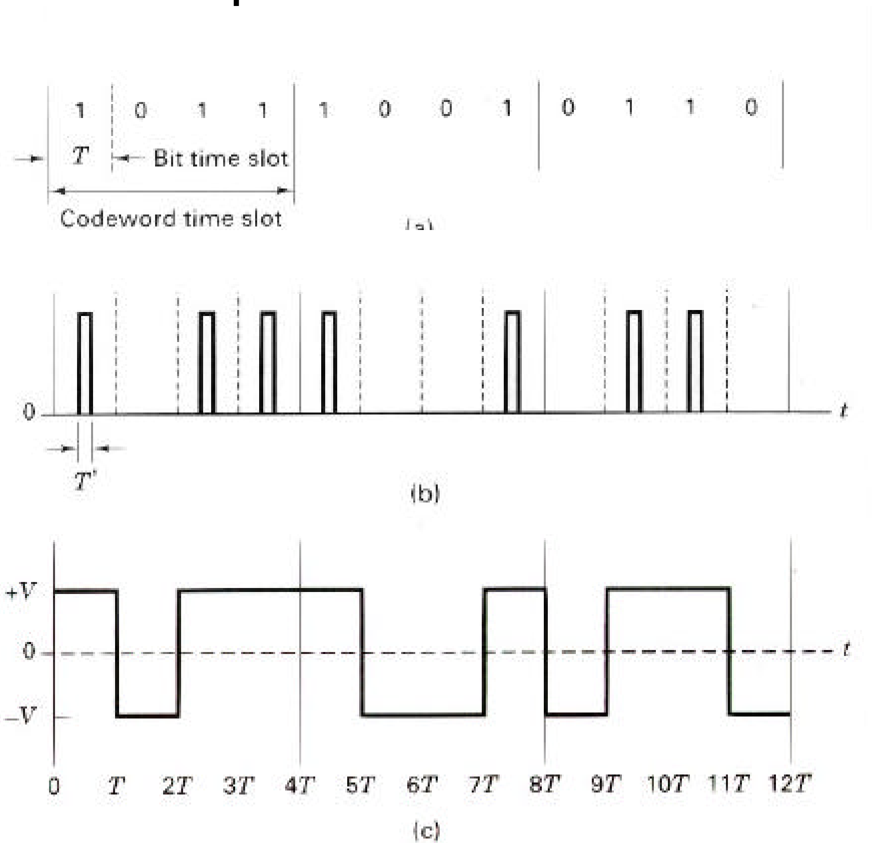

Fig. 1 PCM Sequence , representation and Transmission wave

Various PCM waveforms:

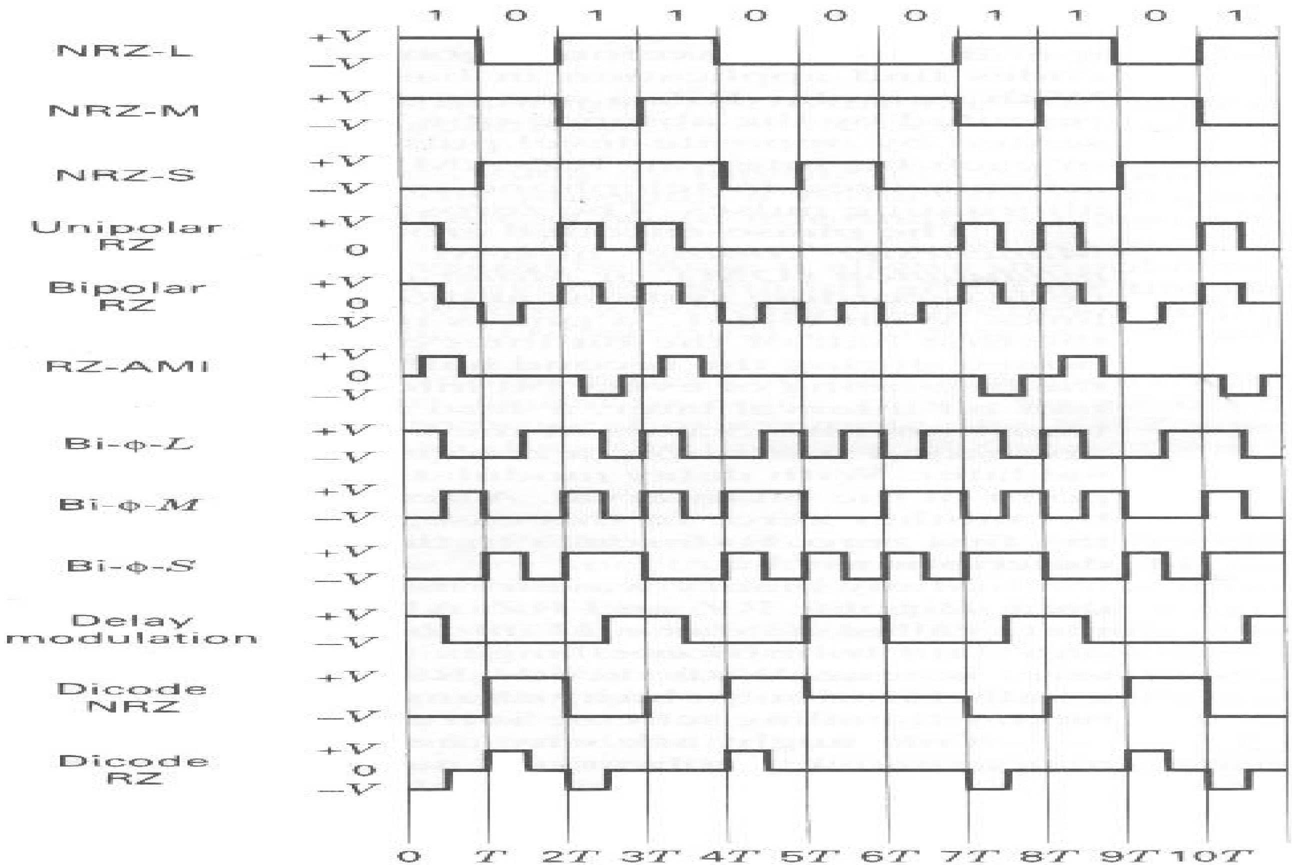

Fig. 2 Various PCM waveforms

Pulse Code Modulation (PCM)

PCM: A message signal is represented by a sequence of coded pulse which is accomplished by representing the signal in discrete form in both time and amplitude. The procedure is sampling, quantizing and encoding as

Fig. 3 PCM System

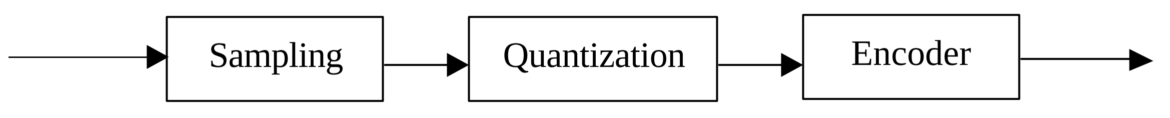

Fig. 4 A/D Converter

Regeneration: The most important feature of PCM systems leis in the ability to control the effects of distortion and noise through the channel. Three basic functions are performed by regenerative repeater: equalization, timing and decision making.

The equalizer shapes the received pulse so as to compensate for the un-perfect channel.

The timing circuitry provides a periodic pulse train for sampling the qualized pulses at the instants of time where the S/N is max.

The decision maker is that the sample so extracted is compared to a predetermined threshold in the device.

Ideally, except the delay, the regenerated signal is exactly the same as the signal originally transmitted. In fact, the regenerated signal differs from the original one for two reasons:

1. Channel noise (bit errors)

2. Jitter, Quantization error.

PCM System Example:

T1 System: T1 system carries 24 voice channels over separate pairs of wires with regenerative repeaters spaced at approximately 2Km interval. Voice channel is limited to a band from 300 to 3100 Hz. With bandwidth W=3.1 KHz, the nominal value of Nyquist rate is 6.2 KHz. The filtered voice signal is usually at a slightly higher, at 8KHz. (Standard sampling rate in telephone system)

There are a total 255 representation levels for voice samples. Hence, each voice channel uses a binary code with an 8-bit words

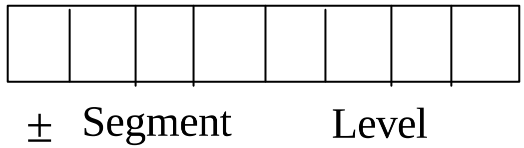

Fig. Voice data word

With a sampling rate of 8KHz, each frame occupies a period 125 μsec. In particular, it consists of 24 8-bit words plus a signal bit that is added at the end of the frame for synchronization. Hence, each frame consists of a total of (24x8)+1=193 bits. Hence, the duration of each bit equals 0.647 μsec, I.e. the transmission rate is 1.544M bits/sec.

Delta Modulation:

Delta modulation provides a staircase approximation to the oversampled version of message signal as

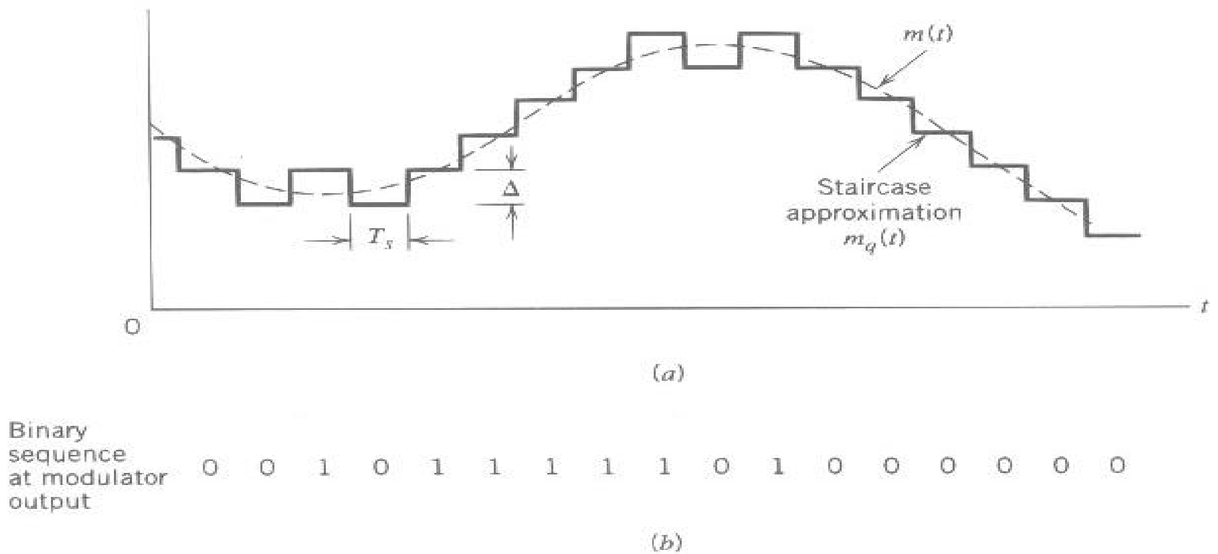

Fig. 5 Delta modulation

The difference between the input and the approximation is quantized into only two level, ±Δ corresponding to positive and negative differences, respectively.

Denoting the input signal as *m(t)*, and its staircase approximation as $m_q(t)$. Then,

$$e(nT_s) = m(nT_s) - m_q(nT_s - T_s)$$

$$e_q(nT_s) = \Delta \cdot \text{sgn}[e(nT_s)]$$

$$m_q(nT_s) = m_q(nT_s - T_s) + e_q(nT_s)$$

where T_s is the sampling period,

$e(nT_s)$ is the error signal representing the difference between the present sample value $m(nT_s)$ of the input signal and the latest approximation.

$e_q(nT_s)$ is the quantized version of $e(nT_s)$.

The quantizer output $e_q(nT_s)$ is finally coded to produce the desired Delta modulation signal.

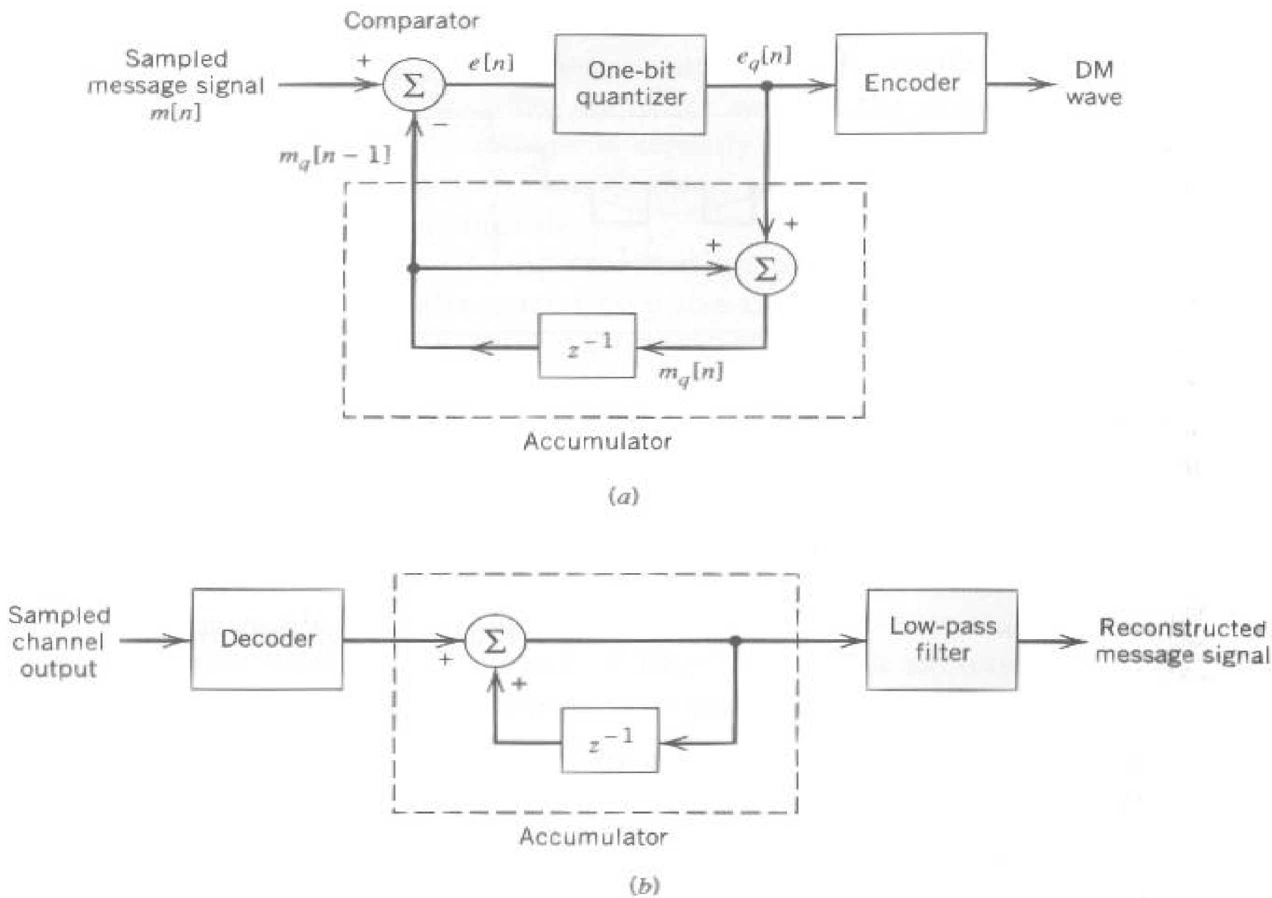

Fig. 6 DM Transmitter and Receiver

The quantizer output is then applied to an accumulator, producing the result

$$m_q(nT_s) = \Delta \cdot \sum_{i=1}^{n} \mathrm{sgn}[e(iT_s)]$$
$$= \sum_{i=1}^{n} e_q(iT_s)$$

The accumulator increments and approximation by a step Δ in a positive or negative direction, depending on the algebraic sign of the error signal $e(nT_s)$.

If $m(nT_s)>m_q(nT_s-T_s)$, + Δ is applied to the approximation. Or, if $m(nT_s)<m_q(nT_s-T_s)$, - Δ is applied to the approximation.

Delta modulation is subject to two types of quantization error:

1. Slope overload distortion: slope of m(t) is too large
2. Granular noise: step-size is too large.

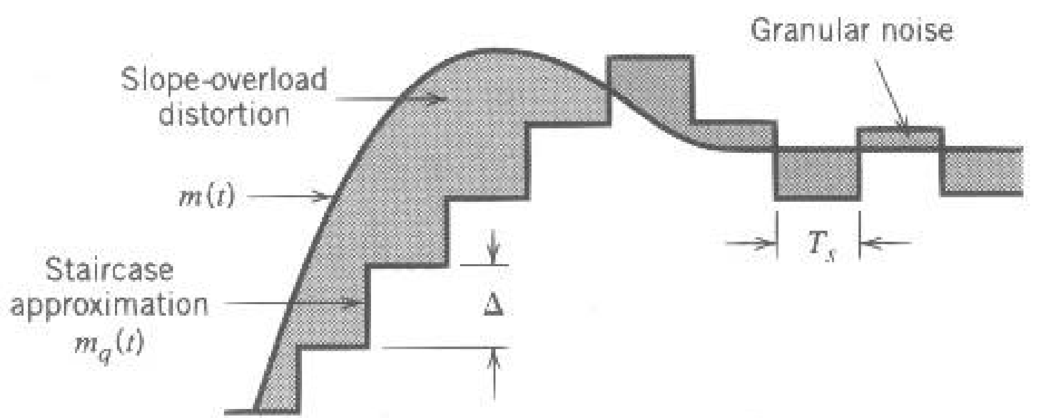

Fig. 7 Quantization error in DM

To avoid the slope overload distortion, the condition

$$\frac{\Delta}{T_s} \geq \max\left|\frac{dm(t)}{dt}\right|$$

should be satisfied. If the step-size Δ is too small, the $m_q(t)$ will falls behind $m(t)$.

Thus, the Delta Modulation needs to have a large step-size to accommodate a wide dynamic range, whereas a small step-size is required for the accurate representation of relatively low-level signal.

Differential Pulse Code Modulation

In particular, if we know the past behavior of the signal up to a certain point in time, it is possible to make some inference about its future value, such a process is called prediction. To predict the future value of the signal m(t) based on the set $\{m(nT_s)\}$, provides motivation for the differential quantization scheme as

$$e(nT_s) = m(nT_s) - \hat{m}(nT_s)$$

which is the difference between the unquantized input sample $m(nT_s)$ and the predicted sample $\hat{m}(nT_s)$ as in Fig. 8

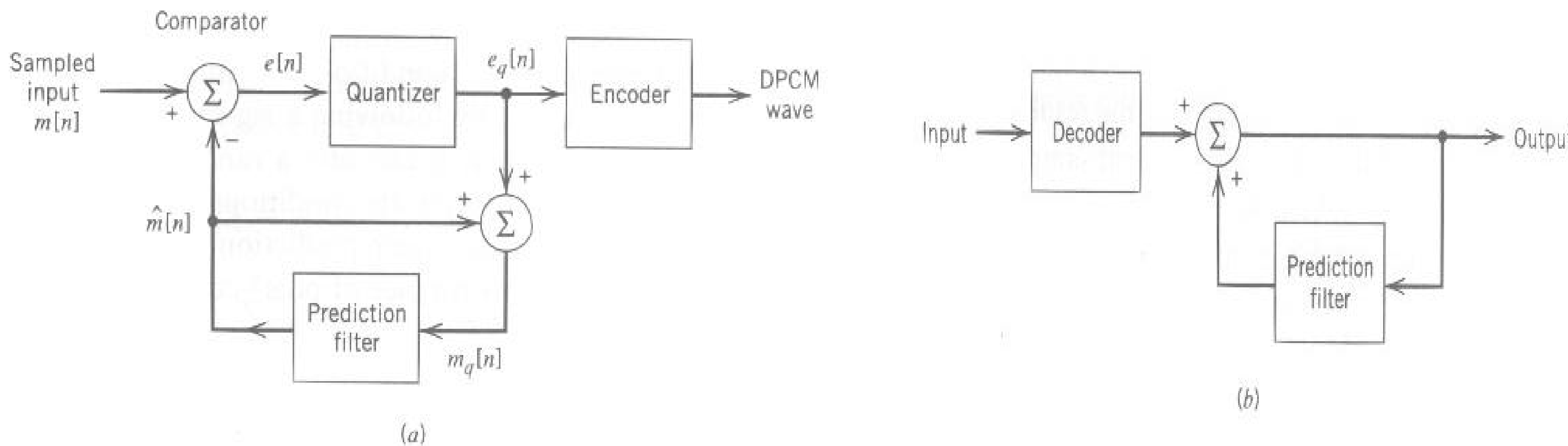

Fig. 8 DPCM Trnasmitter and Receiver

The difference signal $e(nT_s)$ is called the prediction error. On the end of quantizer output,

$$m_q(nT_s) = \hat{m}(nT_s) + e_q(nT_s)$$

$$m_q(nT_s) = \hat{m}(nT_s) + e(nT_s) + q(nT_s)$$

$$\hat{m}(nT_s) + e(nT_s) = m(nT_s)$$

$$m_q(nT_s) = m(nT_s) + q(nT_s)$$

If the prediction is good, the variation of the prediction error $e(nT_s)$ will be smaller than the variance of $m(nT_s)$.

In fact, the DPCM is a special case of DM. The difference is that DM system uses a one-bit (two level) quantizer and DPCM system uses the prediction filter to replace a signal delay element.