QUAD ASYNCHRONOUS RECEIVER AND TRANSMITTER

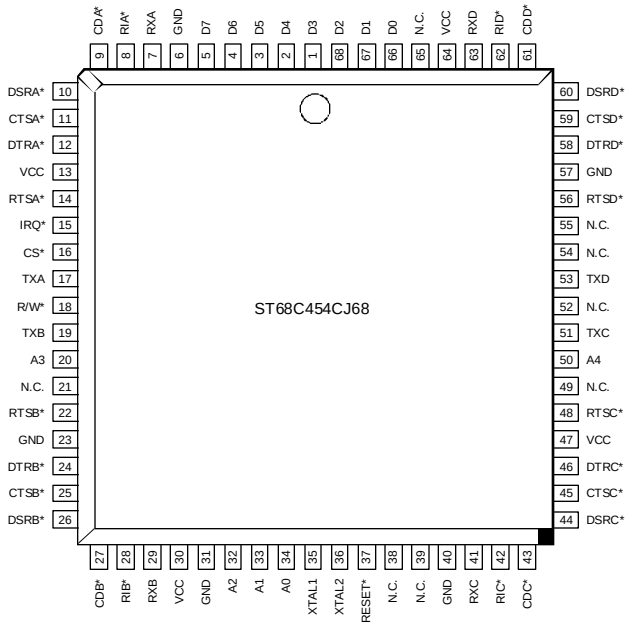
DESCRIPTION

The ST68C454 is a quad universal asynchronous receiver and transmitter with modem control signals. Designed to interface with MOTOROLA, ROCKWELL, HITACHI bus and other popular microprocessors. An internal programmable baud rate generator is provided to select transmit and receive clock rates from 50Hz to 1.5 MHz.

The ST68C454 is an improved, quad version of the NS16450 UART with faster operating access time. The on board status registers will provide the error conditions, type and status of the transfer operations being performed. Complete MODEM control capability, and a processor interrupt system that may be software tailored to the user's requirements to minimize the computing required to handle the communications link.

The ST68C454 is fabricated in an advanced 1.2µ CMOS process to achieve low drain power and high speed requirements.

PLCC Package



FEATURES

- Motorola, Rockwell, Hitachi bus compatible
- Quad ST16C450
- Modem control signals (CTS*,RTS*, DSR*, DTR*, RI*, CD*)
- Programmable character lengths (5, 6, 7, 8)
- Even, odd, or no parity bit generation and detection
- Status report register
- TTL compatible inputs, outputs
- 460.8 kHz transmit/receive operation with 7.372 MHz external clock source

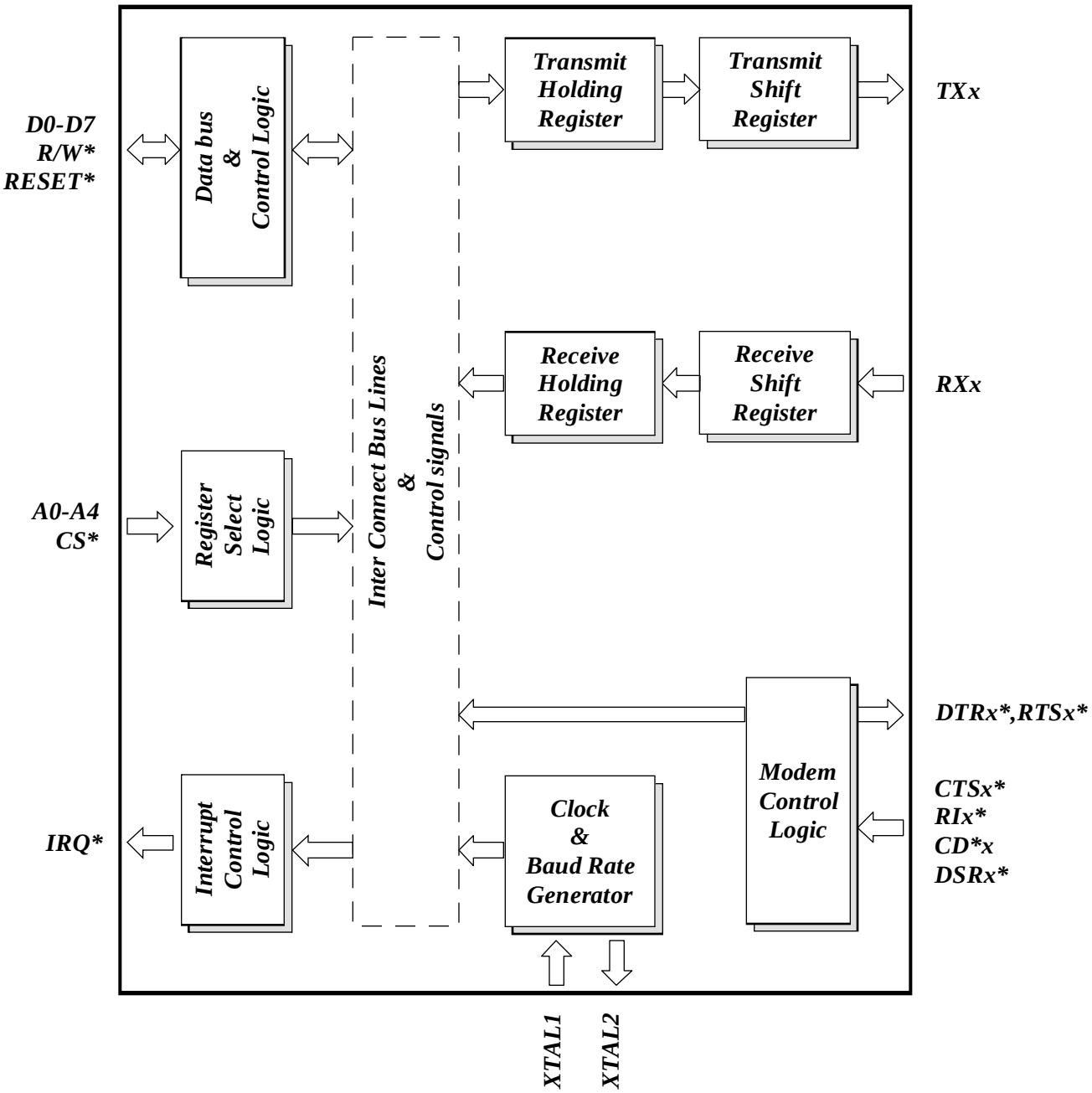
ORDERING INFORMATION

Part number	Package	Operating temperature
ST68C454CJ68	PLCC	0° C to +70° C
ST68C454IJ68	PLCC	-40° C to +85° C

Rev. 2.0

ST68C454

BLOCK DIAGRAM



ST68C454

SYMBOL DESCRIPTION

Symbol	Pin	Signal Type	Pin Description
D7-D0	5-66	I/O	Bi-directional data I/O. Eight bit, three state data bus to transfer information to or from the CPU. D0 is the least significant bit of the data bus and the first serial data bit to be received or transmitted.
RX A/B RX C/D	7,29 41,63	I	Serial data input . The serial information received from MODEM or RS232 to ST68C454 receive circuit. A mark (high) is logic one and a space (low) is logic zero. During the local loopback mode the RX input is disabled from external connection and connected to the TX output internally.
TX A/B TX C/D	17,19 51,53	O	Serial data output A. The serial data of channel A is transmitted via this pin with additional start , stop and parity bits. The TX will be held in mark (high) state during reset, local loopback mode or when the transmitter is disabled.
CS*	16	I	Chip select (active low). A low at this pin will enable the UART A-D CPU data transfer operation.
XTAL1	35	I	Crystal input 1 or external clock input. A crystal can be connected to this pin and XTAL2 pin to utilize the internal oscillator circuit. An external clock can be used to clock internal circuit and baud rate generator for custom transmission rates.
XTAL2	36	O	Crystal input 2. See XTAL1.
R/W*	18	I	Read/Write strobe. A low on this pin will transfer the contents of the CPU data bus to the addressed register. A high on this pin will transfer the contents of the ST68C454 data bus to the CPU.
CD* A/B CD* C/D	9,27 43,61	I	Carrier detect A-D (active low). A low on this pin indicates that carrier has been detected by the modem.
GND GND	6,23,31 40,57	O	Signal and power ground.
DSR* A/B DSR* C/D	10,26 44,60	I	Data set ready A-D. (active low) A low on this pin indicates that MODEM is ready to exchange data with UART.

ST68C454

SYMBOL DESCRIPTION

Symbol	Pin	Signal Type	Pin Description
RI* A/B RI* C/D	8,28 42,62	I	Ring detect A-D indicator . (active low) A low on this pin indicates that modem has received a ringing signal from telephone line.
RTS* A/B RTS* C/D	14,22 48,56	O	Request to send A-D. (active low) To indicate that transmitter has data ready to send. Writing a "1" in the modem control register (MCR bit-1) will set this pin to low state. After the reset this pin will be set to high.
CTS* A/B CTS* C/D	11,25 45,59	I	Clear to send A-D. (active low) The CTS* signal s a MODEM control function input whose conditions can be tested by reading the MSR BIT-4. CTS* has no effect on the transmitter output.
A4	50	I	Address line 4. To select one of the four UARTS.
A3	20	I	Address line 3. To select one of the four UARTS.
A2	32	I	Address line 2. To select internal registers.
A1	33	I	Address line 1. To select internal registers.
A0	34	I	Address line 0. To select internal registers.
IRQ*	15	O	Interrupt output. (active low open collector) This pin goes low (when enabled by the interrupt enable register) whenever a receiver error, receiver data available, transmitter empty or modem status condition flag is detected on UART A-D.
DTR* A/B DTR* C/D	12,24 46,58	O	Data terminal ready A-D. (active low) To indicate that ST68C454 is ready to receive data. This pin can be controlled via the modem control register (MCR bit-0). Writing a "1" at the MCR bit-0 will set the DTR* output to low. This pin will be set to high state after writing a "0" to that register or after the reset.
RESET*	37	I	Master reset. (active low) A low on this pin will reset all the

ST68C454

SYMBOL DESCRIPTION

Symbol	Pin	Signal Type	Pin Description
			outputs and internal registers. The transmitter output and the receiver input will be disabled during reset time.
VCC VCC	13,30 47,64	I	Power supply input.

SERIAL PORT SELECTION GUIDE

CS*	A4	A3	UART X
1	X	X	X
0	0	0	UART A
0	0	1	UART B
0	1	0	UART C
0	1	1	UART D

ST68C454

PROGRAMMING TABLE

A2	A1	A0	READ MODE	WRITE MODE
0	0	0	Receive Holding Register	Transmit Holding Register
0	0	1		Interrupt Enable Register
0	1	0	Interrupt Status Register	
0	1	1		Line Control Register
1	0	0		Modem Control Register
1	0	1	Line Status Register	
1	1	0	Modem Status Register	
1	1	1	Scratchpad Register	Scratchpad Register
0	0	0		LSB of Divisor Latch
0	0	1		MSB of Divisor Latch

REGISTER FUNCTIONAL DESCRIPTIONS

TRANSMIT AND RECEIVE HOLDING REGISTER A-D

The serial transmitter section consists of a Transmit Hold Register A-D and Transmit Shift Register A-D. The status of the transmit hold register is provided in the Line Status Register A-D. Writing to this register will transfer the contents of the data bus (D7-D0) to the transmit holding register A-D whenever the transmitter holding register A-D or transmitter shift register A-D is empty. The transmit holding register empty A-D flag will be set to "1" when the transmitter is empty or data is transferred to the transmit shift register A-D. Note that a write operation should be performed when the transmit holding register empty flag is set.

On the falling edge of the start bit, the receiver internal counter will start to count 7 1/2 clocks (16x clock) which is the center of the start bit. The start bit is valid if the RX A-D is still low at the mid-bit sample of the start bit. Verifying the start bit prevents the receiver from assembling a false data character due to a low going noise spike on the RX A-D input. Receiver status codes will be posted in the Line Status Register A-D.

PROGRAMMABLE BAUD RATE GENERATOR

The ST68C454 contains a programmable Baud Rate Generator that is capable of taking any clock input from DC-24 MHz and dividing it by any divisor from 1 to 2_{16} -1. Customize Baud Rates can be achieved by selecting proper divisor values for MSB and LSB of baud rate generator.

INTERRUPT ENABLE REGISTER A-D

The Interrupt Enable Register A-D masks the incoming interrupts from receiver ready, transmitter empty, line status and modem status registers to the IRQ* output pin.

IER BIT-0:
0=disable the receiver ready interrupt
1=enable the receiver ready interrupt

IER BIT-1:
0=disable transmitter empty interrupt
1=enable transmitter empty interrupt

IER BIT-2:
0=disable receiver line status interrupt
1=enable receiver line status interrupt

IER BIT-3:
0=disable the modem status register interrupt
1=enable the modem status register interrupt

ST68C454

IER BIT 7-4:
All these bits are set to logic zero.

INTERRUPT STATUS REGISTER A-D
The ST68C454 provides four level prioritized interrupt conditions to minimize software overhead during data character transfers. The Interrupt Status Register A-D provides the source of the interrupt in prioritized manner. During the read cycle, the ST68C454 provides the highest interrupt level to be serviced by the CPU. No other interrupts are acknowledged until the particular interrupt has been serviced. The following are the prioritized interrupt levels:

P	D3	D2	D1	D0	Source of the interrupt
1	0	1	1	0	LSR (Receiver Line Status Register)
2	0	1	0	0	RXRDY (Received Data Ready)
3	0	0	1	0	TXRDY(Transmitter Holding Register Empty)
4	0	0	0	0	MSR (Modem Status Register)

ISR BIT-0:
0=an interrupt is pending and the ISR contents may be used as a pointer to the appropriate interrupt service routine
1=no interrupt pending

ISR BIT 1-2:
Logical combination of these bits, provides the highest priority interrupt pending.

ISR BIT 3-7:
These bits are not used and are set zero.

LINE CONTROL REGISTER A-D
The Line Control Register is used to specify the asynchronous data communication format. The number of the word length, stop bits, and parity can be selected by writing appropriate bits in this register.

LCR BIT1-0:
These two bits specify the word length to be transmitted or received.

00=5 bits word length
01=6 bits word length
10=7 bits word length
11=8 bits word length

LCR BIT-2:
The number of stop bits can be specified by this bit.

0=1 stop bit , when word length=5, 6, 7, 8 bits
1=1 and 1/2 stop bit , when word length=5 bits
1=2 stop bits, word length=6, 7, 8 bits

LCR BIT-3:
Parity or no parity can be selected via this bit.
0=no parity
1=a parity bit is generated during the transmission; receiver also checks for received parity

LCR BIT-4:
If the parity bit is enabled, LCR BIT-4 selects the even or odd parity format.
0=odd parity is generated by calculating odd number of 1's in the transmitted data; receiver also checks for same format.
1=an even parity bit is generated by calculating the number of even 1's in the transmitted data; receiver also checks for same format.

LCR BIT-5:
If the parity bit is enabled, LCR BIT-5 selects the forced parity format.
LCR BIT-5=1 and LCR BIT-4=0, parity bit is forced to "1" in the transmitted and received data.
LCR BIT-5=1 and LCR BIT-4=1, parity bit is forced to "0" in the transmitted and received data.

ST68C454

LCR BIT-6:
Break control bit.
1=forces the transmitter output (TX A-D) to go low to alert the communication terminal
0=normal operating condition

LCR BIT-7:
The internal baud rate counter latch enable (DLEN).
0=normal operation
1=select divisor latch register

MODEM CONTROL REGISTER A-D
This register controls the interface with the MODEM or a peripheral device (RS232).

MCR BIT-0:
0=force DTR* output to high
1=force DTR* output to low

MCR BIT-1:
0=force RTS* output to high
1=force RTS* output to low

MCR BIT2-3:
x=not used

MCR BIT -4:
0=normal operating mode
1=enable local loop-back mode (diagnostics). The transmitter output (TX A-D) is set high (Mark condition), the Receiver inputs (RX A-D , CTS* A-D, DSR* A-D, CD* A-D, and RI* A-D) are disabled. Internally, the transmitter output is connected to the receiver input and DTR* A-D, RTS* A-D and MCR A-D bit2,3 are connected to modem control inputs. In this mode , the receiver and transmitter interrupts are fully operational. The Modem Control Interrupts are also operational, but the interrupt sources are now the lower four bits of the Modem Control Register instead of the four Modem Control Inputs. The interrupts are still controlled by the IER A-D.

MCR BIT 5-7:
Not used. Are set to zero permanently.

LINE STATUS REGISTER A-D
This register provides the status of data transfer to CPU.

LSR BIT-0:
0=no data in receive holding register
1=a data has been received and saved in the receive holding register

LSR BIT-1:
0=no overrun error (normal)
1=overrun error, next character arrived before receive holding register was empty

LSR BIT-2:
0=no parity error (normal)
1=parity error, received data does not have correct parity information

LSR BIT-3:
0=no framing error (normal)
1=framing error received, received data did not have a valid stop bit

LSR BIT-4:
0=no break condition (normal)
1=receiver received a break signal (RX was low for one character time frame)

LSR BIT-5:
0=transmit holding register is full; ST68C454 will not accept any data for transmission
1=transmit holding register is empty; CPU can load the next character

LSR BIT-6:
0=transmitter holding and shift registers are full
1=transmitter holding and shift registers are empty

LSR BIT-7:
Not used, set to “0”.

MODEM STATUS REGISTER A-D
This register provides the current state of the control lines from the modem or peripheral to the CPU. Four bits of this register are used to indicate the changed

information. These bits are set to “1” whenever a control input from the MODEM changes state. They are set to “0” whenever the CPU reads this register.

MSR BIT-0:
Indicates that the CTS* input to the ST68C454 has changed state since the last time it was read.

MSR BIT-1:
Indicates that the DSR* input to the ST68C454 has changed state since the last time it was read.

MSR BIT-2:
Indicates that the RI* input to the ST68C454 has changed from a low to a high state.

MSR BIT-3:
Indicates that the CD* input to the ST68C454 has changed state since the last time it was read.

MSR BIT-4:
This bit is equivalent to RTS in the MCR. It is the compliment of the CTS* input.

MSR BIT-5:
This bit is equivalent to DTR in the MCR. It is the compliment of the DSR* input.

MSR BIT-6:
This bit is equivalent to MCR bit-2 during local loop-back mode. It is the compliment of the RI* input.

MSR BIT-7:
This bit is equivalent to MCR bit-3 during local loop-back mode. It is the compliment to the CD* input.

SCRATCHPAD REGISTER A-D
ST68C454 provides a temporary data register to store 8 bits of information for variable use.

BAUD RATE GENERATOR PROGRAMMING TABLE (1.8432 MHz CLOCK):

BAUD RATE	16xCLOCK %ERROR	DVISOR
50	2304	
75	1536	
150	768	
300	384	
600	192	
1200	96	
2400	48	
4800	24	
7200	16	
9600	12	
19.2	6	
38.4K	3	
56K	2	2.77
115.2K	1	

ST68C454 EXTERNAL RESET CONDITION

REGISTERS	RESET STATE
IER A-D	BITS 0-7=0
ISR A-D	BIT-0=1, BIT-7=0
LCR A-D	BITS 0-7=0
MCR A-D	BITS 0-7=0
LSR A-D	BITS 0-4=0, BITS 5-6=1, BIT-7=0
MSR A-D	BITS 0-3=0, BITS 4-7= input signals

SIGNALS	RESET STATE
TX A-D	High
RTS A-D*	High
DTR A-D*	High
IRQ	Three state mode

ST68C454

ST68C454 ACCESSIBLE REGISTERS

A2 A1 A0	Register	BIT-7	BIT-6	BIT-5	BIT-4	BIT-3	BIT-2	BIT-1	BIT-0
0 0 0	RHR	bit-7	bit-6	bit-5	bit-4	bit-3	bit-2	bit-1	bit-0
0 0 0	THR	bit-7	bit-6	bit-5	bit-4	bit-3	bit-2	bit-1	bit-0
0 0 1	IER	0	0	0	0	modem status interrupt	receive line status interrupt	transmit holding register	receive holding register
0 1 0	ISR	0	0	0	0	int priority bit-2	int priority bit-1	int priority bit-0	int status
0 1 1	LCR	divisor latch enable	set break	set parity	even parity	parity enable	stop bits	word length bit-1	word length bit-0
1 0 0	MCR	0	0	0	loop back	Not used	Not used	RTS*	DTR*
1 0 1	LSR	0	trans. empty	trans. holding empty	break interrupt	framing error	parity error	overrun error	receive data ready
1 1 0	MSR	CD	RI	DSR	CTS	delta CD*	delta RI*	delta DSR*	delta CTS*
1 1 1	SPR	bit-7	bit-6	bit-5	bit-4	bit-3	bit-2	bit-1	bit-0
0 0 0	***DLL***	***bit-7***	***bit-6***	***bit-5***	***bit-4***	***bit-3***	***bit-2***	***bit-1***	***bit-0***
0 0 1	***DLM***	***bit-15***	***bit-14***	***bit-13***	***bit-12***	***bit-11***	***bit-10***	***bit-9***	***bit-8***

DLL and DLM are accessible only when LCR bit-7 is set to “1”.

ST68C454

AC ELECTRICAL CHARACTERISTICS

T_A=0° - 70° C, VCC=3.3 - 5.0 V ± 10% unless otherwise specified.

Symbol	Parameter	Limits Min	Typ	Max	Units	Conditions
T_1	Clock high pulse duration	20			ns	
T_2	Clock low pulse duration	20			ns	
T_3	Clock rise/fall time			10	ns	
T_8	Chip select setup time	0			ns	
T_9	Chip select hold time	0			ns	
T_{12}	Data setup time	15			ns	
T_{13}	Data hold time from write or CS*	5			ns	
T_{14}	Write set up time	10			ns	
T_{15}	Write strobe width	50			ns	
T_{16}	Chip select hold time from write	15			ns	
T_{17}	Write cycle delay	45			ns	
T_{18}	Data setup time	15			ns	
Tw	Write cycle=T_{15}+T_{17}	105			ns	
T_{24}	Data hold time	0			ns	
T_{25}	Read cycle delay	25			ns	
Tr	Read cycle=T_{18}+T_{25}	105			ns	
T_{27}	Chip select pulse width	75			ns	
T_{28}	Delay from Write to output			50	ns	100 pF load
T_{29}	Delay to set interrupt from MODEM input			35	ns	100 pF load
T_{31}	Delay from stop to set interrupt			1_{Rclk}	ns	100 pF load
T_{32}	Delay from Read to reset interrupt			200	ns	100 pF load
T_{33}	Delay from initial IRQ* reset to transmit start	8		24	*	
T_{34}	Delay from stop to interrupt			100	ns	
T_{35}	Delay from Write to reset interrupt			75	ns	
T_R	Reset pulse width	10			ns	

* = Baudout* cycle

ST68C454

ABSOLUTE MAXIMUM RATINGS

Supply range	7 Volts
Voltage at any pin	GND-0.3 V to VCC+0.3 V
Operating temperature	0° C to +70° C
Storage temperature	-40° C to +150° C
Package dissipation	500 mW

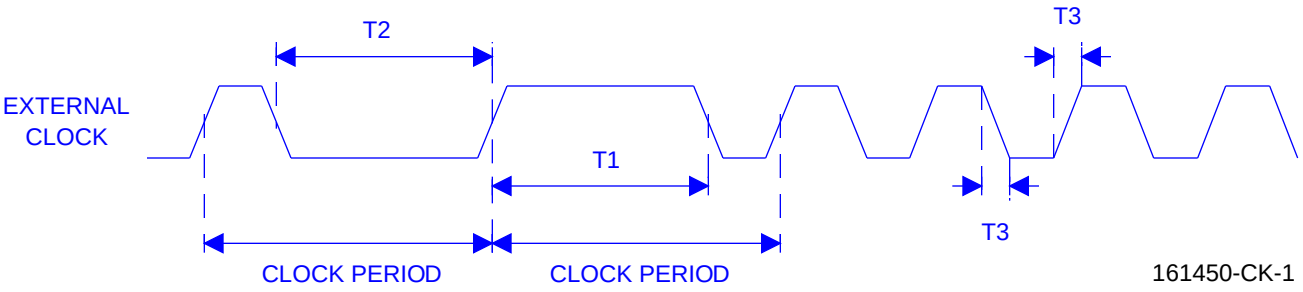
DC ELECTRICAL CHARACTERISTICS

T_A=0° - 70° C, Vcc=3.3 - 5.0 V ±10% unless otherwise specified.

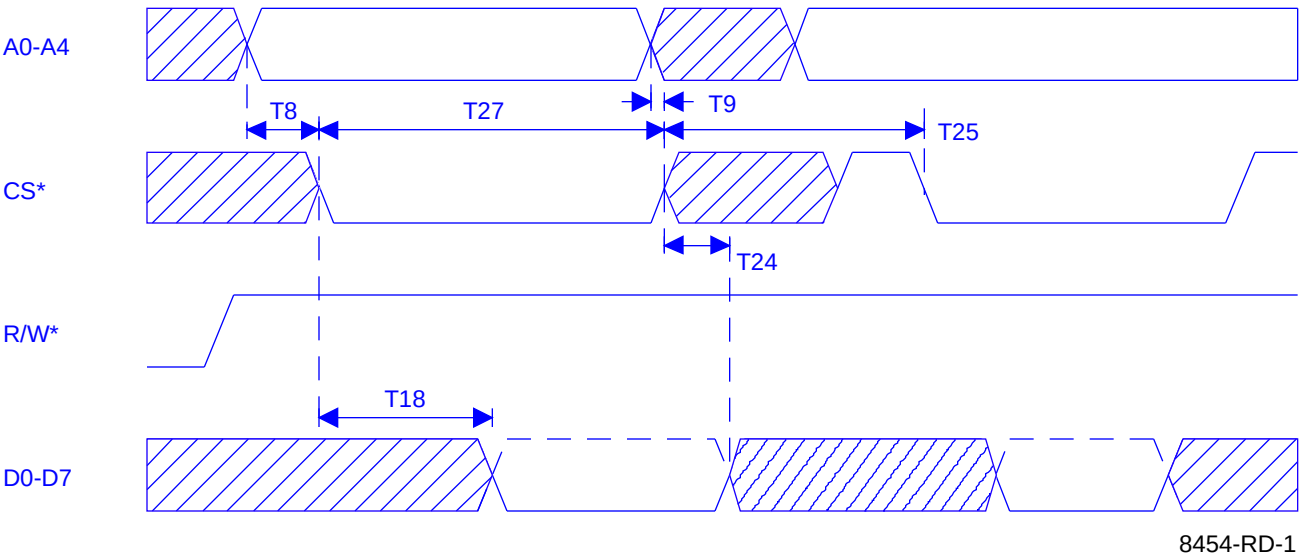
Symbol	Parameter	Limits Min	Typ	Max	Units	Conditions
V_{ILCK}	Clock input low level	-0.5		0.6	V	
V_{IHCK}	Clock input high level	3.0		VCC	V	
V_{IL}	Input low level	-0.5		0.8	V	
V_{IH}	Input high level	2.2		VCC	V	
V_{OL}	Output low level			0.4	V	I_{OL}= 6 mA on all outputs
V_{OH}	Output high level	2.4			V	I_{OH}= -6 mA
I_{CC}	Avg. power supply current		6	12	mA	
I_{IL}	Input leakage			±10	µA	
I_{CL}	Clock leakage			±10	µA	
V_{ILCK}	Clock input low level	-0.3		0.8	V	Vcc=3.0 V
V_{IHCK}	Clock input high level	2.4		VCC	V	Vcc=3.0 V
V_{IL}	Input low level	-0.3		0.8	V	Vcc=3.0 V
V_{IH}	Input high level	2.0		VCC	V	Vcc=3.0 V
V_{OL}	Output low level on all outputs			0.4	V	Vcc=3.0 V, I_{OL}= 8.5 mA
V_{OH}	Output high level	2.0			V	Vcc=3.0 V, I_{OH}= -4 mA
I_{CC}	Avg power supply current		10	12	mA	Vcc=3.0 V

ST68C454

CLOCK TIMING

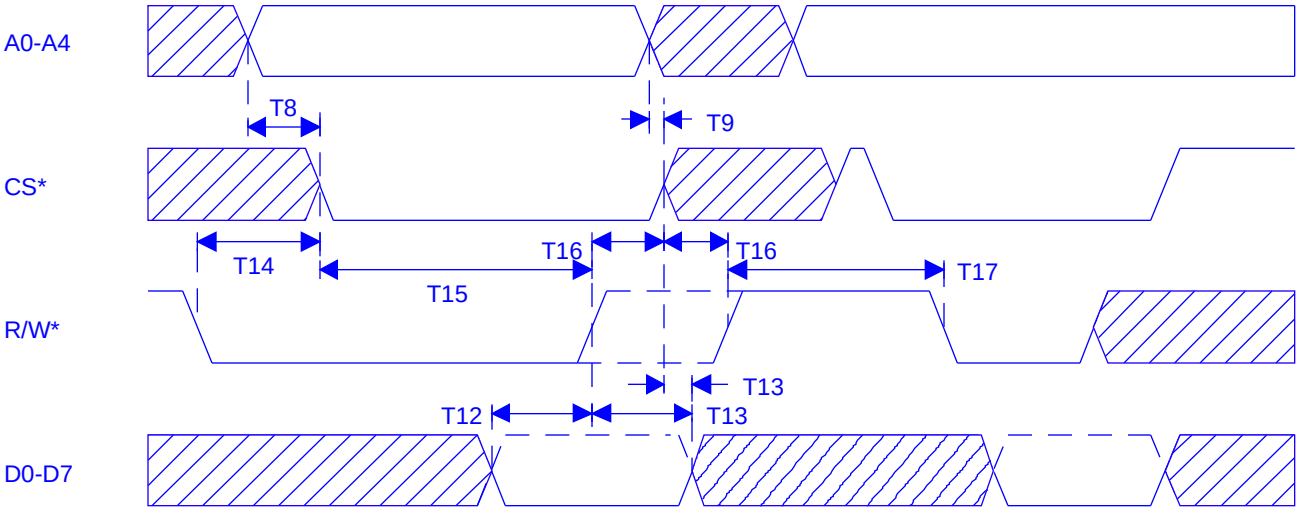


GENERAL READ TIMING



ST68C454

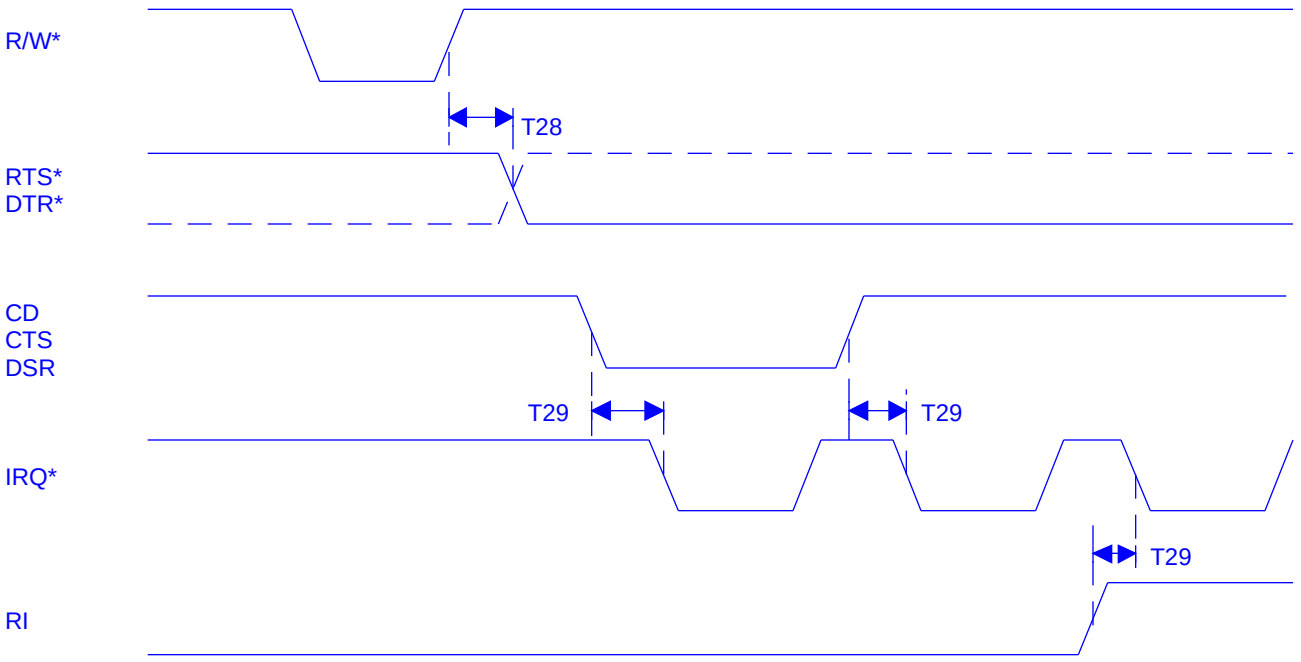
GENERAL WRITE TIMING



68454-WD-1

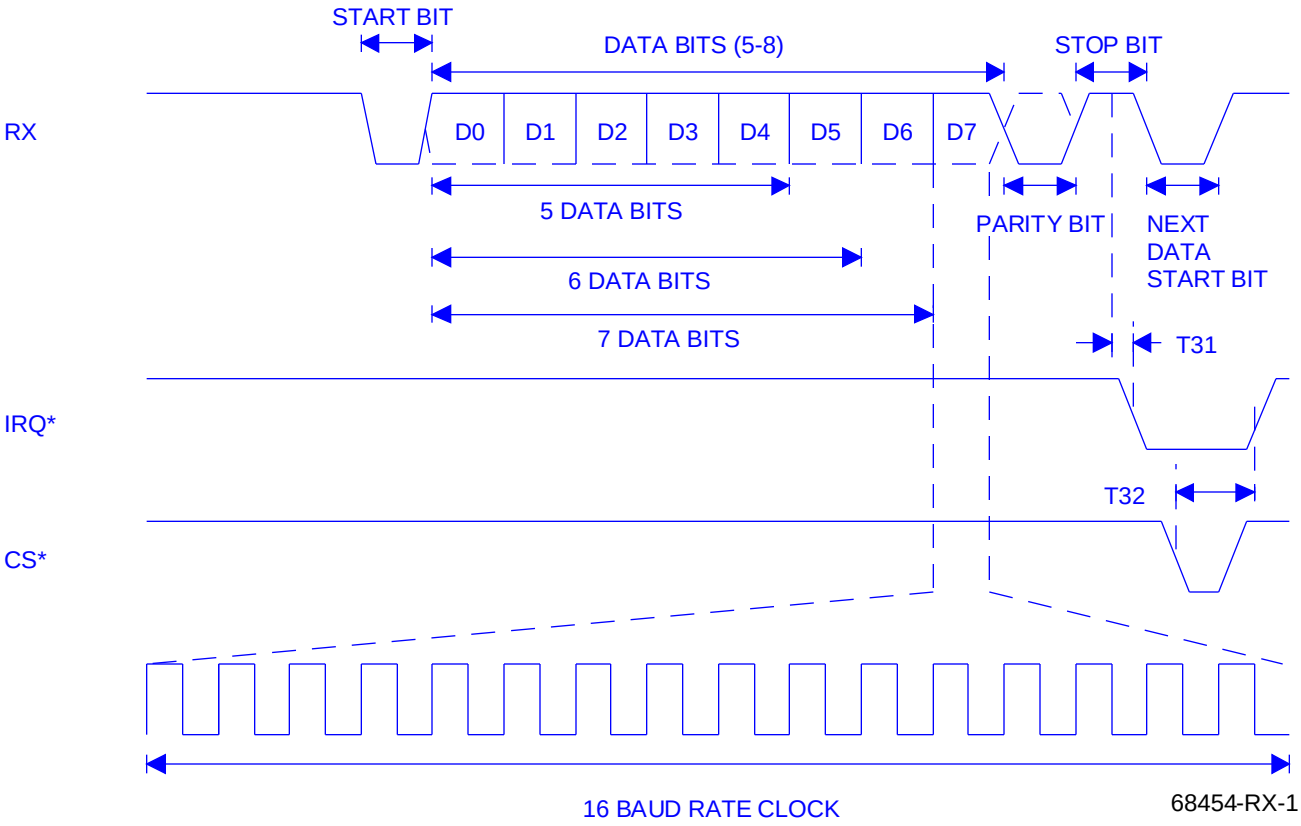
ST68C454

MODEM TIMING



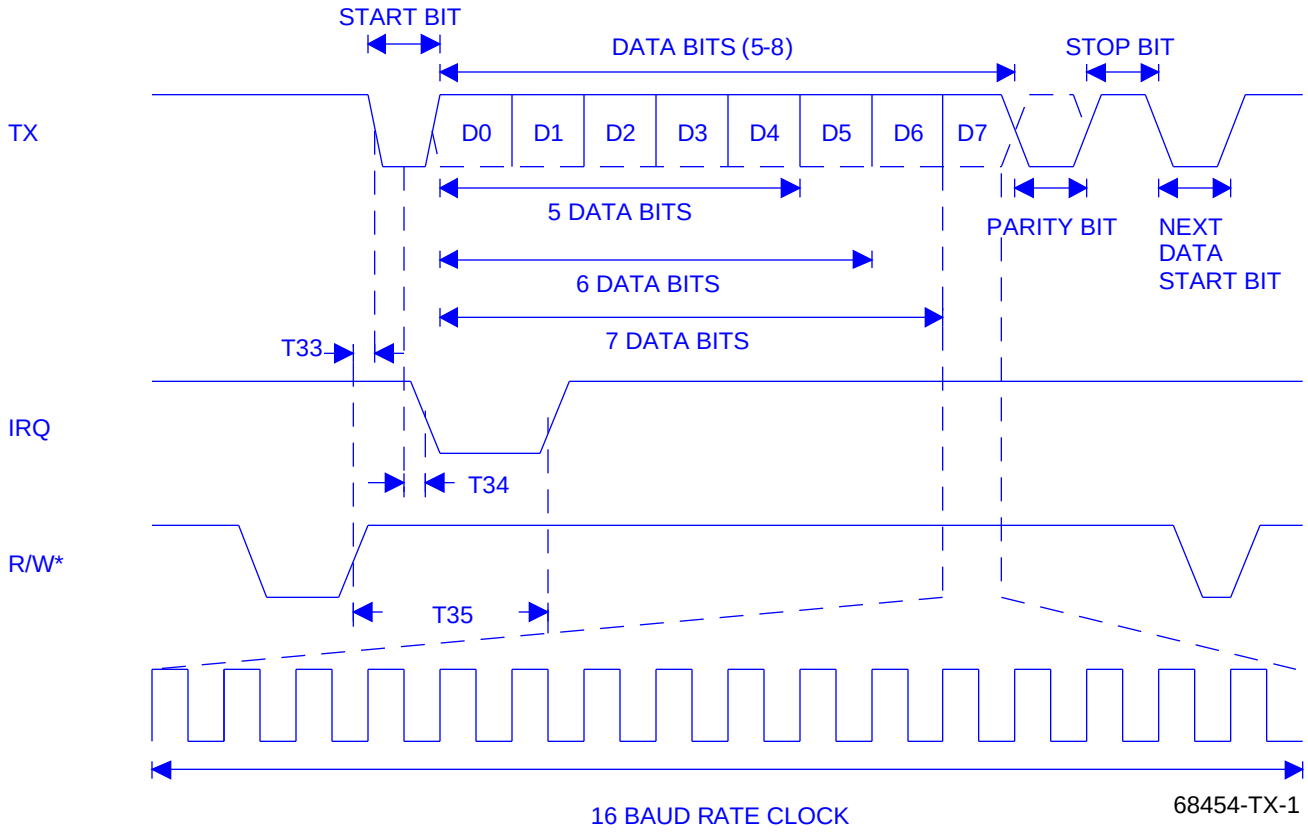
ST68C454

RECEIVE TIMING



ST68C454

TRANSMIT TIMING



ST68C454