1.2.6 Over-slope noise distortion occurrence

The occurrence of over slop distortion for sinusoidal input is derived as follows:

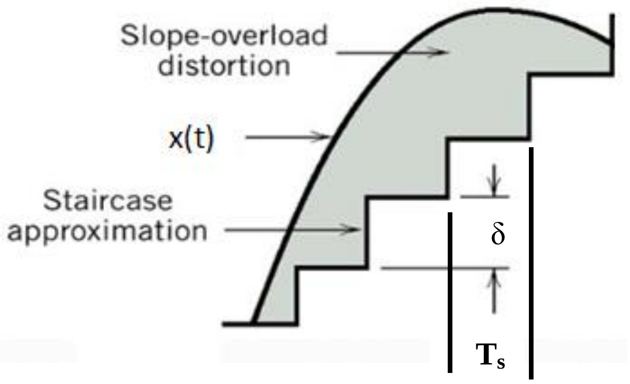


Figure.5 Over slope Noise distortion

Let $x(t) = A_m \sin(2\pi f_m t)$

The slope of the x(t) with respect to the first derivative is:

$$max. slope = \frac{d\,x(t)}{dt}$$

From figure.(5) , the slope is

$$slope = \frac{\delta}{T_s}$$

The occurrence of over slop distortion is:

$$\frac{d\,x(t)}{dt} \geq \frac{\delta}{T_s}$$

$$\left(\frac{d\,A_m \sin(2\pi f_m t)}{dt}\right)_{max} \geq \frac{\delta}{T_s}$$

$$A_m\,(2\pi f_m)\cos(2\pi f_m t) \;\geq \frac{\delta}{T_s}$$

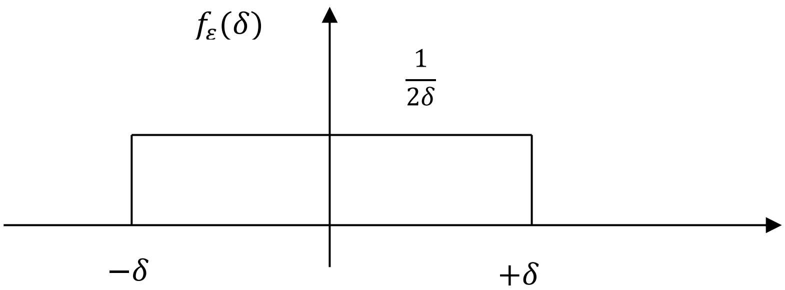
Since max slope, the equation is maximum if cos(x)=1 which result:

$$\boxed{A_m \;\geq \frac{\delta}{2\pi f_m T_s}}$$

The overload amplitude of the modulating signal **is inversely proportional to the frequency f_m** . For higher modulating frequencies, the overload occurs for smaller amplitudes.

1.2.7 Signal to Noise Ratio in DM modulators :

The quantization error in DM is limited to $+\delta \; and - \delta$. Using the uniform distribution, it result:



The quantization noise in DM is given by :

$$quantization\ noise = \frac{\delta^2}{3}$$

The total noise power post filtering at the receiver is :

$$(noise\ power\ )_{receiver} = \frac{w\ T_s\ \delta^2}{3}$$

Where: $w\ is\ the\ bandwidth\ of\ the\ system$

So the signal to noise ratio($\frac{S}{N}$) or SNR is:

$$\frac{S}{N} = \frac{3\ \bar{p}}{w\ T_s\ \delta^2} \dots \dots .. (1)$$

Now for the signal power, the signal must avoid over slope and since it is sinusoidal:

$$A_m \geq \frac{\delta}{2\pi f_m T_s} \dots \dots .. (2)$$

$$p = \frac{\left(\frac{A_m}{\sqrt{2}}\right)^2}{R} \dots \dots \dots . (3)$$

Sub (2) in (3) with R=1:

$$p = \left(\frac{\frac{\delta}{2\pi f_m T_s}}{\sqrt{2}}\right)^2 \dots \dots \dots (4)$$

Sub (4) in (1), we get:

$$SNR = \frac{3}{8\pi^2 \omega\, T_s^3 f_m^2}$$

S/N in delta modulation receiver post filtering

Ex: A DM system is designed to operate at three times the Nyquist rate for a signal with a 3 KHz bandwidth and quantization step size 250mw:

1. Determine the maximum amplitude of a l-KHz input signal for which the delta modulation does not show slope overload.
2. Determine the SNR post filtering at the receiver's side in (1).

Sol:

$$f_s = 3 * 2 * f_m$$
$$f_s = 3 * 2 * 1000$$
$$f_s = 3 * 2 * 6000$$

$$A_m \le \frac{\delta}{2\pi f_m T_s}$$

$$A_m \le \frac{250 * 10^{-3}}{2\pi(1000) * \frac{1}{6000}}$$

$$A_m \le 238.7mv$$

2.

$$\frac{S}{N} = \frac{3}{8\pi^2 \omega\, T_s^3 f_m^2}$$

$$SNR = \frac{3}{8\pi^2(3000)\left(\frac{1}{6000}\right)^3 (1000)^2}$$

Ex: In A DM system, a signal of bandwidth 800 Hz is sampled at a rate of 64 KHz. The maximum signal amplitude $A_m = 1$, Determine:

1. The minimum value of step size to avoid over slope distortion.
2. The SNR post filtering at the receiver's side, if ω =3.5KHz.

<u>Sol:</u> 1.

$$A_m \le \frac{\delta}{2\pi f_m T_s}$$

$$1 \le \frac{\delta}{2\pi * 800 * (\frac{1}{64000})}$$

$$\delta \ge 0.0785$$

2.

$$p = \frac{A_m^2}{2R}$$

$$p = \frac{1}{2} = 0.5\, watt$$

$$(noise\ power\ )_{receiver} = \frac{3.5 * 10^3 * (\frac{1}{64000})\ * (0.0785)^2}{3} = 1.12 * 10^{-4} watt$$

$$SNR = \frac{0.5}{1.12 * 10^{-4}} = 4.46 * 10^3$$

<u>1.3 Scramblers and descramblers</u>

1. ***Scrambling*** :tends to make the data more random by removing long strings of 1's and 0's. The scrambling can help timing extraction by removing strings of 0's. However they also provide unauthorized access to the data. Figure below shows a construction of scramblers.

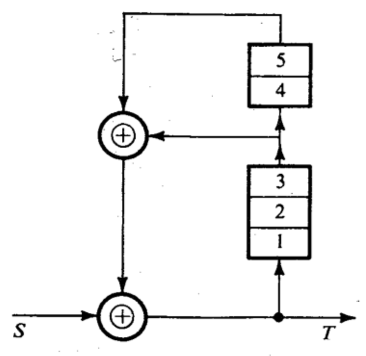


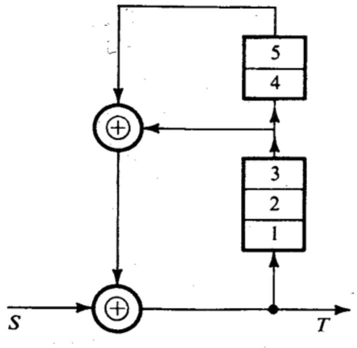
Fig. shows a scrambler

A typical scrambler shown in fig consist of feedback shift registers. Each stage in the shift register delays a bit by one unit. The equation of the scrambler is:

$$S \oplus D^3T \oplus D^5T = T$$

The operation is modulo 2 addition.

Ex: For the scrambler shown below, find the output string if all initials of the shift registers are zero.

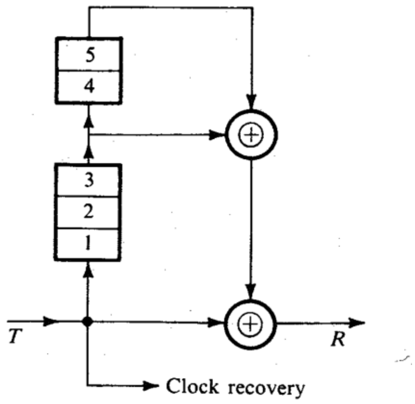


Sol:

input	D_1	D_2	D_3	D_4	D_5	output
1	0	0	0	0	0	1
0	1	0	0	0	0	0
1	0	1	0	0	0	1
0	1	0	1	0	0	1
1	1	1	0	1	0	1
0	1	1	1	0	1	0
1	0	1	1	1	0	0
0	0	0	1	1	1	0
0	0	0	0	1	1	1
0	1	0	0	0	1	1
0	1	1	0	0	0	0
0	0	1	1	0	0	1
1	1	0	1	1	0	0
1	0	1	0	1	1	0
1	0	0	1	0	1	1

Output: 101110001101001

2. Descrambler is the opposite operation of the scrambler, according to this equation:



Any bit error in the sequence, it will affect the entire sequence of the output R.

Ex: Using the descrambler which is opposite to the scrambler in ex. 1, find the output of the descrambler

input	D_1	D_2	D_3	D_4	D_5	output
1	0	0	0	0	0	1
0	1	0	0	0	0	0
1	0	1	0	0	0	1
1	1	0	1	0	0	0
1	1	1	0	1	0	1
0	1	1	1	0	1	0
0	0	1	1	1	0	1
0	0	0	1	1	1	0
1	0	0	0	1	1	0
1	1	0	0	0	1	0
0	1	1	0	0	0	0
1	0	1	1	0	0	0
0	1	0	1	1	0	1
0	0	1	0	1	1	1
1	0	0	1	0	1	1