BaBar Calorimeter DAQ Project

E-LINK Interface Serial Link

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Introduction

This document details the construction and testing of serial link circuitry based upon the HPCL 4000 series opto-couplers. As the link is to be used as a connection to the E-LINK Interface, a test circuit was designed and modified to meet the interface connection specifications.

The E-LINK Interface

The E-LINK Interface is a sub-system of the BaBar EMC DAQ I/O board. It is used as a single communication point for sending and receiving system and status data to and from other systems on the board (i.e. the Finisar, the GLINK, etc.) The interface is accessed from a remote unit a short distance away (≈5m) and requires three signals:- serial data in, serial data out and an external clock. These data links between the interface and the remote unit are arranged as shown below.

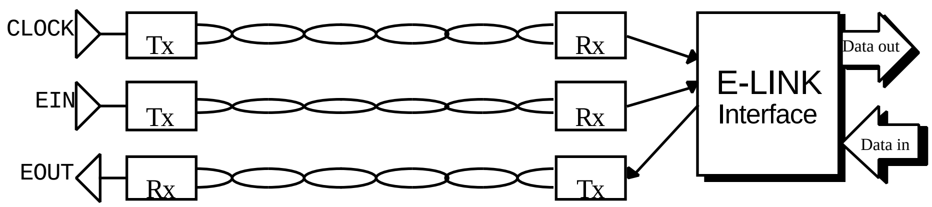

Figure 1: Connection of a remote unit to the E-LINK Interface

So that all the systems to be accessed by the interface can be read several times a second, a data rate of 20kbps was set for the input and output lines. This meant that the external clock had to clock the bits at 20kHz.

Test Circuit

Instead of constructing the entire serial link, we built two transmitter/ receiver channels to test. The two channels were identical except a test signal was applied to one channel and the other channel was left so crosstalk between the channels could be measured.

These next sections detail all that was taken into account when designing the circuit.

Tx & Rx: HPCL 4000 Series Devices

This range consists of an opto-isolated transmitter and receiver (4100 and 4200 respectively) based on a 20mA current loop. This means that the input and output circuits can be powered to the voltage or logic levels required for each end of the link, but a separate current source has to be inserted within the transmission loop.

Total electrical isolation of the signals from the transmission media provides very high immunity to common mode interference and breaks ground loops.

Power Supplies

To emulate the situation in which the circuit would be used, the transmitter circuit, the current loop and the receiver circuit were powered by isolated power supplies.

So as to fit in with the design of the board the IC's were powered with +5Vdc, and to keep the signal completely isolated the current loop was powered with a separate +9Vdc supply.

20mA Current Loop

As the length of the cable was fixed and loop was only connected to one receiver, a resistor connected to the current loop's V_{cc} could be used as a constant current source. The value was calculated to be 175Ω (180Ω NPV) from the supply voltage, the voltage drops given on the data sheet and the (almost negligible at this distance) cable resistance.

The data sheets noted that placing the current source at the transmitter or receiver end yielded different circuit performances. As shown previously, the E-LINK requires a mixture of receivers and transmitters at each end, therefore we needed to test whether the current sources could be grouped at one end of the link or would need to be kept with the transmitters or receivers.

Data Cable

The E-LINK specification was for communication to and from a remote unit approx. 5 metres from the interface. To test the circuit over the specifications (yet well under the 400m limit!) the cable used was an unshielded twisted pair 8 metres in length.

Test Signal

The test input signal was generated by a variable frequency 555 based timer oscillator. The frequency range was calculated from 5kHz (10kbps) to 100kHz (200kbps), far above and below the specified frequency of 20kHz. The shape of the square wave from the 555 were sharpened by a 7414 TTL Schmitt trigger those output was applied to the transmitter.

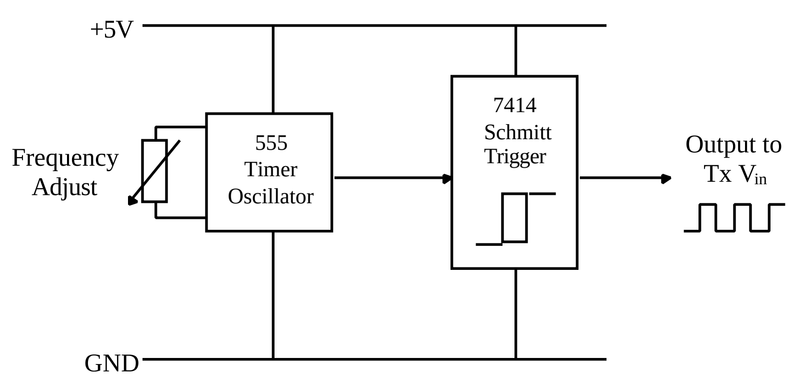

Figure 2: Diagram of test signal generator circuit

The Resulting Circuit

Taking into account the above considerations the following test circuit was drawn up.

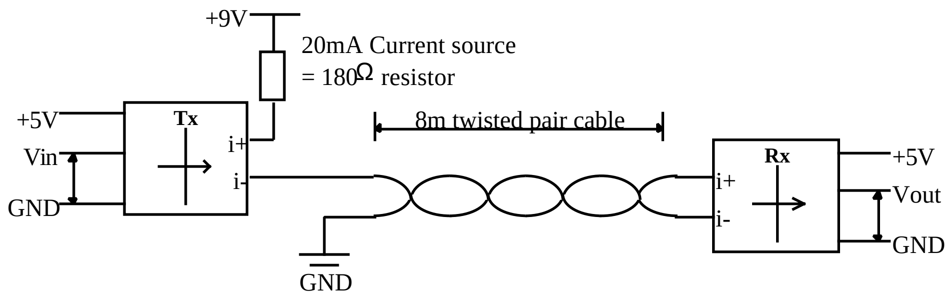

Figure 3: The circuit built to test the link's operation

Here is the same test circuit but with the current source placed by the receiver.

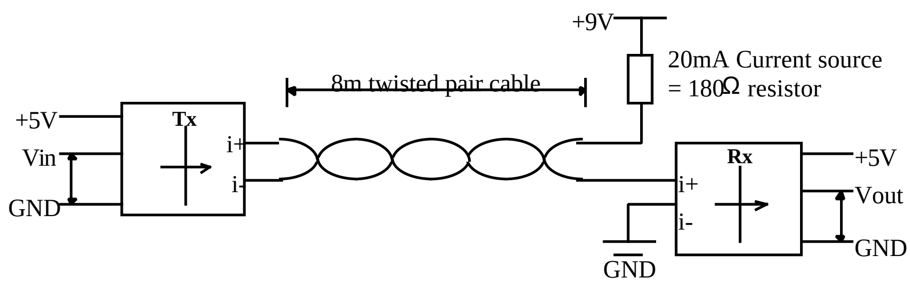

Figure 4: The test circuit with the current source at the receiver end.

The circuit was constructed on two separate pieces of vero-board so that the transmitters and receivers could be kept apart, and the two cables were stretched out next to each other as far as practically possible in the lab.

Equipment

Required for this test were three isolated bench power supplies, an oscilloscope and various assembly equipment (e.g. soldering iron, multimeter, etc).

Results

The circuit was tested over the frequency range of 5kHz to 100kHz with the current source first at the transmitter then at the receiver end. Once a clean output signal was obtained the output of the second channel on the circuit was viewed to measure crosstalk.

The only problem with the circuit was that there was a small amount of ringing on the rising edge of the transmitted pulses. This led to a short spike or even a short pulse appearing just before the actual pulse began. As the circuit was to be used as a clock (where stray pulses would upset timing) this ringing had to be removed.

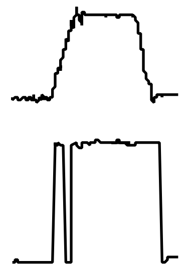

Figure 5: The effect of ringing on the receiver output (not to scale)

It was discovered that for stable operation the transmitter requires a minimum load of 1000pF across the output terminals. Once the capacitor was added any pulse ambiguities caused by ringing and reflections were removed.

Over the given frequency range the circuit performed well, easily up to the maximum test frequency of 100kHz (above this frequency was not tested). Therefore at 20kHz no problems should occur.

Crosstalk was barely visible on the second transmission line, at worst ±20mV spikes at the pulse transition which were easily filtered out by the Schmitt trigger on the receiver input. The current loop was also very good at eliminating common mode interference, particularly while using unscreened cable in an electrically noisy environment.

The transmission line had a voltage swing of 1.1V from 1.4V to 2.5V. The output had a fast rise time of 36ns and a slower fall time of 180ns.

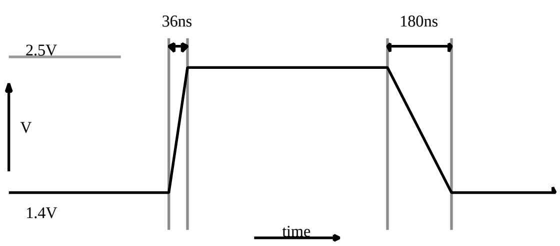

Figure 6: Current loop transmitted signal

This signal at the receiver gave the receiver output a voltage swing of 3.1V (0.3V to 3.4V) with identical rise and fall times of 160ns.

Even though the receiver output signal can be buffered before driving the ELINK, the signal is within the input specifications of the MACH (low<0.8V - high>2.0V) for it to be driven directly.

Conclusions

From studying and experimenting with the components, here are my conclusions for implementing them for the serial link.

For a completely stable circuit I recommend placing a 1000pF capacitor across the outputs of the transmitter as shown below. This guarantees that the transmitter is above its minimum load capacitance.

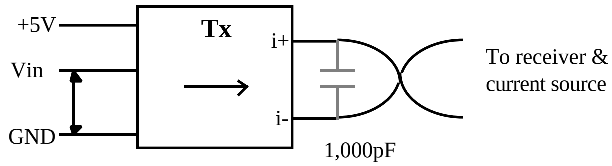

Figure 7: Capacitor added to reduce ringing in the transmitted waveform.

It was found that placing the current source at the transmitter or receiver end of the link had no effect on the performance within the specifications of this test. If a higher data rate was required (above the tested 100kHz) then the data sheets states that current source placement does affect the performance.

The complimentary transmitter and receiver work well, particularly in a noisy environment. They have the capability to work at a much higher frequency (measured up to 100kHz) and at distances longer than 8 metres (data sheet claims 20kBaud at 400m) should they be required.

References

Fast TTL Digital IC's, Mullard Technical Handbook, Bk 4, Pt 8a, 1988.
Optoelectronics Designer's Catalogue, Hewlett Packard.
Application Note 1018, Hewlett Packard.