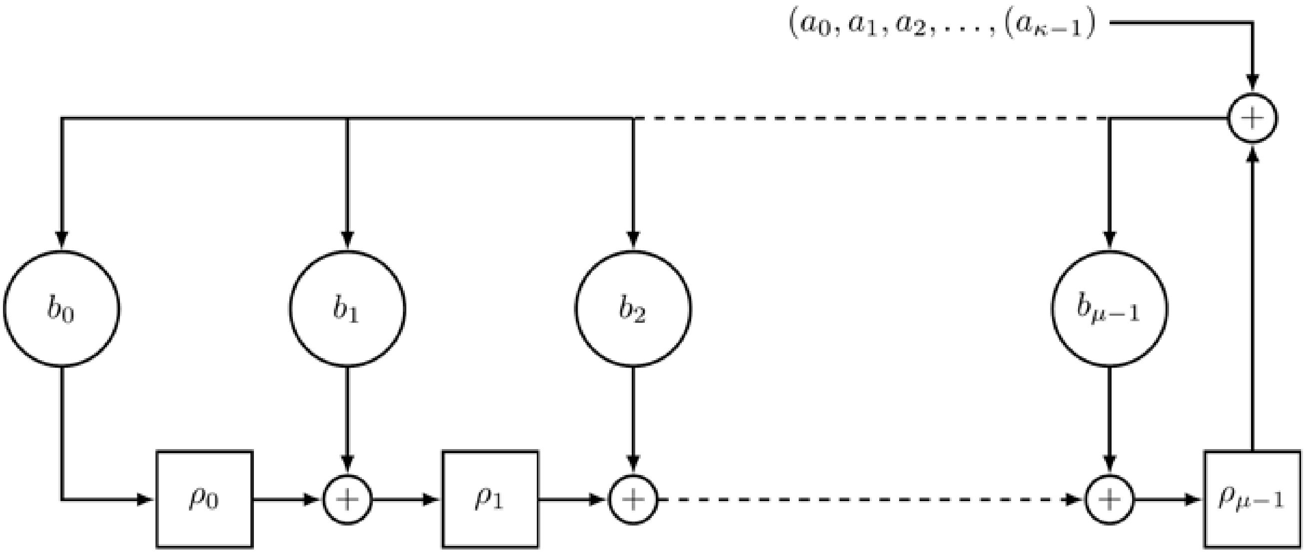
CAN NEWSLETTER MAGAZINE

CRC error detection for CAN XL

CRC generator polynomials for detection of transmission errors in headers and frames of the upcoming CAN XL standard are proposed. Properties, which are chosen to provide error detection performance in the CAN XL scenario, are described.



Linear feedback shift register for use with polynomial codes. All operators are from F $_2$, i.e., + denotes an XOR operation, b_i surrounded by a circle denotes an AND operation with b_i as one of the operands (Source: Dr. Christian Senger)

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These properties include achieving Hamming distance 6 for the full range of possible message lengths. At the beginning of the article, a self-contained recap of CRC codes is given. A new version of the CAN protocol is currently under development: CAN XL. With net data rates up to 10 Mbit/s and beyond, it is designed to bridge the gap between CAN FD and 100Base-T1 Ethernet [1]. Among the design goals for CAN XL are full interoperability with CAN FD as well as large payload length (up to 2 048 byte) in order to enable the use of higher layer protocols such as IP (Internet Protocol) and even encapsulation of complete Ethernet frames [2].

As in any communications system, data transmission in CAN XL is not perfect and transmission errors are inevitable. That is, a transmitted logical zero is detected at the receiver as a logical one or vice versa — a so-called bit error or bit flip. Due to certain physical perturbances in an actual system, bit errors tend to occur in temporally con- fined groups: so-called burst errors.

Based on elaborate mechanisms that exploit the CAN FD/CAN XL frame structure, certain transmission errors can be detected [3], [4] and corresponding measures can be taken. Frame structure-based error detection alone is not able to provide the required state of the art error detection performance for today’s applications, namely probability of undetected bit error below 10^{-20} and guarantee to detect burst errors of a certain length. Thus, in order to provide the required error detection performance, CRC (cyclic redundancy check) codes are employed (Note: that the term “cyclic” at this point is misleading, as many CRC codes used these days do not actually fulfill the definition of a cyclic code (cf. textbooks on error control coding such as [5]). Today, this naming is mainly used for historical reasons).

Competing standards such as Flexray and Ethernet also use CRC codes for error detection and it is our goal to provide at least the same or better error detection performance for CAN XL. This can be accomplished by choosing particular CRC codes, which is the main contribution of this article. Choosing a particular CRC code is based on certain performance criteria such as the probability of undetected error and the maximal length of a burst error that can be detected with certainty. These in turn depend on the messages that need to be protected and thus on the CAN XL frame structure. The choice is particularly challenging in cases where the messages have variable lengths. For that reason, it was decided early on in the design process of CAN XL to protect the comparatively short and fixed-length header by a so-called header CRC and the whole frame (whose length may vary from several to more than 2 000 byte) by a separate CRC, the so-called frame CRC.

CRC codes

In general, the purpose of codes is to cope with trans- mission errors. The main idea is to add redundancy to a message and transmit the resulting codeword. At the receiver, the redundancy can then be used to recover the transmitted codeword, even if it got corrupted during transmission. This is called error correction. A much simpler task is to use the redundancy in order to determine whether the transmission was error-free or not. This is called error detection.

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