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System and methods for auto-baud detection

Abstract

A circuit may enable communication between a primary device and one or more secondary devices. The communication may utilize a Universal Asynchronous Receiver Transmitter (UART) protocol. In operation, the primary device may require information on the baud rate of the secondary device. The UART may operate in an inverted polarity mode, and this inverted polarity may be interpreted by the secondary device as a request to enter an auto-baud detection mode. Using the inverted polarity mode to enter the auto-baud detection mode may prevent excessive delays in the UART communication and may prevent the need for additional pins to implement the auto-baud detection mode.

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References Cited

U.S. PATENT DOCUMENTS

Patent No.	Issued Date	Patentee Name	U.S. Cl.	CPC
5982837	12/1998	Earnest	375/377	N/A
6798869	12/2003	Sidhu et al.	379/93.33	N/A
7116739	12/2005	Yearsley	375/370	H04L 7/0331
9184834	12/2014	Zhang	N/A	H04B 10/50577
11038508	12/2020	de Haas	N/A	H03F 3/26
2003/0194017	12/2002	Woodworth	375/286	H04L 27/24
2022/0061008	12/2021	Bradley	N/A	N/A

OTHER PUBLICATIONS

International Search Report and Written Opinion, Application No. PCT/US2024/038552, 11 pages, Oct. 21, 2024. cited by applicant

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Background/Summary

PRIORITY
(1) This application claims priority to commonly owned Indian Provisional Patent Application 20/231,1049011 filed Jul. 20, 2023, the entire contents of which are hereby incorporated by reference for all purposes.
FIELD OF THE INVENTION
(2) The present disclosure relates to systems and methods for communication between a primary device and a secondary device, specifically to systems and methods for auto-baud detection between a primary device and a secondary device.
BACKGROUND
(3) A primary device may communicate with a secondary device over a serial communication protocol. The serial communication protocol may be implemented by a universal asynchronous receiver-transmitter (UART) circuit or by another type of communication circuit.
(4) A primary device may include a communication circuit with a respective transmitter circuit and a receiver circuit, and a secondary device may include a communication circuit with a respective transmitter circuit and a receiver circuit. In operation, the transmitter circuit in the primary device may communicate with the receiver circuit in the secondary device, and the transmitter circuit in

the secondary device may communicate with the receiver circuit in the primary device. In one of various examples, a primary device may comprise a microcontroller. Microcontrollers are systems on a chip that generally comprise a processor, a memory, a plurality of input/output ports, and a variety of peripheral devices. In particular, a variety of peripheral devices can be provided such as configurable logic cells, complementary waveform/output generators, dedicated arithmetic units, numerical controlled oscillators and programmable switch mode controllers. Microcontrollers may include host controllers to communicate with peripheral devices over a communication protocol, the communication protocol including but not limited to a UART protocol. The primary device may comprise a digital processor with memory and a plurality of programmable input and output ports.

(5) The secondary device may comprise a peripheral device as described previously, including but not limited to a sensor, amplifier, oscillator, battery gauge, data converter and a logic device. The secondary device may communicate with a primary device using a communication protocol, the communication protocol including but not limited to a UART protocol.

(6) The secondary device may comprise a MOSFET driver circuit. The primary device may communicate configuration information to the secondary device, including but not limited to the baud rate of communication between the primary device and the secondary device.

(7) The secondary device may be sensitive to temperature and may operate at a different baud rate than the rate configured by the primary device. Various methods may be used to adjust the baud rate to compensate for variations in baud rate, these methods also called auto-baud detection. In one of various examples of auto-baud detection, a pin generally designated for use by the UART may be reconfigured as an input/output (I/O) pin and used as a communication channel during auto-baud detection, but this auto-baud detection method may not be used in cases with a dedicated UART pin which may not be reconfigured as an I/O pin. The term pin, as used herein, is not meant to be limited to any particular type of physical structure, and may include, without limitation, gull-wing or J-lead terminals, solder balls or lands. In another example of auto-baud detection, the baud rate of communication between the UART circuits may be slowed to accommodate the required delays in the auto-baud protocol. In addition, a byte of data may be transmitted to enable the auto-baud detection. The change in baud rate and the transmission of a byte of data all slow down the auto-baud detection and prevent other peripherals in the microcontroller from using the UART circuit.

(8) There is a need for auto-baud detection which can be implemented by any device with a UART circuit without requiring additional pins, and which does not reduce the baud rate of communication between the UART devices during the auto-baud detection.

SUMMARY

(9) The examples herein enable a system and method for auto-baud detection between a primary device and a secondary device.

(10) According to one aspect, a system includes a primary device. The primary device may comprise a primary device transmitter circuit and a primary device receiver circuit. The device may include a secondary device comprising a secondary device transmitter circuit and a secondary device receiver circuit. The primary device may enable the primary device transmitter circuit and the secondary device may enable the receiver circuit in the secondary device. The transmitter circuit in the primary device may transmit a predetermined voltage for at least a predetermined time during an inverted polarity mode. The receiver circuit in the secondary device may detect the predetermined voltage for the predetermined time and may enter an auto-baud detection mode. The primary device may disable the transmitter circuit in the primary device and enable the receiver circuit in the primary device. The transmitter circuit in the secondary device may transmit a predetermined sequence and the receiver circuit in the primary device may receive the predetermined sequence and may calculate a baud rate based on the received predetermined sequence.

(11) According to one aspect, a method includes steps of: enabling a transmitter circuit in a primary

device, configuring the transmitter circuit in the primary device to an inverted polarity mode to drive a communication path to a predetermined voltage for a predetermined time, detecting, at a receiver circuit in a secondary device, the predetermined voltage for the predetermined time and entering an auto-baud detection mode, configuring, after the predetermined time, the transmitter circuit in the primary device in a non-inverted polarity mode, disabling the transmitter circuit in the primary device, enabling, responsive to entering the auto-baud detection mode, a transmitter circuit in the secondary device and transmitting a predetermined sequence on the communication path, receiving the predetermined sequence at the primary device and calculating a baud rate of the transmission of the predetermined sequence, and disabling the auto-baud detection mode in the primary device.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

(1) FIG. **1** illustrates one of various examples of a system for auto-baud detection between a primary device and a secondary device.

(2) FIG. **2** illustrates a timing diagram of one of various examples of auto-baud detection.

(3) FIG. **3** illustrates a method of auto-baud detection.

DETAILED DESCRIPTION

(4) FIG. **1** illustrates one of various examples of a system **100** for auto-baud detection. System **100** may be a semiconductor system-on-a-chip (SoC), a microcontroller, or may be a combination of discrete components. System **100** may comprise a primary device **110** and a secondary device **150**, which primary device **110** and secondary device **150** may be in communication by a communication path **130**.

(5) Primary device **110** may include primary device communication circuit **120**. Primary device communication circuit **120** may include primary device primary device transmitter circuit **121** and primary device receiver circuit **122**. Primary device **110** may include other circuits and passive components not specifically mentioned. Primary device **110** may include a clock signal for transmitting and receiving data. In some examples, primary device **110** may include a clock circuit generating the clock signal.

(6) Secondary device **150** may include secondary device communication circuit **160**.

(7) Secondary device communication circuit **160** may include secondary device receiver circuit **161** and secondary device transmitter circuit **162**. Secondary device **150** may include other circuits and passive components not specifically mentioned. Secondary device **150** may include a clock signal for transmitting and receiving data. In some examples, secondary device **150** may include a respective clock circuit generating the clock signal.

(8) Primary device **110** may be a microcontroller. Secondary device **150** may be a peripheral device, including but not limited to a sensor, amplifier, oscillator, battery gauge, data converter, power driver, or a logic device. Secondary device **150** may be a MOSFET driver.

(9) Communication path **130** may be a UART interface, and may comprise a transmit line and a receive line.

(10) In operation, primary device **110** may communicate with secondary device **150**. Primary device transmitter circuit **121** may transmit signals over communication path **130** and signals may be received at secondary device receiver circuit **161**. Secondary device **150** may decode signals received at secondary device receiver circuit **161** and may modify operation of secondary device **150** based on the decoded signals. Secondary device **150** may communicate with primary device **110**. Secondary device transmitter circuit **162** may transmit signals over communication path **130** and signals may be received at primary device receiver circuit **122**. Primary device **110** may decode signals received at primary device receiver circuit **122** and may modify operation of primary device

110 based on the decoded signals.

(11) The example illustrated in FIG. **1** is a half-duplex implementation, with primary device transmitter circuit **121** and secondary device transmitter circuit **162**, respectively, and secondary device receiver circuit **161** and primary device receiver circuit **122**, respectively, sharing communication path **130**. Other examples may include a dedicated connection between primary device transmitter circuit **121** and secondary device receiver circuit **161**, and another dedicated connection between secondary device transmitter circuit **162** and primary device receiver circuit **122**. Primary device transmitter circuit **121** may be a push-pull driver or may be an open drain driver with a pull-up resistor on communication path **130**. Secondary device transmitter circuit **162** may be a push-pull driver or may be an open drain driver with a pull-up resistor on communication path **130**.

(12) Primary device communication circuit **120** may be a UART circuit. Communication circuit **160** may be a UART circuit.

(13) In one of various examples, system **100** may implement auto-baud detection. Primary device transmitter circuit **121** may operate in a non-inverted mode, wherein communication path **130** may be held at a logic high level when primary device transmitter circuit **121** is enabled and in an idle state, i.e. not transmitting data. Primary device transmitter circuit **121** may operate in an inverted mode, wherein communication path **130** may be held at a logic low level when primary device transmitter circuit **121** is enabled and in an idle state, i.e. not transmitting data. Secondary device transmitter circuit **162** may operate in a non-inverted mode, wherein communication path **130** may be held at a logic high level when secondary device transmitter circuit **162** is enabled and in an idle state, i.e. not transmitting data. Secondary device transmitter circuit **162** may operate in an inverted mode, wherein communication path **130** may be held at a logic low level when secondary device transmitter circuit **162** is enabled and in an idle state, i.e. not transmitting data. The idle state of the non-inverted polarity mode may be opposite in polarity to the idle state in the inverted polarity mode.

(14) In operation, primary device transmitter circuit **121** may drive communication path **130** with a predetermined voltage for a predetermined time to secondary device receiver circuit **161** and may signal an auto-baud detection mode. Primary device transmitter circuit **121** may drive the predetermined voltage by using the idle state of primary device transmitter circuit **121** in the inverted polarity mode. Primary device transmitter circuit **121** may be a push-pull driver or an open drain pull-down driver. The predetermined voltage may be a ground voltage. Primary device transmitter circuit **121** may be enabled in a non-inverted polarity mode. In one of various examples, primary device transmitter circuit **121** may be enabled by a microcontroller in primary device **110** or may be enabled by communication with another controller. In the non-inverted polarity mode, primary device transmitter circuit **121** may hold communication path **130** at a logic high level when in an idle state. Primary device transmitter circuit **121** may drive the communication path **130**, or communication path **130** may be pulled to a logic high level by a pull-up resistor. Primary device transmitter circuit **121** may be in an idle state when enabled but not transmitting data. Primary device transmitter circuit **121** may then operate in an inverted polarity mode. In one of various examples, primary device transmitter circuit **121** may operate in an inverted polarity mode. When inverted polarity mode is enabled, primary device transmitter circuit **121** may drive communication path **130** to a logic low level, as logic low is the idle state when the inverted polarity mode is enabled. Communication path **130** may remain at a logic low state for a predetermined time. Secondary device receiver circuit **161** may detect the low level on communication path **130** for the predetermined time, and may interpret this as a request by primary device **110** to enter auto-baud detection mode. Secondary device **150** may enter the auto-baud detection mode based on detecting the low level on communication path **130** for the predetermined time. Auto-baud detection mode may be indicated based on setting a register value. After the predetermined time, primary device transmitter circuit **121** may operate in the non-inverted polarity mode and subsequently primary

device transmitter circuit **121** may be disabled. Primary device receiver circuit **122** may be enabled and secondary device transmitter circuit **162** may be enabled. Secondary device **150** may transmit a predetermined sequence over communication path **130** as specified by the auto-baud detection mode. In one of various examples, secondary device **150** may transmit a fixed binary code from secondary device transmitter circuit **162** to primary device receiver circuit **122**. The fixed binary code may represent a control word transmitted from the secondary device transmitter circuit **162** to the primary device receiver circuit **122**. Primary device **110** may receive the predetermined sequence at primary device receiver circuit **122** and may calculate a baud rate of the received predetermined sequence. The predetermined sequence may comprise an acknowledge word. The calculation of a baud rate may be based on a timer, a counter, a phase-locked loop, an external clock or another method. After the predetermined sequence is received, auto-baud detection mode may be disabled.

(15) FIG. **2** illustrates a timing diagram **200** of one of various examples of auto-baud detection. Clock signal **220** may be a clock signal used to transmit and receive data. Clock signal **220** may be a common clock signal in primary device **110** and secondary device **150** as described and illustrated in reference to FIG. **1**. Bus **230** may be a data bus. Bus **230** may be one of various examples of communication path **130** as described and illustrated in reference to FIG. **1**. Bus **230** may enable communication between primary device **110** and secondary device **150** in a system as described and illustrated in FIG. **1**.

(16) In operation, at time **251**, transmitter circuit **121** in primary device **110** may be enabled to transmit over bus **230** in a transmit mode. Transmitter circuit **121** in the primary device **110** may operate in non-inverted polarity mode. In one of various examples, the transmitter circuit in the primary device may hold bus **230** at a logic high level awaiting the first transmission. In other examples, the transmitter circuit in the primary device may operate in an open drain mode, and a pull-up resistor on bus **230** may hold bus **230** at a logic high level awaiting the first transmission. Logic high may be the idle state of the transmitter in the non-inverted polarity mode. At time **252**, the transmitter circuit may transmit in an inverted polarity mode. In the inverted polarity mode, the transmitter circuit may drive bus **230** to a logic low level, as shown at time **253**. Logic low may represent the idle state of the transmitter circuit when the inverted polarity mode is enabled. By changing from the non-inverted polarity mode to the inverted polarity mode, the logic level of bus **230** may be used as a communication signal to initiate the auto-baud detection mode. Time period **262** may represent a delay between the time of configuration of transmitter circuit **121** in the inverted polarity mode at time **252** and the transmitter driving bus **230** to a logic low level.

(17) Bus **230** may remain at a logic low state for a predetermined time. In the example illustrated in FIG. **2**, bus **230** may remain low for at least 1.8 ms, but this is not intended to be limiting. Receiver **161** in the secondary device **150** may detect the logic low level on bus **230** and the secondary device **150** may enter an auto-baud detection mode at least partially in response to detection of the logic low level on bus **230** for the predetermined time. After the predetermined time has elapsed, at time **254**, the transmitter circuit **121** may operate in non-inverted polarity mode, and the transmitter circuit **121** in the primary device may therefore drive bus **230** to a logic high level, which logic high may represent the idle state of bus **230** when the transmitter is in the non-inverted polarity mode. Time period **264** may represent a delay between the configuration in the non-inverted polarity mode at time **254** and the bus **230** being driven to the logic high state. At time **255**, the transmitter circuit **121** in the primary device **110** may be disabled. At time **256**, the primary device **110** may be in an auto-baud detection mode. The auto-baud detection mode of the primary device **110** may be indicated by a configuration register in the primary device **110** or by another method. At time **256**, the secondary device **150** may transmit a predetermined sequence over bus **230** as specified by the auto-baud detection mode. In the example illustrated in FIG. **2**, the secondary device may transmit a fixed binary code. In the example illustrated in FIG. **2**, the fixed binary code may be 0x55h, but this is not intended to be limiting. The secondary device may transmit a

different fixed binary code of any word width. The example illustrated in FIG. **2**, clock signal **220** may be used to sample bus **230** on both the rising edge and the falling edge, but this is not intended to be limiting.

(18) The predetermined sequence may terminate at time **257**. Primary device **110** may receive the predetermined sequence and may calculate a baud rate of the received predetermined sequence. The calculation of the baud rate of the predetermined sequence may be based on a timer, a counter, a phase-locked loop or another method. After the predetermined sequence is received, primary device **110** may disable the auto-baud detection mode at time **258** and auto-baud detection mode may be disabled in secondary device **150**.

(19) The example of FIG. **2** illustrates one of various examples of communication between a primary device and a secondary device. The secondary device may be a MOSFET driver circuit, but this is not intended to be limiting. In other examples, a primary device may communicate with another peripheral device.

(20) FIG. **3** illustrates a method **300** of auto-baud detection.

(21) At operation **310**, a transmitter circuit in a primary device may be enabled in a non-inverted polarity mode and may drive a data bus to a logic high level during an idle state. Additionally, a transmitter circuit may be enabled. At operation **320**, the polarity of the transmitter may be configured to an inverted mode and the data bus may transition to a predetermined voltage. In one of various examples, the data bus may transition to a logic low level for at least a predetermined time. The predetermined voltage may be a ground voltage. At operation **330**, a receiver circuit in a secondary device may detect the logic low level on the data bus for the predetermined time. At operation **340**, after the predetermined time, the polarity of the transmitter may be configured to a non-inverted polarity mode and the data bus may transition to a logic high level. The data bus may be driven by a push-pull driver in the transmitter in the primary device or may be pulled to a logic high level by a pullup resistor. At operation **350**, the transmitter in the primary device may be disabled and the receiver in the primary device may be enabled transmitter in the secondary device may be enabled. At operation **360**, an auto-baud detection mode may be enabled in the primary device and the transmitter in the secondary device may transmit a predetermined sequence over the data bus. In one of various examples, the predetermined sequence may comprise an acknowledge word. At operation **370**, a receiver circuit in the primary device may receive the predetermined sequence and may calculate a baud rate of the predetermined sequence. At operation **380**, the auto-baud detection mode may be disabled in the primary device and in the secondary device.

Claims

1. A system comprising: a primary device comprising a primary device transmitter circuit and a primary device receiver circuit; a secondary device comprising a secondary device transmitter circuit and a secondary device receiver circuit; wherein: the primary device enables the primary device transmitter circuit and the secondary device enables the receiver circuit in the secondary device; the transmitter circuit in the primary device to transmit a predetermined voltage for at least a predetermined time during an inverted polarity mode; the receiver circuit in the secondary device to detect the predetermined voltage for the predetermined time and to enter an auto-baud detection mode; the primary device to disable the transmitter circuit in the primary device and enable the receiver circuit in the primary device; the transmitter circuit in the secondary device to transmit a predetermined sequence; and the receiver circuit in the primary device to receive the predetermined sequence and to calculate a baud rate based on the received predetermined sequence.
2. The system as claimed in claim 1, the secondary device comprising a MOSFET driver.
3. The system as claimed in claim 1, the primary device is a microcontroller.
4. The system as claimed in claim 1, the transmitter circuit in the primary device to transmit a predetermined voltage during an idle state in an inverted polarity mode.

5. The system as claimed in claim 1, the predetermined voltage for the predetermined time comprising a ground voltage for a duration of between about 1.29 msec and about 2 msec.
6. The system as claimed in claim 1, the predetermined voltage transmitted during the inverted polarity mode to be opposite in polarity from a voltage transmitted during a non-inverted mode.
7. The system as claimed in claim 1, the predetermined sequence comprising an acknowledge word transmitted from the secondary device to the primary device.
8. A method comprising: enabling a transmitter circuit in a primary device; configuring the transmitter circuit in the primary device to an inverted polarity mode to drive a communication path to a predetermined voltage for a predetermined time; detecting, at a receiver circuit in a secondary device, the predetermined voltage for the predetermined time and entering an auto-baud detection mode; configuring, after the predetermined time, the transmitter circuit in the primary device in a non-inverted polarity mode; disabling the transmitter circuit in the primary device; enabling, responsive to entering the auto-baud detection mode, a transmitter circuit in the secondary device and transmitting a predetermined sequence on the communication path; receiving the predetermined sequence at the primary device and calculating a baud rate of the transmission of the predetermined sequence; and disabling the auto-baud detection mode in the primary device.
9. The method as claimed in claim 8, the secondary device comprising a MOSFET driver.
10. The method as claimed in claim 8, the primary device comprising a microcontroller.
11. The method as claimed in claim 8, the predetermined voltage for the predetermined time comprising a ground voltage for a duration of between about 1.29 msec and about 2 msec).
12. The method as claimed in claim 8, the configuring the transmitter circuit in the primary device comprising writing one or more control words to the transmitter circuit in the primary device.
13. The method as claimed in claim 8, the predetermined voltage transmitted during the inverted polarity mode to be opposite in polarity from a voltage transmitted during a non-inverted polarity mode.
14. The method as claimed in claim 8, the predetermined sequence comprising an acknowledge word transmitted from the secondary device to the primary device.