SpaceWire - CCSDS Unsegmented Code Transfer Protocol

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Sandi Habinc, sandi@gaisler.com
Aeroflex Gaisler AB, Kungsgatan 12, SE-411 19 Göteborg, Sweden, www.gaisler.com

Abstract
Proposal for CCSDS time code distribution over SpaceWire.

References
Time Code Formats, CCSDS 301.0-B-3
Space engineering: SpaceWire - Links, nodes, routers and networks, ECSS-E-ST-50-12C
Space engineering: SpaceWire protocol identification, ECSS-E-ST-50-51C
Space engineering: SpaceWire - Remote memory access protocol, ECSS-E-ST-50-52C

Proposed name
Space engineering: SpaceWire - CCSDS Unsegmented Code transfer protocol, ECSS-E-ST-50-xxC

Notice
Due to the use of similar terms for time in the CCSDS and ECSS documents the following clarification is provided, based on the exact names used in the documents.

The term "time code" is used when referring to time code formats in the CCSDS Time Code Formats recommendation (specifically the term "time code identification" is used in the definition of the Preamble Field).

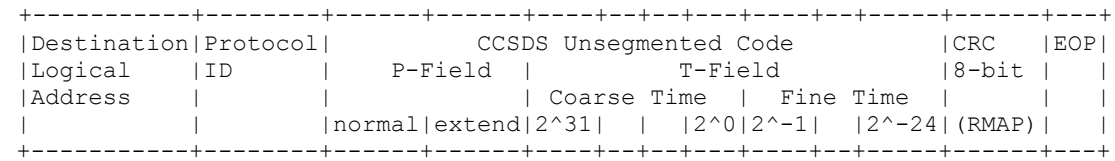
The term "Time-Code" is used when referring to the Time-Code character in the ECSS SpaceWire standard (also referred to as "time control code").

The term "time information" is used when referring to the six least significant bits of Time-Code character in the ECSS SpaceWire standard (also referred to as "six bit time").

The term "control flags" is used when referring to the two most significant bits of Time-Code character in the ECSS SpaceWire standard.

CCSDS Unsegmented Code is abbreviated as CUC. CCSDS Unsegmented Code Transfer Protocol is abbreviated as CUCTP.

CCSDS Unsegmented Code Transfer Protocol Format



Destination Logical Address as per ECSS-E-ST-50-51C.

Protocol ID as per ECSS-E-ST-50-51C, programmable, in range 0xF0 to 0xFE.

CRC is the same as for RMAP as per ECSS-E-ST-50-52C.

EOP as per ECSS-E-ST-50-12C.

CCSDS Unsegmented Code (CUC) as per CCSDS 301.0-B-3 standard:

```
Note: 0 is MSB in CCSDS standards.

P-Field: Preamble Field (1st octet)
Bit:  Meaning:
0     Extension flag (MSB)
      '1' P-Filed extended with 2nd octet {fixed here to '1'}
      '0' No second octet
1 - 3 Time code identification
         "001" 1958 January 1 epoch (Level 1)
         "010" Agency-defined epoch (Level 2)
      Other codes not to be used.
4 - 7  Detail bits for information on the code
4 - 5 (number of octets of coarse time)-1 {fixed here to "11"}
6 - 7 (number of octets of fine time) {fixed here to "11"}
```

The first bit (Bit 0) of the P-Field is the extension flag, used to indicate that a second octet is included in the P-Field for time code identification. Such an expansion may be required to accommodate new time codes or to provide more information (for example, on the clock used). Presently, the value of this bit is "0", indicating that there is not a second octet present. If a second octet is present, its first bit shall be an extension flag with the same definition: "0" implies it is the last octet of the P-Field, "1" implies another octet follows.

“Time code identification” can take either of the values "001" and "010".

“Detail bits for information on the code” are fixed here to "1111"

```
P-Field: Extended Preamble Field (2nd octet)
Bit:     Meaning:
8        Extension flag (MSB)
         '1' P-Filed extended with 3rd octet
         '0' No third octet {fixed here to '0'}
9 - 14   "000000" (reserved for future use)
15       1=Initialize, 0=Synchronize

See below for the meaning of bit 15.

T-Field: Time Field (7 bytes)
Cores Time   Fine Time
2^31 : 2^0   2^-1 : 2^-24
MSB                  LSB

   Core Time: number of seconds
   Fine Time: part of cods, e.g. 2^-1 = 1/2 second, 2^-2 = 1/4 second

The T-Filed is always sent in its full length, i.e. 7 octets.
```

SpaceWire Time-Code as per ECSS-E-ST-50-12C:

```
T0 - T5 contain “time information”
T6,  T7 contain “control flags” {unused, don't care)}
```

Time-Code to T-Field mapping:

```
T5 (MSB) maps to T-Field bit e.g. 2^-1, default
T0 (LSB) maps to T-Field bit e.g. 2^-6, default
```

Actions

Packets with non-matching Destination Logical Address are discarded.

Protocol ID is programmable in range 0xF0 to 0xFE, as per ECSS-E-ST-50-51C.

Packets with incorrect CRC are discarded.

Packets with incorrect EOP, late EOP, early EOP or EEP are discarded.

The P-Field and T-Field of correctly received CCSDS Unsegmented Code Transfer Protocol packets are transferred to the time manager.

Time manager

Each node implements a local Elapsed Time (ET) counter with CUC T-Field format. The actual number of Coarse Time or Fine Time bits implemented is defined by each node.

The SpaceWire Time-Code time information (6 bit) corresponds to 6 bits of the T-Field. The actual mapping can be programmable/configurable, and the default mapping is defined above. The part of the T-Field that is located to the left (more significant) of where the time information is mapped is called “distributed part of the T-Field” hereafter. The part of the T-Field that is located of the right (less significant) of where the time information is mapped is called “maintained part of the T-Field” hereafter. The periodicity of sending/receiving SpaceWire Time-Codes shall correspond to the mapping with the T-Field.

The reception of CUCTP packets and the transferring of the P-Field and T-Field to a time manager can be done either in hardware or in software. The agility of service does not change.

The time information correctly received in a Time-Code (as per ECSS-E-ST-50-51C) is forwarded to the time manager. When the received time information value wraps around from 0x3F to 0x00, the "distributed part of the T-Field" is assumed to be incremented. If a CUCTP packet has been received previously, the complete received T-Field value should be copied to the ET counter at the occurrence of the wrap-around of the time information value.

Note that a CUCTP packet need not be transmitted before each wrap around of the time information value (since the ET will be free-wheeling between the receptions of such packets). It is however necessary that the packet is not sent/received in such way that it is unclear to what specific time information wrap around it belongs. A consequence of this is that the packets can be distributed at a rate much lower than for the SpaceWire Time-Codes, the transmitter needs however to ensure that the packet is sent in the correct time slot, thus the packet need be sent/received in the span between two Time-Codes that carry time information values that wrap around from 0x3F to 0x00 (i.e. in a window of 64 SpaceWire Time-Codes).

The distribution of the CUCTP packet is outside the scope of this protocol specification. It should however be noted that SpaceWire does not inherently support broadcasting of packets. Packets therefore need to be sent individually to each node that is being addressed. This would also apply to CUCTP packets. Some SpaceWire routing switches might support packet distribution that allows broadcasting which could be used to distribute CUCTP packets.

There are several levels of synchronization that can be implemented in a node:
- SpaceWire Time-Code synchronization (default at 64 Hz)
- CUCTP packet synchronization (default at 1 Hz)
- CUCTP packet initialization (occasionally)

The synchronization can be qualified in order to provide monotonous time. Qualification can be done with respect to a window in time encompassing the expected synchronization event. The window is normally defined in number of LSB of the ET counter (Fine Time).

Qualification can also be done with respect to the value of the received Time-Code time information as compared to the local ET counter.

Qualification can also be done with respect to the value of the received T-Field as compared to the local ET counter.

The qualification window width, potential time-outs, etc. are to be locally programmable.

It is possible to force an initialization of the ET counter with respect to the received T-Field. This is controlled on a per packet basis through the use of bit 15 in the 2nd P-Field octet.

When no SpaceWire Time-Codes or no T-Fields (as part of CUCTP packets) have been received, the ET counter shall free-wheel. This allows CUCTP packets to be sent at any interval.

Considerations for draft CCSDS 301.0-P-3.1

Reference: Time Code Formats, CCSDS 301.0-P-3.1

The CCSDS Time Code Formats recommendations are under review and a new draft has been published. The modifications to the CUC format does not affect backward compatibility with the above proposed CCSDS Unsegmented Code Transfer Protocol, provided that bits 1-5 in the 2nd octet are set to 0. Thus no additional octets are added by default. Future expansion is possible but will require modifications.

Bit 7 in the 2nd octet (referred above to as bit 15) is still reserved for mission definition and can be used for the Initialize/Synchronize selection defined above.

Draft P-Field format:

```
P-Field: Preamble Field (1st octet)
Bit 0     = P-Field Extension ('zero': no extension; 'one': field is
            extended)
Bit 1 - 3 = Time code identification
            001 — 1958 January 1 epoch (Level 1 Time Code)
            010 — Agency-defined epoch (Level 2 Time Code)
Bit 4 - 5 = Number of octets of the basic time unit minus one
Bit 6 - 7 = Number of octets of the fractional time unit

P-Field: Preamble Field (2nd octet)
Bit 0     = P-Field Extension ('zero': no extension; 'one': field is
            extended)
Bits 1-2  = Number of additional octets of the basic time added to that
            specified in Octet 1
Bits 3-5  = Number of additional octets of the fractional time added to
            that specified in Octet 1
Bits 6-7  = Reserved for mission definition
```