This ATM determines the probability of sync, false sync, and the probability of loosing sync for an 11 bit and 6 bit frame sync code. The number of bits/frame range from 1344 to 4032. The amount of data lost during loss of sync is also determined.

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1. Introduction

In order to minimize the probability of falsely synchronizing on a data word, the frame sync code length should be made as large as possible and the number of data bits/frame should be kept small. In the active seismic mode of operation, maintaining this high density of sync bits to data bits is not feasible and a compromise must be made.

The selection of an 11 bit sync word with 1344 bits/frame was originally chosen in order to optimize the experiment performance within the constraints of a 10600 bps data rate. This selection gave a reasonably low probability of falsely synchronizing on data. As time went on, however, it was determined that even this density of sync bits to data bits was too high and improved experiment performance could be achieved by lowering this density.

2. Calculations

The formulas used to calculate the probability of sync and the probability of falsely syncing on data words were obtained from the literature* and are:

1) $$P_s = \sum_{x=o}^{e} \binom{n}{x} p^x (1-p)^{n-x}$$

where: P_s = Prob. of sync

e = no. of allowed bit errors (0-9)

n = length of sync code, bits

p = prob. of bit error ($\approx 10^{-4}$)

2) $$P_{Fs} = 1 - \left[1 - \frac{1}{2^n} \sum_{x=o}^{e} \binom{n}{x} \right]^b$$

where: P_{Fs} = prob. of falsely syncing on data

b = ratio of data bits to sync bits

* Williard, M. W., PCM Synchronization, NTC, 1961

Note that the probability of falsely syncing in the code overlap region was not considered since it is much lower than the probability of syncing on data.

After sync is obtained, a 3 bit frame sync window is activated and the decom is programmed to check the incoming bit stream only when the frame sync word occurs. Since the probability of syncing on the code word is P_s, the probability of not syncing or of loosing sync is $P_{L_s} = 1 - P_s$.

The previously mentioned calculations have been made for a probability of bit error of 10^{-4}, 11 and 6 bit code lengths, and 1344-4032 bits/frame. The results of the calculations are presented in Table 1.

From Table 1, it can be seen that the proper choice of e (the no. of allowed bit errors) should be o for synchronization and e = 1 for indicating loss of sync. Using these values, the probability of sync is .999 for the 11 bit code and the probability of loosing sync is 2×10^{-6}. Since the probability of loosing sync is so low, a long resync time could be tolerated since loss of sync would occur very seldom.

3. Time Required to Indicate Loss of Sync

Loss of sync is indicated after a preset correlation threshold is not exceeded for a preset number of frames. The preset correlation threshold can be set from 0-9 allowed bit errors. The number of times that the sync word is checked can be set at 0-19. If the sync word is not checked (set at 0), then when the correlator does not exceed the threshold, the decommutator immediately starts the search mode and tries to resync. Since sync can be lost and not known until the next sync word appears, the maximum time required to indicate loss of sync is 1 frame length with an average of 0.5 frame lengths.

When the sync word is checked (1-19 times), the maximum time required to indicate loss of sync is equal to the number of frames checked plus 1. The average time is equal to the number of frames checked plus 0.5.

4. Time Required to Resync After Loss of Sync Indicated

Again, the number of allowed bit errors (0-9) and the number of frames to be checked must be set into the decommutator. After the decommutator indicates loss of sync as described in section 3, the scanning mode is initiated. If the sync word is not checked (set at 0), then the maximum time required to resync is 1 frame length with an average of 0.5 frame lengths. When the sync word is checked (1-19 times), the average resync time per false alarm is equal to the number of frames checked plus 0.5.

Table 1

No. of Sync bits n	No. of Bits/ Frame	No. of Allowed Bit Errors e	Prob. of Sync P_s	Prob. of False Sync P_{Fs}	No. of False Alarms $b\,P_{Fs}$	Prob. of Loosing Sync P_{Ls}
11	1344	0	.999	.06	7	10^{-3}
		1	.999998	. 5	60	2×10^{-6}
11	2688*	0	.999	.12	24	10^{-3}
		1	.999998	.77	187	2×10^{-6}
11	4032	0	.999	.18	66	10^{-3}
		1	.999998	.89	325	2×10^{-6}
6	1344	0	.9995	.989	220	5×10^{-4}
		1	.9999996	≈ 1	222	4×10^{-7}

* Max. bits/frame is 4096, However, Goddard recommends a max. of 2048. A waiver from them probably would be required to exceed 2098 bits.

If sync is lost by only ± 1 bit, the decommutator will automatically resync in 1 bit time immediately after the correlator first does not exceed threshold. This is due to the 3 bit frame sync window built into the decommutator.

5. Amount of Data Lost When Sync is Lost

If all frame checks are set to 0, then the total maximum lost time is 2 frames of data. Average lost time is 1 frame of data. The probability of resyncing correctly is a function of the code length and bits/frame. For an 11 bit code and 2688 bits/frame, the probability of false sync is 0.12 with an average number of false alarms equal to 24. However, since the frame check is set on 0, these false alarms are never checked and we have a 0.12 probability of not being synced correctly. This will be indicated during the next frame, however, as a probable loss of sync.

If all frame checks are set to 1, then the average lost time is $1.5+1.5 \times 24=37$ frames of data for the above 11 bit code. The probability of falsely resyncing is about .01.

For the code of 11 bits and 2688 bits/frame and 1 error allowed for a loss of sync indication, the probability of loosing sync is quite small (2×10^{-6}). Hence, the number of times that 37 frames of data is lost would be very small.