LocalTalk™ Physical Layer Alternatives

INTRODUCTION

This application note discusses three approaches to the LocalTalk physical layer. One approach uses the TIA/EIA-422-B (RS-422) standard over a twisted pair wire medium. Another uses the RS-422 drivers and receivers but the bus is transformer-coupled over standard phone cables. The third approach is compatible with TIA/EIA-232-E (RS-232) in a point to point environment.

The analysis focused on driver supply current and maximum switching frequency. While all three approaches utilize the same drivers and receivers, the load presented is different. Therefore, the affects on current and frequency are different.

The DS8925 LocalTalk Dual Driver/Triple Receiver is used for the analysis of all applications.

LocalTalk Port Requirements

The LocalTalk physical layer is partially defined by RS-422. In addition to the electrical characteristics described by RS-422, LocalTalk specifies a data rate of 230.4 kbits per second over a maximum distance of 300 meters. Typically, LocalTalk uses the mini 8-pin connector, see *Figure 1*.
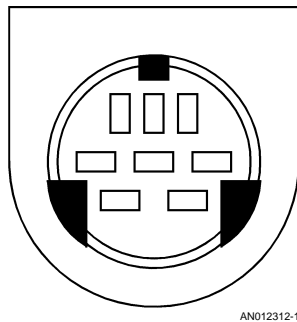

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FIGURE 1.

The bits are encoded using a frequency modulation technique called FM-0. In this method, the bit-time is nominally 4.34 μs. A "1" is defined as one transition during the bit-time; a "0" will have two transitions, as shown in *Figure 2*.
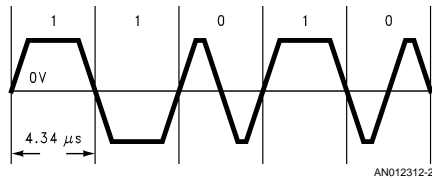

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FIGURE 2.

Historically, the line drivers and receivers used were the 26LS30 and 26LS32. The National devices were the DS3691 and DS26LS32A respectively. Since RS-422 and LocalTalk define a multi-drop serial bus, each connecting node will require a differential driver (TXD, transmit data) and a differential receiver (RXD, receive data). Additionally, a typical host port will also have single-ended signals for handshaking (HSKi and HSKo) and possibly a general purpose input (GPi). The single-ended signals conform to TIA/EIA-423-B (RS-423) and are interoperable with RS-232.

The DS8925 integrates the 26LS30 and 26LS32 functions in one economical bipolar device for LocalTalk applications. The differential driver is RS-422 compliant and, when measured single-ended, each output is also RS-423 compliant.

Twisted-Pair Application

The standard RS-422 implementation utilizes a twisted-pair wire with 100Ω parallel termination. Such an implementation is for point-to-point communication. In a multi-user environment, control of the bus must be established before point-to-point communication can begin. The DS8925 includes single-ended channels for this process.

Transformer-Coupled Application

Often the link is transformer-coupled and carried on standard telephone cable. In this type of application, only the transmit and receive data lines are used. The transformer is a 1:1 turns ratio transformer and provides isolation between the drivers and the cable. RS-422 was not intended for multi-point applications; in case of contention the transformer isolates the drivers from the bus.

RS-232 Application

Many types of peripherals can be connected to a LocalTalk host and only need the proper software drivers, such as a PostScript™ printer. While not being strictly compliant, most LocalTalk hosts are compatible with the standard so that a RS-232 peripheral device can communicate. The differential driver on the DS8925 used in the previous two applications is also designed and specified for single-ended communication.

When configured for a RS-232 application, the differential driver and receiver are used single-endedly. Since the driver is RS-423 compliant it will provide the ±3.7V signal, the unused driver output is left open. The differential receiver can detect RS-232 signals at the "−" input if the "+" input is referenced to ground.

Affects of Loading on Supply Current

The DS8925 will provide twice the normal RS-422 output voltage when supplied with V_{CC} = +5V and V_{EE} = −5V. The output current is dependent on the load, up to the point that short-circuit limiting (I_{OS}) occurs. *Figure 3* shows the DC differential output current of the DS8925 and the intersecting load lines.
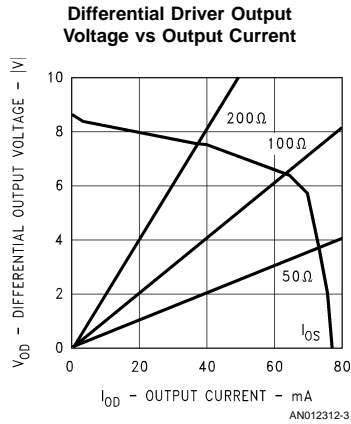
**Differential Driver Output
Voltage vs Output Current**

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FIGURE 3.

The other element of interest is the supply current due to the switching frequency of the driver. The total current required will be the no-load switching current plus the dynamic current determined by the load. *Figure 4* shows the no-load current versus switching frequency for the DS8925.

**No-Load Supply
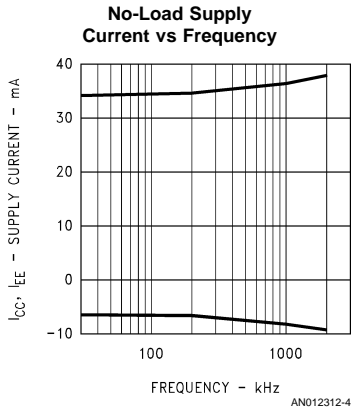Current vs Frequency**

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FIGURE 4.

Driving up to 1 MHz requires almost 45 mA (no-load). This is the base-line for comparison. The differences will be due to the load: the resistive component and the capacitive component.

The total supply current required to drive the 100Ω terminated twisted-pair is about 150 mA. The difference between this and the no-load current is due to the 100Ω parallel termination (about 65 mA) and the capacitance in the cable (about 40 mA).

Driving the transformer-coupled cable up to 1 MHz requires about 50 mA total supply current. The transformer presents a high impedance to the driver, thus the total supply current is only slightly more than the no-load current at this frequency.

Frequency modulation (FM) has little effect on the 100Ω terminated application, but this is very important to the transformer. FM assures at least one transition per bit, unlike a Non-Return to Zero (NRZ) scheme. Without transitions, a string of identical bits (i.e., 00000000) could generate a wave form that appears to be low frequency and thus the transformer would generate a proportionally low amplitude output. With FM, identical bits appear as a 50% duty cycle wave form. The worst case for FM is alternating bits (i.e., 10101010) because the pulse width changes with each bit. See *Figure 5*. This was verified in testing and although the amplitude is affected, the impact is not significant.
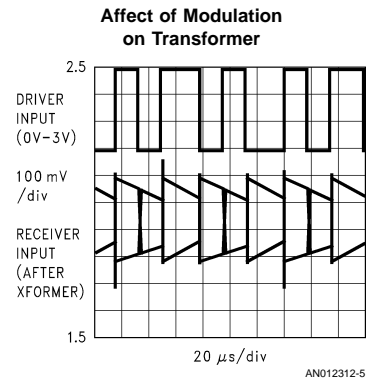
**Affect of Modulation
on Transformer**

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FIGURE 5.

The RS-232 application requires about 45 mA total supply current to drive a signal at 1 MHz. The loading for RS-232 is 3 kΩ from the signal to ground and the voltage level is guaranteed to be ≤±3.7V. With the second driver driven either LOW or HIGH, the total current does not change. The only change is that I_{EE} is nearly 1 mA greater than I_{CC} when the second driver is LOW, the opposite is true when it is HIGH.

Affects of Loading on Data Rate

The data rate for this device becomes limited by the slew rate before the affects of loading occur. As noted above, there is considerable difference between the current required to drive the different types of loads. The switching current is less of a factor at these low frequencies. The main factor affecting the differential data rate is the slope of the differential output. At about 2 MHz the rise and fall times take up nearly the entire period. Above this frequency, the amplitude is reduced and the wave appears triangular. This is the case at the driver's output with either of the first two types of load.

Since the driver has very large amplitude, typically 9V with no load, the amplitude can be significantly reduced before the receiver fails to detect the transitions. The test set-up performed up to 6 MHz and still detected valid data at the receiver. LocalTalk is intended to operate below 1 MHz; therefore, physical layer loading should not affect data rate performance.

RS-232 is specified up to 20 kbits/s, but many applications exceed 100 kbits/s. The test set-up performed over 4 MHz and still met the minimum output levels. Beyond 4 MHz, the amplitude decreases and would not meet RS-232 levels. Again, this was due to the edge rates and not the loading.

Maximum cable length testing was not performed. However, RS-422 defines a maximum cable length of 1200 meters. Lo-calTalk is defined to be less than 300 meters. RS-232 is limited to about 15 meters (defined in terms of cable capacitance).

Transformer Set-Up

The bench fixture for testing the transformer-coupled physical layer was assembled from available "tel-net" adapter products. The transformer and RJ-11 connectors were left attached to their PCB and connected to the fixture. The terminators provided with the adapters were used at each end and a 25-foot length of standard residential phone cable was used between the two nodes. The fixture used two socketed DS8925s and had provisions for inserting loads in series prior to the adapter. See *Figure 6*. Only the differential driver and differential receiver were used on each device.
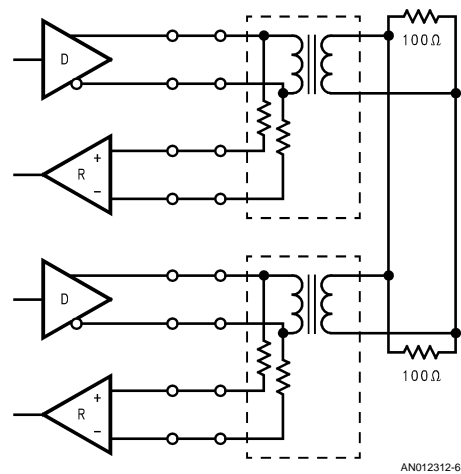

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FIGURE 6.

Radio Frequency Interference (RFI) filters were inserted in the transformer application. There was very little affect on supply current or data rate because of the high impedance presented by the transformer. Such filters would reduce the supply current required for the 100Ω parallel terminated application as this increases the total impedance.

The fixture has the capability to have each device referenced to a separate ground, to test ground offset. No degradation was observed.

The signals could be probed at the driver outputs and receiver inputs. Most information was gathered at the first device's driver input compared to the second device's receiver output, or by monitoring the supply current to each device.

CONCLUSION

The DS8925 was used for all analysis because it was designed for both RS-422 and RS-423. The results showed that this type of device can meet the requirements of many different implementations of LocalTalk.

All of the applications that were analyzed exceed the data rate expectations by a significant amount. The transformer-coupled and RS-232 applications require much less total supply current than the 100Ω terminated application. Alternative devices exist for each implementation, but most of the current is due to the loading. Therefore, a single device such as the DS8925 can effectively support all of these applications.

REFERENCES

"Guide to the Macintosh® Family Hardware" second edition, Addison-Wesley Publishing Company, Inc.

"Inside AppleTalk", Addison-Wesley Publishing Company, Inc.