Meter Bus Application

No CE Marking

November 1995 Revision 5.1

Dear Customer,

Texas Instruments would like to thank you for your request for the ANALOG BOARD Revision 5.1 design kits.

The following disclaimer applies to these design kits.

In compliance with the EMC Directive (Council Directive of 3 May 1989 on the approximation of the laws of the Members States relating to electro-magnetic compability (89/336/EEC) and the German Act: "Notification of the Amended Electromagnetic Compatibility Act of 30. August 1995" (para. 5 sec. 5 EMVG) the design kits you ordered have not been CE marked. The target users of these design kits are NOT end users, but exclusively profe-ssionals (ie. designers, application engineers, etc.), who are proficient in EMC matters. The design kits are intended for development only.

Again, Texas Instruments would like to thank you for your request.
If you have any questions, please contact your local Texas Instruments Field Sales Representative or one of your factory representatives.

Sincerly

Texas Instruments
January 1997

Table of Contents

1. Introduction

Electronic utility meters are becoming commonplace for measuring the consumption of electricity, water, gas and other forms of energy. The reading of such meters by personnel is unacceptably inconvenient and costly. This has stimulated the development of a remote bi-directional link between users and a central unit; such a system offers the possibility of near-continuous measurement, allows the supplier to change tariffs and to connect or disconnect users.

The METER-BUS meets existing and anticipated future requirements for such a system, and has achieved widespread acceptance and standardisation.

Texas Instruments has developed a special bus driver and receiver for METER-BUS user meters (slaves), the TSS721 Transceiver. This IC is powered via the METER-BUS, so that no local battery or PSU is necessary. It also does not take power from any test or measurement equipment.

A corresponding analog board has been developed for the central unit. To ensure compatibility, this analog board has been conceived such that the TSS721 can be powered with 42 V.

This applications proposal is concerned primarily with the analog part of the central unit; only the basic functions of the PC interface are explained.

Warning:

This equipment is intended for use in a laboratory test environment only. It generates, uses and can radiate radio frequency energy and has not been tested for compliance with the limits of computing devices pursuant to subpart J of 15 of FCC rules, which are designed to provide reasonable protection against radio frequency interference. Operation of this equipment in other environments may cause interference with radio communications, in which case the user at his own expense will be required to take whatever measures may be required to correct this interference.

2. Specification

The specification (extract) is based on the DIN Proposal "Physical Layer der busfaehigen Schnittstelle", which resulted from the meeting of the working group SWG 1, CEN/SPA 176, WG 4, on 18.06.90.

Parameter		min	typ	max	Unit
*Number of slaves @ 1000 m				255	
*Number of slaves @ 4000 m				64	
Capacitance of slaves				1	nF
Master to Slave direction	**MARK	24		36	V
	SPACE		MARK-12 Volt		V
Slave to Master direction	MARK	0		1.5	mA
	SPACE	11		20	mA
***Baud rate		300		2400	baud
Isolation resistance		1			MOhm

Notes:

* Using standard cable, for example Y-(St)Y ... ·2 ·0.8 mm.
The number of slaves, on this development board, is limited up to output current of 150 mA.

** The voltage MARK max = 42 V

*** The ANALOG -BOARD features communication up to 9600 baud.

3. Description of Operation

As part of the Master, the analog board is provided with the following functions:

- Bus voltage modulation (TRANSMITTER) when transferring data from Master to Slave
- Bus current detection (RECEIVER) when transferring data from Slave to Master
- Powering of the bus
- Remote powering of slaves (via TSS721)
- Bus current detection on overload (OVERLOAD WARNING)
- System enlargement (REPEATER)
- Voltage regulation (VOLTAGE SUPPLY)
- Terminal connector (RS232 DRIVER)

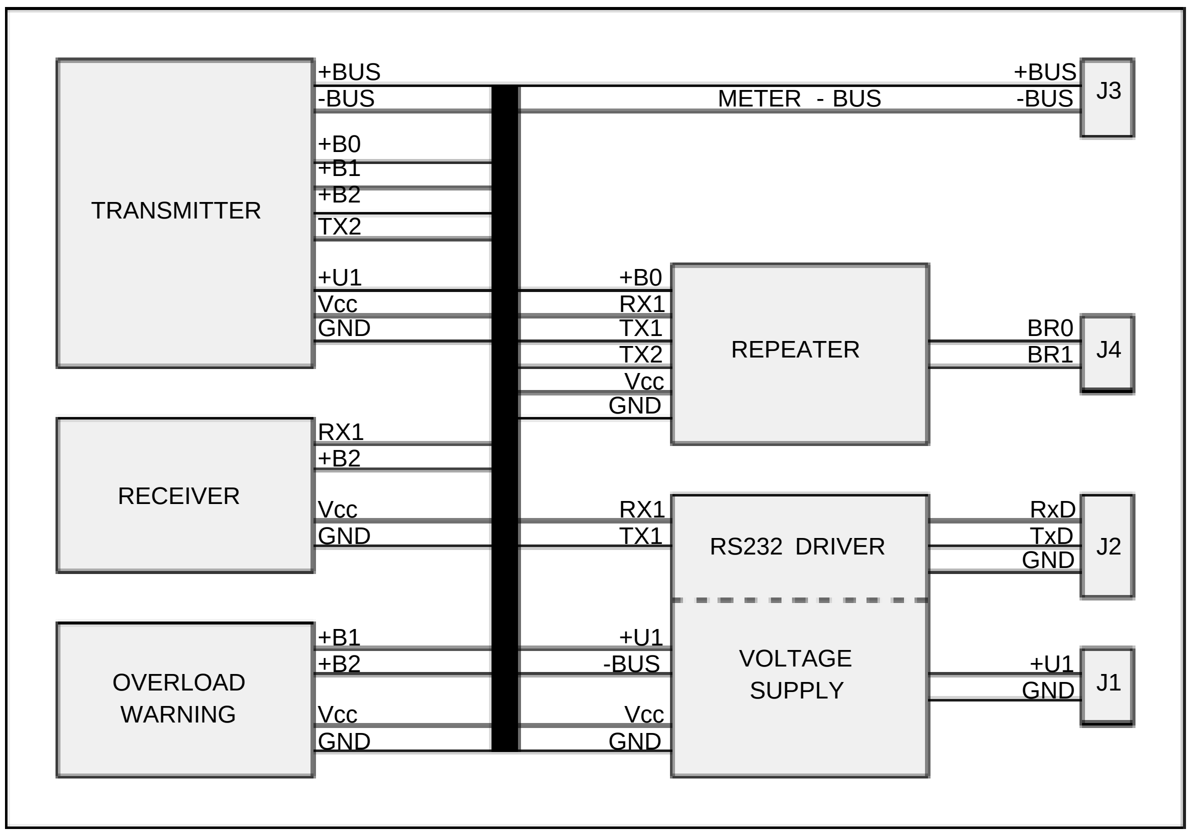

Figure 1: Block Diagram of ANALOG BOARD

4. Circuit Description

The individual parts of the circuit in the block diagram (Fig. 1) will now be separately described.

The supply voltage + U1 (+ 18 V) should be provided by an external power supply. All voltages must be isolated from earth by a high resistance, and must also must have short-circuit protection with current limiting. The auxiliary voltage V_{CC} is derived from the supply voltage. With this arrangement a DC/DC converter can be used to convert +U1 into the required -BUS = -30V.

4.1 Voltage Supply

The use of the DC/DC converter IC101 simplifies the multiple powering of the METER-BUS board and converts the +U1 = 18V voltage into the auxiliary voltage of -30V. The +U1 = 18V supply is loaded with about 1.5A at a bus current of I_{BUS} = 150 mA. The auxiliary voltage V_{CC} ensures a stable working point for the amplifier input voltage.

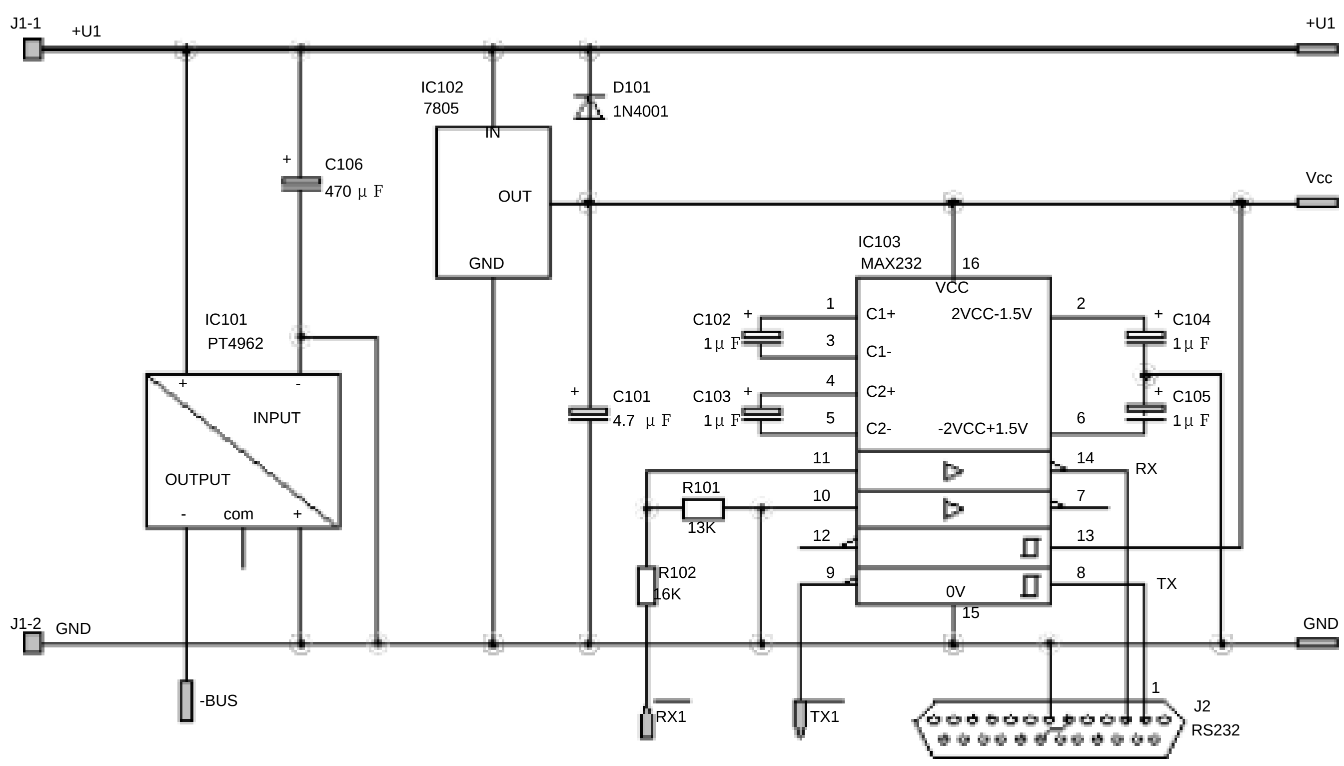

Figure 2: Supply Voltage and RS232 Connection

The single 5V supply RS232 driver IC103 connects the METER-BUS Master with a PC, either directly or via a MODEM. Half-duplex RS232 transmission at 300 - 9600 Baud is compatible with the METER-BUS. The signal TX1 controls the bus voltage modulation in the direction to the slave, and the signal RX1 is the result of the current modulation from the slave.

4.2 Transmitter

The information in the direction MASTER to SLAVE is transmitted with bus voltage modulation. The modulation pulses pass from the input TX2 via the RS232 driver IC103 (see Fig. 3) or the isolating opto coupler OC502 for REPEATER operation (see Fig. 6). The modulation amplitude (Mark -12 V) is set by the resistors R204 and R205 and the Vcc voltage.

The Transmitter includes the power stages for the METER-BUS. The power amplifier IC201 is configured common-mode to GND to ensure the matching of the voltage reference Vcc to the bus level and the low impedance of the bus. This is in order to be able to set the output (Pin 3,6) accurately to 12 V with respect to ground potential (GND).

The use of a basic load (R208 + R213 and C206) in the central unit sets the working point for the specified data rate: the influence of external capacitances (wiring, number of slaves connected) on the rate of pulse rise- and fall-times can thus be kept within limits.

The remaining part of the circuit establishes the bus current when transmitting data from Slave to Master, and also supplies power for remotely powered slaves. Bus current detection is only possible if the bus voltage remains constant - i.e. slow load changes must be regulated. The starting point for such regulation is the charged state of the capacitor C202. Voltage changes on the bus are detected by comparator IC202 and compensated by current source transistor T202 until the voltage across the capacitor C204 has reached the same level as C202. The operation of the regulator stage is arranged so that in an unregulated state the resistor R208 is not conducting current. The time constants are chosen such that during data modulation (fast pulses) the slow regulation does not follow bus voltage changes.

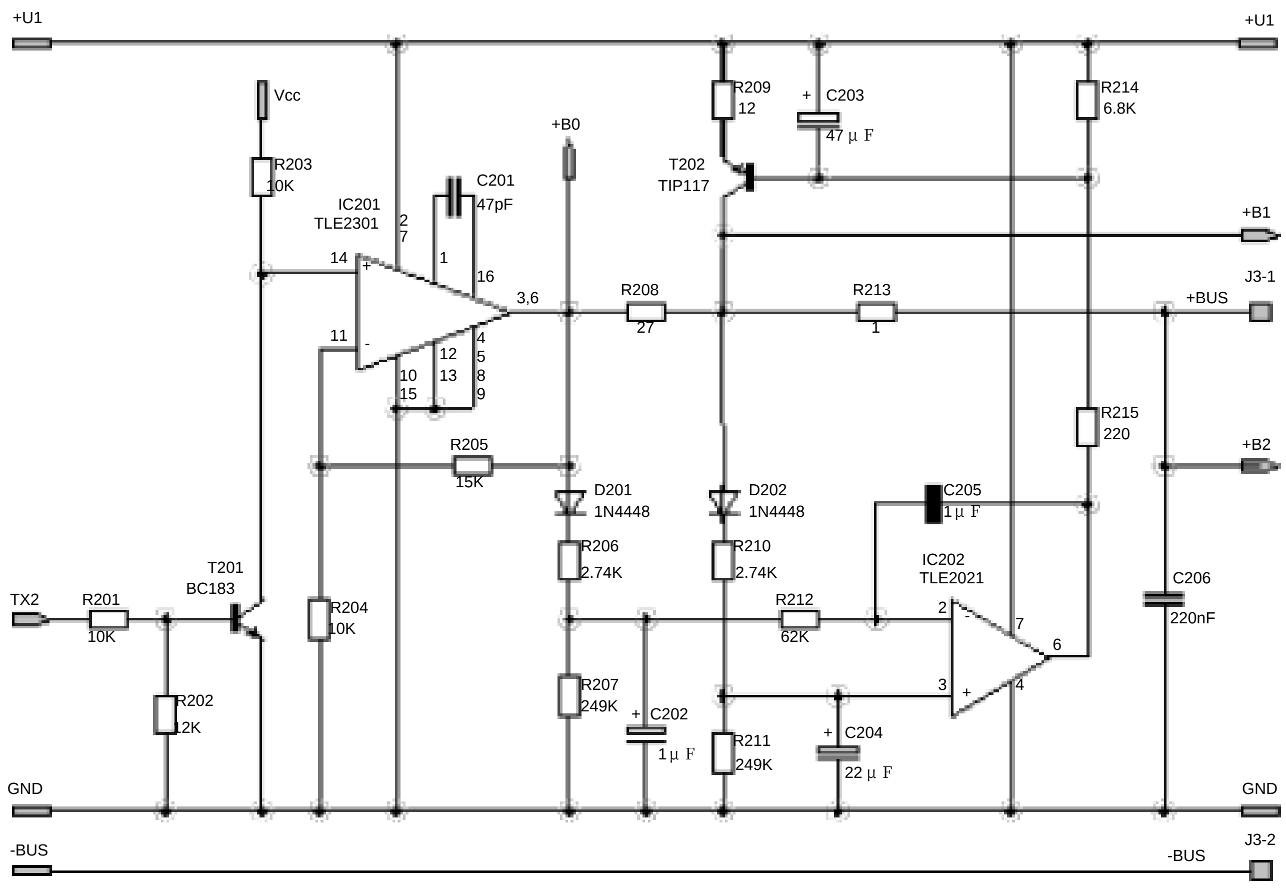

Figure 3: Transmitter

The function of the resistors R208 and R213 is explained in the sections RECEIVER and OVERLOAD WARNING.

4.3 Receiver

The receiver (see Fig. 4) detects the current pulses when data is transmitted from Slave to Master. The current sink in the slave results in a voltage drop at the terminating resistors R208 + R213 (Transmitter).

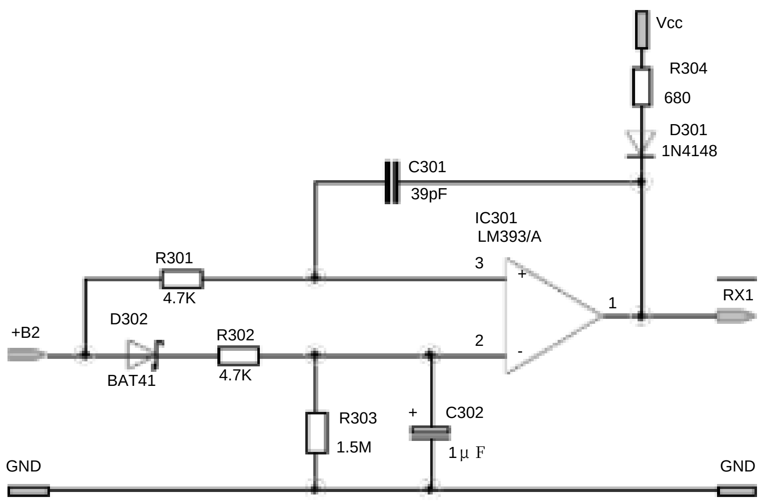

Figure 4: Circuit Diagram of Receiver

The Schottky diode D302 together with the resistors R302 and R303 sets the switching threshold, which remains stored in the capacitor C302 as a result of the long time constant. When the comparator IC301 (/A) detects a smaller voltage it recovers the signal which has been recognised. The output RX1 is supplied from the bus voltage +B0 via opto coupler OC501.

4.4 Overload Warning

This part of the circuit is necessary to indicate faults as follows:

- T Short circuit between both bus lines
- T Excessive load (too many slaves) on the bus

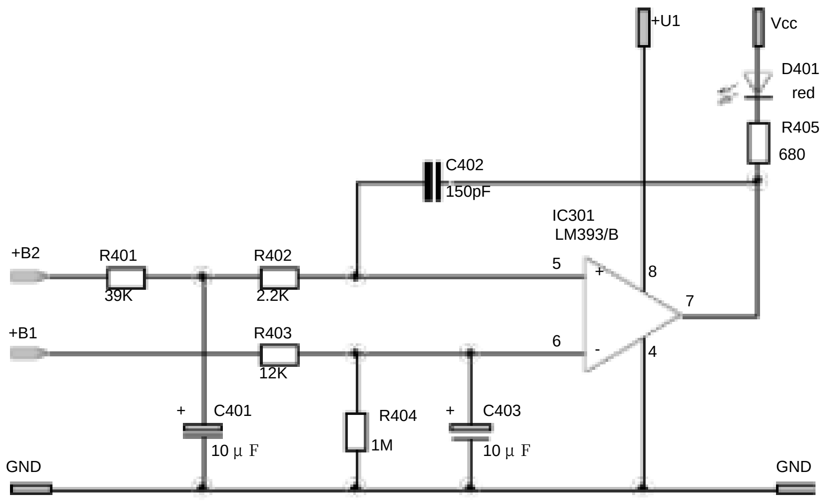

Figure 5: Overload Warning

If the voltage drop over the 1 Ohm resistor R213 (TRANSMITTER) is greater than that over the resistor R403 then the comparator IC301 switches the LED D401 on.

4.5 Repeater

The repeater increases the distance between the Master and last Slave and also the slave loading. The transceiver TSS721 loads the Master equivalent to one slave. The opto-couplers OC1 and OC2 isolate the Repeater from the Master Analog Board.

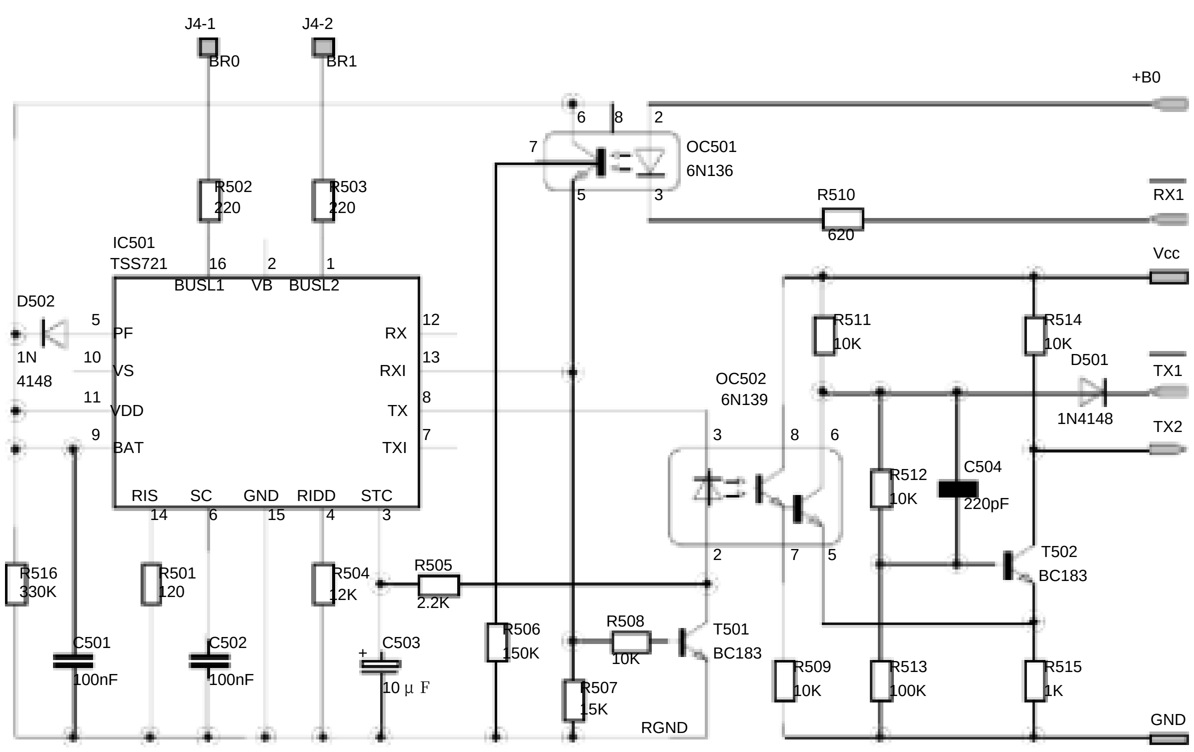

Figure 6: Repeater Support

5. METER-BUS Application

This application proposal is based on the use of a PC with an RS232 termination. It supports the development, functional test and direct operation of small to medium sized test requirements.

The following diagram shows the principle of a Master-Slave configuration. In a building, a telephone line is laid between the central unit and connection sockets, to which the slaves are in turn connected. The master is connected to a PC, either directly or via a MODEM.

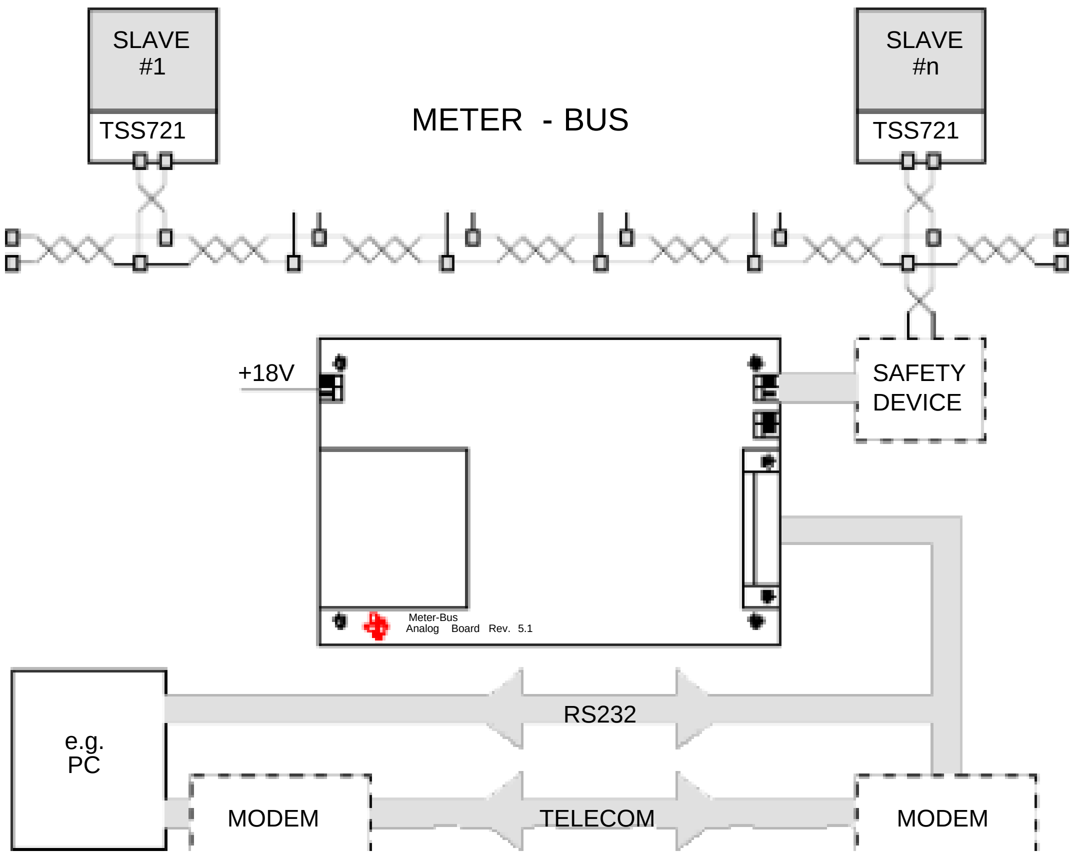

Figure 7: Block Diagram Meter-Bus Master

5.1 PCB: METER-BUS Interface

All the circuits in Figs 2 –6 are on a single circuit board with dimensions of 160 ·100 mm. The connectors on the boards are as follows:

- J1: Supply Voltage
- J2: RS232 connection
- J3: METER-BUS connection
- J4: Repeater connection

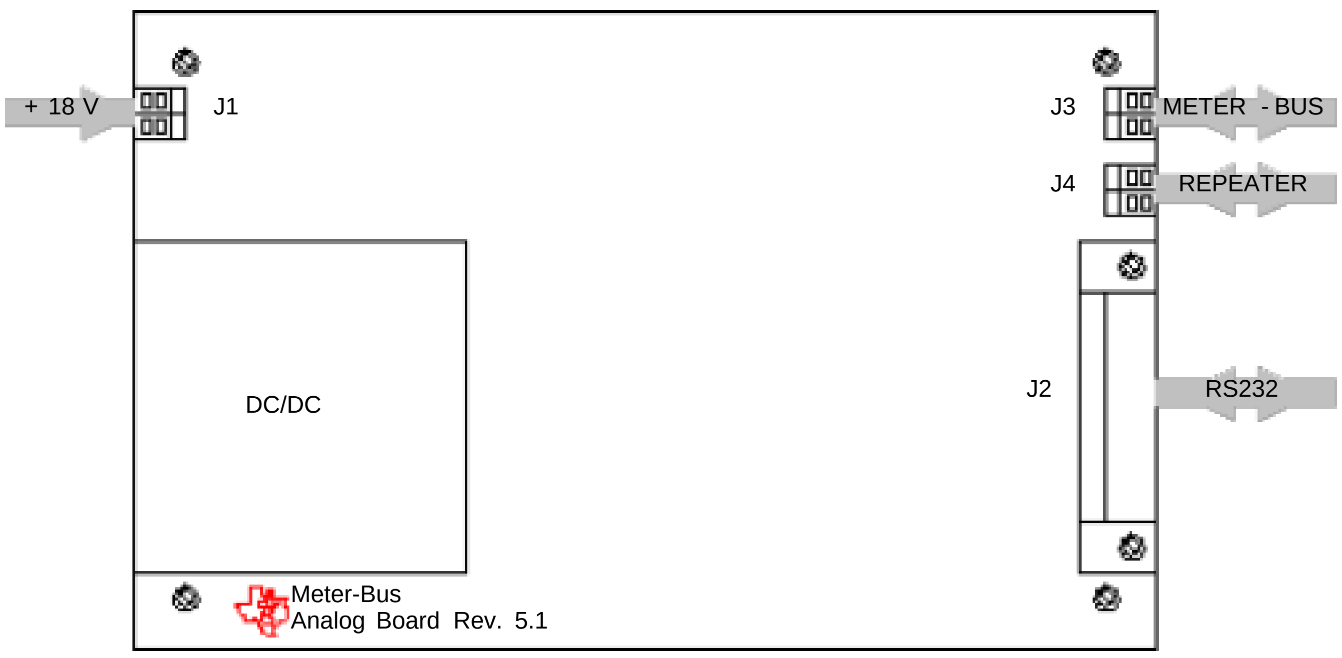

Figure 8: PCB: Meter-Bus Interface

5.2 Protection

Various alternatives exist to protect the system against excess voltages, which could otherwise cause faulty operation or damage. Fig. 10 shows a simple approach using transient suppressor SD1 and a capacitor C1. The best solution depends very much on the application and environment, and is therefore left to the user, e.g. a short in the bus wiring blows the fuse F1. The RF emission can be reduced by connecting the cable shield to the virtual ground BGND.

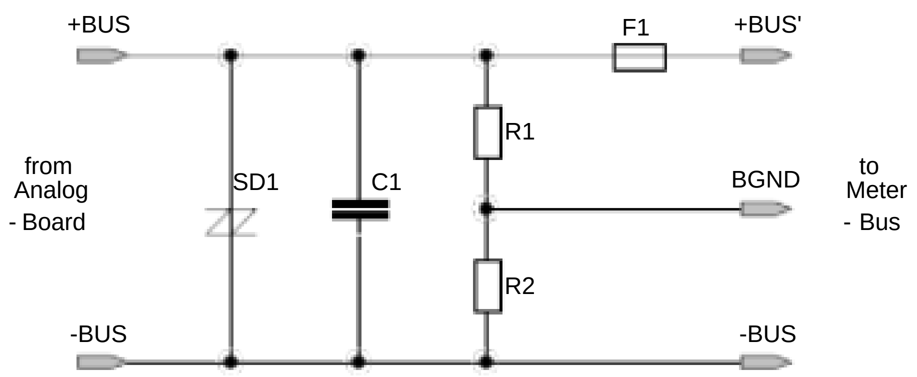

Figure 10: Simple Protection Circuit

6. Appendix A - Transmission Wave Forms

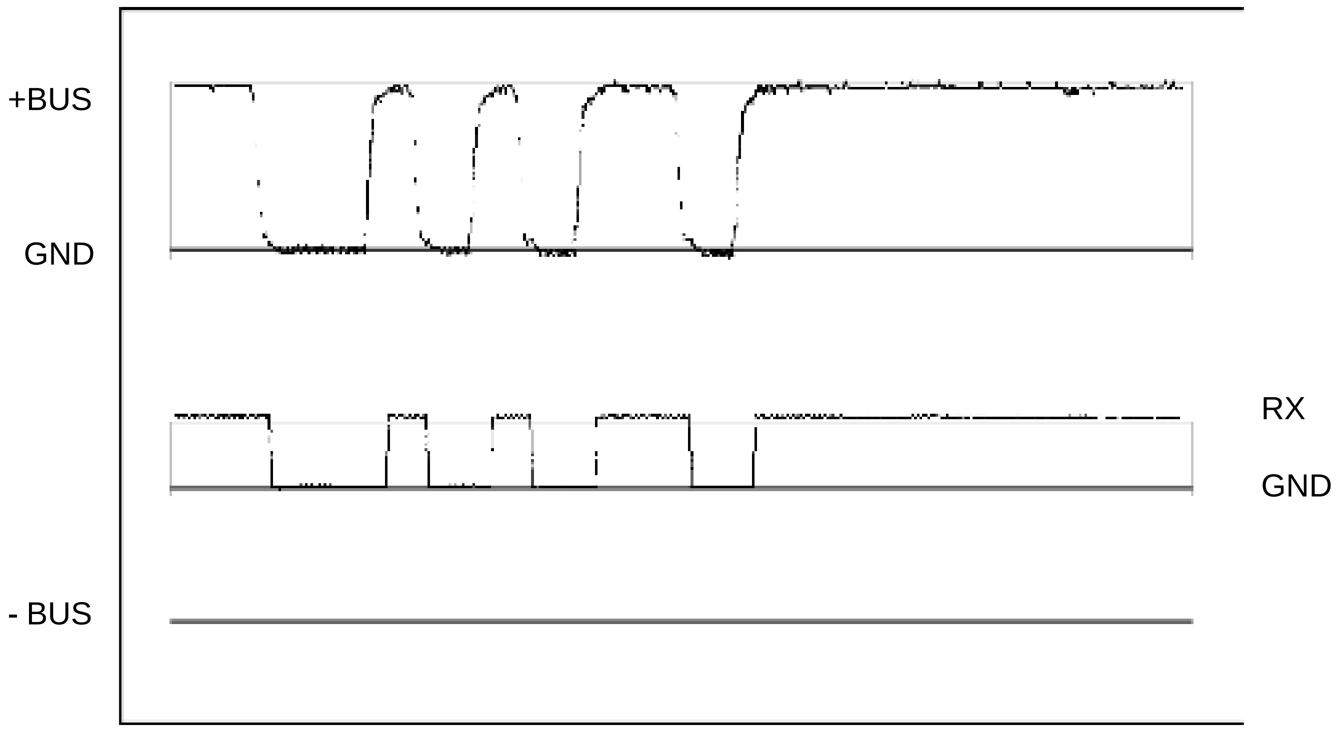

Figure 10: Direction: MASTER TO SLAVE

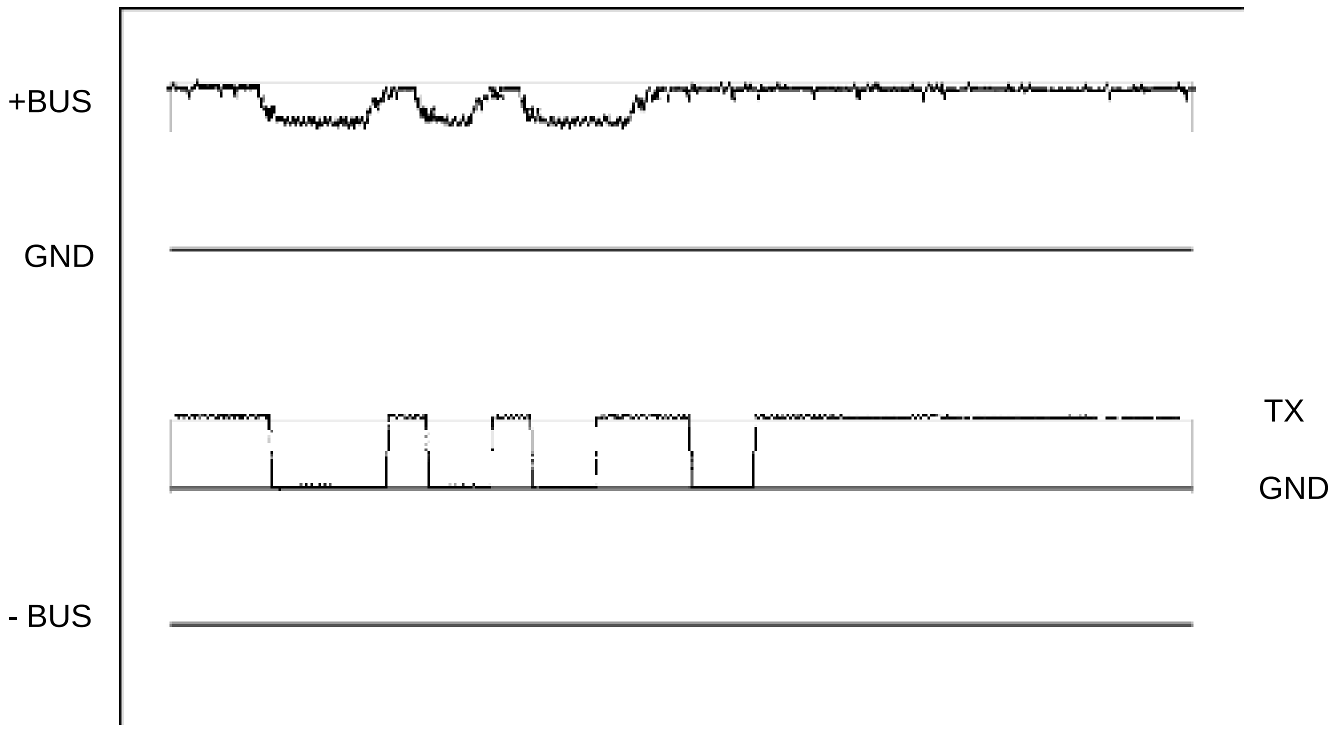

Figure 11: Direction: SLAVE TO MASTER

7. Appendix B - Parts List

PCB (Fig 7):

Position	Component	Type	Qty	Notes
	PCB	160 x 100 mm	1	
	Stand	height 6 mm	4	
	screw	M3	4	

Reference Voltage (Fig 2):

Position	Component	Type	Qty	Notes
C101	Capacitor	4.7 µF16 V	1	Tantalum
C102, C103, C104, C105	Capacitor	1 µF16 V	4	Tantalum
C106	Capacitor	470 µF25 V	1	Elco
R101	Resistor 0.25 W	13 K 5%		
R102	Resistor 0.25 W	16 K 5%		
D101	Diode	1N4001	1	
IC101	DC-DC-Converter	PT 4962	1	9 .. 18V ±15V190 mA
IC102	Voltage regulator	7805	1	TO220
IC103	RS232 Transceiver	MAX232	1	
J1	Terminal block	WAGO 257	2	Power Supply
J2	Connector	166753-3	1	Sub-D, 25-pole, female

Transmitter (Fig 3):

Position	Component	Type	Qty	Notes
R201, R203, R204	Resistor 0.25 W	10 K 5%	3	
R202	Resistor 0.25 W	12 K 5%	1	
R205	Resistor 0.25 W	15 K 5%	1	
R206, R210	Resistor 0.25 W	2.74 K 1%	2	
R207, R211	Resistor 0.25 W	249 K 1%	2	
R208	Resistor 0.25 W	27 5%	1	
R209	Resistor 0.25 W	12 5%	1	
R212	Resistor 0.25 W	62 K 5%	1	
R213	Resistor 0.25 W	1 5%	1	
R214	Resistor 0.25 W	6.8 K 5%	1	
R215	Resistor 0.25 W	220 5%	1	
C201	Capacitor	47 pF 100V	1	Ceramic
C202	Capacitor	1 µF 25V	1	Tantalum
C203	Capacitor	47 µF 25V	1	Tantalum
C204	Capacitor	22 µF 25V	1	Tantalum
C205	Capacitor	1 µF 100V	1	MKT
C206	Capacitor	220 nF 100V	1	MKT
D201, D202	Diode	1N4448	2	
T201	Transistor	BC183	1	npn, TO92
T202	Transistor	TIP117	1	pnp-Darl., TO220
IC201	Amplifier	TLE2301	1	TI
IC202	Amplifier	TLE2021	1	TI
J3	Terminal block	WAGO 257	2	Bus connects, female

Receiver (Fig 4):

Position	Component	Type	Qty	Notes
R301, R302	Resistor 0.25 W	4.7 K 5%	2	
R303	Resistor 0.25 W	1.5 M 5%	1	
R304	Resistor 0.25 W	680 5 %	1	
C301	Capacitor	39 pF 100V	1	Ceramic
C302	Capacitor	1 µ F25V	1	Tantalum
D301	Diode	1N4148	1	
D302	Diode	BAT41	1	Schottky
IC301 *	Comparator	LM393	1/2	LM393/A

* Note: 2nd half of the LM393/B is used for overload warning.

Overload Warning (Fig 5):

Position	Component	Type	Qty	Notes
R401	Resistor 0.25 W	39 K 5%	1	
R402	Resistor 0.25 W	2.2K 5%	1	
R403	Resistor 0.25W	12K 5%	1	
R404	Resistor 0.25 W	1M 5%	1	
R405	Resistor 0.25 W	680 5%	1	
C401, C403	Capacitor	10 µ F35V	2	Tantalum
C402	Capacitor	150 pF 100V	1	Ceramic
D401	LED red		1	Overload
IC301 *	Comparator	LM393	1/2	LM393/B

Repeater (Fig 6):

Position	Component	Type	Qty	Notes
R501	Resistor 0.25 W	120 5%	1	
R502, R503	Resistor 0.25 W	220 5%	2	Bus protection
R504	Resistor 0.25 W	12K 5%	1	
R505	Resistor 0.25 W	2.2 K 5%	1	
R506	Resistor 0.25 W	150 K 5%	1	
R507	Resistor 0.25 W	15 K 5%	1	
R508, R509, R511, R512, R514	Resistor 0.25 W	10 K 5%	5	
R510	Resistor 0.25 W	620 5%	1	
R513	Resistor 0.25 W	100K 5%	1	
R515	Resistor 0.25 W	1K 5%	1	
R516	Resistor 0.25 W	330K 5%	1	
C501, C502	Capacitor	100 nF 100V	2	MKT
C503	Capacitor	10 µF 16 V	1	Tantalum
C504	Capacitor	220 pF 100V	1	MKT
D501	Diode	1N4148	1	
T501, T502	Transistor	BC183	2	npn, TO92
IC501	Bus-Transceiver	TSS721	1	TI
OC501	Optocoupler	6N136	1	
OC502	Optocoupler	6N139	1	
J4	Terminal block	WAGO 257	2	Bus connectors, female