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Charging a Stylus using Mobile Device Near Field Communication (NFC) Coil

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ABSTRACT

This disclosure describes techniques to charge a stylus using the existing near field communication (NFC) integrated circuit and coil on the mobile device. The storage slot for a stylus in a case that holds a mobile device is designed such that upon insertion, the stylus NFC coil automatically aligns with the phone NFC coil, thereby enabling charging during storage. Effectively, the storage slot functions as a charging dock for the stylus. Since the storage slot of the phone case is the normal home for the stylus, charging takes place in the background and becomes a seamless experience for the user. A Hall sensor on the main logic board of the mobile device is used to detect the presence of the stylus; no other hardware changes are required. The device NFC mode is automatically configured to allow other NFC functionality while selectively charging the stylus when the battery level of the stylus falls below a threshold.

KEYWORDS

- Stylus
- Near field communication (NFC)
- NFC charging
- NFC coil
- Wireless charging
- Card emulation (CE)
- Foreign object detection (FOD)
- Bluetooth MAC address
- Hall sensor
- Phone case

BACKGROUND

A stylus can be used with mobile devices such as smartphones, tablets, laptops, etc. as a supplemental user input device in addition to traditional touch input. Active styluses, like other wireless devices, require battery power to operate. These devices need to be charged when their battery levels are low. Currently, the charging techniques for styluses can be classified as wired

(e.g., using USB or another wired interface) and wireless (e.g., garaged, magnet-attached, external charging box, etc.). Both wired and wireless charging have drawbacks. For example, wired charging requires user intervention such as plugging in a USB cable. Wireless charging requires dedicated components on the base device (smartphone, tablet, laptop, etc.) to support charging the stylus, which adds to the design complexity and cost of the base device.

DESCRIPTION

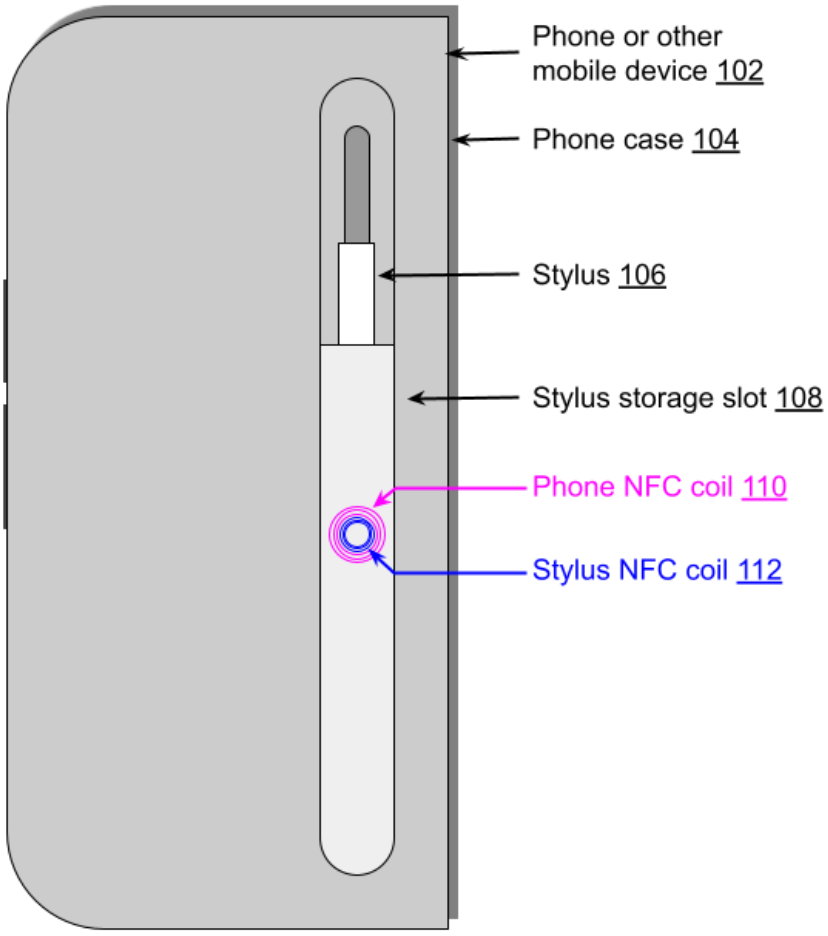

Fig. 1: NFC charging of a stylus

Many mobile devices include built-in near-field communication (NFC) capability. NFC hardware includes an integrated circuit and coil. This disclosure describes techniques to charge a stylus using the existing NFC hardware available on a device. As illustrated in Fig. 1, the stylus

(106) is inserted (as is typical) into a storage slot (108) that is built into the phone case (104, an accessory) that holds the phone or other mobile device (102).

The storage slot is designed such that upon insertion, the stylus NFC coil (112, in blue) automatically aligns with the phone NFC coil (110, red), thereby enabling charging during storage. Effectively, the storage slot functions as a charging dock for the stylus. Since the user ordinarily stores the stylus in the storage slot of the phone case, charging takes place in the background and is therefore such a seamless experience for the user that the user may well be unaware of it. Aside from a Hall sensor on the main logic board (MLB) of the mobile device to detect the presence of the stylus, no hardware changes are required.

The NFC hardware of a device is commonly used for activities such as secure credit card transactions (e.g., using the phone as a payment instrument); using the phone as a card or tag reader, exchanging digital content; pairing with other devices; etc. For financial transactions (where the device supplies credit/debit card credentials via NFC), the phone NFC enters a card emulation (CE) mode. To use the phone as a card/tag reader, the phone NFC enters a read/write (RW) mode. When using the phone NFC to charge the stylus as described herein, there can be coexistence problems with the three modes - charging, CE, and RW.

During NFC operation, the phone polls the three modes in sequence. When the stylus is charging, the NFC remains in charging mode until the charging finishes. Any CE or RW requests during the charging period may get ignored. Also, the stylus tag can be misread as an NFC card during the CE or RW modes. The coexistence problems can thus be summarized as:

- **Mode blocking:** stylus charging can potentially block other NFC activities (e.g., those that entail the CE or RW modes).

- **Multi-card collision:** in CE or RW mode, the stylus can potentially be misread as a card, which can impact NFC transactions.

The aforesaid mode-blocking and multi-card collision problems are addressed as follows. A Hall sensor in the phone (or other device) is used to detect the presence or absence of the stylus. When a stylus is paired to the phone for the first time, the phone registers the unique identity (UID) of the stylus. The stylus reports its battery level to the phone, e.g., via Bluetooth. When the stylus is outside the storage slot, if the battery level drops below a threshold (e.g., 10%), an alert is provided on the phone to remind the user to insert the stylus for charging.

The mode-blocking problem is addressed by introducing periodic gaps (e.g., of about two seconds) in the charging cycle that enable CE/RW-mode listening or polling. During charging, if the phone is near an NFC reader or a credit card/NFC tag, foreign object detection (FOD) on the wireless charger pauses stylus charging. Charging is resumed after the transaction is completed.

When the user inserts the stylus into its storage case, the on/off status of the stylus is checked, and the stylus turned off if it is detected to be on. The battery level of the stylus is monitored, and charging restarts when the battery level drops below a threshold. This ensures the availability of the NFC for CE/RW-mode activity so long as the battery level is above the threshold. Furthermore, when the stylus is fully charged, its NFC is turned off to ensure high sensitivity for the phone in other modes.

The multi-card collision problem is addressed by tagging the stylus with a Type V tag IC that external card readers do not recognize. However, the phone as a reader generally recognizes Type V tags in RW mode. Multi-card collision can therefore be avoided as follows. When the stylus is in the storage slot and its battery level falls below 10%, the NFC charging mode of the

phone is enabled, the stylus is sent a command (e.g., via Bluetooth) to turn on its NFC for charging, and testing for the stylus UID can be skipped.

If the user accidentally leaves the stylus outside the storage slot for a duration long enough that the stylus battery drains out, the stylus will lose its Bluetooth connection to the mobile device, potentially impacting subsequent charging. Under such circumstances, the following procedure can be used to smoothly restart charging at the next available opportunity:

- When the user inserts the stylus to its storage slot and a Bluetooth connection is attempted, the number of Bluetooth connection failures is counted. If the count is less than or equal to a certain threshold (e.g., 3), charging the stylus is automatically started charging until the Bluetooth connection is reestablished. If the Bluetooth connection fails for more than the threshold number of trials, an alert is provided on the phone that notifies the user of a Bluetooth malfunction or of an unpaired stylus. The count is reset once the stylus is taken out of the storage case (which, as explained earlier, is effectively a charging dock for the stylus).
- After a charging cycle, the stylus NFC is turned on right after the stylus is taken out of the charging dock.
- Before the stylus ships from the factory, its NFC is set to a default-on state, and the Bluetooth MAC address is stored in the NFC tag.

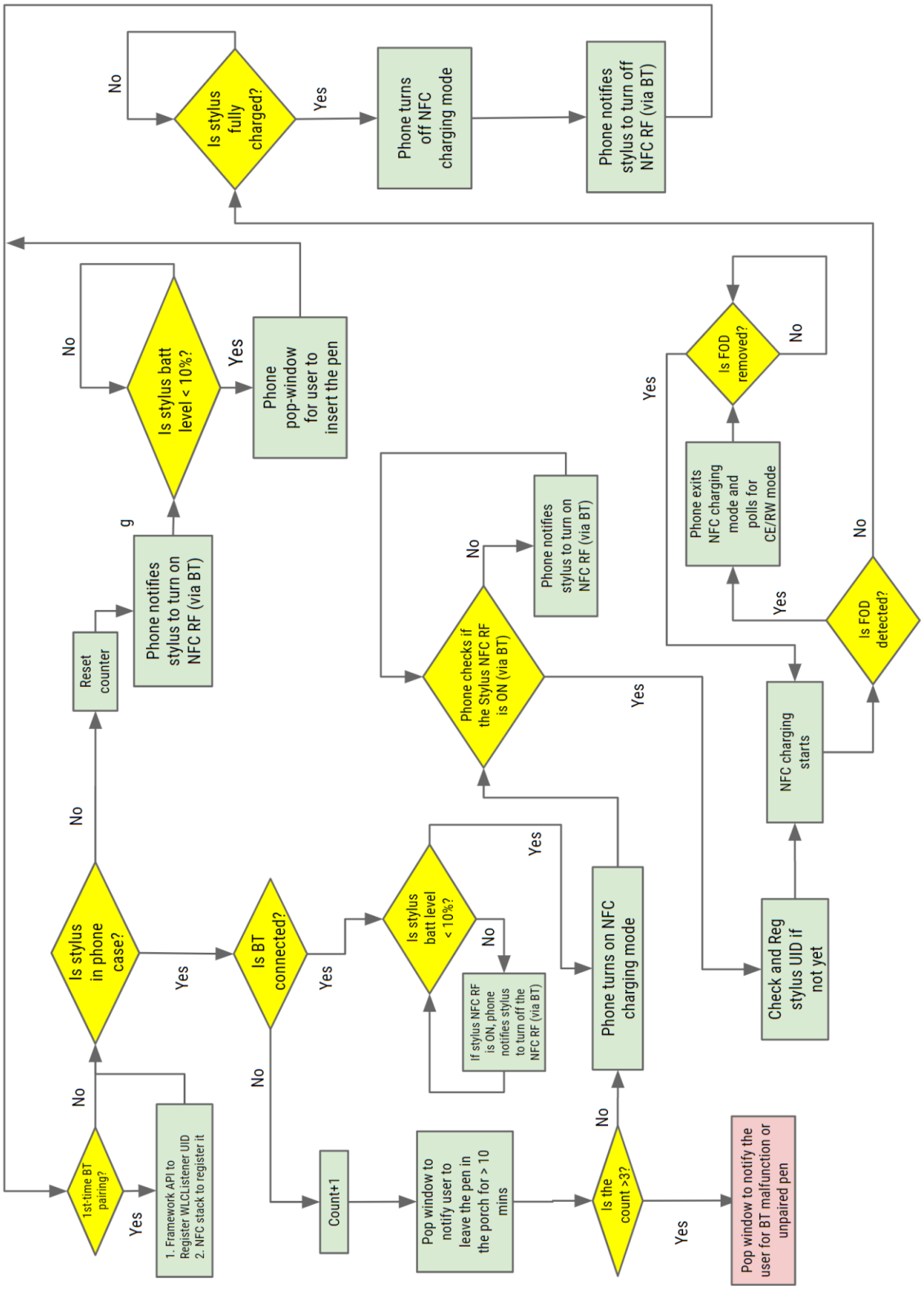

Fig. 2: Flowchart for NFC charging of the stylus

Fig. 2 illustrates a flowchart for NFC charging of the stylus. As illustrated, the method shown in the flowchart enables:

- harmonious operation of the three NFC modes;
- registration of the UID of the stylus with the device upon the first insertion of the stylus into its storage slot;
- device NFC hardware to function variously and near-simultaneously as a card emulator, a tag reader, and a stylus charger;
- battery level dependent start and end of stylus charging;
- communication between the device relating to the state of the stylus, power-on/off commands to the stylus, startup and shutdown sequences for the NFC of the stylus, etc.;
- user notifications for low battery levels, malfunctioning Bluetooth connection, unpaired stylus, etc.

CONCLUSION

This disclosure describes techniques to charge a stylus using the existing near field communication (NFC) integrated circuit and coil on the mobile device. The storage slot for a stylus in a case that holds a mobile device is designed such that upon insertion, the stylus NFC coil automatically aligns with the phone NFC coil, thereby enabling charging during storage. Effectively, the storage slot functions as a charging dock for the stylus. Since the storage slot of the phone case is the normal home for the stylus, charging takes place in the background and becomes a seamless experience for the user. A Hall sensor on the main logic board of the mobile device is used to detect the presence of the stylus; no other hardware changes are required. The device NFC mode is automatically configured to allow other NFC functionality while selectively charging the stylus when the battery level of the stylus falls below a threshold.