Application Report

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TSU6721 Accessory and Charger Detection Flow

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ABSTRACT

This document describes the TSU6721 and its physical implementation of accessory detection, BC1.2-compatible charger detection, and application guidelines for ACA detection. In addition, this document provides an example detection sequence for a UART cable and a Dedicated Charging Port (DCP) charger. This document references the *USB Battery Charging Specification*, version 1.2.

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1 TSU6721 Detection Sequence

1.1 TSU6721 Top Level Operation

The TSU6721 is a micro-USB switch capable of automatically detecting both accessories that have a resistor on the ID pin and all chargers compatible with the *USB Battery Charging Specification* Revision 1.2 (BC1.2). The TSU6721 begins in a sleep/wake cycle and monitors both VBUS and the ID pin. Figure 1 shows the behavior of the TSU6721 before and immediately after a micro-USB connection is made. The blue boxes in this chart reference the TSU6721 ADC conversion (Figure 3) and TSU6721 charger detection (Figure 5) flowcharts in this document.

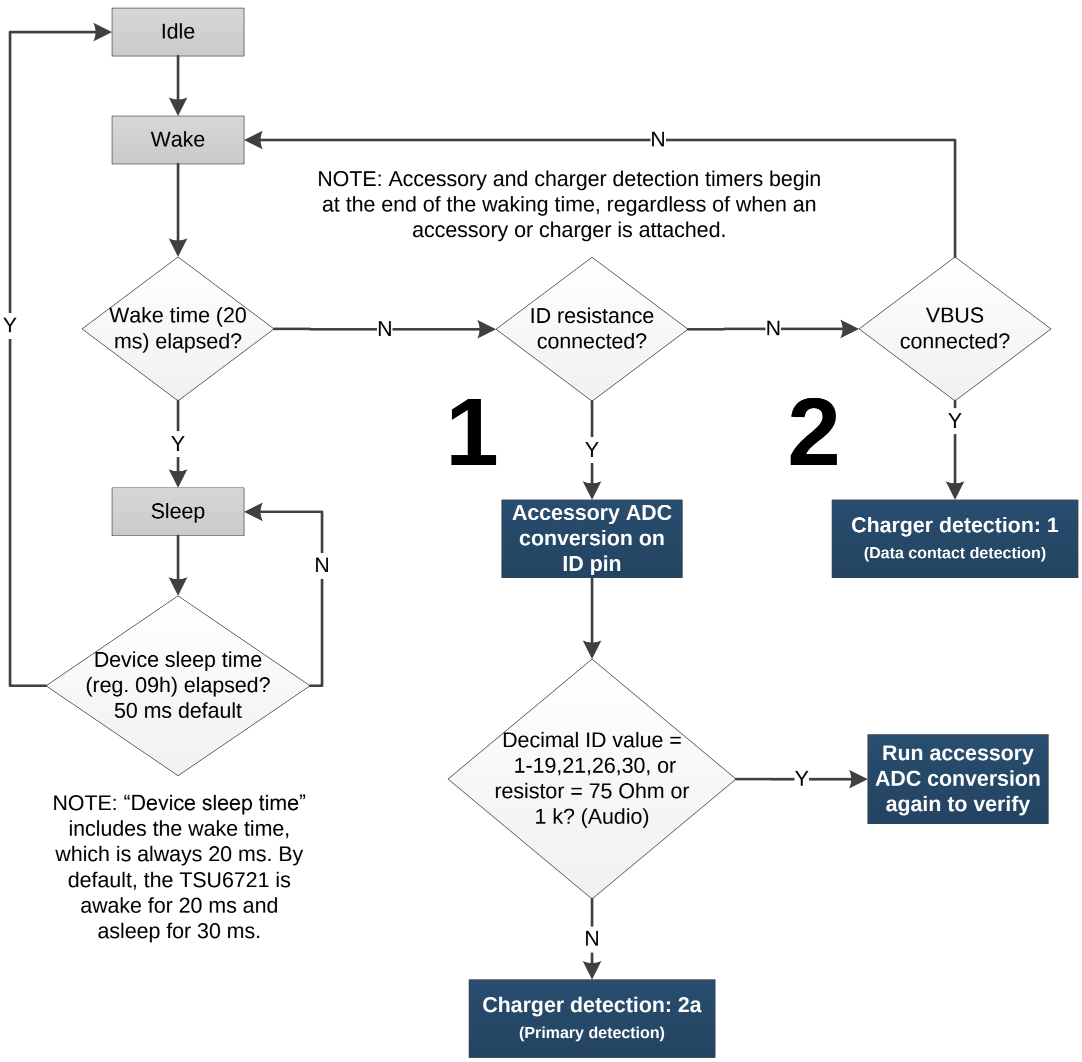

Figure 1. TSU6721 Top-level TSU6721 Detection Flowchart

1.2 TSU6721 Accessory Detection Summary

The TSU6721 uses a current source and a voltage reference V_{REF} to detect resistance values on the ID pin. The current source creates V_{ID} on the ID pin. A 5-bit ADC counter (ADC[4:0]), starting at 00000, is connected to a DAC, which outputs V_{REF}. ADC[4:0] increments during detection, increasing V_{REF}. When V_{REF} exceeds V_{ID}, the output of the comparator falls from 1 to 0, and the 5-bit ADC counter value is latched. Once the same ADC counter value has been latched twice in a row, the TSU6721 uses an ADC-to-ID lookup table to determine the size of the ID resistor. Each 5-bit counter value is associated with an ID resistor value and an accessory type (see Table 2 of the TSU6721 datasheet).

Figure 2 shows a schematic of the ADC conversion mechanism that happens during accessory detection, and Figure 3 shows the process the TSU6721 uses to detect the resistor values associated with each type of accessory.

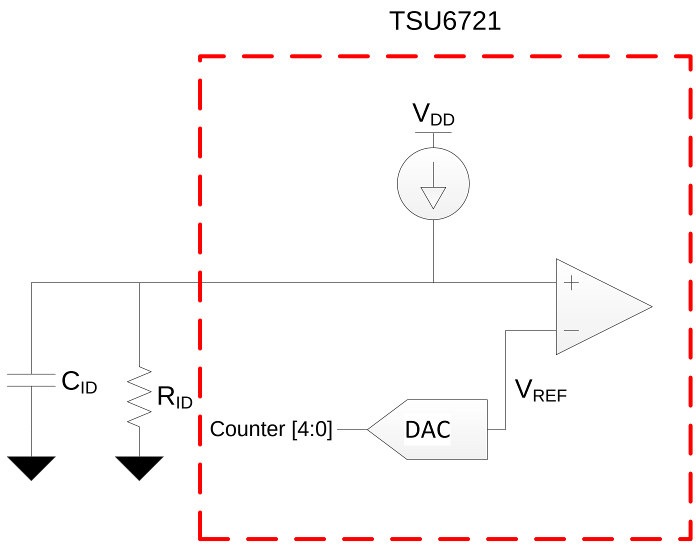

Figure 2. TSU6721 Simplified ADC Conversion Schematic

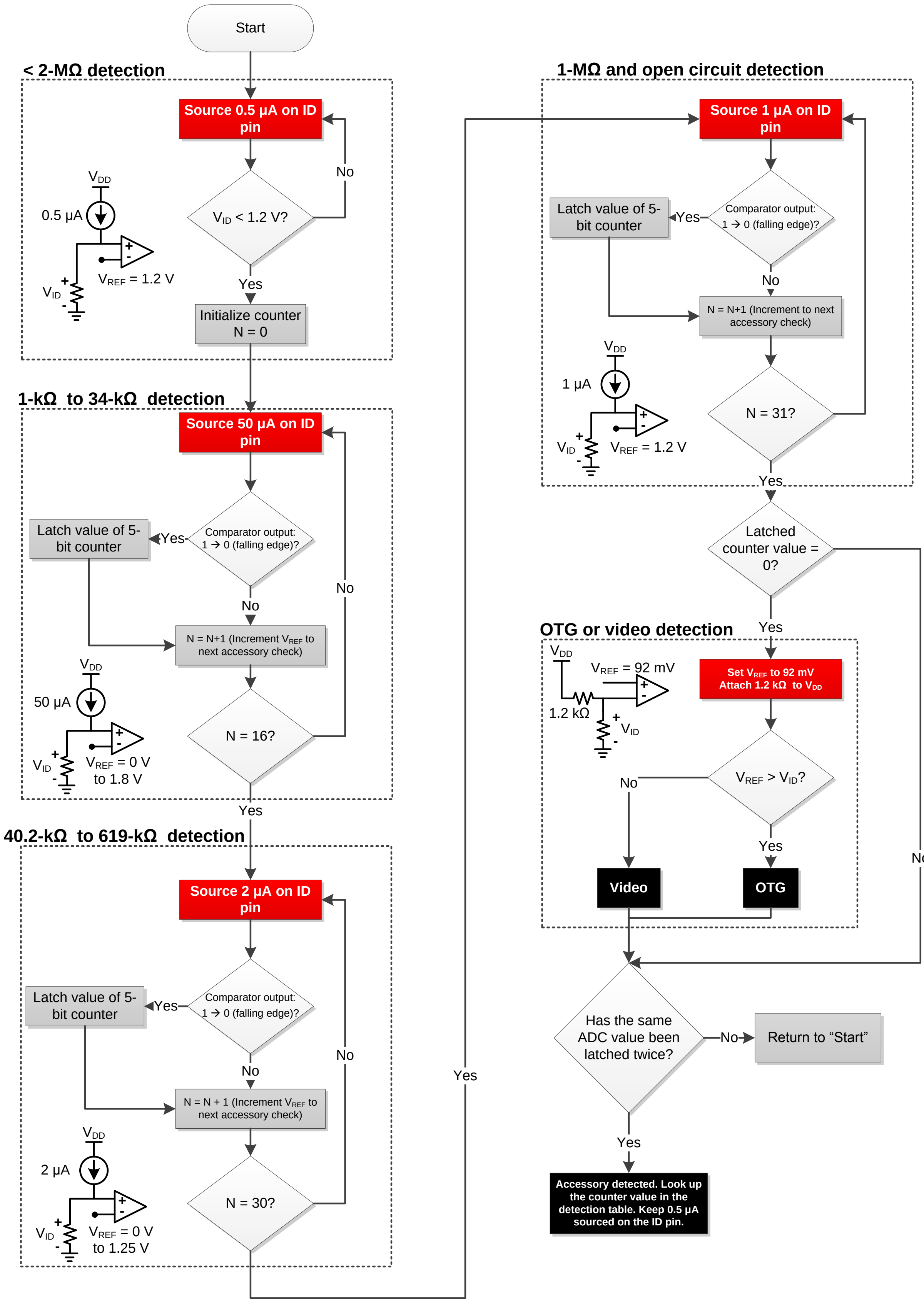

Figure 3. TSU6721 ADC Conversion Step for Accessory Detection on ID Pin

1.3 TSU6721 Charger Detection Sequence

The second generation of TI's micro-USB devices, which includes the TSU6721, is designed to detect all chargers compliant with the BC1.2 standard. The detection algorithm used in the TSU6721 implements portions of detection from the BC1.2 spec for portable devices (PDs) that are allowed to be bypassed, but does not implement them by using the BC1.2 suggested schematics. DCD and secondary detection use circuitry that achieves the same results as the BC1.2 guidelines.

For DCD, the TSU6721 features an adjustable timeout period. The detection algorithm is faster if DM has settled and become stable before the timeout has occurred, using the same threshold (DM < 0.8 V) and a constant current sink instead of a pull-down resistor.

For secondary detection, additional circuitry has been added that can automatically distinguish between CDP and DCP. The entire charger detection algorithm finishes before the 1 second allotment in the good battery algorithm. After a CDP has been detected, software enumeration begins. If software enumeration fails, the charger must be a DCP, and USB communication is not possible. This is necessary for emerging DCP-like chargers that short DP and DM with a resistance of less than 200 Ω, but also apply a constant voltage on DP or DM. These chargers are outside of the BC1.2 specification. If 0.3 V < DM < 0.9 V during primary detection, these chargers will still be detected as CDP or DCP, but may be determined to be CDP though communication is not possible. At this point software enumeration is attempted by the system, which will then fail, resulting in a DCP configuration (1.5 A charging current without USB communication).

Refer to Figure 4 and Figure 5 to compare the BC1.2 implementation with the TSU6721 implementation of charger detection.

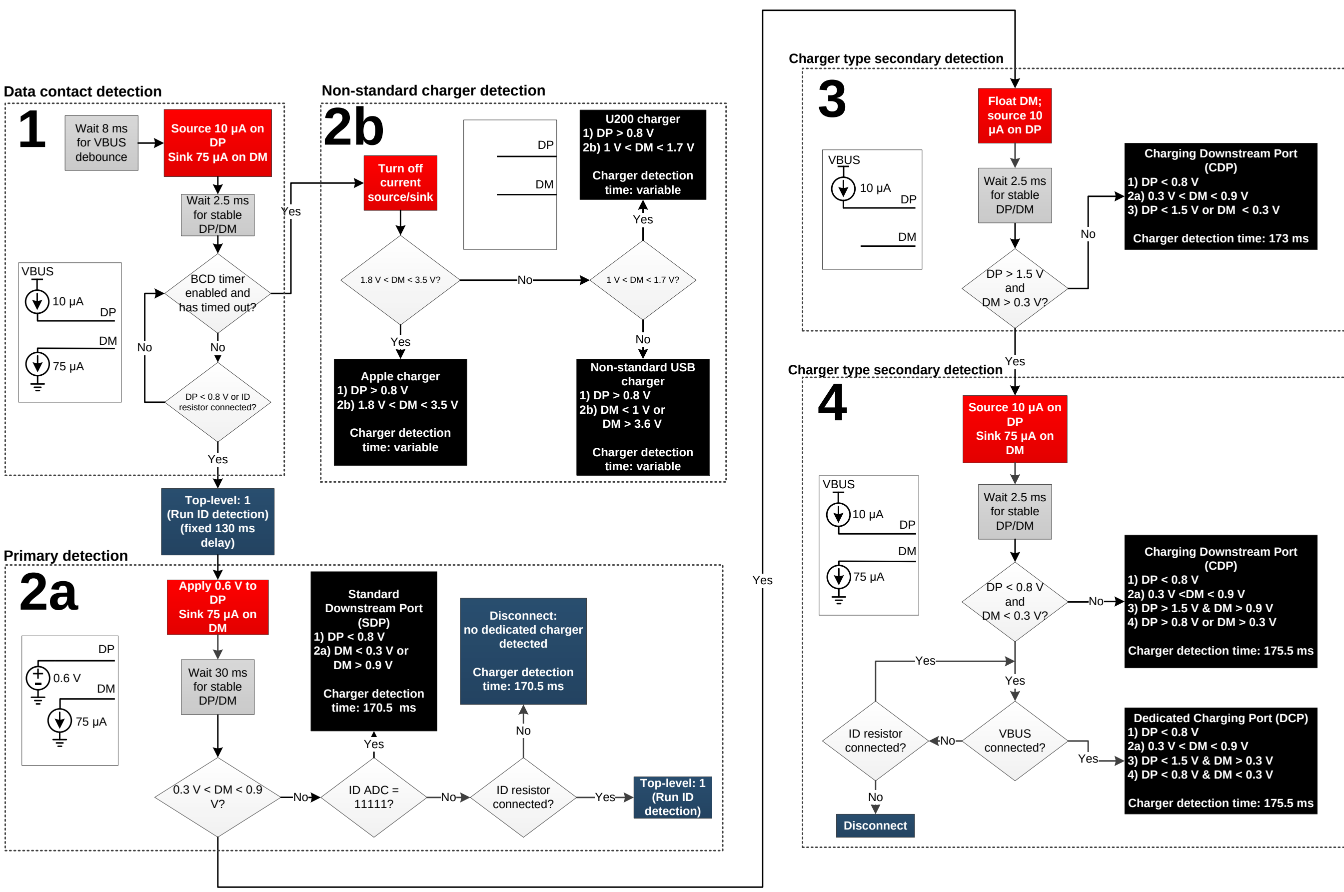

Figure 4. TSU6721 Charger Detection Flowchart

2 BC1.2 Charger Detection Algorithm

2.1 BC1.2 Summary

The BC1.2 standard explains five steps for the detection of compatible chargers:

1. VBUS detection
2. Data contact detect (DCD)
3. Primary detection
4. Secondary detection
5. Accessory charger adapter (ACA) detection

VBUS detection is implicit in any system that intends to implement automatic charger detection.

Data contact detect is a section written to solve a physical problem encountered as a result of the mechanical structure of the micro-USB connector. The length of the D+, D–, and ID pins are shorter than the VBUS and GND pins. DCD is written into BC1.2 to overcome this potential problem but it should be noted that BC1.2 does not require a portable device (PD) to implement DCD if the device waits between 300ms and 900ms between VBUS detect and primary detection.

Primary detection is essential for distinguishing between a standard downstream port (SDP) and higher current chargers, or dedicated charging port (DCP) and charging downstream port (CDP). Primary detection is required by all PDs.

Secondary detection can be used to distinguish between CDP and DCP chargers. BC1.2 states that a PD ready to be enumerated before 1 second has elapsed from VBUS detection is allowed to skip secondary detection.

In the Good Battery Algorithm of BC1.2, additional branches of detection for detecting devices other than SDP or a charging port are allowed if they do not interfere with the flow of the Good Battery Algorithm by means of additional activity on DP, DM, or the ID Pin.

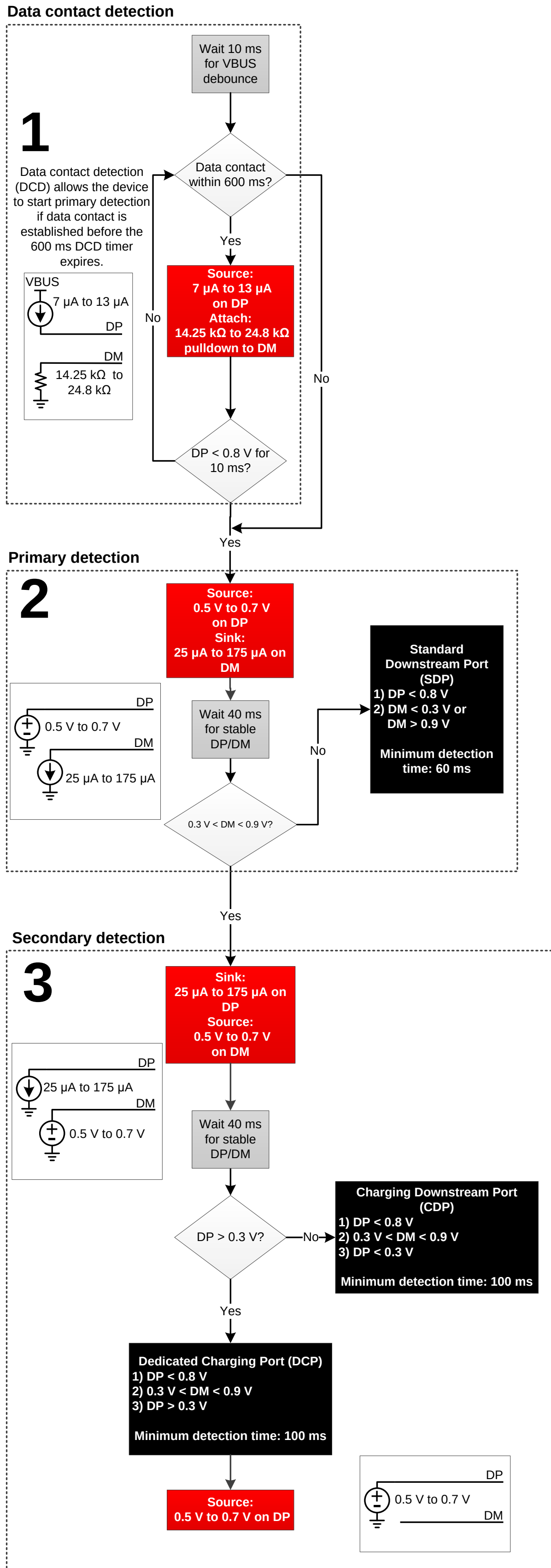

Figure 5. BC1.2 Charger Detection Flowchart

3 Using the TSU6721 with Accessory Charger Adapters (ACA)

3.1 ACA Overview

The accessory charger adapter (ACA) architecture is designed to allow a portable device (PD) to interface both with an accessory and a charger at the same time through the same port. ACA does not allow USB communication to a charger; the USB lines are reserved for the accessory only. One example is a cell phone attached to a headset. Without the ACA architecture, a user cannot use the headset during charging.

ACA detection is not a requirement of a PD. Only PDs that have a micro-AB receptacle can support ACA detection. The TSU6721 was designed for applications that have a micro-B receptacle. To implement the TSU6721 in an application with a micro-AB receptacle, the PD must be capable of handling ACA detection. See section 6 of the BC1.2 specification for more details on ACA.

3.2 Using the TSU6721 with ACA

Figure 6F shows how the TSU6721 is used in an ACA system.

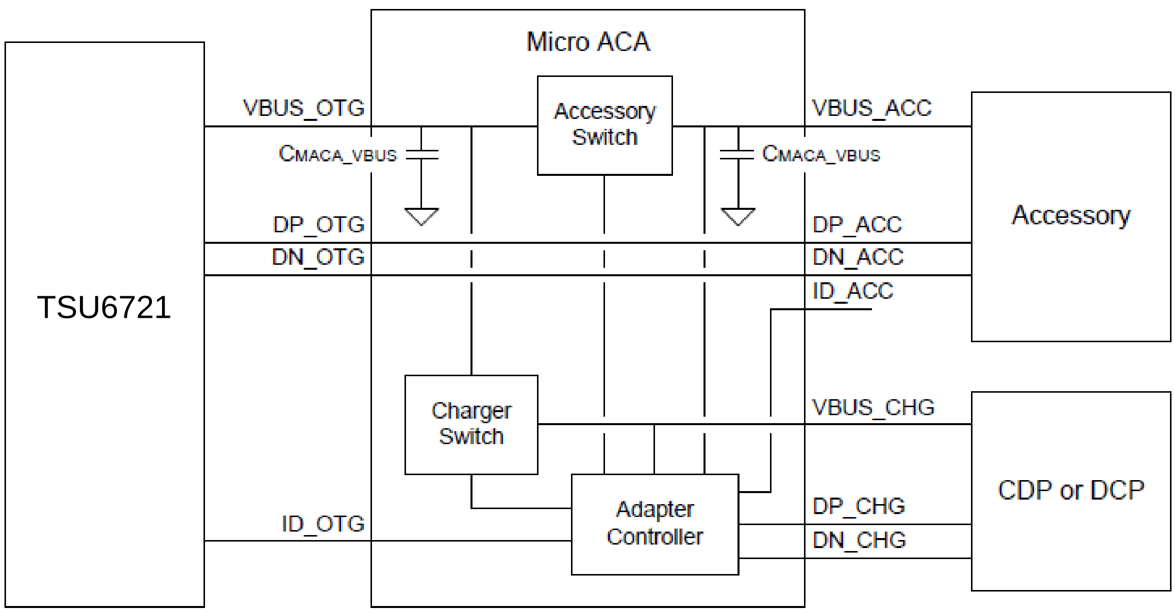

Figure 6. TSU6721 in an ACA System

An ACA attachment is indicated by 5 different windows of resistance between ID and GND, whose values are shown in Table 1. The ACA also passes the DP/DM lines from the accessory directly to the OTG Port to enable communication/detection.

Table 1. ACA ID Resistor Values

PARAMETER		MIN	MAX	UNIT
RID_A	ACA ID pulldown, OTG device as A-device	122	126	kΩ
RID_B	ACA ID pulldown, OTG device as B-device, can't connect	67	69	kΩ
RID_C	ACA ID pulldown, OTG device as B-device, can connect	36	37	kΩ
RID_FLOAT	ACA ID pulldown when ID_OTG is floating	220		kΩ
RID_GND	ACA ID pulldown when ID_OTG pin is grounded		1	kΩ

When in an ACA system, the TSU6721 will need to be set to manual switching mode by writing a 0 to register 02h, bit 2. DP, DM, and ID can then be switched using registers 13h and 14h, respectively. In addition, the TSU6721 must be put in raw data mode by writing a 1 to register 02h, bit 3. Raw data mode causes the TSU6721 to continue running ADC conversion, which detects in the ID resistor value after the ADC counter value has been latched. The TSU6721 will still report “attach” and “detach” interrupts to the host processor, but the host processor will have to service these interrupts to determine the ADC counter value of the attached resistor.

Table 2 shows the correlation between standard ACA ID resistor values and the possible TSU6721 ADC counter values that these resistors will generate.

Table 2. ACA ID Resistor Values

ACA Resistor	TSU6721 ADC Counter Value
RID_GND	00000b
RID_C	01111b 11110b
RID_B	10010b 10011b
RID_A	10101b
RID_FLOAT	10111b 11000b 11001b 11010b 11011b 11110b

4 Examples of TSU6721 Accessory and Charger Detection

4.1 TSU6721 Accessory Detection Example

Consider a 150-kΩ ID resistor connected from the ID pin of the TSU6721 to GND. The following steps occur before the switches are closed inside the TSU6721:

1. (Figure 1) At the end of the next 20 ms wake cycle, the TSU6721 detects an attachment on the ID pin and begins ADC conversion.
2. (Figure 3) After the counter reaches N = 22 = 10110b, the output of the comparator (Figure 2) changes; as a result, the TSU6721 latches the value of N.
3. (Figure 3) ADC conversion runs again and latches the value N = 22 = 10110b a second time.
4. (Figure 1) The detected accessory has a latched ADC counter value of 22 (UART cable), and is not considered an audio accessory. The TSU6721 then begins charger detection.
5. (Figure 4) The TSU6721 starts charger detection at the primary detection step (2a). Since DM is floating, its voltage will not be between 0.3 V and 0.9 V. The latched ADC counter value is not 11111b, and there is an ID resistor connected. Therefore, ADC conversion runs again.
6. (Figure 3) ADC conversion runs again and detects a UART cable.
7. The TSU6721 waits an amount of time specified in register 09h (see TSU6721 datasheet) before connecting DP and DM to RxD and TxD.

4.2 TSU6721 Charger Detection Example

Consider a Dedicated Charging Port (DCP) connected to the TSU6721 by realizing a short from DP to DM and a VBUS input of at least 3.5 V. The following steps occur before the switches are closed inside the TSU6721:

1. (Figure 1) At the end of the next 20 ms wake cycle, the TSU6721 detects an attachment on the VBUS pin and begins the data contact detection step.
2. (Figure 4) Data contact is established and the TSU6721 allows 130 ms for the ADC to run.
3. (Figure 3) ADC conversion runs and returns an ADC counter value of 11111b because a DCP leaves the ID pin as an open circuit.

4. (Figure 4) In Figure 4, step 2a, the voltage on DM is equal to 0.6 V because of the short between DP and DM. Continue to Figure 4, step 3.
5. (Figure 4) In Figure 4, step 3, a current source to an open DP and DM causes them to exceed their threshold voltages. Continue to Figure 4, step 4.
6. (Figure 4) In Figure 4, step 4, the short-circuited DP and DM allow current flow and fall below the threshold voltages, allowing the TSU6721 to declare that a DCP has been detected.
7. The TSU6721 waits an amount of time specified in register 09h (see TSU6721 datasheet) before connecting DP, DM, and ID to DP_HT, DM_HT, and IDBP.