Overcoming touch display challenges during device development

A common set of design challenges arise during the development of devices with touch displays. A lot of stubborn issues you might be facing are actually fairly easy to trace to well-understood root causes and solutions. This white paper walks you through best practices for avoiding those challenges in the first place (or correcting them if you are struggling with them).

Table of contents

ANTICIPATING TOUCH DESIGN CHALLENGES

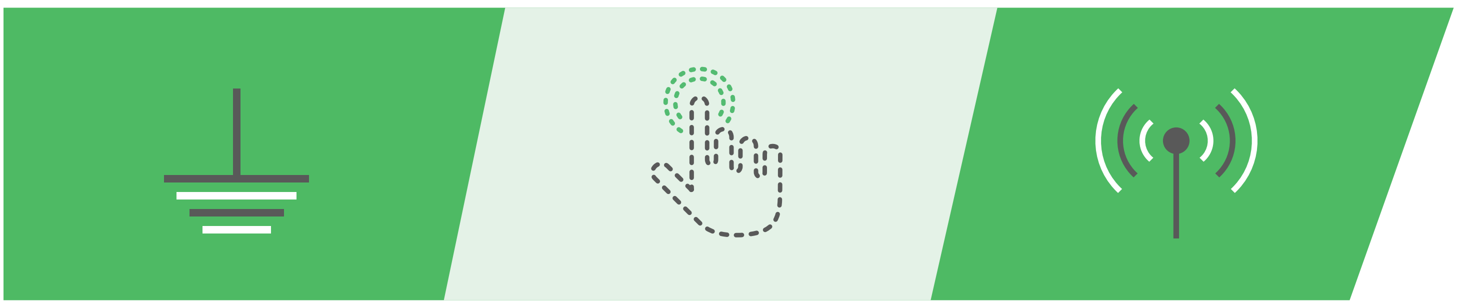
Touch displays are proliferating in all sorts of devices, giving users powerful and intuitive ways to control and interact with everything from phones and computers to kiosks and industrial equipment. While design concepts for the use of touch displays are well established, engineering and product design teams often come up against problems that can be hard to solve. Root-cause analysis to track down and resolve issues can be frustrating, time consuming and expensive.

Anticipating stumbling blocks that are likely to arise during the design and development of devices equipped with touch displays can go a long way toward streamlining the path to market. It can also increase product quality and reduce frustration within product teams. In this paper, we'll cover the top three common causes of challenges during device development:

- **Grounding design**. Touch displays can be temperamental in terms of what is grounded and how. Developing an appropriate applied ground approach is critical to creating your expected touch display behavior and performance
- **False touch.** Electromagnetic interference can cause problems such as ghost touch effects and offset between where the cursor should be and where it actually is
- **EMI testing.** Proper device design is critical to passing EMI tests on a device's path to market, and consultation with engineers at the touch display hardware provider is immensely valuable

The material here will help you understand key concepts to keep in mind for each topic area and give you best practices that will help avoid or resolve problems.

Overcoming design challenges...



...in grounding design... ...and with false touch... ...and with EMI testing.

MEETING CHALLENGES IN GROUNDING DESIGN

If the applied ground approach for a device equipped with a touch display doesn't follow best practices, a variety of issues can arise. Poor noise immunity is particularly common, meaning that the device is vulnerable to electromagnetic interference (EMI) and fails to operate properly in common circumstances. Common examples of EMI sources range from signal transmissions in wireless networks to radiation sources such as power lines.

Long-term drift is another potential issue that can arise from improper grounding design, which consists of changes in output voltage from power-up over time. In practical terms, long-term drift can degrade the performance of a touch display during use, causing a poor user experience or even making the system unusable.

Common challenges associated with grounding:
- **Poor noise immunity,** where interference negatively affects device operation
- **Long-term drift,** where shifts in voltages degrade performance of the display over time

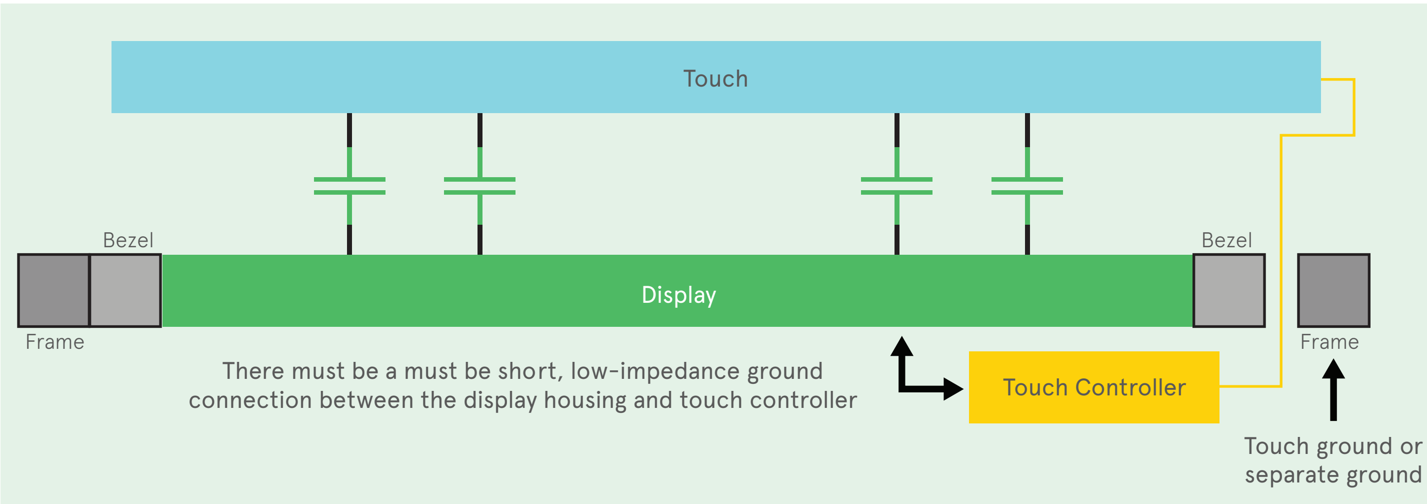
Stable grounding design is critical to making sure that projected capacitive (PCAP) displays work properly. There are two key considerations here: you must keep ground connections (tracks or wires) as short as possible, and keep impedance to a minimum. This requirement is particularly critical in ground connections between display housings and touch controllers. The diameter of the ground connection also has an effect, although this factor is less important than length because of the skin effect, which causes the majority of the current to be conducted by the outer skin of the conductor.

In addition to making the connection itself as short as possible, using self-drilling screws, serrated washers and braided ground straps can help ensure a high-quality ground. It is also helpful to eliminate as many connectors as possible from the ground line. Remember that each connector adds impedance and also introduces stray or parasitic capacitance effects that can make circuits behave in unintended ways.

Taking extra care to ensure that ground connections are short and have low impedance can often mean the difference between a design that works as intended and a design that fails.

Another important consideration for your grounding design is to scrupulously avoid ground loops, which can create interference from unintended current flows. Instead, you can use star topologies for ground distribution, helping avoid a situation where two points that are both intended to be at ground have a potential between them. An earth ground is ideal, if possible.

Any floating conductive parts near the touch sensor can cause erratic behavior in the touch function. To minimize problems related to EMI, all conductive parts should have the same electrical ground potential as the touch controller.



In addition to enacting these general design principles, keep the following best practices in mind as you consider grounding issues associated with touch display devices:

- **Don't rely on signal cables alone** for grounding connections, because they are insufficient in circumstances where high-frequency noise is a factor
- **Provide clearance for the flat printed circuit cable (FPC)** including a minimum of one millimeter between the FPC and the housing frame
- **Ensure the same ground potential** for the display housing and the touch controller; the frame can connect to the display/touch ground or a separate ground
- **Connect all conductive parts to ground,** especially when a plastic housing is used or for parts near the touch sensor, to avoid EMI from floating conductors

RESOLVING CHALLENGES RELATED TO FALSE TOUCH

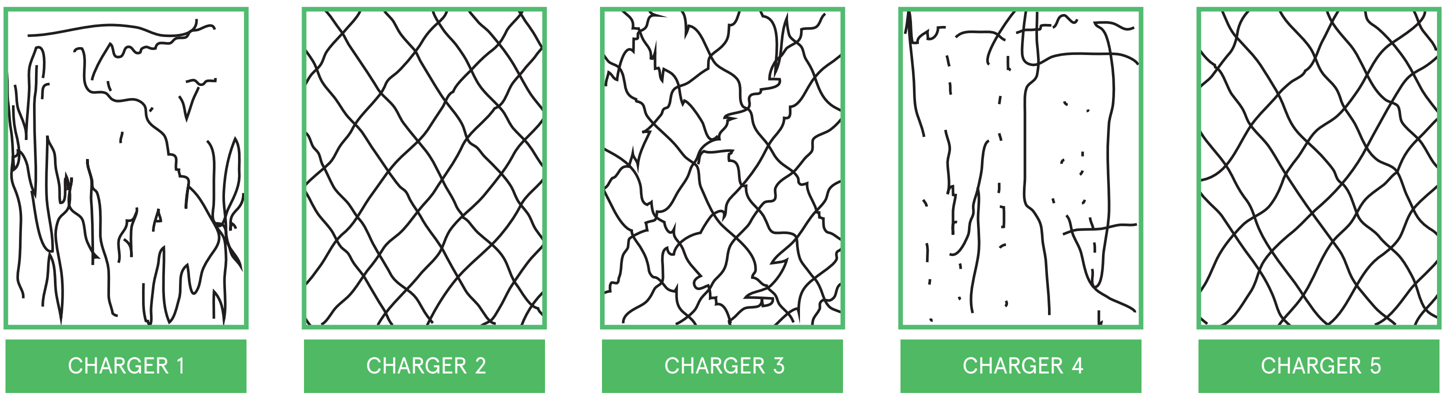
Touch sensors act as antenna arrays, bringing in strong levels of EMI from any number of sources—and this can affect the function of the touch screen and controller in unwanted ways. How well your system can tolerate the interference depends on the filter integrated in the controller and many other factors, some of which we cover in this paper. While filters continue to improve and other measures can reduce the impact of EMI on touch display devices, to create a sound design you should attend to the sources of interference instead of just reducing their effects.

False touch issues often manifest themselves in unintended touch effects. The screen may respond to touches that the user isn't actually making or else ignore the touches being made. A related problem is for there to be a noticeable offset between where the cursor appears on the display and the corresponding location on the touch sensor. Either can be maddening for users and a black eye on your product's reputation.

Common challenges associated with false touch:
- **Unintended touch effects,** including during CE certification
- **Offset in cursor location,** relative to intended position

The key to overcoming false touch challenges is to start with the selection of components and how they are implemented. For example, the quality of interference filters built into touch controllers varies widely among suppliers and within their product lines. The complexity and expense of passing electromagnetic compatibility (EMC) testing leads some component makers to reduce costs by going to market with parts that barely meet regulatory requirements.

Likewise, power supplies can be major root causes of false touch effects. Dirty power abnormalities such as low power, varying voltage, frequency variations and energy spikes can wreak havoc on device operation. With an eye toward these issues, power supply manufacturers have driven up quality dramatically in the past few years. Still, the quality of power from different suppliers continues to vary.



Inevitably, the display is a significant source of noise in a PCAP system. This fact makes it very important to maintain adequate distance between the touch sensor and thin-film transistor (TFT) polarizer. Because the critical distance is different for every display and device, determining the right spacing is more art than science. You'll typically need to conduct trial-and-error testing, and this can be particularly challenging if you are trying for a slim overall device form factor.

Because higher frequencies carry more energy than lower frequencies, the noise level increases with the pixel clock. That means that a well-designed TFT circuit becomes even more important at higher display resolutions. Minimizing the noise generated by the TFT circuit can often more than compensate for the increased interference as resolution goes up.

Design of a high-quality TFT timing controller must include a proper ground plane, especially if the device needs to satisfy industrial or higher EMC requirements. If you are using a plastic housing, consider metalizing the inner surface and connecting it to ground or earth as a shield. Connect the controller to the display housing with a braided, low-inductive metal ground strap with strap eyes attached. Fix one eye with one of the controller mounting screws, which reliably binds the cable to the controller's own ground cable. Screw the other eye onto a reliable ground point on the display housing.

As described earlier in this paper, proper grounding design is critical to achieving high interference immunity for the projected capacitance touchscreen (PCT) system. Additional measures to keep away grounding headaches include the following:

- **Glue copper foil** using conductive glue between the housing shell and the display housing
- **Shield against emissions noise** using ferrite cores on feeding lines such as USB, power and display cables
- **Include the touch controller** in the system's star-shaped ground layout

You should also place the active high-frequency-emitting components and other sources of noise as far away as possible from the sensor FPC and the touch controller circuits. In particular, consider the placement of the TFT data cable and backlight cable. The most critical radiation to consider in this area is in the range of 100kHz to 1MHz, which corresponds to the working frequencies of many touch controllers.

While it's not the first thing to consider, the amplitude of the burst voltage is also a significant factor in a device's ability to tolerate interference. Increasing the burst voltage clearly increases the signal-to-noise ratio, but this approach has its limits. Specifically, as the voltage increases, so does the level of radiation emitted by the touch screen. At some point, that level becomes incompatible with European Standard (EN) regulations. The preferred range is about 18 to 30 volts, although lower burst voltages may be sufficient in some cases.

OVERCOMING CHALLENGES RELATED TO EMI TESTING

Passing EMI testing can be a big obstacle in bringing an industrial or higher rated product to market. Device makers spend a lot of time and effort to make sure things go smoothly, and it's important to do what you can to put a product on the road to success. Planning is crucial here, because the earlier in the design and development process that you can implement measures, the less expensive and complex they usually will be.

Common challenges associated with EMI testing:
- **Design uncertainty,** around touch functionality for EMI testing
- **Hardware pre-testing,** to enable predictable results when testing for certification

IDENTIFY ENVIRONMENTAL REQUIREMENTS EARLY

Before you make any investments designing around specific hardware components, you need to do your due diligence. As early as possible in every design project, you should discuss requirements and the potential components that will fulfill them with engineering resources at your hardware supplier. That guidance is indispensable, and you should consider any potential vendors' ability to provide it before deciding on them as preferred partners.

To establish design requirements for a device, begin with external factors related to how the device will be used. For example, circumstances such as the following (among many, many others) must be considered beginning early in the design process:

- **Heavy gloves being worn by users**
- **Highly conductive liquids on the sensor**
- **Conductive bridges (e.g., rain or metal parts) between the sensor and metal bezel**
- **Presence of unusual electromagnetic fields**

Be sure to allow buffer time in project timelines for contingencies around such requirements, which may be prone to eating up large swaths of time for extra design and testing. Also be pragmatic about whether the environmental requirements (and the combination of those requirements) is feasible to design around. It may be that the requirements need to be revisited right away, if the time and/or cost requirements to address them are too high.

MITIGATE CHALLENGES WITH SMART PHYSICAL DEVICE DESIGN

Sound physical device construction is an important contributor to successful EMI testing. For example, sound electrical grounding depends on a sturdy device and proper grounding materials, such as thick grounding studs. You should also use shake-proof washers and self-cutting screws where possible to improve quality of the electrical connections.

In some cases, grounding the LCD by means of the data cable and/or mechanical fixing screws won't be enough. Another option is to experiment with bridging to an adjacent ground plane with adhesive copper foil. If you place emitting components behind an LCD panel, consider using the LCD as a shielding element by more robustly grounding its housing. Adding ferrite cores can be a simple measure to reduce noise originating from incoming lines such as USB, power and display cables.

A wide range of sources can contribute to noise in the device design, including data and signal cables, pulse width modulation (PWM) circuits for LED backlights and wireless transmitters (Wi-Fi, Bluetooth, etc.). You need to consider the placement of ground planes, including metal chassis, fittings, housings and bezels relative to such sources. Keep the following general guidelines in mind:

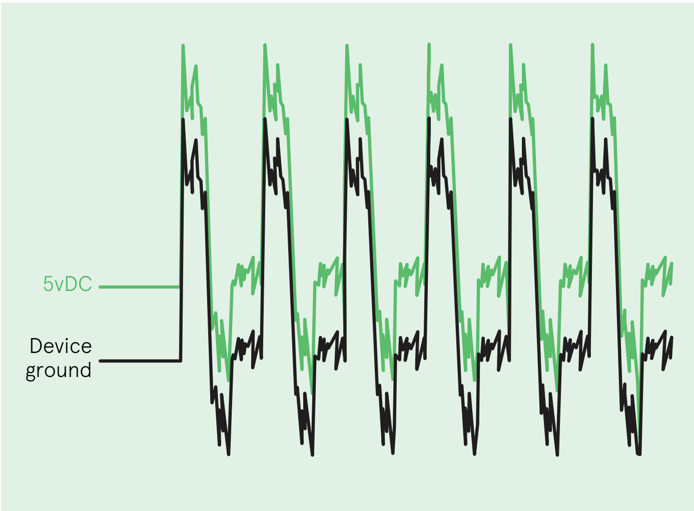
- **Maintain adequate distance between LCDs and touch sensors**, which will increase with the size of the screen and may be as much as 10mm or more for large screens
- **Place emission sources carefully**, routing low-voltage differential signaling (LVDS) cables away from touch cables, for example, and keeping emitting components such as wireless transmitters and inverters away from touch sensors and controllers
- **Avoid parasitic capacitive couplings** by maintaining adequate distance between the touch FPC and any metal component, and provide a mechanical barrier so fluid can't bridge between touch components and a metal bezel

CHOOSE COMPONENTS THAT MEET SPECIFIC NOISE REQUIREMENTS

When you are choosing components, comparing the EMI immunity among products from various vendors can be difficult to impossible. Because there are no standard methodologies for measuring signal-to-noise ratio, for example, the figures you get from vendors may not be as useful as you might hope. Choosing the right touch controller is made even harder by the fact that both signal and noise depend heavily on the specific device.

There is no viable "normal" level for noise from LCDs, organic light-emitting diode (OLED) displays and USB chargers. That noise is notoriously spiky, and spikes create jitter. Vendors typically specify signal-to-noise ratios in the absence of noise, using the root mean square (RMS) noise (standard deviation) of analog-to-digital convertors (ADCs). With Gaussian noise, you can multiply the RMS noise by 6 to calculate the peak-to-peak noise with 99.7% confidence.

Another noise issue comes from the fact that battery-powered devices typically don't have a reliable earth ground. Chargers generate common-mode noise, meaning that fluctuations occur across both output leads in tandem. That is, the lack of a true zero-volt reference means that the ground follows the noise dynamically. A finger on the touchscreen may provide a discharge path to earth ground, which amounts to a source of additional noise.



The amplitude of the noise injected by a finger can be an order of magnitude higher (or more) compared to the finger-touch signal, in some cases. Common measures to mitigate the effects of that noise include the following:

- **Use high-quality, low-noise chargers**
- **Use non-linear line filters**
- **Choose touch controllers with state-of-the-art frequency hopping**

  Note: Many controllers on the market are able to scan all available bandwidth and jump to the best available frequency. Some optimize that capability with a dedicated signal processor that does fast Fourier transform (FFT) analysis in real time.

Select touch controllers with a drive-electrode voltage within the range of 10-30 volts. Bear in mind that, while a high amplitude signal is generally desirable from the standpoint of signal-to-noise ratio, this is not always the case. Recent design advances have produced newer controllers that provide superior signal-to-noise characteristics at lower voltages, compared to earlier generations. In addition, going above 30 volts can lead to levels of emitted radiation that run afoul of European conformity (CE) certification guidelines.

In that regard, consider that higher drive-signal voltages are only one factor in getting positive EMI testing results. Others include better filter algorithms, improved raw-signal scanning and the internal touch design. Note that lower impedance allows for faster charging of touch nodes, so you can apply more filtering within the same timeframe, without decreasing the report rate.

Whenever possible, you can get a huge advantage toward successfully completing CE certification by pre-testing in-house or through pre-testing offered by hardware vendors. One advisable test to consider in this way is IEC EN 61000-4-6, *EMC Part 4-6: Testing and measurement techniques — immunity to conducted disturbances, induced by radio-frequency fields*. This test is often the most difficult one to pass, but by pre-testing using a prototype as close as possible to the final product, you can increase your chances of passing CE certification on the first try.

CONCLUSION

Touch displays are becoming more prevalent every day, in devices that range from consumer electronics to industrial and medical equipment. Still, it can be very challenging to design those devices so the touch display performs as you mean it to. Signal interference from internal and external sources can cause erratic behavior by the touch display—and that could be the death knell for your product's user experience.

To address those issues, you need to take the right steps, including proper ground design, component selection and physical device assembly. And those are just the top challenges in display design—you'll likely encounter a range of additional challenges, such as longevity, slim design and mechanical robustness along your path to market. Partnering with a hardware provider that can advise you at every step of the way is critical to your success. With a deep bench of expertise that covers every challenge you'll encounter with device design, coupled with pre-vetted and tested display solutions, Avnet offers you that guidance and ability to speed your time to market.

As your partner of choice and hardware component provider, we can deliver display solutions that enable you to build better devices, faster, at lower cost.

WANT TO KNOW MORE ABOUT AVNET DISPLAYS?
VISIT AVNET.COM/SIMPLEPLUS FOR MORE.

Avnet
2211 S. 47th Street
Phoenix, AZ 85034
1-800-332-8638
avnet.com