SINGLE OPTIC-FIBER LINK HIGH-SPEED DATA COMMUNICATION PROTOCOL BASED ON THE MANCHESTER CODE

Vinothkumar, M., Venu Gopala Krishnan. J * and M.S. Durairajan

Dept. of Computer Science Engineering

*Dept. of Electronics and Communication Engineering

Madha Engineering College, Kundrathur, Chennai- 69, Tamil Nadu, India

ABSTRACT

Satisfy the requirements of complex distributed power electronic system (PES) communication, this paper has proposed a single optic-fiber link data communication protocol based on the Manchester code due to an vacancy in the common- ly-adopted protocols, analyzed the encoding and decoding prin- ciple of Manchester code, defined the formats of command frame and data frame, calculated the communication time and error rate, and described the mechanism of fault identification and handing. All this leads to a distributed master-slave control struc- ture suitable for high-power multiphase inverter and a point-to- point data communication mode. Experiments prove the protocol to be correct and feasible. The Manchester code communication protocol based on FPGA program is simple in the structure of hardware and software. When the system clock is 100MHz, the communication bandwidth can reach 40Mbps, which can meet the needs for communication of PES with kHz or 10kHz switch- ing frequency.

Keywords: *power electronics system; distributed control; Manchester code; communication protocol and multiphase inverter*

INTRODUCTION

One of the basic characteristics of modern PESs is a highly- integrated and high-performance digital chip is used as control core, which takes advantage of information flow produced by the digital controller to control the power flow conditioned by the half/full-controlled power switches for energy conversion. Considering the power quality, the control system usually op- erates with a switching frequency of kHz or 10kHz or below that. In each switching cycle, the control system performs a specific control algorithm and logic processing according to the feedback status and control instructions [1].

With an increase in power level of a complex PES, modu- larized and distributed ideas are generally incorporated in the design of software and hardware. In order to simplify the com- plexity of control and improve the system reliability and main- tainability, the algorithm computation, instruction execution and status data acquisition of the control system are usually conducted hierarchically or according to different tasks. The whole control system is composed of multiple subcontrollers, which form a distributed control architecture [2] and [3]. The status data interaction goes on between the subcontrollers in every cycle. Therefore, the simple, reliable and efficient data communication will help reduce the difficulty and hardware cost in developing a distributed system and improve the func- tional class and adaptability of the system.

EXPERIMENT

To verify the correctness of the proposed single optic-fiber link communication protocol, the FPGA programing can func- tion well in communication of command and data frame as well as fault handling. Because the actual master-slave system uses a point-to-point mode, the address in the frame is omitted (4-5). Considering a certain margin, the system clock of FPGA is set at 100MHz, the encoding data clock is set at 20MHz, and the optical transceiver adopts HFBR1414 and AFBR2418. When the controller is in the self-transmitting and self-receiving mode, the waveforms are captured by use of SignalTap II Log-ic Analysis tool, as shown in Fig.1.

In Fig.1, code_start is the encoding enable signal of the transmitter; data is the command or data to be sent; m_out is the encoding output waveform; m_in is the received serial en- coding stream by the receiver; syn_rst_clk is the synchronous clock; Rxdata is the decoding data; checkout_bit is the even-odd check bit. Fig.1 (1) and (11) show that the command and data frames can be correctly encoded and decoded according to their frame format definitions. Fig. 2 shows that when a data validation error is created by changing the received CRC data artificially, the communication protocol will immediately give a request command to the transmitter for sending the data again. Furthermore, the captured time of the command frame trans- mission is about 1100ns and the time of the 3-word data frame transmission is about 5910ns, which correspond to the calcu- lated values in (2) and (3). As the experimental waveforms are consistent with the protocol definitions, the communication protocol based on the Manchester code proves to be correct and feasible.

As for the master-slave control structure based on the Man-chester code communication protocol, its control system is simple in structure, with a clarify task division of its master and slave controllers. Each three-phase inverting unit can stably operate. The whole propulsion system has good power-regulation and dynamic characteristics. The typical current (torque) waveform of a three-phase inverting unit in sudden load variation is shown in Fig.3. Besides, in the design of a high-power IGBT intelligent digital driver, the adoption of the point-to-point communication protocol based on the Manchester code can help upload the port voltage, current, temperature, di/dt, and dv/dt of the IGBT, which will make it possible for a power electronic device to useless or no sensors in control [6-7].

In conclusion, the single link Manchester code high-speed data communication protocol proposed in this paper has ad- vantages of high portability and simplicity. Not depending on additional external synchronization or clock, it can automati- cally receive command and data and perform a real hot swap communication. It has good prospect of engineering applica- tion in single point communication and system integrated communication (8).

CONCLUSION

According to the communication requirements of the PES, this paper has proposed a single optic-fiber link high-speed data communication protocol based on the Manchester code with a rapid development of a single board, presented the data transmit-receive protocol implemented by FPGA programming with a simple hardware structure, and analyzed the encoding and decoding principle of Manchester code, data communica- tion time, data error rate, and fault handling mechanism. As a result, a systematic communication control structure and a point-to-point data transmission mode have come into being. Experiments show that the proposed communication protocol is so correct, simple and efficient as to meet the requirements of data communication of the PES with 10kHz switching fre- quency or below. For high switching frequency applications, limited by the nature of the proposed protocol, a higher decoding system clock is required, which is difficult to implement in actual system. Therefore, it requires other modes of communi- cation. The future research direction is how to improve the speed and fulfill the practical application.

REFERNECES

1. HANG Lijun, HU Haibing, LU Zhengyu, "Novel high speed and intelligent communication topology based on PEBB for power electronic system integration," *Proc. of the CSEE*, 2006, 26(20): 50-56.
2. ZHU Minglei and ZHAO Rongxiang, "Parallel convertor system with high speed distributed master-slave control method," *J. of Zhejiang University (Eng. Sci.).*, 2013, 47(11): 2031-2037.
3. ANTONELLI G, "Interconnected dynamic systems: An overview on distributed control ," *Control Systems, IEEE*, 2013, 33(1):76-88.
4. XIAO Fei, FU Lijun, XIE Zhen, "Contrast analysis on synchronization strategies for power electronic distributed digital control network," *Automat. of Elect. Power System*, 2012, 36(13):81-85.
5. SUN Chi, ZHANG Cheng, AI Sheng. "Topology and protocol of practical high-speed fiber ring net for large-capacity power electronic systems," *Proc. of the CSEE*, 2012, 32(15): 63-73.
6. MILOSAVLJEVIC Ivana, "Power electronics system communications," Virginia Polytechnic Institute and State University, 1999. ZHANG C, MA W, SUN C, "A switchable high-speed optic-fiber ring net topology and its method of high-performance synchronization for large-capacity power electronics system," *Int. Journal of Elect. Power & Energy Systems.*, 2014, 57: 335-349.
7. MA Weiming, "Typical applications of power electronics in naval ship power systems," *Trans. of China Electrotechnical Society*, 2011, 26(5):1-7.
8. HU Liangdeng, SUN Chi, CHEN Yulin, et al, "On-line measuring method of high-power IGBT collector current," *in Proc 17th ICEMS, IEEE*, 2014: 1945-1951.

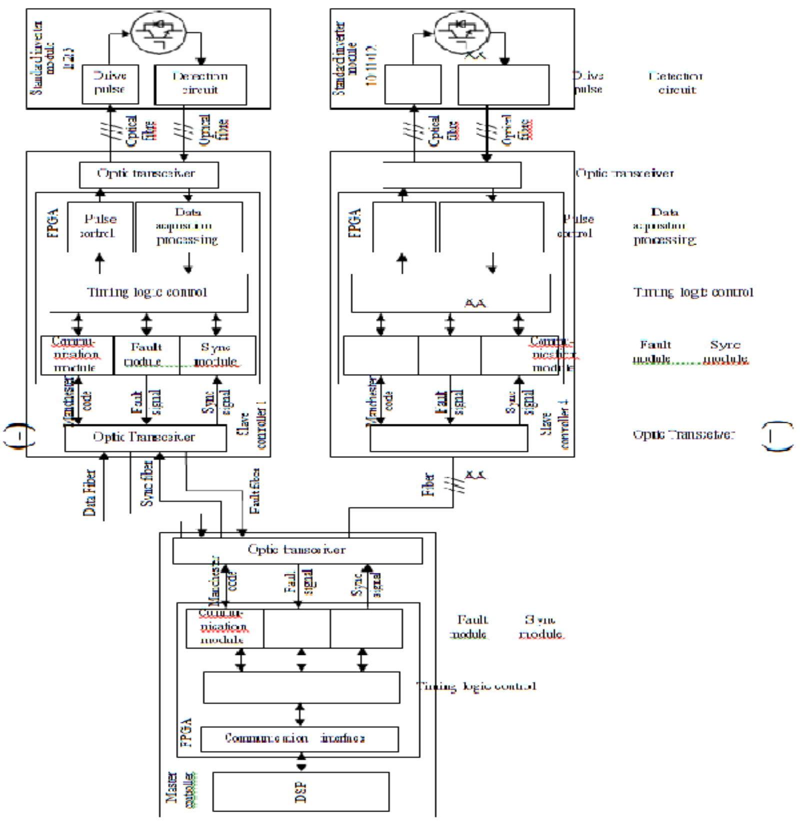
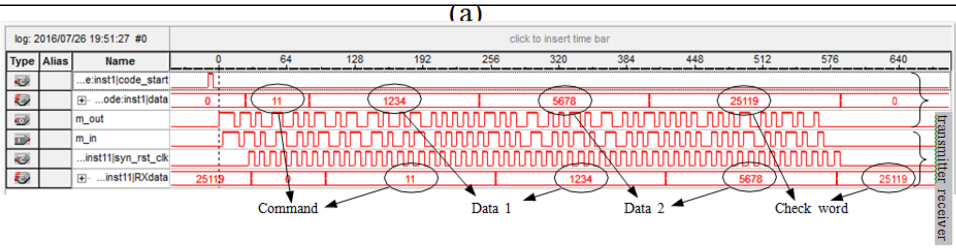
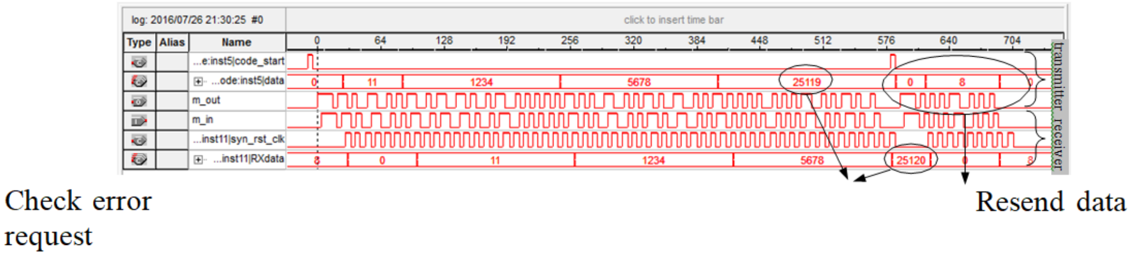


Fig.1 Diagrams of main circuit and control structure. (1) Diagram of propulsion inverter. (11) The distributed master-slave communication control structure.

(a)



(b)



(c)

Fig.2. Experimental waveforms of the communication protocol. (a) Command frame format. (b) Data frame format. (c) Error handling mechanism.

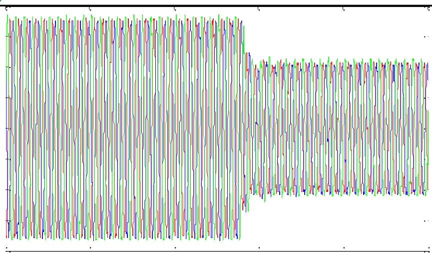


Fig 3. Current (torque) waveform of a three-phase inverting unit.