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Novel legacy A-C cable with the capability of predicting abnormal charging

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ABSTRACT

This disclosure describes techniques to monitor the operation of a USB type C connector to prevent damage to charging ports and/or connected devices. The operating temperature of a USB type C connector is monitored by the use of a negative temperature coefficient thermistor (NTC) positioned close to the USB connector. Voltage across the NTC falling below a threshold indicates high temperature and causes the system to disconnect the connector from the power supply. In addition to over temperature protection, if the power supply falls below a threshold, the described system disconnects the connector from the power supply.

KEYWORDS

- USB-C
- Type-C connector
- Negative temperature coefficient (NTC)
- Overvoltage protection
- Overcurrent protection
- Undervoltage protection
- Temperature protection
- Charging cable

BACKGROUND

Universal serial bus (USB) type C connectors have seen widespread adoption as connectors to provide power to devices such as laptops, smartphones, wireless headsets, smart speakers, tablets, etc. USB-A to USB-C cables are preferred by users with devices with USB-C ports due to the availability of power supplies with a USB-A port. However, in some instances, the USB-C connectors can get damaged. This is caused by a lack of ability to turn off power delivery when abnormal charging happens, e.g., due to the presence of a foreign body such as dust, water, etc. that pollutes the USB-C connector. Even with charging cables that support overvoltage protection (OVP) and overcurrent protection (OCP), a micro short caused by a foreign body may not trigger the protection circuits. When a micro short occurs in the charging port, a very small area within the USB-C connector may reach a high temperature and cause the connector to burn out.

DESCRIPTION

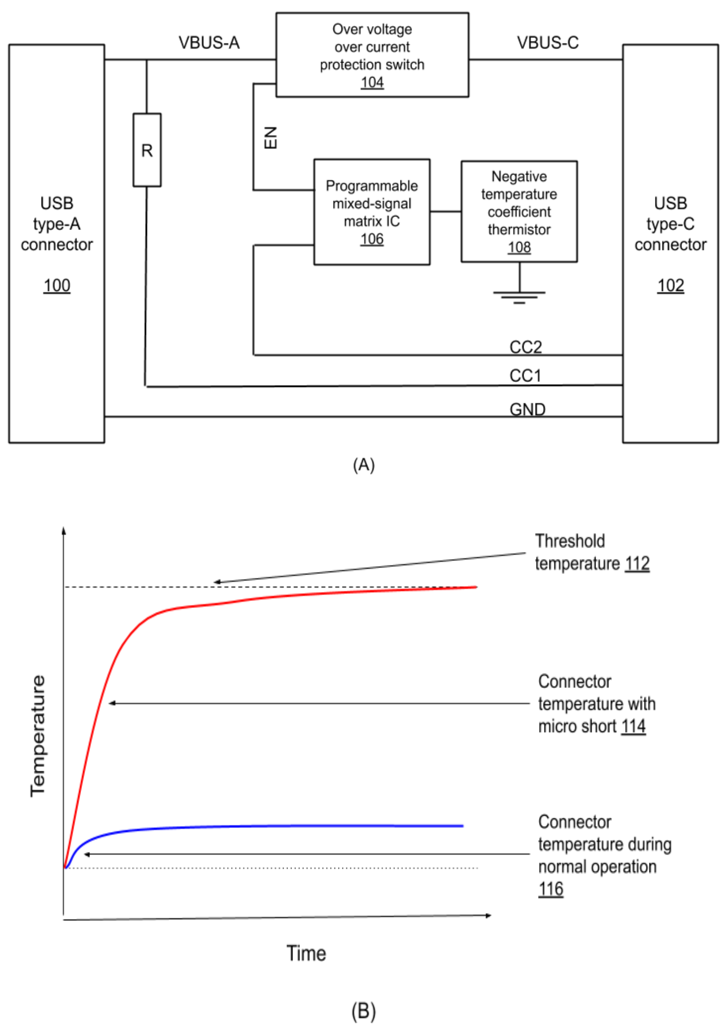

Fig. 1: (A) Circuit for real time temperature detection USB Type-C connector; (B) Temperature vs. time of normal and abnormal charging

Fig. 1 (A) illustrates an example circuit that monitors the voltage, current, and temperature of a USB-A to USB-C cable. Power is delivered from the USB-A connector (100) across node VBUS-A to an integrated circuit (IC) with overvoltage protection (OVP) and overcurrent protection (OVC) switch (104). The switch is enabled by a programmable mixed signal matrix IC (106) that monitors a negative temperature coefficient thermistor (NTC) (108) that is positioned closely to the USB-C connector (102). During normal charging operation, VBUS-A passes through to VBUS-C to deliver power to the device via the USB-C connector.

Fig. 1 (B) illustrates an example of the temperature of the USB-C connector rising during normal operation (116) and operation with a micro short within the connector (114). During normal operation, the temperature of the USB-C connector rises slightly due to the power consumption of ICs within the connector. When a micro short exists within the connector, the heat converges to the connector causing a high rate of change of temperature. By monitoring the rate of change in temperature, the health of the USB-C connector can be predicted and the OVP/OVC switch can disconnect the power source to the connector. In addition, the temperature of the NTC can be monitored to turn off power delivery when the NTC temperature exceeds a threshold temperature (112).

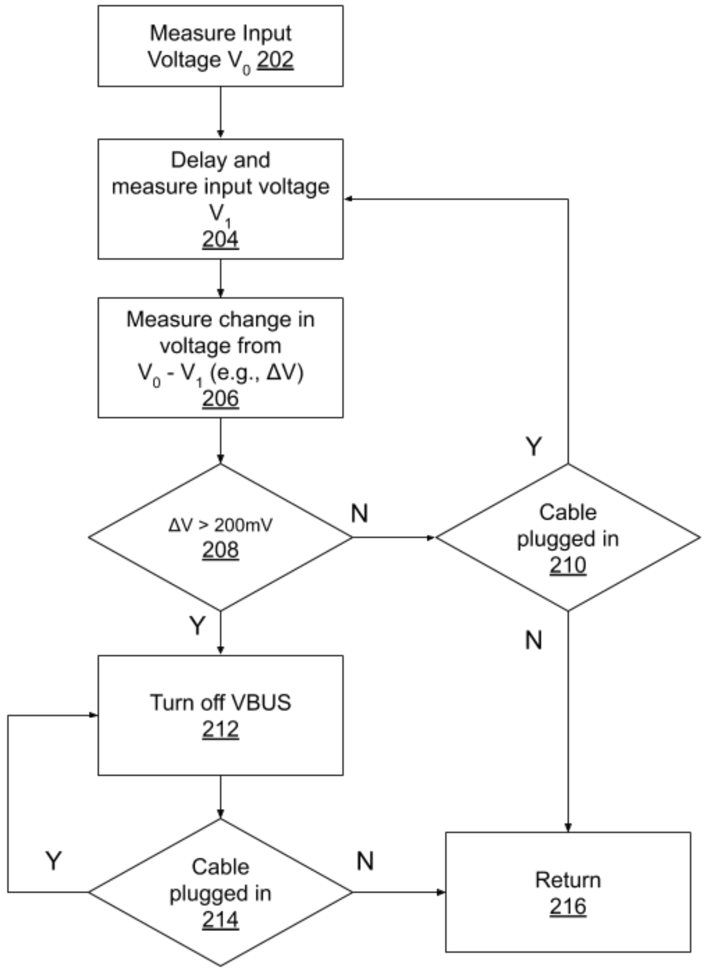

Fig. 2: Predicting abnormal charging by monitoring NTC

Fig. 2 illustrates an example process in which the programmable mixed signal matrix IC predicts abnormal charging via the USB-C connector. The initial voltage across the NTC is measured as a reference (202). After a delay period, the voltage across the NTC is measured again (204). The difference between the initial voltage and the voltage after delay is calculated (206).

If the difference between the two measured voltages is less than or equal to 200mV (208), it is determined that the cable is plugged in (210). If the cable is plugged in, the cable is in normal charging operation and the IC continues to monitor the voltage across the NTC. If the difference in measured voltages is greater than 200mV, VBUS is disconnected and power delivery is disabled (212). Once VBUS is disconnected, a check is performed to determine whether the user disconnected the USB-C connector from the device (214). If a device is plugged in, VBUS remains disconnected. Once the device is disconnected from the connector, the operation of the connector is reset (216).

In addition to over temperature protection, the described techniques provide undervoltage protection by monitoring normal operation of the power source. During normal operation, the voltage range provided by a USB-A connector is in the range of 4.2 volts to 5 volts. When the current delivered by the power source falls within the window of over current threshold, the voltage supplied by the USB-A connector drops under 4 volts before the overcurrent protection circuit is triggered. If the supplied voltage is below a threshold voltage, the programmable mixed signal matrix IC disables the OVP/OVC circuit to disconnect the power source from the device.

By monitoring the operating condition of the connector in this manner, the described techniques provides overvoltage protection, undervoltage protection, overcurrent protection, and over temperature protection for a USB-C connector.

CONCLUSION

This disclosure describes techniques to monitor the operation of a USB type C connector to prevent damage to charging ports and/or connected devices. The operating temperature of a USB type C connector is monitored by the use of a negative temperature coefficient thermistor (NTC) positioned close to the USB connector. Voltage across the NTC falling below a threshold indicates high temperature and causes the system to disconnect the connector from the power supply. In addition to over temperature protection, if the power supply falls below a threshold, the described system disconnects the connector from the power supply.