Wireless CAN without WLAN or Bluetooth

In two developed concepts, dual-mode radio enables CAN participants to be integrated wirelessly into a CAN network. Constructed from a few components, a protocol-free, real-time transmission and thus transparent integration into CAN is provided.

Embedded control units and sensors generally communicate in modern electronic and mechatronic systems via serial bus systems such as CAN or LIN. Communication is usually wired, so that the cable harness for communication can become very large [1]. It is therefore obvious to save cables and associated plugs, e.g. for non-safety-critical comfort systems, and to replace them with directional radio links for short distances. However, existing radio systems such as WLAN or Bluetooth do not meet the requirements of the applications in terms of real-time capability and robustness. They are also expensive compared to conventional cabling. The alternative presented in this article can be constructed from a few components and enables protocol-free, real-time transmission, and thus transparent integration into a serial bus system such as CAN.

The CAN system is widely used in automotive and industrial applications to establish local networks and enable communication between control units [2]. The network participants, such as control devices or sensors, are connected to the common bus lines via short stubs. The transmission medium usually consists of a twisted two-wire line (CAN-H, CAN-L) via which the signals are transmitted differentially at up to 1 Mbit/s (or up to 8 Mbit/s for CAN FD). A micro-controller is connected to the lines via a CAN transceiver, which converts the digital signals of the micro-controller into the differential signals and vice versa. Although this would be desirable and advantageous in numerous applications, wireless CAN transmission according to the CAN standard is currently not planned.

Current options for wireless CAN transmission rely on protocol-based radio standards such as WLAN or Bluetooth. Thus the CAN data in the transmitter must be converted to the wireless protocol and reset in the receiver. Transparent and real-time transmission in the sense of the CAN network is not possible in this way. The radio connection thus functions as a gateway between two CAN networks.

CAN in dual-mode radio

The wireless CAN described below is based on dual-mode radio. Two free space modes are used for data transmission and the receiver evaluates the differences between the parallel phase modulated signals. With the dual-mode radio (Figure 1), all basic modulation types can be implemented and combined with each other [4]. However, the concept was limited to the modulation of a data signal using phase modulation.

The advantage of the dual-mode system is that it requires only a few components compared to classic radio systems. The transmitter uses only one oscillator. Since the oscillator does not have to meet high requirements in terms of phase noise or frequency stability, it can be selected cost-efficiently. Furthermore, the phase shifters and the 3-db signal splitter can be set up discretely or by means of cables, depending on the frequency. The critical components of the system are the switches, since the maximum possible data rate depends on them. The receiver also consists only of a mixer and possibly amplifiers.

A disadvantage of the system is that the antennas must be aligned at ±30°, so the dual-mode system is not able to provide omnidirectional radiation. Depending on frequency and type, the antennas require the most space compared to the rest of the system.

Two concepts for wireless CAN

The easiest way to integrate a dual-mode radio link into a CAN network is to pick up the differential CAN signals and feed them directly to the dual-mode modulator. The problem on the receiver side is that the received unbalanced signals have to be converted back into a CAN-compliant differential signal. This approach was not followed in the concept because the effort for generating the CAN signals

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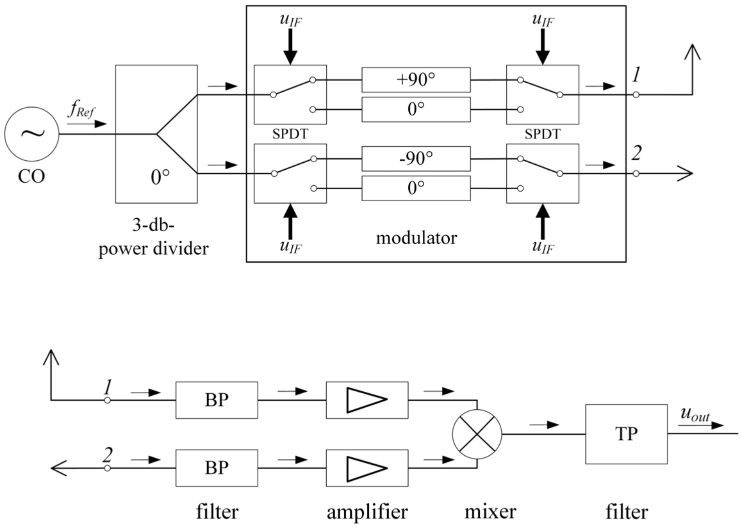

Figure 1: Principle structure of a dual-mode radio system with transmitter (top) and receiver (bottom) (Source: FH Aachen)

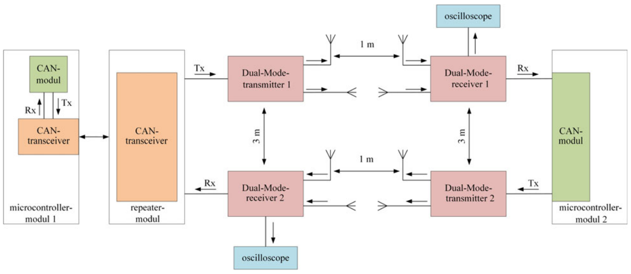

Figure 2: Wireless connection of a CAN node realized by separating the Rx/Tx signals (micro-controller with CAN module, right) via dual-mode radio to a CAN network (Source: FH Aachen)

is too great. Instead, two concepts based on CAN transceivers and a repeater circuit were developed, implemented, and tested.

In the wired connection of a CAN node, communication between transceiver and micro-controller takes place via two standardized signals, Rx (receive data), and Tx (transmit data). In the first concept for wireless integration of the CAN node (Figure 2), the connection between transceiver and micro-controller was cut, so that the transceiver still converts the differential CAN signals to the Rx/Tx signals on the network side. Between transceiver and micro-controller lies the dual-mode radio link, which is formed by a transmitter/receiver pair for each direction. The transceiver evaluates differential signals that are to be transmitted from the network to the micro-controller and transmits them as Tx signals to the dual-mode transmitter. The conversion to the radio link takes place in the dual-mode transmitter. The received signals are evaluated and sent as an Rx bit stream directly to the CAN module of the micro-controller. The other direction of the data transfer works in the same way. The transmission delays caused by the radio system are very low that the CAN timing with regard to arbitration or acknowledgement generation is adhered to and it is not apparent to the CAN network that the CAN node is integrated via a radio link. Since only the dual-mode connection is required as hardware, this concept is very cost-effective.

In the second concept, the micro-controller is replaced by a CAN repeater circuit (Figure 3) [3]. The CAN repeater circuit can be used, for example, to expand an existing CAN network. This makes it possible to set up a CAN radio gateway between two CAN networks without using a micro-controller. Alternatively, you can simply connect two CAN nodes in a galvanically-isolated point-to-point connection. This solution is also very cost-effective due to the small number of components required.

In order to determine the quality of the radio transmission and the maximum data rate of the discrete dual-mode radio system, a bit error rate measurement (BER) was first performed (Figure 4) and eye diagrams recorded (Figure 5) - at a clock frequency of 1 MHz, the maximum data rate of high-speed CAN. Not a single transmission error occurred during the 30-minute measurement, resulting in a statistical bit error rate of 10^{-9}. The wide open eye of the diagram confirms the good signal characteristics as well as the resistance of ▷

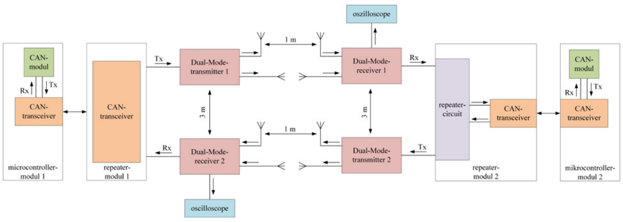

Figure 3: Use of dual-mode radio as gateway via CAN repeater (Source: FH Aachen)

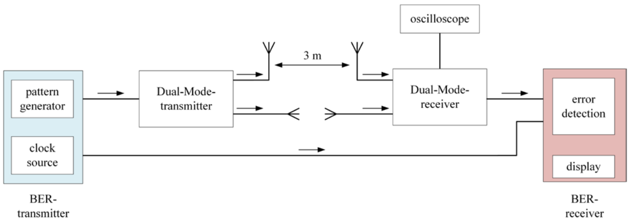

Figure 4: Block diagram for setting up the bit error rate measurement (Source: FH Aachen)

the radio system to interference pulses, noise, and jitter. A closing of the eye could only be determined at a data rate of 8 Mbit/s. Thus a transmission of CAN FD data is also provided.

Both concepts were implemented and tested after the functional verification for the 4,5-GHz dual-mode radio link. The two network participants were each approx. 1 m away from each other. For the tests, a micro-controller module sends CAN messages with an identifier x55 and defined user data. The correct reception of the data was checked using the other micro-controller module and the corresponding oscilloscope. The acknowledgement of the received data by sending the ACK bit of the CAN transmission was also checked. In both cases, perfect CAN communication up to a bit rate of 1 Mbit/s via the dual-mode radio link could be demonstrated. There were no CAN errors during the tests.

Conclusion

The wireless CAN described here is based on dual-mode radio and enables CAN participants to be integrated wirelessly into a CAN network. Both presented and developed concepts function correctly and enable the construction of wireless CAN interfaces. For the CAN nodes involved, it is irrelevant whether the data transmission is wired or via the radio link. With this concept, the cable can be replaced 1:1 and the other advantages listed above can be realized. Due to the simple design with only a few components, a transfer of the discrete design into a simple and small IC for use in embedded systems is possible and in planning. The development of suitable ICs up to component size would enable even better integration into embedded systems.

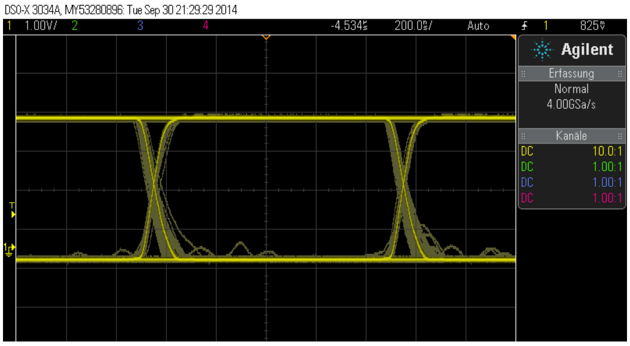
DS0-X 3034A, MY53280896: Tue Sep 30 21:29:29 2014

Figure 5: Eye diagram at 1 MHz (Source: FH Aachen)

The dual-mode system works independently of the antennas used, so that an optimized antenna geometry can be used for embedded applications with the IC. The antennas used in this study do not yet provide optimal characteristics. The use of directional antennas, such as patch arrays or printed Yagi antennas, would be advantageous as it reduces crosstalk between two dual-mode systems and allows the transmitter and receiver to be integrated into one housing.

Compared to classic radio systems, dual-mode radio offers two security aspects. Since dual-mode radio uses two antennas with different polarizations, a potential attacker must insert two receiving antennas with exactly the same polarization into the radio path in order to be able to monitor the signal. Furthermore, by using a voltage-controlled oscillator, it is possible to make the baseband signal noisy and distribute the high-frequency energy over a wider frequency range. This ensures that the dual-mode signal almost disappears in the noise. Demodulation of the signal by the receiver is still possible, but finding the dual-mode signal is more difficult for an attacker without a more-detailed knowledge of the system. ◀

References

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CAN Newsletter Online: Wireless CAN

Machine-to-machine

Wireless CAN bridge

The CAN-Sync wireless CAN bridge from Humanistic Robotics (HRI) allows the user to transmit CAN data wirelessly over a transparent point-to-point bridge, without modifying the data. J1939 and CANopen are supported.

Read on

WLAN gateway

Wireless CAN data transmission

With the CANbox by Caemax (Germany), measurement data can be sent or received from one or two CAN interfaces. The data can be buffered and forwarded via WLAN, e.g. to the WLAN client on the user's notebook.

Read on

Wireless CAN interface

For off-highway vehicles

Mico Incorporated (USA) introduced its Mobeus Electrohydraulic wireless CAN interface for Mobeus Electrohydraulic braking systems. It is compatible with J1939.

Read on

Wifi bridge

Wireless CANopen and J1939 access

The Wi-Fi CAN Bridge (WCB) by Electrum Automation (Sweden) enables wireless CAN access over Wi-Fi 802.11b/g. It enables monitoring the CAN network directly from a smartphone and supports CAN, CANopen, and J1939 protocols.

Read on

Android app

Mobile diagnostics from a single source

RM Michaelides (Germany) has developed a combination of their Dashboard visualization software with the wireless CAN interface CANlink WLAN. The combination provides error diagnosis from a single source.

Read on

GSM/UMTS unit

Remote diagnostics reduce travelling

Proemion (Germany) has presented the CANlink mobile, which lets users diagnose a vehicle or machine from a remote location without being there. It features CAN connectivity.

Read on

Isolation unit

Hazardous environments

With the CBI-100 CAN isolator from Cervis (USA), the isolation of CAN data from hazardous environments is enabled. The product is specified for the use with the company's GWM sensor/data acquisition modules.

Read on

CAN in Automation

The non-profit CiA organization promotes CAN and CAN FD, develops CAN FD recommendations and CANopen specifications, and supports other CAN-based higher-layer protocols.

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