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AN INTELLIGENT FIBEROPTIC DATA BUS FOR FLY-BY-LIGHT APPLICATIONS

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Abstract

An active Fiberoptic Data Bus compatible with MIL-STD-1553B which could be used for Fly-By-Light, Stores management, AEW etc., on an aircraft has been developed. The data bus is considered intelligent because it can automatically sense which station is in the transmit mode and control the active interface accordingly, so that smooth flow of data takes place on the bus.

The tests carried out on the bus including those on the Jaguar Avionics Rig to check its validity are also described. As no software is involved in the operation of the bus, this could be used on any aircraft having its own software.

Introduction

The data bus is in the round robin configuration (Fig.1) with the interface at every remote terminal (RT) or bus controller (BC) being transparent excepting for the one which is transmitting at the moment.(1). Therefore, even though the bus is in the round robin (loop) configuration, electronically it is open because, at the transmitting terminal the interface is non-transparent i.e., while it receives the signal transmitted by itself, it does not re-transmit the same unlike the transparent terminals which re-transmit the received signals.

The transparency of the interface is controlled by the intelligent circuit of the interface itself without the use of any microprocessor or software. The design of the bus is based on the necessity to use the existing BC and RTs on any aircraft. As the existing RTs and BC are meant for transformer coupling, transformer coupling of any station is taken for granted.

Description of the Interface (Fig.2)

As in the case of the wire data bus the Fiberoptic (F.O) data bus is coupled to the BC or RTs through transformers, because the aim of developing this bus is to replace the wire data bus with the active F.O. data bus without changing any of the terminals and its operating conditions on the aircraft.

If the interface is not intelligent i.e., if it cannot recognise that the RT it is interfacing with the F.O. data bus is in the transmit or

FIBEROPTIC DATA BUS CONFIGURATION

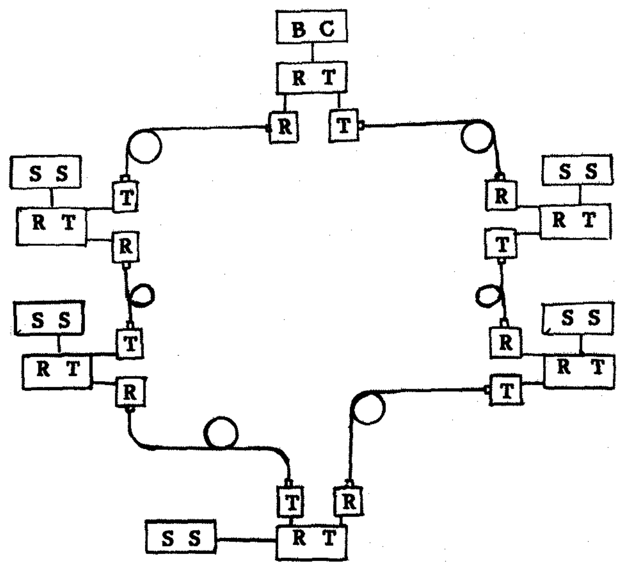

FIG.1

INTELLIGENT F.O. INTERFACE

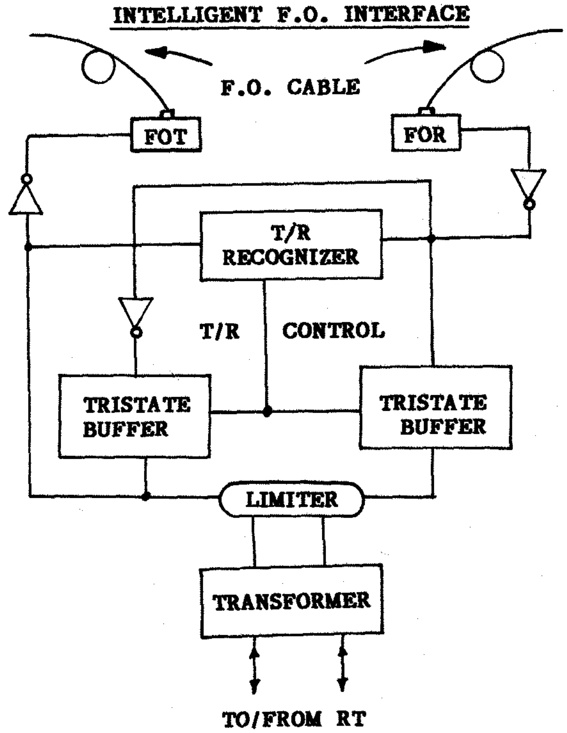

FIG.2

receive mode, and is normally transparent, chances are there for it to be transparent during transmit mode also. In such a case the message transmitted and received by its own receiver after a small delay (between 200 ns and 4 us) will be re-transmitted and completely distort the message originally transmitted beyond recognition and make it invalid.

In order to avoid this catastrophe, the interface is made to recognise whether a terminal is in the transmit or receive mode (Fig.2). This is done, making use of the fact that a message received at a transmitting terminal is always delayed from the original message by a time interval depending upon the number of terminals hooked on to the data bus. A delay recognition circuit then produces a signal to inhibit the received signal from being re-transmitted over the bus. This is designated as the T/R recogniser in Fig. 2. Two re-triggerable oneshot (monostable multivibrator) circuits are used here. One oneshot is triggered by the transmitted signal, if there is any, while the second is triggered by the received signal. The first oneshot when triggered first will inhibit the other from getting triggered. The 'Q' output (O/P) of the second oneshot controls the two sets of tristate buffers which when enabled will transmit the received signal to the RT through the transformer and also provide the input (I/P) to the F.O transmitter (FOT) for re-transmission over the bus, when there is a received signal in the absence of a signal being transmitted by the same RT.

As re-transmission of the messages received is done through the same tristate buffers, this ensures that no distortion of a message being transmitted occurs because there is no re-transmission by the same station. When a station re-transmits the message it receives from another station it is said to be transparent and when re-transmission is inhibited then it is non-transparent.

The two TTL inverters used after the F.O. receiver provide the DATA & $\overline{\text{DATA}}$ required for the RT. The inverter before the F.O. transmitter provides isolation of the I/P to the F.O. transmitter from the I/P to the other circuits operating from the same point.

In addition, to keep the I/P to the interface TTL compatible, diode clamping is employed. This is necessary because an RT O/P is expected to be in the range 18 to 27 V p-p as given in para 4.5.2.1.1.1 of MIL-STD-1553B.

Test Procedures

MIL-STD-1553B definitions are taken as guidelines for testing the data bus.(2). In order to obtain the necessary signals for transmission over the data bus, BC and RT simulators to produce the three message formats specified by para 4.3.3.6 were developed.(3). The BC simulator produces word formats specified by para 4.3.3.5 for command,data and status words. The simulated command word as in para 4.3.3.5.1 comprises the command sync waveform as in para 4.3.3.5.1.1, the RT address field, T/R bit, subaddress/mode field (not used in our tests), data word count field and the parity bit. Similarly, the data words comprise the data sync waveform as in para 4.3.3.5.2.1, 16 bits of data and an odd parity bit as in para 4.3.3.5.2. The RT is designed to automatically generate the status word after decoding the address field, T/R bit and the data word count of the received command word and sends it as specified in paras 4.3.3.6.1, 4.3.3.6.2 & 4.3.3.6.3.

Various command messages to transmit and to receive data words varying in count from 1 to 32 were generated and transmitted over the data bus to the different RT addresses. Six different data words were selected with values 8000H, 7FFFH, 0000H, FFFFH, 5555H & AAAAH (H=HEX) as specified in para 4.5.2.1.1.4. The addressed RT simulators were found to respond as expected i.e., transmit the status word and the number of data words as per data word count received or transmit the status word after receiving the indicated number of words when the message was received over the F.O. data bus - indicating error free operation of the data bus.

The I/P signal to the bus interface was given with various voltages ranging from a minimum of 15 V p-p to a maximum of 30 V p-p and the interface along with the F.O.data bus were found to exhibit error free operation of the data bus.

The F.O. data bus was then tested using two DBMCs of LORAL SDA KONIK 100F in place of a BC and an RT. As before various data word counts and data words with the values 8000H, 7FFFH, 0000H, FFFFH, 5555H & AAAAH were sent and received with the corresponding sync waveforms - varying the I/P voltages to the data bus from 3.6 V to 15 V peak. The receiving DBMC showed that the command and data words were received without any error over the data bus.

Finally the data bus was fitted on the Jaguar Avionics Rig connecting its BC and two RTs to the F.O. data bus. The message formats used with the DBMCs were used here also and were received without error by the RTs connected through the F.O. data bus.

The risetime, falltime, delay time, response time etc.,were all measured using a 50 MHz oscilloscope and were found to be well within the specified limits of the standards as in paras 4.3.3.7, 4.3.3.8, 4.3.3.9, 4.5.2.1.2.1, 4.5.2.2.1.2 and 4.5.2.2.2.1.

Conclusion

The cable termination stubs and stubs with every terminal necessary for wire data bus may be dispensed with in the case of an F.O. data bus. Though it would be a great advantage to use F.O. data buses without coupling transformers (the F.O. cable provides the necessary electrical isolation, as it is a total dielectric), the F.O. data bus is used with the isolation transformers in order that the existing RTs may be used without disturbing their usual mode of operation (4,5).

This data bus is capable of being used in the dual, triple or quad redundant mode.

It is opined by many that the totem pole (loop) connection of the various RTs & BC on the bus is a disadvantage because,if one interface fails the entire bus fails, but, according to Marvel & Weiss in "In today's co-ax data buses, the loss of even one link may cause the entire bus to be declared 'bad'".(6). This is also true of the F.O. data bus, so, if one interface goes bad the redundant bus may be brought into action de-activating the first bus, with the use of a built-in bus monitor.

No software is involved in the operation of the interface to the bus and hence, even though the bus has been tested in the Jaguar Avionics Rig it can be used on any aircraft having its own software for the operation of the bus. This bus can be used for any application where digital information is required to be transmitted.

Acknowledgement

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References

(1) Mrs.L.C.Manoharan & S.Muthuvel - MIL-STD-1553B compatible F.O. data bus - Symposium on F.O. Applications, NAL,Bangalore, Feb.19,20,1987,Proceedings

(2) Department of Defense (USA), MIL-STD-1553B - Wright-Patterson AFB,Ohio,USA, Sept.21,1978

(3) Mrs.L.C.Manoharan - Digital Signal Processing for Transmission & Reception over a F.O. Data Bus.- IEEE Asian Electronics Conference - 1987, Hong Kong Sept.14,1987, Proceedings.

4. MIL-STD-1773, Brief Specs.

(5) Mattew J. Relis - Military Avionic LANS Point towards Fiberoptics - Defense Electronics, Oct.1983, pp87 - 106

(6) Orin E. Marvel & Don Weiss - A Fiberoptic Data Bus - Concept to Development - DoD/Industry F.O.s Standards Conference Vol.II, Washington D.C., Ap.21-23,1981