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SEVEN KEY CONSIDERATIONS BEFORE YOU START YOUR SLIC OR FXS 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 a POTS (Plain Old Telephone Service) line. Common examples of POTS terminal equipment include telephones, modems, fax machines, set top boxes, and alarm dialers.

Typically, the phone lines (or “loops”) provided by the phone company originate at a nearby central office. The interface circuit that terminates the loop at the phone company’s central office is sometimes called a SLIC (Subscriber Loop Interface Circuit) or an FXS (Foreign Exchange Subscriber) interface. The two terms SLIC and FXS are now used interchangeably in the industry. For the remainder of this article, we will refer to this as a SLIC-FXS interface.

In the idle state, the SLIC-FXS interface applies a DC voltage in the range of 48 to 60 VDC to the loop. When the phone connected to the other end of the line is idle (“onhook”), no DC current flows. If someone picks up the handset of the phone, a DC current will flow in the loop, allowing the SLIC-FXS circuit to detect that the phone has gone “offhook.” While the phone is offhook, the SLIC-FXS circuit feeds a DC current in the range of 20 to 100 mA to the phone. For a conventional telephone that does not use AC mains power, this current provides the only source of power to the phone.

To ring the phone or any other POTS terminal equipment connected to the far end of the loop, the SLIC-FXS circuit applies a high voltage AC ringing signal to the loop. An important function of the SLIC is to quickly detect when the terminal device has gone offhook while ringing is applied, so that the high voltage ring signal can be quickly removed from the loop and replaced with a constant DC voltage feed. This function is called “ring trip.”

In the offhook state the SLIC provides normal analog transmit and receive functions for speech or data signals. It also constantly monitors the DC current in the loop to detect signals such as pulse dialing or an onhook transition.

In general, the SLIC-FXS interface is a *source* of power applied to the loop. In most cases, it is not isolated from earth ground. On the other hand, the interface in the terminal equipment at the other end of the loop (such as a phone or fax machine), is a power *sink*. This type of interface is typically called a DAA or FXO interface, and is very different from the SLIC-FXS interface. The DAA-FXO circuit is always isolated from earth ground, so that only one end of the loop (at most) is grounded. DAA-FXO circuits have been described in a separate article.

While the basic functionality of the SLIC-FXS interface is common to many applications, there are several 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 SLIC-FXS phone line interface.

1) Will the application be for short loops or long loops?

Recall that the term “loop” refers to the 2-wire twisted pair copper line between the SLIC-FXS interface and the terminal device at the other end, such as a telephone. A conventional phone line provided by the local phone company can be up to about 20,000 feet long.

On the other hand, there are many applications where the loop length will be far shorter, such as the connection between an office PBX and an analog telephone set located within the same building. Another broad category of short loop applications are so called “terminal adapters” that allow an analog phone to be used on a digital phone service such as ISDN, cable TV phone service, fiber-to-the curb, or VOIP (Voice Over Internet Protocol) telephone services. For these applications, the maximum loop length is typically less than 1000 feet.

It turns out that dramatic simplifications can be achieved in the design of the SLIC-FXS circuit if, *and only if*, the application will be limited to short loops. By taking advantage of the fact that the loop length is known to be short, ringing signals can be generated a simpler way that is typically called “balanced ringing.” With balanced ringing, the ring-trip function can be greatly simplified as well, but ring-trip with balanced ringing can only be used on short loops.

SLIC-FXS integrated circuits that are optimized for short loop applications are typically called “ringing SLICs” because a balanced ringing signal is generated directly on the SLIC chip instead of with an external ring generator.

So, if the application has to support long loops, the so called “ringing SLICs” with balanced ringing should not be used.

2) Is unbalanced ringing required?

Conventional phone lines use “unbalanced ringing,” which means that the AC ringing signal is superimposed on a DC bias voltage. The ring trip function is implemented by sensing an increase in the DC current that flows when the answering phone goes offhook.

Balanced ringing has no DC bias, and ring trip is implemented by sensing the increase in the AC ringing current that occurs when the answering phone goes offhook. For reasons that are too complicated to go into here, the ring trip function with balanced ringing becomes unreliable on long loops.

Since conventional phone lines use unbalanced ringing, some types of inexpensive terminal devices such as certain answering machines, fax machines, and modems have been optimized to respond specifically to unbalanced ringing. When these devices are used on lines that implement balanced ringing, their ring detect functions sometimes don’t work. Fortunately such situations are rare, but they do occur.

Thus, unbalanced ringing should be used whenever long loop compatibility is required, or when there is concern for 100% compatibility with all existing terminal devices.

3) How will safety compliance be implemented?

In most countries, the applicable safety requirements for equipment with a SLIC-FXS interface will be based on a national version of the international reference standard, IEC 60950. For example, the USA national standard is UL 60950, and for Europe it is EN 60950. There are some differences between the two versions, but many of the requirements that apply to a SLIC-FXS interface are identical between the two versions.

In IEC 60950, phone lines are classified as “TNV” circuits. A SLIC-FXS circuit that connects to a phone line that goes outside the building is classified as a TNV-3 circuit, while one that connects to a phone line that remains inside the building is classified as a TNV-2 circuit. Due to the fact that both types have high AC ringing voltages, they are both considered semi-hazardous, and potential user contact with either TNV-2 or TNV-3 circuits must be carefully limited. Since TNV-3 circuits have exposure to lightning and power cross events, additional requirements apply to TNV-3 circuits that do not apply to TNV-2 circuits.

The main problem for safety compliance of SLIC-FXS circuits is that they are typically not isolated from the circuit ground and chassis of the equipment in which they reside. Yet, IEC 60950 requires a 1000 VRMS or 1500 VRMS isolation barrier between the phone line and anything that a user can touch, such as the enclosure or a USB port. This isolation requirement would appear to impose a significant challenge for the SLIC-FXS designer, since it is generally difficult and expensive to fully isolate a SLIC-FXS interface.

Fortunately, there is an exemption from the isolation requirement for equipment that has a permanent connection to earth ground. Most equipment that implements SLIC-FXS interfaces uses this exemption to meet the safety requirements. However, to qualify, the equipment must be connected to ground with a separate, permanent ground wire that is not part of the AC mains plug. In other words, a separate grounding lug and special installation instructions must be provided.

The permanent ground exemption works fine for large equipment that is installed in a telephone closet, but it is not a practical solution for a small terminal adapter that sits on a user’s desk. For such applications, compliance must be achieved with either careful design of the enclosure or the use of a complex single-fault analysis.

A different type of safety requirement appears in only the USA and Canadian safety standards. This test, called the “power cross test” or “overvoltage test,” requires that the equipment must not become a fire or safety hazard when various levels of AC power mains voltages are applied to TNV-3 phone line circuits. The tests are quite complicated because they simulate a wide range of voltage and current combinations in an effort to generate the maximum possible heating in the equipment. In general, the use of a simple fuse is helpful but not sufficient to guarantee compliance. There are some exemptions from this test for equipment that contains a suitable fire enclosure.

The main point here is that the specific method that will be used for safety compliance must be carefully worked out at the outset of the project, in order to avoid expensive redesign activity that might be required if the finished product fails to meet the applicable safety requirements.

4) What type of lightning surges and power cross events must the interface withstand?

SLIC-FXS circuits that connect to outside lines (TNV-3) are subject to environmental stresses such as lightning and AC power cross events. In general, the applicable safety and EMC requirements in a given country will require some degree of immunity to these stresses.

If the product will be subject to the Telcordia GR-1089-CORE EMC requirements that are typically imposed by network providers in the USA, there will be several very severe tests for immunity to lightning and power cross. While GR-1089-CORE is not a regulatory requirement imposed by USA law, it is typically used as part of the purchase specifications for equipment used by network providers. Thus, if the product will be sold to a network provider, compliance with GR-1089-CORE will likely be required.

Interestingly, GR-1089-CORE does not restrict the lightning and power cross immunity requirements to outside phone lines. Even phone lines that are used strictly within a building are required to pass certain lightning and power cross tests. Lightning tests on internal lines have also been added to the international reference standards ITU K.21 and K.22. By themselves, K.21 and K.22 are just reference standards, but some countries call out portions of these standards in their national regulatory requirements.

While it might seem odd that lightning could affect a phone line that remains inside a building, experience has shown that even inside lines, if they are long enough, can pick up surges from lightning. For example, if lightning strikes the top of a steel frame building and travels through the steel frame to ground, surge energy can be coupled into inside phone lines that run parallel to the building's steel frame. The tests that apply to inside lines are not as severe as the those that apply to outside lines, but they are still difficult to pass.

5) 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." Typically, homologation requirements in a given country fall into three categories:

1) Safety
2) EMC (Electromagnetic Compatibility)
3) Telecom

Safety and EMC requirements apply to SLIC-FXS interfaces in most countries. In Europe, Brazil, Mexico, India, and South Korea, the EMC requirements are quite extensive. In addition to placing requirements on radiated and conducted RF emissions, these countries have requirements for immunity to various types of radiated and conducted interference in the environment.

Telecom regulatory requirements sometimes do not apply to SLIC-FXS interfaces. In many cases, SLIC-FXS interfaces are not intended for connection to the PSTN (Public Switched Telephone Network). Examples of such applications include inside extensions on PBX (Private Branch Exchange) equipment for office communications systems, and terminal adapters that allow analog terminal devices such as telephones and fax machines to be used on digital phone services such as ISDN and VOIP applications. Fortunately, most countries impose few, if any, telecom regulatory requirements for these applications. Australia is a notable exception, with extensive regulatory requirements for any type of SLIC-FXS port that can connect through a switching device to the PSTN.

If no regulatory requirements apply in a target country, it is still advisable to make sure that the electrical characteristics of the SLIC-FXS interface are compatible with typical terminal equipment in the target country. For example, some countries use 50 Hz ringing, while others use 25 Hz or 20 Hz. A French telephone designed for 50 Hz ringing may not respond at all to a 20 Hz ringing signal.

In some cases, a SLIC-FXS interface does connect to the PSTN. A typical example would be if the circuit is on a central office line card in equipment that is used by a network provider. In these situations, the applicable requirements will typically be a combination of customer requirements imposed by the network provider, plus the applicable safety and EMC requirements imposed by local government regulations. For example, in Europe the EMC regulatory requirement that applies to PSTN network equipment is ETSI EN 300 386. The requirements in EN 300 386 are generally more difficult than the requirements in EN 55022 and EN 55024 that apply to terminal equipment.

6) 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 PSTN 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 ES 202 971, EIA-464, 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. Telcordia GR-57 and GR-909 specify transmission performance and other related signaling requirements for SLIC-FXS interfaces. Compliance with these Telcordia industry standards is typically required by the PSTN network operators in North America.

7) Are there specific requirements for power consumption?

Applications that must operate from battery power may have strict requirements for low power operation and various shutdown modes that conserve battery power. Applications that operate exclusively from AC mains power typically have few limitations on power consumption, except in cases where several ports are placed on a high density line card where heat dissipation becomes an issue.

Summary

While all SLIC and FXS interfaces perform the same basic functions, the specific requirements that will apply for a given application can vary significantly. There are important architectural choices that should be made at the outset of your design. These include determining whether your application must support long loops, what type of ringing is required, how the safety compliance requirements will be met, and what types of regulatory and customer requirements must be met. Determining these things at the start of the design process can help to avoid costly redesign efforts.

About the Author

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