

System Design with Port Powered Converters

RS-232 port-powered devices are often preferred over those that require an external power supply for matters of convenience. This is often a good choice, but it is important to be aware of the inherent limitations that are faced in using these port-powered devices.

Limitations arise due to two main factors. The first is the amount of power that is available from the RS-232 port. The second is the amount of power dissipated in the RS-422 or RS-485 system.

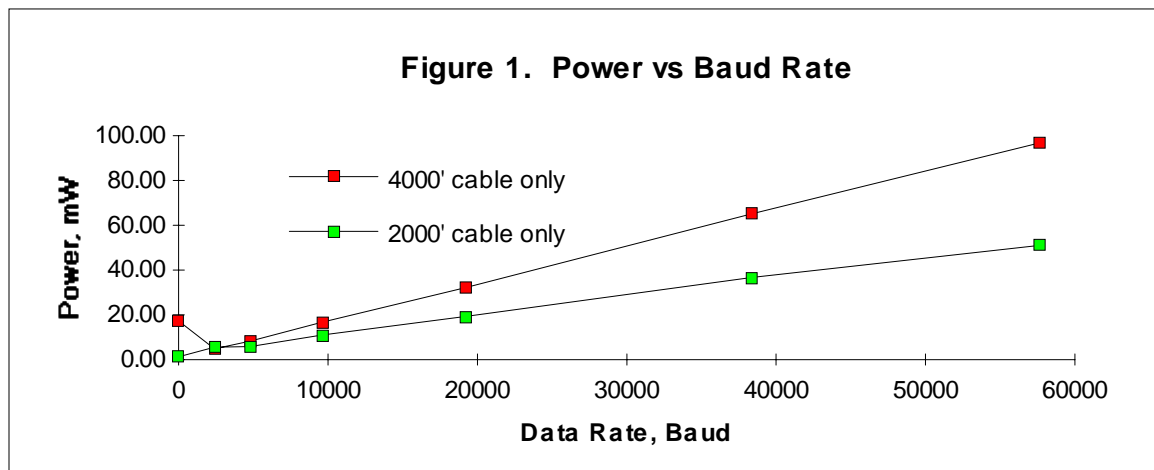
Power Dissipation

Power is consumed by the following:

- a) The RS-232 side cable
- b) Termination resistors on the RS-422 or RS-485 transmission line
- c) The RS-422 or RS-485 cable
- d) The converter itself

For the remainder of this article, it will be assumed that the RS-232 side cable is short, 6 ft (1.8 m), so that it will dissipate an insignificant amount of power. This is a reasonable assumption for most applications.

The effect of the RS-422 or RS-485 cable on the power dissipated varies according to several factors. These are the quality of the cable, the length of the cable, and the data rate. In the examples that follow, the cable that was used was a 1000-ft long cable that is recommended for RS-422 and RS-485 applications. The data rate used was 19 kbps. If an application calls for a longer cable or a higher baud rate, more power will be dissipated in the cable. Below is a figure that shows how this power dissipation varies with respect to baud rate.



The remainder of this article provides examples and anecdotal evidence to illustrate the effect of the remaining two power-dissipation factors; namely, termination resistors and the power consumed by the converter itself. These examples will then be used to form a set of guidelines to help determine whether a particular port-powered converter will be suitable for an application.

The Basic Setup

Each test was performed in a 3-node setup, with the third node being connected through the previously mentioned 1000-ft cable. It should be noted that the number of nodes, until one approaches the maximum of 32 nodes, does not have a significant affect on the power requirement of the system. A much more significant factor is the length of cable used. If a converter is determined to be appropriate in this setup, it should be appropriate for a setup that requires a similar or lower cable length, even if a few more nodes are required. The data rate used was 19 kbps. Each converter was tested with and without the use of a 120 Ω terminating resistor. A more detailed description of the setup is included in the appendix.

Handshake Lines: High or Low

Because it is not always possible for the user to raise the handshake lines, the tests were performed with both positive and negative voltage supplies whenever this was appropriate. The converters tested all required less input power when a positive voltage supply was used. If possible, it is preferable that the handshake lines be raised.

The reason for this is the way in which port-powered converters derive their power. The 5 V V_{cc} is obtained from the handshake lines. If these lines are asserted (high), then this voltage is obtained directly. However, if the handshake lines are low, a charge pump must be used to invert the voltage and provide a positive V_{cc} . The method that is used to do this is not 100 % efficient and it is therefore preferable to raise the handshake lines if possible.

Termination

Another issue that one needs to consider when deciding whether to use a port-powered converter is the necessity of terminating resistors. The purpose of these resistors is to greatly reduce interfering signal reflections by terminating the cable with an impedance that matches that of the line. This becomes important in situations where the cable is very long, because the longer the cable, the longer it will take the reflections to travel back and forth and decrease significantly in amplitude. Unfortunately, terminating resistors significantly increase the load on the converter, drawing more current and therefore requiring more power. In most cases, the power required to power a converter with termination was found to be greater than the power available from an RS-232 port. Termination of a port-powered converter is only possible in a few cases involving the most efficient converters and the highest voltage RS-232 drivers. Generally, termination is not recommended with port-powered converters. An externally powered converter would be best if termination is necessary.

Converter Power Consumption

So far, the effect that external factors relating to the setup have on power consumption has been considered. Another very important factor that must be taken into account is the power consumption by the converter itself. This consumption varies greatly between types of converters. Because of this, testing was performed on many different converters, selected to be representative of a large number of the converters offered by B&B Electronics. The results of these tests were documented in tabular form and relevant observations were documented during testing. These results follow.

Test Results

Unterminated RS-422 and RS-485 Converters:

Model	V _{in} at 10% Signal Loss	Power required at 10% Loss
422LPCOR, +V input	4.6 V	64 mW
422LPCOR, -V input	-10.6 V	150 mW
422PP9TB, -V input	-7.6 V	73 mW
485LP9TB, +V input	5.6 V	52 mW
485SD9TB, +V input	5.4 V	44 mW
485SD9TB, -V input	-8.0 V	69 mW
485DRJ, +V input	5.4 V	55 mW
485DRJ, -V input	-7.8 V	76 mW

RS-422 and RS-485 Converters Terminated with 120 Ω resistor:

Model	V _{in} at 10% Signal Loss	Power required at 10% Loss
422LPCOR, +V	5.5 V	203 mW
422LPCOR, -V	-16.6 V	554 mW
422PP9TB, -V	-11.2 V	361 mW
485LP9TB, +V	5.3 V	109 mW
485SD9TB, +V	5.4 V	86 mW

485SD9TB, -V	-8.9 V	139 mW
485DRJ, +V	5.5 V	85 mW
485DRJ, -V	-9.4 V	171 mW

The initial supply voltage that was applied to each converter was chosen as the voltage that would bring V_{cc} as close as possible to 5 V. The power requirement listed is for the point at which the output signal is 10% lower than it was with the initial supply voltage. 10% loss is a very strict failure criterion and the converter should be able to operate reliably below this point.

Power Available from Serial Port

An RS-232 port can supply only limited power to another device. The number of output lines, the type of interface driver IC, and the state of the output lines are important considerations.

The types of driver IC's in use in serial ports can be divided into four general categories.

- * Drivers which require plus (+) and minus (-) voltage power supply such as the 1488 series of interface integrated circuits. (Most desktop and tower PC's use this type of driver)
- * Low power drivers which require one +5 volt power supply. This type of driver has an internal charge pump for voltage conversion. (Many industrial microprocessor controls use this type of driver)
- * Low power drivers which require one +3.3 volt power supply. This type of driver also has an internal charge pump for voltage conversion.

Ports using the lower voltage RS-232 drivers are not able to provide as much power as the full voltage drivers. Several of these drivers were tested and the results recorded in tabular form. Drivers were chosen to represent the range of required supply voltages that are available today. A PC serial port typically has three drivers, TD, RTS, and DTR, so the power provided would be three times that listed in the power output column.

Driver Chip	Vcc (V)	Power out (-), mW	Power out (+), mW
TI 1488	12.00	30.0200	30
MAX 232	5.0	17.9096	20
MAX 202	4.99	19.2027	20

MAX3244	3.3	9.577	10
MAX3244	5.0	10.2305	11
MAX3245	3.3	9.434	11
MAX3245	5.0	9.8645	10

The Columns:

Vcc: This was the Vcc provided

Power out (-), mW: This is the power that was produced with a positive driver input and negative output.

Power out (+), mW: This is the power that was produced with a negative driver input and positive output.

Loop Back Connections

Many port powered converters will have loop back connections, such as RTS connected to CTS. These loop back connections each dissipates about 8.3 mw per input line. The only reason to make these connections is that some software requires these connections. If you have control over the software, change the software so that the loop back conditions are not required. Also, don't complete the loop back connections in the cables you are using

Conclusion

Port-powered converters are a very convenient choice for many applications. It is important to keep in mind though that there are cases in which the RS-232 port is incapable of providing enough power and an external source must be used. In this case, one option is buying a converter that provides the option to either port-power or use an external power source. B&B also offers battery-powered converters, USB converters, and PCMCIA/PC/ISA cards, and of which may be the best choice. Several factors should be considered when deciding to use a port-powered converter. It is necessary to know how much power the serial port to be used is capable of providing. If the type of driver is known, the power output can be found from the previous table, keeping in mind that there are three drivers present in the serial port. If the driver type is not known, then the power output can be determined through a simple experiment such as the one described in the appendix.

The next consideration is the setup in which the converter will be used. The two most important factors regarding setup are the length of cable required and the necessity of termination. The tests that were performed for this article all used 1000 feet of cable. Extending the length of the cable has a substantial effect on the amount of power consumed by the system. Regarding termination, port powering is not a viable option if it is necessary to use terminating resistors. A much less important aspect of the setup is the

number of nodes that will be used. With a given cable length, additional nodes will have little effect on power consumption until the number used is nearing the maximum of 32 nodes.

The final major consideration is the specific power requirements of the converter to be used. Tests were performed on many converters that B&B offers both with and without terminating resistors. These tests used a failure criterion that was extremely strict. Because of that, the required power that was determined is a very conservative estimate and the converters should be able to function with slightly less power. A table is provided which lists the power requirements of many of B&B Electronics' RS-485 and RS-422 converters. These results can be generalized to cover most of the converters that are currently available from B&B. It is a good idea to check this table in order to determine whether or not a particular converter can be powered with the serial port that is available.

Insufficient power is the cause of many of the problems that can occur with port-powered converters. Following these guidelines will help to determine whether port powering is a possibility for a particular application.

Appendix

Setup for Converter Power Requirement Tests:

Each converter was connected to three other converters as loads, the third being connected through a 1000-ft cable.

For the RS-422 converters the input waveform was a 9 V p-p, 10 kHz square wave with a 50 % duty cycle and centered at 0 V. This frequency corresponds to a baud rate of 19 kbps. The input was applied to the RS-232 TD input of the second converter and looped back to the converter being tested. This was to avoid the converter being tested obtaining extra power from the signal itself. On the RS-232 side of the converter tested, the RD and TD pins were jumpered together for a worst-case load where the signal was passed in both directions.

For the RS-485 converters, the input waveform differed in that it did not go below 0 V and the peak to peak voltage was reduced to 3.12 V. This waveform was applied directly to the RS-232 TD pin of the converter being tested. All converters were set to be in two wire (half-duplex) mode.

For both the RS-485 and RS-422: most converters were tested with both a positive and a negative voltage supply. Those that weren't are made to be used with only one voltage supply polarity. The polarity of the voltage supply used corresponds to the state of the handshake lines, when port powering, raised handshake lines are the equivalent of a positive voltage supply in these tests.

Setup for Driver Power Output Tests:

Each time a driver was tested, a DC power supply was used to supply the V_{cc} stated in the table. One of the T_{in} pins was connected alternately to V_{cc} and then ground in order to test operation on the negative and positive output sides respectively. The corresponding T_{out} pin was connected through a 3 k Ω resistor to ground. The output power was calculated using the measured voltage across this load resistor.

For the MAX3244 and MAX3245: the FORCEON and FORCEOFF' pins were connected to V_{cc} at all times to force the driver to remain in operation.

Note on using termination:

The 485SD9TB and 485DRJ converters have internal bias resistors which have values that were determined assuming that termination would not be used. These resistor values did not affect the power requirements of these converters and therefore were not changed for testing. However, the resistors should be replaced when operating with termination.

Note on External Capacitors Used:

Many of the RS-232 drivers require external capacitors for use. When this is the case, the data sheet for the driver includes a listing of minimum capacitance values. When drivers were tested with more than one set of capacitor values, always at or above the minimum, it was found that the power output was not noticeably affected. Therefore, the results listed are those that were found when using the minimum capacitance values, or the closest values that were readily available.