1 FEATURES

- Single-chip MBUS Transceiver
- UART Communication Speeds Up to 38,400 baud
- Integrated 3.3 V VDD LDO Regulator with Extended Peak Current Capability of 15mA
- Supports Powering Slave Device from the Bus or from External Power Supply
- Adjustable I/O Levels
- Low Bus Voltage Operation
- Extended Current Budget for External Circuits: at least 0.88mA
- Polarity Independent
- Power-Fail Function
- Fast Startup – No External Transistor Required on STC Pin
- Industrial Ambient Temperature Range of −40°C to +85°C
- Available in:16-pin SOIC
- These are Pb-free Devices

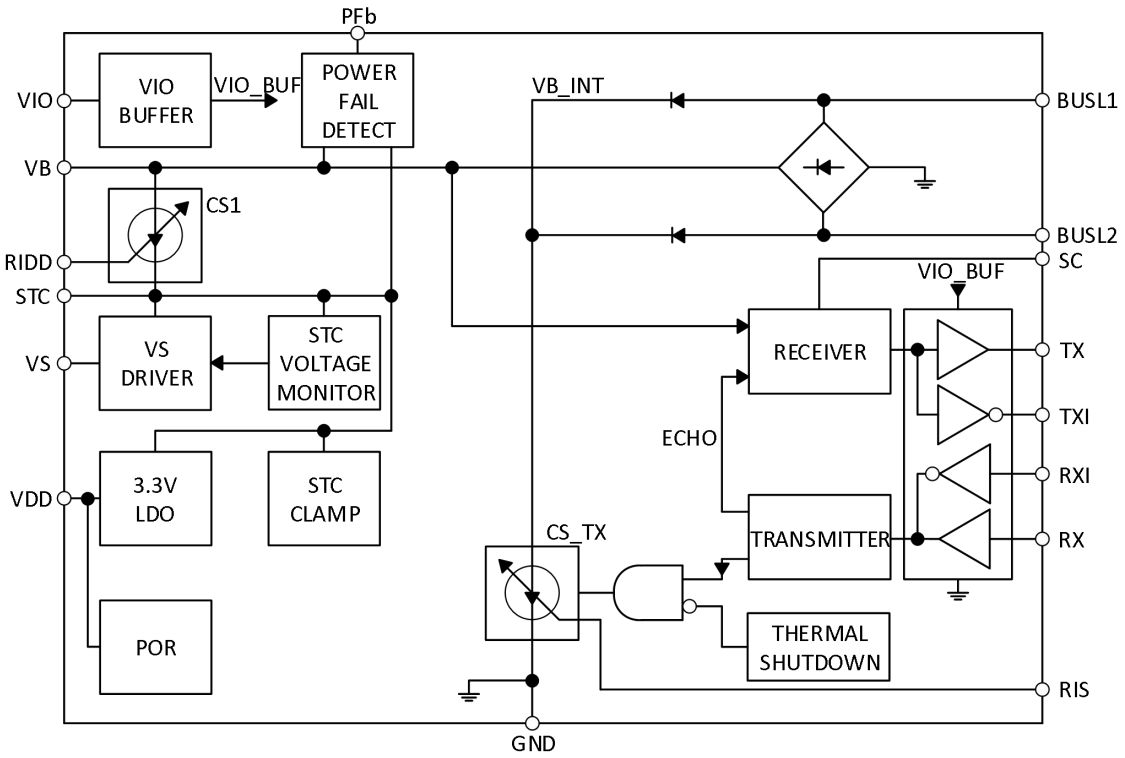
2 APPLICATIONS

- Multi-energy Utility Meters
  - Water
  - Gas
  - Electricity
  - Heating systems

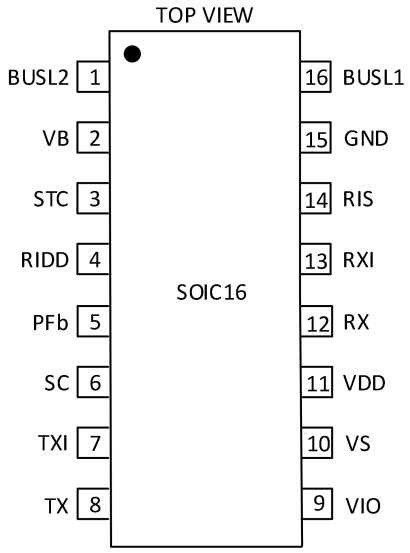
3 DESCRIPTION

The MC721 is a single-chip integrated slave transceiver for use in two-wire Meter Bus (M-BUS) slave devices and repeaters. The transceiver provides all of the functions needed to satisfy the European Standards EN 13757−2 and EN 1434−3 describing the physical layer requirements for M-BUS. It includes a programmable power level of up to 2 unit loads,which are available for use in external circuits through a 3.3V LDO regulator. The MC721 can provide communication up to the maximum M-BUS communication speed of 38,400 baud (half-duplex).

BLOCK DIAGRAM



4 PIN CONFIGURATION AND FUNCTIONS



Pin		Description
Name	No.	
BUSL2	1	MBUS line. Connect to bus through 220Ω series resistors.Connections are polarity independent
VB	2	Rectified bus voltage
STC	3	Storage capacitor pin. Connect to bulk storage capacitor(minimum 10µF, maximum 330µF–2700µF)
RIDD	4	Mark current adjustment pin. Connect to programming resistor
PFb	5	Power Fail, active low
SC	6	Mark bus voltage level storage capacitor pin.Connect to ceramic capacitor (typically 220nF)
TXI	7	UART Data output (inverted)
TX	8	UART Data output
VIO	9	I/O pins (RX, RXI, TX, TXI, PFb) high level voltage
VS	10	Gate driver for PMOS switch between bus powered operation and external power supply
VDD	11	Voltage regulator output. Connect to minimum 1µF decoupling capacitor
RX	12	UART Data input
RXI	13	UART Data input (inverted)
RIS	14	Modulation current adjustment pin
GND	15	Ground
BUSL1	16	MBUS line. Connect to bus through 220Ω series resistors.Connections are polarity independent

5 SPECIFICATIONS

5.1 ABSOLUTE MAXIMUM RATINGS(1)

Parameter	Parameter	Rating	UNIT
T_J	Junction Temperature	-40 to +150	°C
T_S	Storage Temperature	-55 to +150	°C
V_{BUS}	Bus Voltage (|BUSL1 – BUSL2|)	-50 to +50	V
V_{TX}, V_{TXI}	Voltage on Pin TX, TXI	-0.3 to +7.5	V
V_{RX}, V_{RXI}, V_{IO}	Voltage on Pin RX, RXI, VIO	-0.3 to +5.5	V
ESD_{HBM}	ESD Rating – Human Body Model	4.0	kV
ESD_{MM}	ESD Rating – Machine Model	250	V
ESD_{CDM}	ESD Rating – Charged Device Model	750	V

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device

functionality should not be assumed, damage may occur and reliability may be affected.
1. All voltages are referenced to GND.

5.2 THERMAL CHARACTERISTICS

Parameter	Parameter	Rating	UNIT
$R_{\theta JA}$	Thermal Characteristics, Thermal Resistance, Junction-to-Air	125	°C/W

5.3 RECOMMENDED OPERATING CONDITIONS(2)(3)

Parameter	Parameter	Rating	UNIT
T_A	Ambient Temperature	-40 to +85	°C
V_{BUS}	Bus Voltage ($\|V_{BUSL1} - V_{BUS2}\|$)	9.2 to 42	V
V_{IO}	VIO Pin Voltage (4)	2.5 to 3.8	V

2. Refer to ELECTRICAL CHARACTERISTICS and APPLICATION INFORMATION for Safe Operating Area.
3. All voltages are referenced to GND.
4. V_{STC} must be at least 1V higher than V_{IO} for proper operation.

5.4 ELECTRICAL CHARACTERISTICS(5)

Symbol	Parameter		MIN	TYP	MAX	UNIT
ΔV_{BR}	Voltage drop over bus rectifier ($V_{BUS} - V_B$) (R_{IDD} (6) = 4.02kΩ)		-	-	1.25	V
ΔV_{CS}	Voltage drop over CS1 ($V_B - V_{STC}$)	R_{IDD}(6)≥13kΩ	1.30	-	-	V
		R_{IDD}(6)≤4.02kΩ	1.70	-	-	
I_{BUS}	Total Current Drawn from the Bus, Mark State	R_{IDD}(6)=30kΩ	-	1.32	1.50	mA
		R_{IDD}(6)=13kΩ	-	2.71	3.00	
ΔI_{BUS}	Bus Current Stability (over $_{\Delta}V_{BUS}$ = 10V, RX/RXI = mark)		-	0.2	2	%
I_{STC}	Idle Current Available for the Application to Draw from STC and V_{DD} (Including Current Drawn from IO Pins)	R_{IDD}(6)=30kΩ	0.88	1.05	1.20	mA
		R_{IDD}(6)=13kΩ	2.10	2.35	2.60	
$\Delta I_{STC,SPACE}$	Additional Current Available for the Application when Transmitting a Space		-	200	-	µA
I_{CC}	Internal Supply Current (R_{IDD}(6)= 13k,RX/RXI = mark)		-	359	500	µA
I_{IO}	Current Drawn by the V_{IO} Pin		-0.5	-	0.5	µA
$V_{STC,clamp}$	Clamp Voltage on Pin STC ($I_{DD} < I_{STC}$)		6.0	6.5	7.0	V
$V_{B,PFb}$	Threshold Voltage on V_B to Trigger PFb (7)		V_{STC}+0.3	-	V_{STC}+0.8	V
$V_{PFb,OH}$	PFb Voltage High (I_{PFb}=−100µA)		V_{IO}-0.6	-	V_{IO}	V
$V_{PFb,OL}$	PFb Voltage Low(8) (I_{PFb}=50µA)		0	-	0.6	V
V_{RIDD}	Voltage on RIDD Pin		1.15	1.20	1.25	V
$V_{VS,OH}$	Voltage on VS during High State ($V_{STC} > V_{STC}$, V_{DD} ON, I_{VS}=−5µA)		V_{STC}-0.4	-	V_{STC}	V
$R_{VS,PD}$	Pull-down Resistor on VS during Low State (V_{DD} > 2V, $V_{STC} > V_S$)		50	100	150	kΩ

5. All voltages are referenced to GND.
6. Resistor with 1% accuracy.
7. PFb comparator has a 70mV hysteresis.
8. PFb pin is pulled down with an on-chip resistor of typically 2MΩ.

5.5 VDD REGULATOR ELECTRICAL CHARACTERISTICS [9]

Parameter	Parameter	MIN	TYP	MAX	UNIT
V_{DD}	Voltage on V_{DD} [10] (I_{DD} < 15mA)	3.1	3.1	3.1	V
I_{DD}	Peak Current that can be Supplied by V_{DD} [11]	15	-	-	mA
$I_{DD, OFF}$	V_{BUS} = 0V, V_{STC} = 0V	-0.5	-	0.5	μA
$V_{POR, ON}$	Power on Reset Threshold, Release	2.65	2.85	3.15	V
$V_{POR, OFF}$	Power on Reset Threshold, Reset	2.55	2.75	3.00	V
$V_{STC, VDD ON}$	Threshold Voltage on Pin STC to Turn On V_{DD} Regulator, Pull the VS Pin High and Enable the PF Function	5.6	6.0	6.4	V
$V_{STC, VDD OFF}$	Threshold Voltage on Pin STC to Turn Off V_{DD} Regulator and Pull the PFb and VS Pins Low	3.7	4.0	4.3	V

9. All voltages are referenced to GND.
10. Including output resistance of V_{DD}.
11. Average current draw limited by I_{STC}.

5.6 RECEIVER ELECTRICAL CHARACTERISTICS[12]

Symbol	Parameter		MIN	TYP	MAX	UNIT
V_T	Receiver Threshold Voltage		V_{SC}-8.2	-	V_{SC}-5.7	V
V_{SC}	Mark Level Storage Capacitor Voltage		-	-	V_B	V
$I_{SC, charge}$	Mark Level Storage Capacitor Charge Current		-40	-25	-15	μA
$I_{SC, discharge}$	Mark Level Storage Capacitor Discharge Current		0.3	0.6	-0.033×$I_{SC,CHARGE}$	μA
CDR	Charge/Discharge Current Ratio		30	40	-	
$V_{TX, OH}$, $V_{TXI, OH}$	TX/TXI High-level Voltage (I_{TX}/I_{TXI} = −100μA) [13]		V_{IO}-0.6	-	V_{IO}	V
$V_{TX, OL}$, $V_{TXI, OL}$	TX/TXI Low-level Voltage	(I_{TX}/I_{TXI}=100μA)	0	-	1.5	V
		(I_{TX}=1.1mA)				
I_{TX}, I_{TXI}	V_{TX}=7.5V, V_{STC}=6V		0	-	16	μA

12. All voltages are referenced to GND.
13. VSTC must be at least 1V higher than VIO for proper operation.

5.7 TRANSMITTER ELECTRICAL CHARACTERISTICS [14]

Symbol	Parameter	MIN	TYP	MAX	UNIT
I_{MC}	Space Level Modulating Current (R_{RIS} = 100Ω [15])	12.5	15.0	18.0	mA
V_{RIS}	Voltage on RIS Pin	1.2	1.4	1.6	V
$V_{RX, IH}$, $V_{RXI, IH}$	RX/RXI Input High	V_{IO}-0.8	-	5.5	V
$V_{RX, IL}$, $V_{RXI, IL}$	RX/RXI Input Low	0	-	0.8	V
I_{RX}, I_{RXI}	Current Drawn or Sourced from RX/RXI Pins [16] (V_{IO} = 3V)	±6	-	±30	μA

14.All voltages are referenced to GND.
15.Resistor with 1% accuracy.
16.Including internal pull-up resistor on RX and internal pull-down resistor on RXI.

6 APPLICATION SCHEMATICS

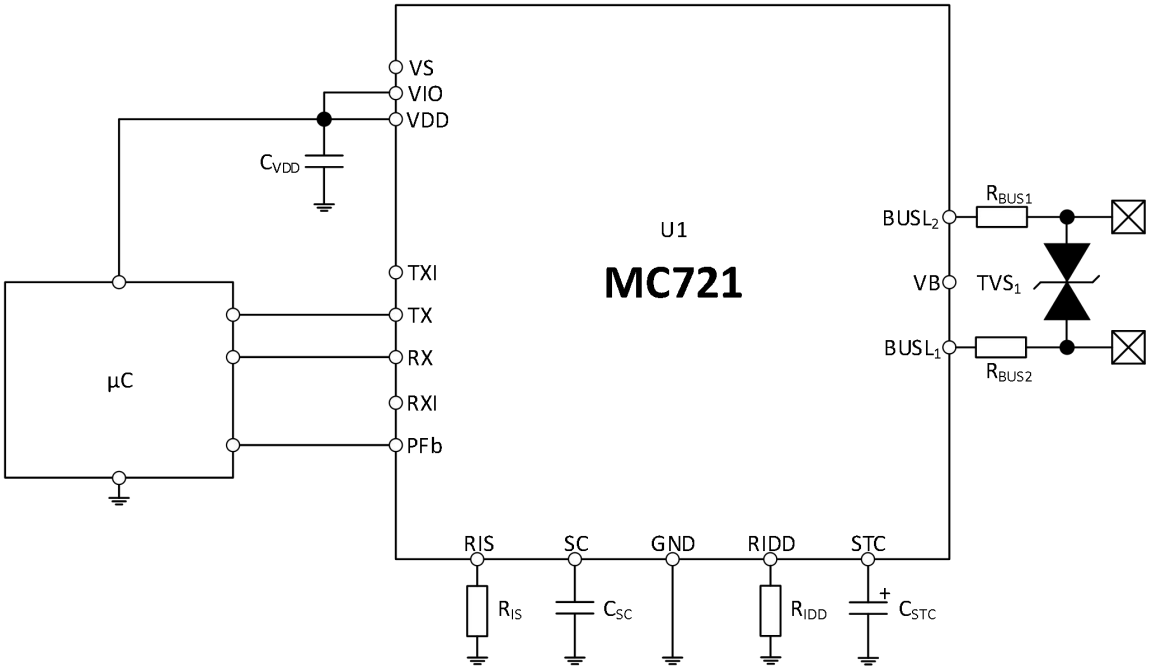


Figure 1.General Application Schematic

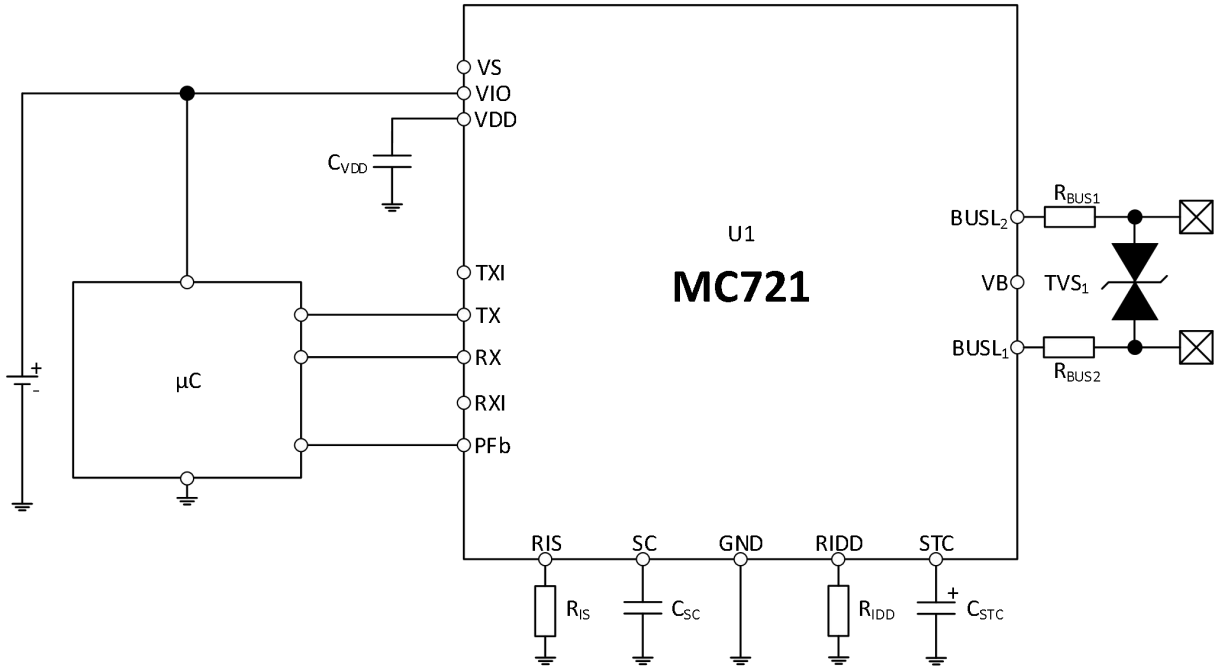


Figure 2.Application Schematic with External Power Supply (Battery)

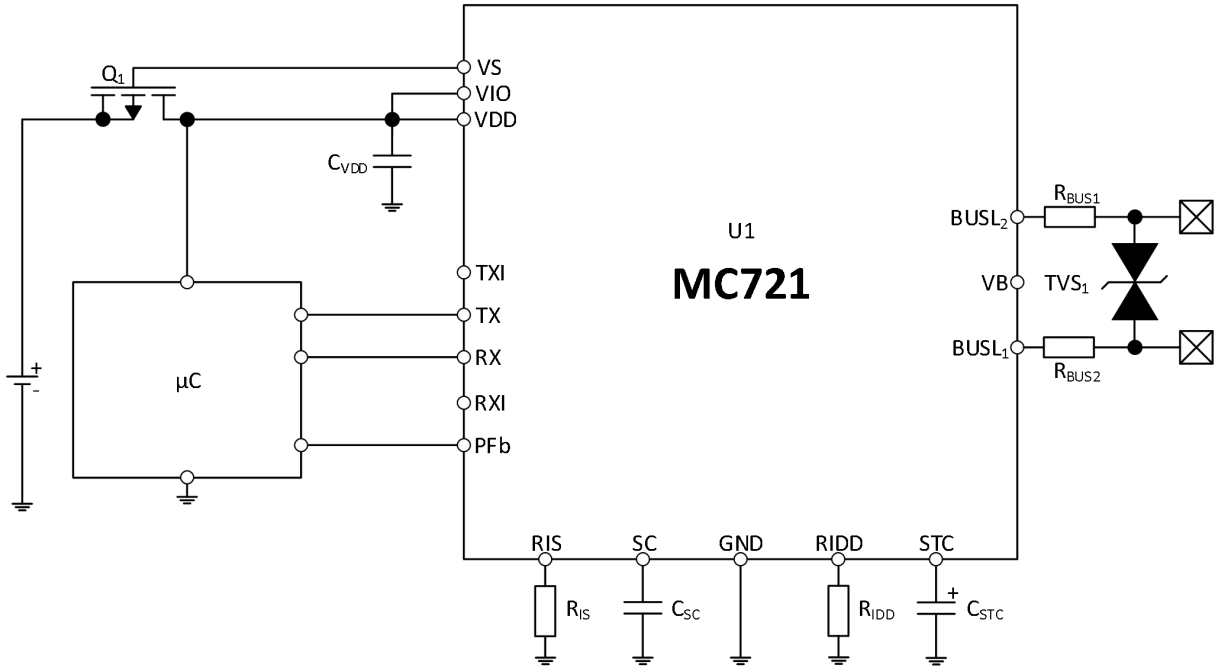


Figure 3.Application Schematic with Backup External Power Supply

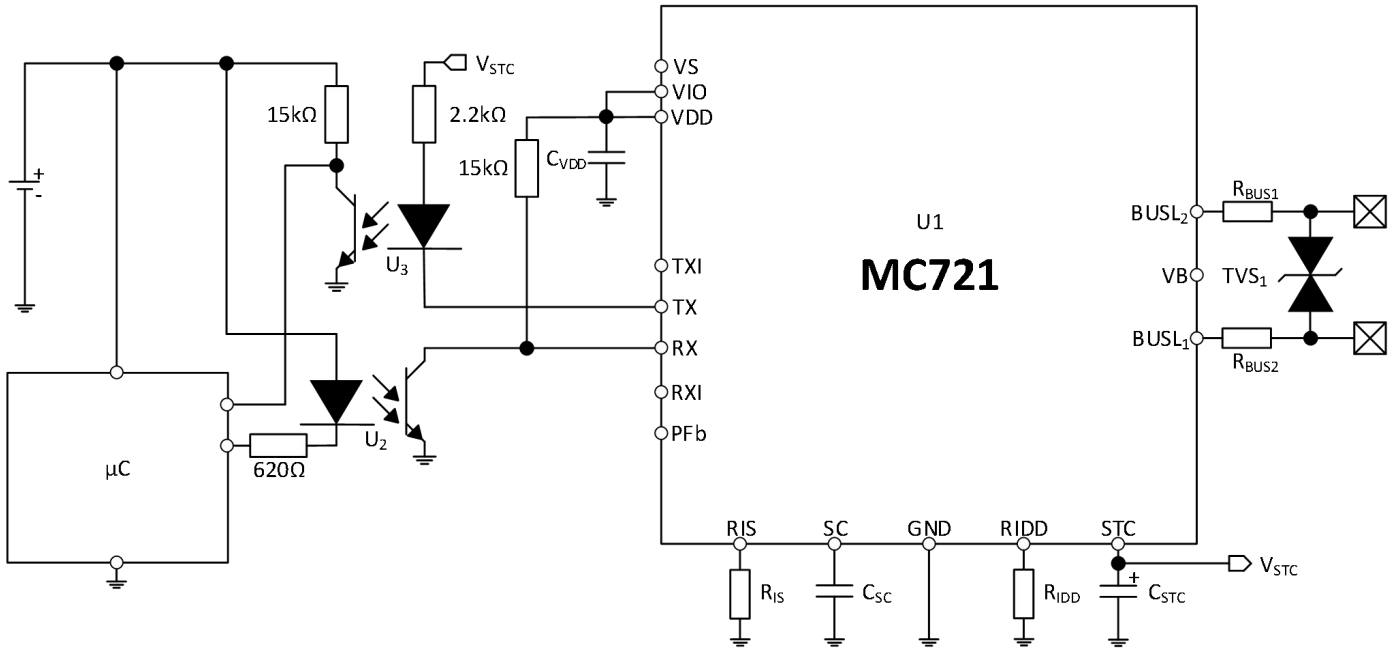


Figure 4.Optically Isolated Application Schematic

7 TYPICAL BILL OF MATERIALS

Reference Designator		Value(Typical)	Tolerance	Manufacturer	Part Number
U1		-	-	GATEMODE	MC721
TVS1		40V	-		
C_{VDD}		>1μF	-20%,+80%		
R_{IS}		100Ω	1%		
C_{SC}		220nF	-20%,+80%		
R_{BUS1},R_{BUS2}		220Ω	10%		
R_{IDD}	1 UL	30kΩ	1%		
	2 UL	13kΩ	1%		
	3 UL(17)	8.45kΩ	1%		
	4 UL(17)	6.19kΩ	1%		
	5 UL(17)	4.87kΩ	1%		
	6 UL(17)	4.02kΩ	1%		
C_{STC}	1 UL	≤330μF	10%		
	2 UL	≤820μF	10%		
	3 UL(17)	≤1200μF	10%		
	4 UL(17)	≤1500μF	10%		
	5 UL(17)	≤2200μF	10%		
	6 UL(17)	≤2700μF	10%		

8 APPLICATION INFORMATION

The MC721 is a slave transceiver for use in the meter bus (M-BUS) protocol. The bus connection is fully polarity independent. The transceiver will translate the bus voltage modulation from master-to-slave communication to TTL UART communication, and in the other direction translate UART voltage levels to bus current modulation. The transceiver also integrates a voltage regulator for utilizing the current drawn in this way from the bus, and an early power fail warning. The transceiver also supports an external power supply and the I/O high level can be set to match the slave sensor circuit. A complete block diagram is shown on page 1. Each section will be explained in more detail below.

METER BUS PROTOCOL

M-BUS is a European standard for communication and powering of utility meters and other sensors. Communication from master to slave is achieved by voltage-level signaling. The master will apply a nominal +36V to the bus in idle state, or when transmitting a logical 1 (“mark”). When transmitting a logical 0 (“space”), the master will drop the bus voltage to a nominal +24V. Communication from the slave to the master is achieved by current modulation. In idle mode or when transmitting a logical 1 (“mark”), the slave will draw a fixed current from the bus. When transmitting a logical 0 (“space”), the slave will draw an extra nominal 15mA from the bus. M-BUS uses a half-duplex 11-bit UART frame format, with 1 start bit, 8 data bits, 1 even parity bit, and a stop bit.Communication speeds allowed by the M-BUS standard are 300, 600, 2400, 4800, 9600, 19200 and 38400 baud, all of which are supported by the MC721.

BUS CONNECTION AND RECTIFICATION

The bus should be connected to the pins BUSL1 and BUSL2 through series resistors to limit the current drawn from the bus in case of failure (according to the M-BUS standard). Typically, two 220Ω resistors are used for this purpose. Since the M-BUS connection is polarity independent, the MC721 will first rectify the bus voltage through an active diode bridge.

SLAVE POWER SUPPLY (BUS POWERED)

A slave device can be powered by the M-BUS or from an external supply. The M-BUS standard requires the slave to draw a fixed current from the bus. This is accomplished by the constant current source CS1. This current is used to charge the external storage capacitor C_{STC}. The current drawn from the bus is defined by the programming resistor R_{IDD}. The bus current can be chosen in increments of 1.5mA called unit loads. ELECTRICAL CHARACTERISTICS list the different values of programming resistors needed for different unit loads, as well as the current drawn from the bus (I_{BUS}) and the current that can be drawn from the STC pin (I_{STC}). ISTC is slightly less than IBUS to account for the internal power consumption of the MC721. The RIDD resistor used must be at least 1% accurate. Note that using 5 and 6 Unit Loads is not covered by the M-BUS standard. When the voltage on the STC pin reaches $V_{STC, VDD\ ON}$ the LDO is turned on, and will regulate the voltage on the VDD pin to 3.3V, drawing current from the storage capacitor. A decoupling capacitor of minimum 1µF is required on the VDD pin for stability of the regulator. On the STC pin, a minimum capacitance of 10µF is required. Furthermore, the ratio C_{STC}/C_{VDD} must be larger than 9. The voltage on the STC pin is clamped to $V_{STC, clamp}$ by a shunt regulator, which will dissipate any excess current that is not used by the MC721 or external circuits.

SLAVE POWER SUPPLY (EXTERNAL)

In case the external sensor circuit consumes more than the allowed bus current or the sensor should be kept operational when the bus is not present, an external power supply, such as a battery, is required.When the external circuitry uses different logical voltage levels, simply connect the power supply of that voltage level to V_{IO}, so that the RX,RXI,TX,TXI and PFb pins will respond to the correct voltage levels. The MC721 will still be powered from the bus, but all communication will be translated to the voltage level of V_{IO}.If the external power supply should be used only as a backup when the bus power supply fails, a PMOS transistor can be inserted between the external power supply and VDD as shown in Figure 3. The gate is connected to VS, and will be driven high when the voltage on STC goes above the turn-on threshold of the LDO, nl. $V_{STC, VDD\ ON}$. For more information see the paragraph on the power on sequence and corresponding Figure 9.

COMMUNICATION, MASTER TO SLAVE

M-BUS communication from master to slave is based on voltage level signaling. To differentiate between master signaling and voltage drop caused by the signaling of another slave over cabling resistance, etc., the mark level VBUS, MARK is stored, and only when the bus voltage drops to less than V_T will the MC721 detect communication. A simplified schematic of the receiver is shown in Figure 6.The received data is transmitted on the pins TX and TXI, as shown in the waveforms of Figure 5. An external capacitor must be connected to the SC pin to store the mark voltage level. This capacitor is charged to V_B.Discharging of this capacitor is typically 40x slower, so that the voltage on SC drops only a little during the time the master is transmitting a space. The value of C_{SC} must be chosen it the range of 100nF−330nF.

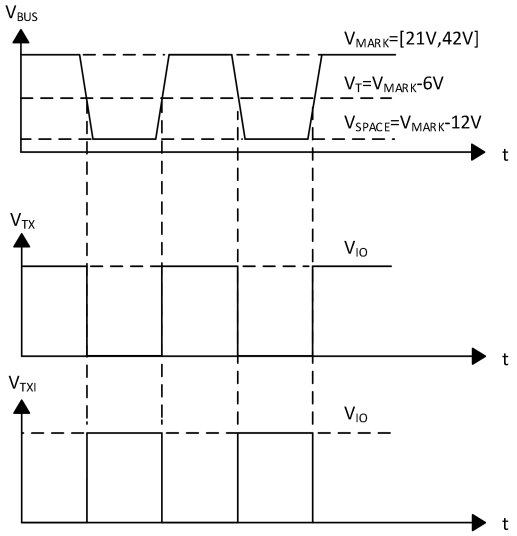


Figure 5.Communication,Master to Slave

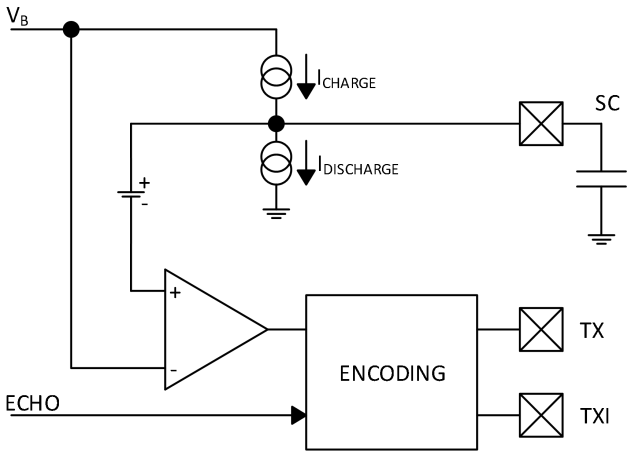


Figure6.Communiation,Master to Slave

COMMUNICATION, SLAVE TO MASTER

M-BUS communication from slave to master uses bus current modulation while the voltage remains constant. This current modulation can be controlled from either the RX or RXI pin as shown in Figure 8.

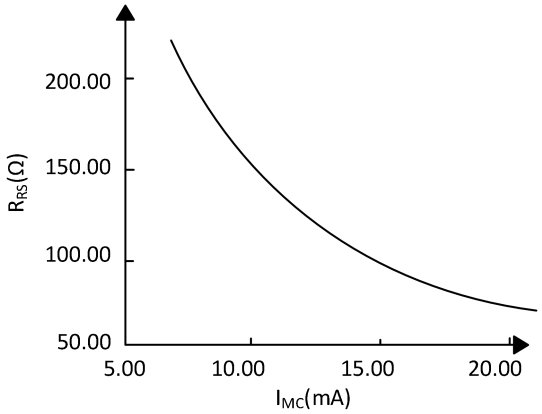


Figure 7.Typical Realtionship between RIS and Current Modulation Level

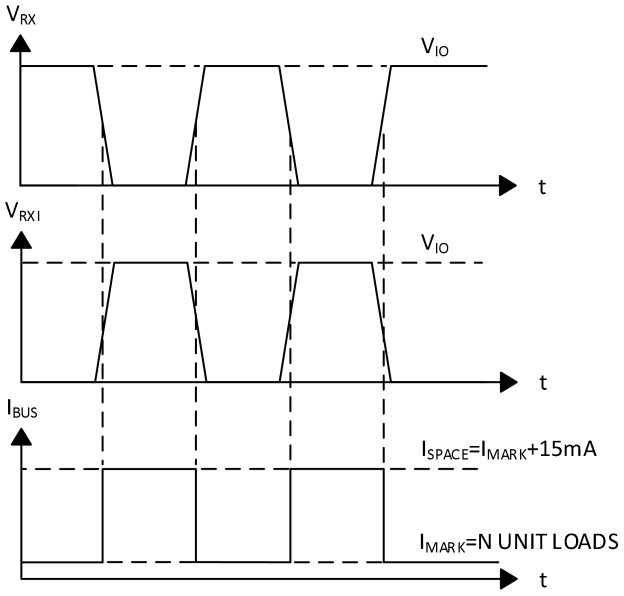


Figure 8.Communication,Slave to Master

When transmitting a space (“0”), the current modulator will draw an additional current from the bus.This current can be set with a programming resistor R_{RIS}. To achieve the space current required the M-BUS standard, R_{RIS} should be 100Ω . A simplified schematic of the transmitter is shown in Figure 9.
Because the M-BUS protocol is specified as half-duplex,an echo function will cause the transmitted signal on RX or RXI to appear on the receiver outputs TX and TXI. Should the master attempt to send at the same time, the bit wise added signal of both sources will appear on these pins, resulting in invalid data.

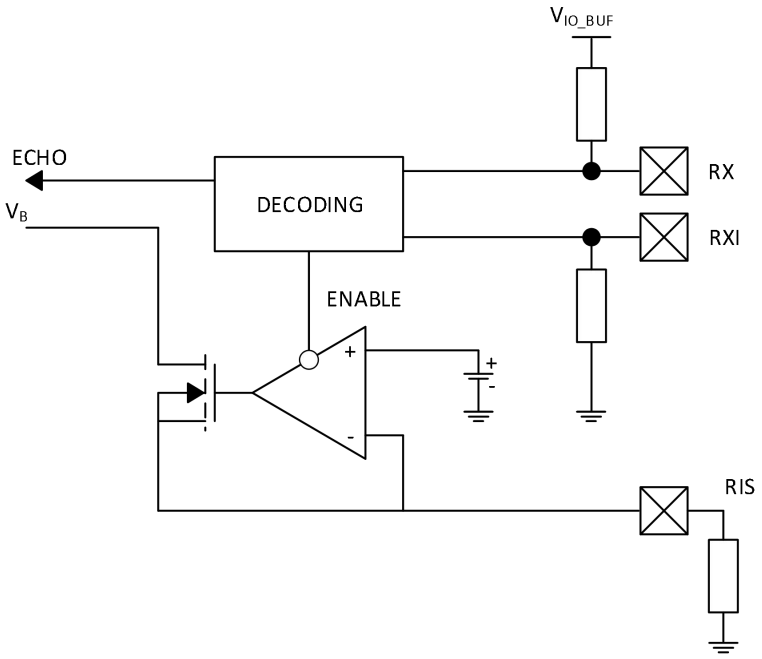


Figure 9.Communication,Slave to Master

POWER ON/OFF SEQUENCE

The power-on and power-off sequence of the MC721 is shown in Figure 10. Shown also in Figure 10 is the operation of the PFb pin. This pin is used to give an early warning to the microcontroller that the bus power is collapsing,allowing the microcontroller to save its data and shut down gracefully. The times t_{on} and t_{off} can be approximated by the following formulas:

$$t_{on} = \frac{C_{STC}}{I_{STC}} V_{STC,VDDON}$$

$$t_{off} = \frac{C_{STC}}{I_{CC} + I_{DD}} (V_{STC,Clamp} - V_{STC,VDDOFF})$$

Where I_{CC} is the internal current consumption of the MC721 and I_{DD} is the current consumed by external circuits drawn from either VDD or STC.
These formulas can be used to dimension the value of the bulk C_{STC} needed, taking into account that the M-BUS standard requires ton to be less than 3s.
For certain applications where the power drawn from the bus is not used in external circuits, the storage capacitor value can be much lower. The MC721 requires a minimum STC capacitance of 10µF to ensure that the bus current regulation is stable under all conditions.

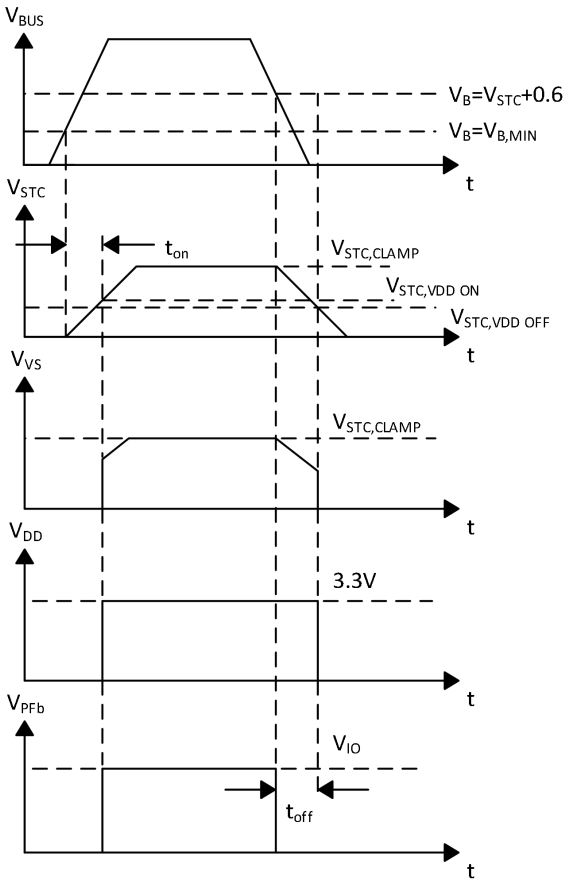


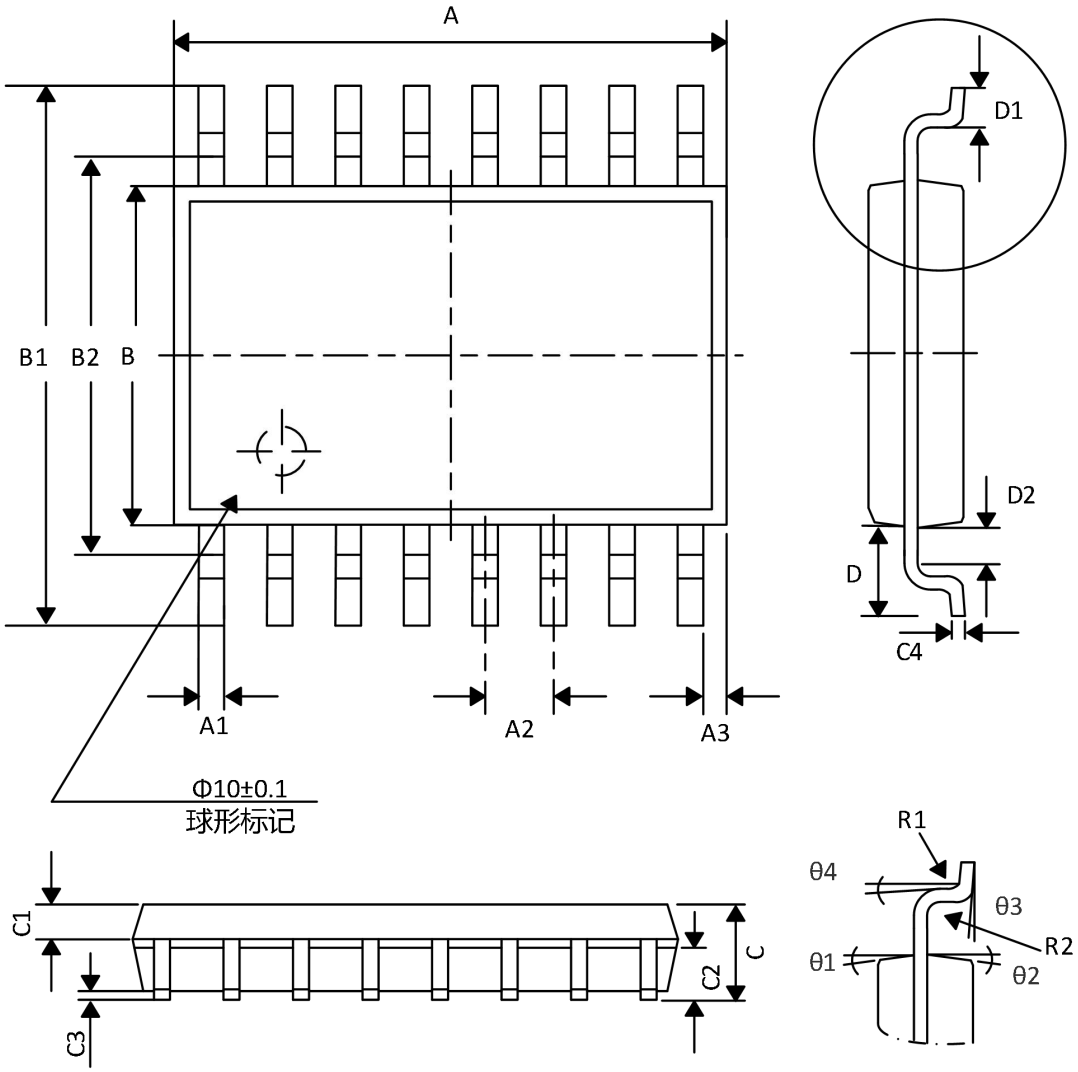
Figure 10.Power on and Power off

THERMAL SHUTDOWN

The MC721 includes a thermal shutdown function that will disable the transmitter when the junction temperature of the IC becomes too hot. The thermal protection is only active when the slave is transmitting a space to the master.

PACKAGE DIMENSION

SOP16



DIMENSION / SYMBOL	MIN（mm）	MAX（mm）	DIMENSION / SYMBOL	MIN（mm）	MAX（mm）
A	9.80	10.00	C4	0.203	0.233
A1	0.356	0.456	D	1.05TYP	
A2	1.27TYP		D1	0.40	0.70
A3	0.302TYP		D2	0.15	0.25
B	3.85	3.95	R1	0.20TYP	
B1	5.84	6.20	R2	0.20TYP	
B2	5.00TYP		θ1	8°~12°TYP4	
C	1.40	1.60	θ2	8°~12°TYP4	
C1	0.61	0.71	θ3	0°~8°	
C2	0.54	0.64	θ4	4°~12°	
C3	0.05	0.25			

Tel: (+86) 13135660803
Email: sales@gmmicro.com

Order Information

Order number	Package	Marking information	Operation Temperature Range	MSL Grade	Ship, Quantity	Green
MC721	SOP16	MC721	-40 to 85°C	3	T&R, 2500	Rohs