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www.randolph-telecom.com 781.721.2848

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TEN KEY CONSIDERATIONS BEFORE YOU START YOUR DAA OR FXO PHONE LINE INTERFACE DESIGN

By Joe Randolph

Introduction

The conventional 2-wire analog phone line that telephone companies provide to residential and business customers is commonly called POTS (Plain Old Telephone Service). Common examples of POTS equipment include telephones, modems, fax machines, set top boxes, and alarm dialers. This same basic type of phone line is used by certain types of business telephone systems and for interfaces between VOIP (Voice Over Internet Protocol) equipment and the PSTN (Public Switched Telephone Network).

When used for a modem, the phone line interface in the terminal equipment is typically called a DAA (Data Access Arrangement). For voice applications, the interface is typically called an FXO interface (Foreign Exchange Office). For the purposes of this article, we will use the term "DAA-FXO" interface.

While the basic functionality of the DAA-FXO interface is common to all the above product types, there are important differences that depend on the target application. This article summarizes some of the key considerations that should be taken into account when designing a DAA-FXO phone line interface.

1) Will the interface be used for data, voice, or both?

Voice applications require the ability to transmit a higher peak-to-peak signal than data modems. This is because human speech has higher short term peaks than the comparatively constant levels associated with data modems. The PSTN is designed to handle speech signals up to 3.1 volts peak to peak, corresponding to the peaks of a +3 dBm sine wave.

For optimal performance on the PSTN, voice equipment should be able to transmit without distortion at these levels. In some cases there are regulatory requirements or industry specifications where the ability to transmit at +3 dBm is a requirement.

Data modems do not typically generate such high peak transmit levels. In general, a high speed data modem only requires the ability to transmit at about 1.5 volts peak to peak, corresponding to a -3 dBm sine wave. Low speed data modems require even less transmit signal swing.

It should be noted that phone line interfaces typically have the greatest difficulty transmitting at high levels when the DC loop current in the phone line is low. Operation at loop currents down to 18 mA is typically required. For some types of DAA-FXO circuits, it can be very difficult to transmit a +3 dBm sine wave when operating on only 18 mA of loop current.

Another key difference between voice and data applications is the AC impedance that the interface must present to the phone line. This is typically measured indirectly as return loss with respect to a specified impedance. Most data modems are designed to match a simple 600 ohm resistance, and this impedance is acceptable for data modems in every country except Australia. Voice products are often required to match a complex reference impedance that includes a capacitive element. Many countries that accept 600 ohms for data modems impose a complex reference impedance for voice products. In Australia, both modems and voice products must match a complex reference impedance.

2) If the application is a modem, what speed is the modem?

There are many different types of modems, and the performance requirements for the line interface vary significantly for the different types. High speed, full duplex data modems in the 14.4 K to 56 K range such as ITU standards V.32bis, V.34, and V.90 typically require lower distortion, lower noise, and higher bandwidth in the line interface than what is required for low speed modems. Failure to take distortion, noise, and bandwidth into account can lead to serious performance limitations.

Low speed modems in the 300 bps to 2400 bps range such as ITU Standards V.21, V.22, and V.22bis are much less sensitive to the distortion and bandwidth of the line interface. If an application does not require high speed data communication, the use of a low speed modem may save some cost in the line interface and may also improve the reliability of the data connection.

Fax modems are a special case that deserves mention. The high speed image transfer portion of the fax protocol is “half duplex,” which means that it passes data in only one direction at a time, as opposed to the typical full duplex data modem that transmits and receives data simultaneously. The only full duplex portion of the fax protocol takes place at low speeds in the range of 300 to 2400 bps. The net result is that fax modems, even if they use high speed image transfer in the 14.4 K to 33.6 K range of the ITU V.17 and V.34bis standards, are much less sensitive to noise and distortion than full duplex data modems. This provides some opportunity for cost savings in the line interface design.

3) What are the size constraints for the interface?

Sometimes the least expensive or best performing DAA-FXO line interface will be transformer based, but transformer-based designs are typically larger than solid state designs. Through the use of specially designed miniature transformers, a transformer-based design can be made quite small, using about one square inch of circuit board area.

However, for the absolute smallest implementation, the various silicon DAA-FXO chip sets from vendors such as Clare, Integration Associates, Silicon Labs, and Teridian will usually require less board space than a comparable transformer-based version. There can be some performance tradeoffs when using a silicon DAA-FXO, so if adequate space is available a transformer-based version should be considered.

4) In what countries must the interface be approved?

The target countries where a product will be sold are an important consideration. The process of gaining regulatory approval for selling the product in a given country is often called “homologation.”

Various countries impose different (and sometimes conflicting) requirements on the electrical characteristics of a DAA-FXO interface. In the past, there were several conflicting requirements such as ring detection and AC impedance that required a high degree of configurability in a worldwide design, but now there are far fewer of these conflicting requirements. This is especially true since Europe stopped regulating most of these parameters a few years ago. Today, a carefully designed DAA-FXO circuit can be used in most countries worldwide with few, if any, configurable parameters.

While compliance with most of the basic electrical characteristics is now greatly simplified, there has been a recent trend of increasingly difficult international requirements for EMC (Electro-Magnetic Compatibility). The EMC requirements can include limits not only on radiated and conducted RF emissions, but also on the equipment's susceptibility to interference from radiated and conducted RF in the environment. In particular, immunity to conducted RF noise on the phone line can be a difficult requirement to meet. Countries where such immunity is now a regulatory requirement include Europe, Brazil, Mexico, India, and South Korea.

Several countries require that the line interface must not be damaged when subjected to specified lightning surges. The requirements in Taiwan and South Africa are particularly severe. In Brazil, the line interface must not be damaged by specified "power induction" events that simulate 60 Hz AC power appearing on the phone line.

In summary, it is helpful to know at the outset of your design the countries where you intend to eventually seek regulatory approval. If the worst-case requirements are accounted for in the initial design phase, there will be less likelihood of requiring major redesigns to gain regulatory approval in any given country. These days, the applicable EMC requirements typically require more attention than they have in the past.

5) Do any industry requirements apply?

It is important to know who your customers will be. If a product will be sold directly to consumers in retail outlets, perhaps the only requirements that absolutely must be met are those required by local law, such as the applicable regulatory requirements for safety, EMC, and network compatibility.

However, even for consumer products, if your customer is a large retail chain or reseller, the customer may impose additional industry requirements as part of their purchase specification. Industry standards such as ETSI TBR 21 and ES 203 021, EIA-470, and ITU K.20 and K.21 are not legally required for regulatory compliance, but they are often imposed by the customer as part of a purchase specification.

Similarly, if your product will be used by a network provider, there will typically be significant additional requirements imposed by the customer to ensure adequate reliability in the field. In North America, Telcordia NEBS GR-1089-CORE imposes some of the most stringent lightning and power cross immunity requirements in the world. Compliance with this industry standard is typically required by all of the PSTN network operators in North America.

6) Will the interface ever have another device connected in parallel?

Some DAA-FXO interfaces are more sensitive than others to the available DC voltage and current on the phone line. In general, modems do not have to operate with another device offhook (active) on the phone line at the same time, so they can use 100% of the available power on the phone line. On the other hand, many voice products such as telephones have to continue to operate normally when

another phone is offhook on the line at the same time. This means that the two terminal devices must share the available power. Some types of DAA-FXO interface handle this condition better than others.

7) Is Caller ID detection required?

If the product must be able to detect caller ID signals, this will have an effect on the design of the interface and the available choices. Since caller ID does not operate the same way in every country, the list of countries where the product will be sold must be considered as well.

8) Is any type of line status sensing required?

Some applications, such as set top boxes, share the household phone line. Often it is desirable for these devices to avoid placing automatic calls when the phone line is already in use. Also, for emergency calls that might need to be placed from a household phone, it can be helpful for the automatic calling device to terminate any call that it has in progress if a parallel phone goes offhook. Some DAA-FXO circuits can provide these types of line status sensing quite readily, while others can not.

9) Is lightning immunity a major concern?

In some cases it can be helpful to self-impose a lightning immunity requirement that exceeds what would normally be required by the applicable regulatory requirements. The vast majority of lightning surges that appear on phone line interfaces have open-circuit voltages of less than 1500 volts and short-circuit currents under 50 amps, and most DAA-FXO circuits can handle these surges reasonably well.

Unfortunately, due to various conditions in the network, a very small percentage of terminal devices will be subjected to surges that have open-circuit voltages up to 5000 volts and short-circuit currents up to 100 amps.

For products that are sold in low to moderate volumes, or products where field reliability is not critical, it may be acceptable to have a small percentage of installed units fail due to lightning damage.

However, for products sold in large volumes or products used in critical applications, even a small percentage of the installed units failing from lightning damage can present serious problems. For a set top box that has 10 million units installed in the field, even a failure rate of only 0.1% per year translates to 10,000 lightning failures per year. For such applications, designing a more rugged DAA-FXO interface can provide significant benefits regarding warranty repair costs, field repair costs, and customer satisfaction.

10) Are there specific requirements for power consumption?

Applications that are battery powered may place constraints on the active power consumption of the DAA-FXO interface, or require special power-down modes when the interface is idle. For applications

that are powered from the AC mains, power consumption in the DAA-FXO interface is typically not an issue.

Summary

Despite the fact that DAA and FXO phone line interface circuits perform essentially the same basic functions, there can be significant differences in the requirements that apply for a specific application. To minimize the chances of major schedule delays or expensive redesigns, it is helpful to consider these differences at the outset of the design process.

About the Author

Joe Randolph is an engineering consultant who has been designing phone line interfaces for over 20 years. He has completed designs for compliance with every major international standard, and has experience with all types of DAA and FXO line interface technology, including transformer, optical, and capacitive isolation circuits. His contact information is:

Joe Randolph
Randolph Telecom, Inc.
Phone: 781-721-2848 (USA)
Email: jpr@randolph-telecom.com
Web Site: http://www.randolph-telecom.com