Dictionary of telemetry terms

TEC/NOT/026

This paper defines some terms commonly used in telemetry. The following topics are discussed:

17.1 Definitions

17.1.1 Basic terms

Barker Codes

A selection of bits to be used as frame sync words so as to minimize the probability of false lock. For more information, see the *Reference* section of *Applications Handbook*.

Hamming Code

A method by which extra bits can be added to a word so as to detect one (or more) bit errors (and possibly fix them).

IRIG

Inter-Range Instrumentation Group of the Range Commanders Council (RCC).

Pulse Amplitude Modulation (PAM)

Pulse modulation in which a voltage is sampled periodically and transmitted as an analog signal whose amplitude is proportional to the sampled voltage. Because PAM is susceptible to transmission noise, it has been replaced by PCM in most telemetry applications. For more information, see *TEC/NOT/024, Evolution of Pulse Code modulation (PCM)*.

Pulse Code Modulation (PCM)

Pulse modulation in which a signal is sampled periodically, converted to a digital value, and transmitted as a serial binary code. For more information, see *TEC/NOT/024 - Evolution of Pulse Code modulation (PCM)*.

Telemetry

The science of gathering information at some remote location and transmitting the data to a convenient location to be examined and recorded.

Time Division Multiplexing (TDM)

A process by which two or more channels of information are transmitted over the same link by allocating a different time interval for the transmission of each channel.

17.1.2 Serial transmission

Bandwidth

The frequency range occupied or required by a signal; the frequency range containing useful information. PCM signals contain harmonics that are usually removed by pre-modulation filtering to reduce the bandwidth needed for telemetry transmission or tape recording. However, insufficient bandwidth may result in the loss of essential information and prevent the recovery of PCM encoded data.

Bit Error Rate (BER)

Probability of a bit being received incorrectly. Every data link has a theoretical minimum error rate depending on the noise present. A reasonable encoder/decoder system linked via copper would have a BER of 10-9. BERs are specified for encoders, data links (especially radio), bitsyncs and decoders.

Another popular expression (especially among bit sync suppliers is that the bit-rate is within 1 dB of theory. This means that the error rate, when plotted in dBs versus noise, is within 1 dB of the theoretical best case graph.

Bit-rate

The number of PCM output bits transmitted in 1s, such as 2 Mbps. The bit-rate must be stable in order for the PCM decoder to regenerate the bit clock needed to determine the logic level of each data bit in the PCM code.

Bit synchronizer

Responsible for recovering *clean* clock and data from a (usually noisy) PCM stream.

Decoder

Typically comprises a bitsync and frame synchronizer and outputs (to DPR, A/D status) for selected parameters. Decoders can be considered low-end ground stations. Ground stations have decoder modules included.

PCM code

Any of several encoding schemes used to convert a parallel digital value into a serially transmitted sequence of binary ones and zeros such that a PCM receiver can decode and recover the original digital value. For more information, see *TEC/NOT/024 - Evolution of Pulse Code Modulation*.

Signal to Noise Ratio (SNR)

At any point in an electronic circuit, device or transmission system, the ratio of one parameter of a desired signal to the same or a corresponding parameter of the noise. In broadcast communication the signal-to-noise ratio is often quoted in decibels.

Synchronization pattern

A pattern of ones and zeros that are chosen because they are easy to distinguish from randomly occurring data words. The pattern is used to synchronize the PCM decoder so that it can accurately locate the positions of the data words in the PCM stream. Appendix C of IRIG 106-96 lists recommended PCM synchronization patterns.

Manchester encoding

Popular name for BIØ-L. For more information, see the *Reference* section of *Applications Handbook*.

Pre-modulation filtering

The use of filters to limit the bandwidth or frequency spectrum of the PCM signal before sending it to a telemetry transmitter or data link. Appendix A of IRIG 106-96 describes frequency considerations for telemetry systems.

17.1.3 Data structures

Channel

A signal that carries data information, such as temperature. This term normally refers to a specific data input or output of the PCM encoder/decoder system as well as the associated data word(s) in the frame format.

Checksum

A word sometimes added at the end of a frame, which is the sum of the data already sent. For example in an 8-bit system the last word would be a modulo 256 addition of the data in the words already sent.

Commutation

The process of sampling data channels. Channels can be sampled at different rates to accommodate different data bandwidths. A normal channel is sampled once each minor-frame. Channels can also be sampled at multiples (super-commutation) and submultiples (sub-commutation) of the minor-frame rate.

Commutator

Originally a rotating mechanical switch with many contacts used for sequentially switching voltages. Early telemetry systems used two synchronized units (called a commutator and decommutator) to pass analog voltage samples through a link between the units. Commutators can be connected in series and driven at different speeds to allow channels to be sampled at different rates. Modern telemetry systems use electronic switches and multiplexors.

Current value table (CVT)

Usually a dual ported ram (DPR) in which the latest values of parameters received are stored in predefined locations.

Decommutator

Finds the sync word and subsequent data words.

Dynamic format switches

Decoders capable of dynamic format switching can be set up to find a format identifier which identifies the correct format to use so as to decommutate the rest of the frame.

The bits/word, words/minor frame and minorframes/major frame may change as determined by the format identifier. Usually the new format definition would take effect as of the next word but it could also take effect as of the next frame.

Dynamic format switching is useful in applications where the demands change as the test progresses or in the event of an error or failure.

Frame Alternating Component (FAC)

In an FAC format, every second syncword is inverted. This may be useful in applications where slow signals are being sampled and it is possible that signals could take the value of the syncword. FAC can be used together with SFID and URC.

Frame Code Complement (FCC)

FCC is one method of sub-frame identification whereby the syncword is the last (first) minor-frame inverted. This method has the advantage that no extra words in the format are required to identify the major-frames. The disadvantage is that a complete major-frame may be lost before sync is achieved.

Frame synchronization strategy

The method by which synchronization within a major-frame is achieved. To define the frame sync strategy, the following information must be given:

(a) The syncword (usually the Barker code)

(b) The syncword mask (some bits in the syncword may not have to match)

(c) The syncword error tolerance (allowable mismatches in the syncword)

(d) The bits per minor-frame

(e) The sub-frame-sync-strategy (in case there are FCC is being used)

(f) The matches to check allowed (usually 1) 1 to 16

(g) The matches to lock allowed (usually 0, that is, no check state) 0 to 15

(h) The misses to search allowed (usually 1) 1 to 16

(i) The misses to loss allowed (usually 0 that is, no search) 0 to 16. The frame synchronizer powers up in the LOSS state. After finding the syncword to within the specified tolerance (SYNCWORD ERROR TOLERANCE) in the correct place, a given number of times consecutively (MATCHES TO CHECK) it moves into the state check. Then after the required MATCHES TO LOCK it moves into lock.

If it misses the syncword while in lock MISSES TO SEARCH times then it goes into SEARCH. If while in search it misses the syncword MISSES TO LOSS times then it goes into loss again.

If a match is found in SEARCH then return to LOCK.

If a miss is found in CHECK then return to LOSS.

If the bit-sync reports a loss condition then the frame sync may be programmed to go to LOSS.

The user should have the choice of whether or not to consider data in SEARCH and CHECK stages valid.

It is a good idea to start looking for the sub-frame identifier while in check.

Format identifier

A word, typically less than 16 bits long, located in the PCM stream which identifies the format being decommutated (used only with dynamic format switching).

Frame structure

The PCM output is arranged into a data structure consisting of one or more frames. Each frame starts with a synchronization pattern followed by the data channel words. The synchronization pattern enables the PCM decoder to locate the beginning of each frame. When there are many data channels, the PCM output is structured into a major-frame comprising two or more minor-frames. Complex frame formats (Class II) may use several different formats indicated by a frame format identification word.

Major-frame

One complete cycle of data sampling in which all parameters are sampled at least once. A major-frame contains enough minor-frames to sample every parameter.

Major-frame pulse

A pulse, typically one bit long, which goes high while the first bit of the major-frame is being transmitted. See also minor-frame pulse and word pulse.

Matches to lock

See frame synchronization strategy.

Matches to search

See frame synchronization strategy.

Minor-frame

The number of bit intervals starting with a frame synchronization pattern and continuing to the occurrence of the next synchronization pattern. A frame count word is usually included to identify each frame. The simplest PCM format contains one minor-frame.

Misses to loss

See frame synchronization strategy.

Misses to check

See frame synchronization strategy.

Normal commutation

A channel is sampled exactly once in each and every minor-frame.

Parity

Even or odd parity can be added to each word as extra security against bit errors.

Parameter

Any signal included in the PCM stream.

Parser

A parser stores traffic, with tags, from a message (MIL-STD-1553) or frame (IRIG-106 PCM) in a receive buffer. If a message has been received with zero errors it is loaded into the input buffer of a double buffered Current Value Table (CVT) one message wide. After the last parameter of interest has been read the complete message is loaded into the output buffer.

Pre modulation filter

Used primarily with radio links, the filter is usually a sixth order low pass filter whose 3dB point is chosen so as to limit the bandwidth required to send the PCM signal.

Snarfer

A snarfer stores all traffic and tags from a bus in a FIFO. For example in a FIFO 16 words deep, each word has 16 bits for traffic and seven bits for content identification.

Subcommutation

A channel is sampled one or more times in each major-frame, but not in every minor-frame.

Sub-frame

One cycle of the parameters from a commutator whose rate is a submultiple of the minor-frame rate. A sub-frame occupies the same word in each minor-frame. A sub-frame has a depth of four if it is repeated every four minor-frames. Note: A format may have many minor-frames yet have no sub-frames.

Sub-Frame identification (SFID)

SFID is one method of sub-frame identification whereby one sub-frame (usually the first after the syncword) contains a word in each location unique to that minor-frame. The simplest, and most usual, method is a sub-frame counter which starts at the minor-frame count and counts down.

This method has the disadvantage that extra words in the format are required to identify the minor-frames. The advantage is that a minor-frame can be identified immediately.

Supercommutation

A channel is sampled two or more times in each minor-frame.

Synchronous embedded data

Data from another stream which is included in the format after synchronization.

Example one: A slow PCM stream is merged into unused bits of another stream after it has been decommutated so that selected parameters can be merged into certain, CC.

A standard decoder would then be capable of handling this embedded stream.

Example two: An encoder sequentially reads a FIFO containing data from an RS-232 receiver. The system transmitting the data does so only after receipt of the major-frame pulse, thus guaranteeing synchronization. A format may have many minor-frames yet have no sub-frames. See also asynchronously embedded data.

Unique Recycling Code (URC)

URC is one method of sub-frame identification whereby one word (usually the first after the syncword) in the first (last) minor-frame contains a unique pattern to identify the minor-frame. This method has the disadvantage that an extra word in the format is required to identify the minor-frames and extra precautions must be taken to ensure that the URC can not appear elsewhere in the sub-frame, also a complete major-frame can be lost before sync is achieved.

Word

A digital or binary value appearing in the PCM output and occupying a specific time interval. Numeric values are usually expressed in binary or 2's complement format.

Word length

The number of bits in a PCM output word. (Note: Synchronization patterns are counted as one word and are typically twice as long as the average data word.) All words for a particular data channel are the same length. Many PCM systems have fixed word lengths for all channels, such as all words being 12 bits long. Other PCM systems support variable word lengths, in which each data channel can have an independently defined word length.

17.1.4 Class II data structures

Fragmented word

A word divided into segments that occupy various locations in the same minor-frame. For example, a 64-bit floating-point data word could be divided into four segments of 16 bits.

Format change

The frame format may change with regard to structure, word length or location, commutation sequence, sample interval, or minor-frame boundaries, and may not have a definable major frame length. The current format structure is indicated by a frame format identification (FFI) word placed in a fixed position in every minor-frame.

Asynchronous embedded format

A secondary data stream inserted into specified word positions in the major frame. The internal data structure of the embedded format is independent of the major-frame.

Asynchronous data merge

Data, such as serial RS-232 and parallel MIL-STD-1553 messages, are inserted into specified word positions in the major-frame. To aid in recovering the data, flag bits indicating stale and overflow conditions are appended to each data word.

Tagged data format

A format with fixed length containing a stream of data words, or blocks of words, with associated identifiers (tags). The stream may contain alternating tag and data words, or blocks of MIL-STD-1553 bus data.

17.2 References

http://tecnet0.jcte.jcs.mil/RCC/manuals/106-01/

http://www.lancaster.sparta.com/otis/IRIG_Files/IRIG_Chapter4.htm