

How to Design and Test Multitouch Hardware Solutions for Windows 7

Guidelines for Providing a High-Quality User Experience and Logo Compliance

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Abstract

This paper provides information about the design and test of multitouch hardware solutions for the Windows® family of operating systems. It provides guidelines for independent hardware vendors (IHVs) and original equipment manufacturers (OEMs) to address quality standards that multitouch hardware solutions must meet so that users will have a successful experience with multitouch. The paper also includes associated logo requirements and tests.

This paper also provides guidelines for developers, integrators, and testers of multitouch digitizers and systems to build and test solutions that provide a high-quality user experience and meet the requirements of the Windows Logo Program for multitouch.

Note: Although the information and the logo requirements that are referenced within this paper are focused on multitouch digitizer solutions, many general concepts and principles also apply to multitouch trackpad devices and systems.

This information applies for the Windows 7 operating system.

References and resources discussed here are listed at the end of this paper.

For the latest information, see:

http://www.microsoft.com/whdc/device/input/Multitouch_Design-Test.mspx

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The User Experience—and Why It Is Important

Multitouch is a new and exciting mode of interaction that holds the promise of delighting users and inspiring developers. The digitizer technologies that enable natural and intuitive gestures are revolutionizing human-computer interaction and heralding a new era of natural user interfaces.

Or are they?

Multitouch technology will fail if the user experience that it delivers is not truly great. Broad adoption will come only if every user experience with this technology is effortless, intuitive, and consistent. For this to occur, every component in the technology stack must be responsive, robust, and tuned to work in the ways that real people interact with touch-screens. The strict and sometimes complex demands of the user experience hit the hardware level the hardest, because the digitizer is at the very front lines of interaction. Behind every touch that the digitizer detects is a user who has very high expectations and a very low tolerance of dubious quality.

At Microsoft, we believe in the promise that multitouch technology is poised to deliver, and we believe that the time for this technology is now. We have opened our doors to work with device and system manufacturers, with driver developers and software developers, and with everyone in the multitouch ecosystem to set the standards for a high-quality user experience that the technology can deliver and our customers deserve.

This paper focuses on how device and driver components can define a high-quality user experience by the set of features that they support and how they implement those features. It breaks the user experience into general principles, contexts of use, and individual areas of functionality, and it outlines the Windows® logo requirements that are pertinent to each one.

The paper also offers design and testing tips on how to meet the standards. This white paper is only part of the story, though. Read the related materials and feel free to contact us at tab-ext@microsoft.com if you are working in this area. We stand ready to provide assistance in understanding and meeting these requirements and to address any other questions that you might have.

Design and Test Cycle

You should use the requirements that are described in this paper as factors in the design of multitouch devices and drivers, and as standards for testing throughout the product cycle. We also recommend testing and verification with real users outside the lab at major development milestones. Lessons from real-world usability testing are often invaluable.

Because testing of the user experience is impossible to execute in a fully automated manner, we will supply manual test applications in the Windows Logo Kit (WLK) 1.4. These tests will prompt the test operator to conduct certain multitouch operations on the screen, such as touching graphical dots in different places and tracing lines. From this input, many of the logo requirements can be automatically verified.

Because the end-user experience is so fundamental to the success of multitouch solutions, we want to establish a practice of objectivity and consistency for the manual tests, with the goal that passing or failing a test is registered with complete fairness, transparency, and consistency. To achieve this, test operators must be able to run the tests in the same way regardless of which hardware lab, in which company, in which country of the world they are in. We will publish precise details on the human and environmental parameters for executing the manual tests, so that the methodologies and contexts of testing are identical and reproducible for everyone who wants to run them.

Furthermore, we will reserve the right to request device manufacturers to submit their devices and drivers to us for final verification of the device, as a prerequisite for device logo certification. In these cases, our engineers will run the tests in exactly the ways they were published and will validate individual solutions against the specified criteria. We will also engage with the submitters on individual problems and provide advice on addressing issues where possible.

For systems, hardware integrators are strongly encouraged to test and retest the digitizers at every phase of integration. With certain types of digitizer technology, even the simple matter of placement in casings or other environments can introduce physical or electromagnetic artifacts that affect use or functionality. For example, bezel placement can affect the ability of optical or infrared digitizers to cover all areas of the screen and proximity to some electronic circuitry or other types of hardware can affect the touch detection consistency of capacitive digitizers.

The same testing labs and support levels that will run the manual verification tests for device logo certification are available to original equipment manufacturers and original device manufacturers to submit their integrated systems for testing and support. We strongly recommend that the system manufacturers use this service to find and address user experience and logo issues early in the production cycle. Note, however, that this will be an optional but not required step for system-level logo certification.

Because the logo program for multitouch provides a strong measure of the quality of hardware solutions with regard to the user experience, we are currently planning to make logo certification a requirement for devices to interoperate with the multitouch features in Windows 7. That is, devices that have not obtained certification through the multitouch logo program cannot gain access to multitouch features in the operating system.

Components of Quality and the Logo Requirements

This section divides the quality of the user experience into several dimensions, highlights any associated logo requirements, and offers tips about how to design and test to meet the requirements.

Consistency

Consistency of the user experience across applications and usage environments is fundamental to satisfaction with multitouch technology. The following dimensions of consistency and robustness are a requirement for success.

Screen Coverage

Logo Requirement: Input requirements apply equally to all touchable areas, including edges and corners

Some digitizer technologies work better than other technologies at recognizing input consistently across all touchable areas of the screen. Many can have problems, in particular, at the edges and corners. Poor casing and bezel placement can also cause screen coverage issues for otherwise well-performing digitizers when they are integrated into systems during manufacture.

All systems must respond equally well to contacts at the extremes of the screen because window and desktop management in Windows emphasizes interaction in edges and corners.

Consider a maximized word processor or browser application. Window controls and primary functionality for the application are typically at the top, scrolling happens at the edges, and the Windows taskbar is kept by most users at the bottom (or if not, along another edge). The Windows Start menu is usually at the lower left, the application's Close button is at the upper right, and most frequent application interaction control is often at the upper left, such as the Back button in Microsoft® Internet Explorer 7 and the Pearl in Microsoft Office 2007 applications. Typically, at least three edges and three corners hold important interaction points.

The WLK will include manual tests that require contact across the screen, including all edges and corners. It is very important to run these tests not just on the raw digitizer but at all phases of construction, when digitizer placement or contact with other components could affect the digitizer's ability to perform well in edges and corners.

Battery Power

Logo Requirement: For battery-operated devices, the requirements are met whether the device is running on AC or battery power

Mobile scenarios are some of the most compelling for multitouch users. It is important to maintain consistency of the touch experience whether mobile touch machines are plugged in or running on battery power. Certain digitizer technologies

can be susceptible to changes in performance when they are running on DC input. In these cases, you should customize designs to both power sources, so that users have no change of experience and do not even need to be aware of the power mode in their behavior.

For portable devices, the logo test pass should be run twice—once on AC power and once on battery power—and the device must pass all tests for both passes.

No Ghost Noise

Logo Requirement: No data is reported for locations where contact is not made

The importance of eliminating phantom input cannot be overstated. Random input can have a major and destructive affect on user workflow, and can quickly shatter the trust that the user has in touch technology.

Note that this applies not only when users interact with the computer, but also when the computer is not receiving input and is immobile or in motion. In the real world, users are likely to place mobile computers in different environments, walk between locations, and otherwise move around. The placement and movement of the machine should not make it susceptible to ghost noise.

The logo tests will be sensitive to unprompted input and will include a period of inactivity and movement when no input is to be detected. However no logo test can possibly cover all the contexts of use for the machine. You should test devices and systems creatively, beyond the directions for the logo tests. As noted earlier, inconsistent detection of input is probably the fastest way to turn users irrevocably against multitouch technology.

Input that is triggered by real contact from the environment and not from user input is a similar type of issue. Some digitizer technologies are susceptible to detecting the alighting of small insects or other environmental flotsam on the screen, and this can be equally destructive for users. Contact detection should be tuned as much as possible to recognize valid finger contact and not other nonhuman contact such as insects or airborne detritus. Note that the WLK does not currently support tests that validate this requirement.

Performance

Logo Requirement: No specific requirement (see “Sampling Rate” later in this paper)

The responsiveness of the touch digitizer will be a primary factor in determining the success of any given system or device. Users will not tolerate slow response under any circumstances.

Therefore, it is important to build and test for performance from the ground up. You should not include any firmware or driver processing that is not dedicated exclusively to providing Windows multitouch processes with correct human interface device

(HID) packets. For example, doing supplementary gesture recognition in the device or drivers is strongly discouraged.

Drivers should use parallel or hybrid mode for data reporting and should optimize for high packet rates and fast reporting of the Confidence usage wherever possible. For a discussion of reporting modes, see “Digitizer Drivers for Touch, Multitouch, and Pen Devices,” which is listed in “Resources” at the end of this paper.

Except for sampling rate, we cannot specify any direct requirements or explicit tests to measure component responsiveness or resource usage metrics. However, the manual test applications that will be supplied in the WLK will require reasonable end-to-end response times to operate effectively.

HID Compliance

Correct behavior in terms of adherence to HID protocols for multitouch is fundamental for the Windows 7 operating system to respond appropriately to device and driver input.

For more details about the HID extensions for multitouch, see the *Digitizer Drivers for Touch, Multitouch, and Pen Devices* white paper.

Digitizer Device Class

Logo Requirement: Multitouch digitizers appear to the operating system as HID digitizers and not as a mouse or other proprietary device

Multitouch functionality in Windows 7 will not be available to devices that are not identified as HID digitizers. As defined in the USB *HID Usage Tables* specification, this identification consists of the digitizer page (0x0D), along with usage ID 0x04 to specify the Collection Application for touch-screens.

Devices that function as multiple input mechanisms, such as mouse devices, must include a top-level collection for the primary device and one for a mouse in their report descriptor.

The WLK will include automated testing to validate device class as specified in the report descriptor.

Supported Usages

Logo Requirement: No specific requirement; falls under general HID compliance

To get the most out of touch in Windows 7, multitouch digitizers should observe the core HID and multitouch extension usages as defined in the specifications. For more information on HID pages and usages, refer to the USB *HID Usage Tables* specification. For more information on individual usages, see “Digitizer Drivers for Touch, Multitouch, and Pen Devices.”

Support for the following usages must be implemented:

- X (page 0x01, usage 0x30) and Y (page 0x01, usage 0x31).
- Contact Identifier (page 0x0D, usage 0x51).
- Tip switch (page 0x0D, usage 0x42).
- In-range (page 0x0D, usage 0x32).
- Maximum count (page 0x0D, 0x55).

The device should report known physical dimensions by using the Physical Dimensions property of the x and y usage. Inaccurate information about the physical dimensions can affect Windows ability to do accurate gesture recognition, so if for any reason the digitizer cannot report accurate physical dimensions, it should report them as 0 units.

Report Integrity and Sequencing

Logo Requirement: No specific requirement; falls under general HID compliance

Correct USB HID behavior also applies to the integrity of each usage report package and the sequencing of the usage reports.

The multitouch tests in the WLK will validate adherence to the usage details of the *Human Interface Device (HID) Extensions and Windows/Device Protocol for Multitouch Digitizers* specification. The tests will also validate that the packet sequencing is correct, for example, that tip switch packets are sent in the correct order (up, down, up, down).

Core Accuracy

The following considerations define the touch experience for individual contacts between finger and screen, and therefore core accuracy and responsiveness of multitouch interaction as the user experiences it.

Resolution

Logo Requirement: At least 100 ppi and at least display resolution are present

The resolution at which touch detection works is fundamental to multitouch accuracy. Pixel-level resolution is important for graphical applications and many other scenarios. If data is reported at lower resolution, the precision of the user experience decreases and requirements in other areas (such as accuracy and integrity of line-drawing) are unlikely to be met.

The logo tests will include querying the device for supported resolution and are likely to include a component to calculate and log the resolution of incoming data.

Sampling Rate

Logo Requirement: Sampling rate is at least 50 Hz per finger

Sampling rate per finger should be at a minimum 50 packets per second and can be up to 133 packets per second, which is the maximum supported over USB. A high packet rate ensures high performance and perceived responsiveness of the system, as well as data integrity for contacts in fast motion. For efficiency in meeting this requirement, we recommend that drivers use the parallel or hybrid data reporting modes (and not the serial mode). For more information, refer to “Digitizer Drivers for Touch, Multitouch, and Pen Devices.”

The WLK will include measurement of packet rates across all tests that include a manual input operation.

Jitter

Logo Requirement: For all fingers, if a contact is stationary, the reported position data does not change

Reporting a stationary contact as stationary is necessary for a good touch experience for tapping and “tap-and-hold” interactions. If movement is reported when the contact is maintained in the same location, the interaction can be misrecognized as a drag or other movement. This leads to user frustration and the perception of an untrustworthy system.

Logo tests will include an application that prompts for manual finger contacts on stationary points, and jitter will be determined on the basis of the data sent for those contacts.

Offset

Logo Requirement: The physical contact with the device and the contact position that the device reports is within 2 mm of each other for all fingers, whether each contact is stationary or in motion

Minimal offset between the actual and reported points of contact is a primary factor in real and perceived system accuracy. The upper limit is 2 mm for permitted offset and should never be exceeded.

The logo tests will include manual input operations in different areas of the screen and will display the location of the received input. The operator of the tests will be asked to take manual measurements of offset for each contact. It cannot be stressed enough that, although such a test methodology leaves some room for subjective interpretation, test operators should consider as “passed” only those devices that meet the offset requirement crisply and consistently.

Separate and Simultaneous Contact

Logo Requirement: [The offset requirement] applies when multiple fingers make contact simultaneously or separately

Maintaining minimal offset is also important whether multiple touches are made simultaneously or in sequence, with or without overlap, or in other scenarios. Digitizers should be able to distinguish and correlate x and y coordinates for points of contact with a high degree of accuracy, and this should not depend on sequential placement or other factors.

The logo tests will include prompts for manual input that require different sequences of touch points, including simultaneous and separate touches and overlapping periods of contact.

Line Accuracy

Logo Requirement: For all fingers, tracing a line, circle, or other predetermined pattern produces data that is within 0.5 mm of the expected data pattern and without interruption to the pattern; the pattern may be offset per the offset requirement

High accuracy of contacts in motion is another primary foundation of the multitouch user experience. Recognition of gestures for pinch and rotate relies on fast and accurate location reporting. This also applies to the standard interaction primitives, such as panning, scrolling, and dragging. Applications will develop new customized gestures and movements that will depend on high accuracy and response rates.

Correctly reporting the integrity of contact during motion is also important. False reports signaling loss of contact will result in a frustrating user experience for actions like drag and drop, and for gesture recognition in general.

The WLK will include tests that prompt the tester to trace lines, arcs, and other patterns on the screen with his or her fingers. From these, accuracy and offset of the original patterns versus the traced patterns will be displayed and logged.

Contact Width and Height

Logo Requirement: None currently

Supporting the HID usages for height and width of contact (digitizer page 0x0D, with proposed usages 0x48 and 0x49) enables applications to provide richer touch support, such as applications that have different functionality for finger-tip versus finger-pad gestures, or graphics applications that use the dimensions of the contact for brush sizing.

This support also enables Windows to better interpret input and conduct palm rejection where appropriate.

Although support for these usages is not required for the Windows 7 multitouch logo, we strongly recommend that digitizers support them. Testers should consider

building a simple custom test application that produces graphical output that represent the location and dimensions of contact points. Such an application provides a useful manual test to validate digitizer behavior on these usages.

Confidence Usage

Logo Requirement: None currently

The Confidence Usage (page 0x0D, usage 0x47) is a measure that is associated with contact data that signals the digitizer's confidence that the contact is valid and intentionally interactive. Setting this value to 0 signifies noninteractive input, such as a palm resting on the screen or an accidental contact.

Although there is no logo requirement associated with Confidence Usage, again, we strongly recommend that digitizers support Confidence Usage and report it as quickly as possible. If it is not supported, the device is expected to provide its own means of accidental touch rejection.

Note that if Confidence Usage is supported but not reported quickly enough, user workflow can be affected sufficiently to make supporting Confidence meaningless in practice.

Pressure Usage

Logo Requirement: None currently

Support for Pressure Usage, although not required for the logo, is another distinguishing factor that enables applications to enrich the multitouch user experience. Variances in pressure can be used to great effect in gaming and graphical applications, as well as allowing more interactive possibilities at the level of individual user interface controls. The more "tactile" the perceived response, the more compelling the interaction for the user.

Obviously, some digitizer technologies are more able to detect pressure variation than other technologies. If your digitizer technology supports pressure detection and your implementation can provide it robustly and consistently, then we recommend implementation of Pressure Usage.

Finger Uplift

Logo Requirement: None currently

Double-tapping is one of the most common interaction primitives in Windows, and it is one of the most important to get right. With certain digitizers that are based on optical and infrared technologies, users have noticed that they must lift their fingers higher than expected for double-tap to work. In these cases, it appears the devices were not adequately detecting the raised finger and thereby not reporting the loss of contact in the midst of the double-tap.

Although no logo requirement is directly associated with this aspect, it should be clear that digitizers, on which double-tap requires special effort, are unlikely to obtain broad acceptance among users. We recommend that developers optimize for a double-tap experience that is smooth and intuitive—effectively thoughtless—for users. Frequent testing and tuning among a community of real users is highly recommended.

Ink and Touch Together

Logo Requirement: None currently

Many user scenarios for touch machines additionally include the use of pen, especially for text input. In addition to getting multitouch right in itself, technology providers should also consider the interaction of pen and touch. The primary use cases involve simultaneous contact of pen and hand when the user is writing while resting the writing hand on the screen.

To prevent false recognitions of touch gestures from the noninteractive hand, palm rejection must work well. The “in-range” usage for pen also must be robust and rapid. When the Windows `wisptis.exe` process determines that pen is in range, it ignores touch packet input.

Confidence Usage should also be applied smartly. When the pen uplifts, any existing contact on the screen is very likely to be a resting palm or other unintentional input.

Device and Driver Fundamentals

Several Device Fundamentals requirements apply equally to digitizers as to any device that is connected to a PC. Each one of the requirements is important, and meeting it is required to obtain the logo. However, the following is a selection of the requirements that are most pertinent to this paper because they are a challenge for existing solutions or not addressing them in the design phase can cause major problems later in the cycle.

Sleep and Hibernate States

Logo Requirement (DEVFUND-0043): All devices and drivers support S3 and S4 sleep states of the system that they are integrated on or connected to

This requirement specifies that all devices must be able to resume from sleep and hibernate states and be fully functional after waking up.

All the WLK tests for multitouch should be rerun—and should pass—after the machine is returned from a state of sleeping or hibernation.

Reliability and Stability

Logo Requirement (DEVFUND-0016): Drivers are architected to maximize reliability and stability and do not "leak" resources such as memory

It is obvious that the quality of driver code, in terms of architecture and coding standards, is fundamental. Although the effect on the user experience of poor design and flawed code may be less directly tied to the touch hardware, it is nevertheless harmful to the Windows experience.

We recommend digitizer driver writers use the full resources of the Windows Driver Kit (WDK) during building and testing, and consider obtaining certification as a driver developer. More resources can be found on the Windows Hardware Developer Central (WHDC) Web site. At a minimum, you should run the following quality tools on drivers and address any resulting issues:

- Driver Verifier
- CheckINF
- PREfast for Drivers (PFD)
- Static Driver Verifier (SDV)

Driver Quality Rating

Logo Requirement (DEVFUND-0027): All drivers maintain a high driver quality rating (DQR) or the manufacturer makes a fixed driver available to customers within 90 days

This requirement is for solutions that include kernel-mode drivers. The eligible DQR, based on crash-to-installation ratio, must be maintained after a driver has been released for 120 days and for the life of the product. To maintain a logo or signed designation, driver manufacturers or OEMs that distribute the driver must make a fixed driver available to customers on Windows Update within 90 days if the DQR rating of any drivers that falls from the eligible range.

Finishing the Job: Driver Distribution and Updates

Drivers that have obtained the Windows logo can be distributed cleanly and efficiently to users through Windows Update. Literally millions of users update their systems in this way every week. Windows Update provides an efficient and trouble-free experience for users to update any aspect of their system when it is needed, while still maintaining control over individual updates.

All driver suppliers should use Windows Update to distribute drivers and driver updates. The benefits to the user are that the user experience is timely and seamless. The benefits to the supplier are the broad reach and coverage of Windows Update, and the reduced administration and cost overhead compared to releasing drivers through proprietary channels.

You can manage settings for distribution by using the Driver Distribution Center on the WHDC site, as well as review download statistics and Windows Error-Reporting data. For more details, see “Distributing Drivers on Windows Update.”

Summary and Call to Action

High-quality hardware and drivers are the foundations of a good user experience for multitouch. The multitouch logo program for Windows 7 is designed to ensure that solutions on the market meet the expectations of users and provide a successful multitouch experience across applications and environments of use.

Only digitizers and drivers that meet the logo requirements will be able to operate as multitouch input devices in Windows 7. If the device drivers are not included in-box with Windows or certified by Microsoft according to the logo standards, they will not be loaded for multitouch capabilities.

Logo certification for devices will also require a manual validation phase in Microsoft test labs, where the Microsoft engineers will run certification tests in the WLK, exactly as specified, before the logo is granted.

Finally, drivers and driver updates should be distributed by using Windows Update. This is the last important piece in the user experience. Windows Update offers the simplest and most efficient way for users to find and install drivers.

Resources

Contact us at tab-ext@microsoft.com if you are working in this area.

Developer Tools

<http://www.microsoft.com/whdc/DevTools/default.aspx>

Digitizer Drivers for Touch, Multitouch, and Pen Devices

http://www.microsoft.com/whdc/device/input/DigitizerDrvs_touch.aspx

Universal Serial Bus (USB) HID Usage Tables

http://www.usb.org/developers/devclass_docs/Hut1_12.pdf

Windows Hardware Developer Central

<http://www.microsoft.com/whdc/default.aspx>

Windows Logo Program

<http://www.microsoft.com/whdc/winlogo/default.aspx>

Windows Quality Online Services (Winqual)

<http://winqual.microsoft.com>

Windows Update

<http://windowsupdate.microsoft.com>

Distributing Drivers on Windows Update

www.microsoft.com/whdc/maintain/DrvUpdate.msp.

Appendix: Multitouch Digitizer Logo Requirements

Input requirements apply equally to all touchable areas, including edges and corners. For battery-operated devices, the requirements must be met whether the device is running on AC or battery power.

- Multitouch digitizers appear to the operating system as HID digitizers, and not as a mouse or other proprietary device
- Sample rate: at least 50 Hz per finger
- Resolution: at least 100 ppi and at least display resolution
- Jitter: For all fingers, if a contact is stationary, the reported position data must not change
- Contact accuracy: For all fingers, tracing a line, circle, or other predetermined pattern should produce data that is within 0.5 mm of the expected data pattern and without interruption to the pattern; the pattern may be offset per the following offset requirement
- Contact offset: The physical contact with the device and the contact position that the device reports must be within 2 mm of each other for all fingers; this applies whether each contact is stationary or in motion, and when multiple fingers make contact simultaneously or separately; no data must be reported for locations where contact is not made