Western Digital.

Field Failure Vcc Power Analysis

VCC waveform from customer's platform

VCC is periodically turned-off

Figure#1: Vcc waveform---After Acc sleep mode, Vcc was found dropped every 3s~4s.

Protocol Bus Trace from customer's platform

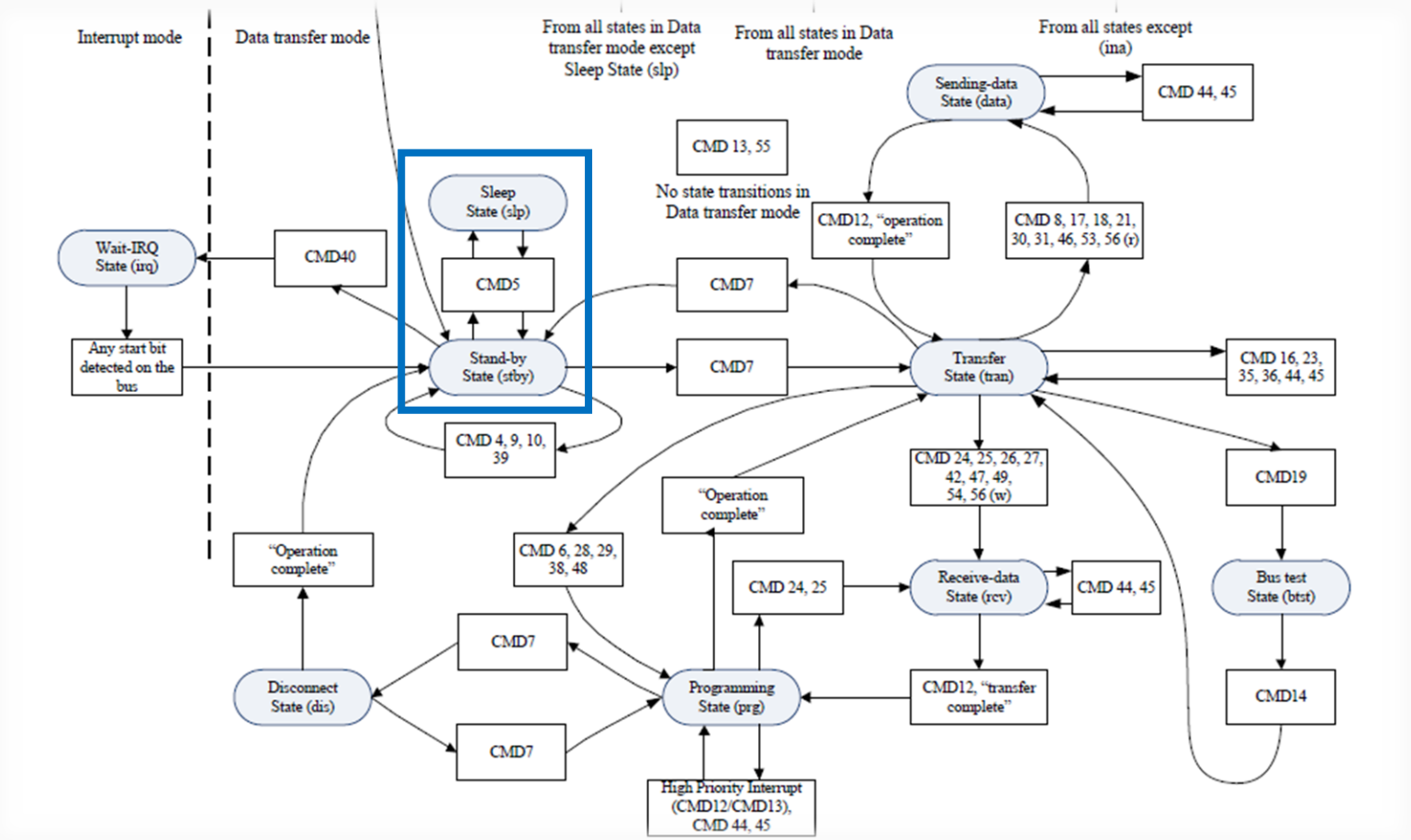
No Power Off Indication before Host turn off VCC when in Sleep State

POWERED_ON is set as 0x01, PON function is enable.

364972	344s:978ms:692us 969 ms	CMD00(GO_IDLE_STATE)	ARG:00000000 CRC:4A	-	MMC:0.4MHz	Nrc:Over 64K Cycles
364973	344s:980ms:867us 002 ms	CMD01(SEND_OP_COND)	ARG:40200000 CRC:06	-	MMC:0.4MHz	Ncc:822
364974	344s:981ms:000us 132 us	R3	RSP:3F40FF8080FF [47:0]	-	MMC:-	Ncr:5
364975	344s:993ms:352us 012 ms	CMD01(SEND_OP_COND)	ARG:40200000 CRC:06	-	MMC:0.4MHz	Nrc:4893
364976	344s:993ms:485us 132 us	R3	RSP:3FC0FF8080FF [47:0]	-	MMC:-	Ncr:5
364977	344s:993ms:675us 189 us	CMD02(ALL_SEND_CID)	ARG:00000000 CRC:26	-	MMC:0.4MHz	Nrc:28
364978	344s:993ms:807us 132 us	R2	RSP:3F450100444136303332018418D91F885B [135:0]	-	MMC:-	Nid:5
364979	344s:994ms:220us 412 us	CMD03(SET_RELATIVE_ADDR)	ARG:00010000 CRC:3F	-	MMC:0.4MHz	Nrc:29
364980	344s:994ms:370us 150 us	R1	RSP:0300000500FB [47:0]	-	MMC:-	Ncr:12
364981	344s:994ms:550us 180 us	CMD07(SELECT/DESELECT_CARD)	ARG:00010000 CRC:6E	-	MMC:0.4MHz	Nrc:24
364982	344s:994ms:700us 150 us	R1b	RSP:070000070075 [47:0]	-	MMC:-	Ncr:12
364983	344s:994ms:885us 185 us	CMD06(SWITCH)	ARG:03220101 CRC:1D	Host shall notify before powering off	MMC:0.4MHz	Nrc:26
365071	345s:029ms:372us 018 us	CMD06(SWITCH)	ARG:03B90301 CRC:08	HS400 timing	MMC:48.7MHz	Nrc:839
365072	345s:029ms:374us 001 us	R1b	RSP:0600000800CB [47:0]	-	MMC:-	Ncr:12
365099	345s:045ms:552us 027 us	CMD06(SWITCH)	ARG:03210101 CRC:6C	Cache is ON	MMC:198.0MHz	Nrc:5309
365100	345s:045ms:552us 000 us	R1b	RSP:0600000800CB [47:0]	-	MMC:-	Ncr:34
365589	347s:495ms:701us 117 ms	CMD06(SWITCH)	ARG:03200101 CRC:43	Triggers the Flush	MMC:198.0MHz	Nrc:Over 64K Cycles
365590	347s:495ms:701us 000 us	R1b	RSP:0600000800CB [47:0]	-	MMC:-	Ncr:34
365591	347s:495ms:730us 029 us	CMD13(SEND_STATUS)	ARG:00010000 CRC:29	-	MMC:186.4MHz	Nrc:5573
365592	347s:495ms:731us 000 us	R1	RSP:0D00000E005D [47:0]	-	MMC:-	Ncr:33
365649	347s:497ms:058us 032 us	CMD13(SEND_STATUS)	ARG:00010000 CRC:29	-	MMC:198.0MHz	Nrc:6136
365650	347s:497ms:059us 000 us	R1	RSP:0D000009003F [47:0]	-	MMC:-	Ncr:33
365651	347s:497ms:118us 059 us	CMD07(SELECT/DESELECT_CARD)	ARG:00000000 CRC:41	-	MMC:186.4MHz	Nrc:11371
365652	347s:497ms:133us 014 us	CMD05(SLEEP_AWAKE)	ARG:00018000 CRC:51	-	MMC:198.0MHz	Ncc:2788
365653	347s:497ms:133us 000 us	R1b	RSP:0500000600BB [47:0]	Busy	MMC:-	Ncr:34

Figure#2: No Power Off Indication before Host turn off VCC when in Sleep State

eMMC State Machine Diagram (Sleep/Stand-by)



Power(VCC/VCCQ) during Sleep Diagram

The master can execute any sequence of V_{CC} and V_{CCQ} power-up/power-down. However, the master must not issue any commands until V_{CC} and V_{CCQ} are stable within each operating voltage range. After the slave enters sleep mode, the master can power-down V_{CC} to reduce power consumption. It is necessary for the slave to be ramped up to V_{CC} before the host issues CMD5 (SLEEP_AWAKE) to wake the slave unit.

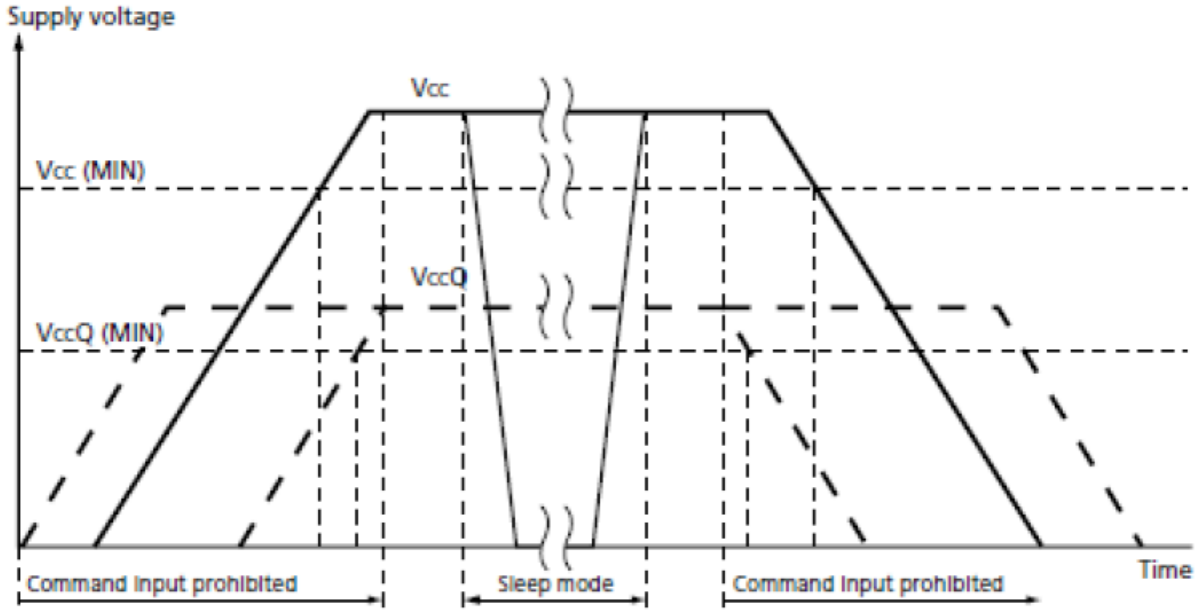


Figure 74 — *e*•MMC power cycle

6.6.21 Sleep (CMD5)

A Device may be switched between a Sleep state and a Standby state by SLEEP/AWAKE (CMD5). In the Sleep state the power consumption of the memory device is minimized. In this state the memory device reacts only to the commands RESET (CMD0 with argument of either 0x00000000 or 0xF0F0F0F0 or H/W reset) and SLEEP/AWAKE (CMD5). All the other commands are ignored by the memory device. The timeout for state transitions between Standby state and Sleep state is defined in the EXT_CSD register S_A_TIMEOUT. The maximum current consumptions during the Sleep state are defined in the EXT_CSD registers S_C_VCC and S_C_VCCQ.

Sleep command: The bit 15 as set to 1 in SLEEP/AWAKE (CMD5) argument. Awake command: The bit 15 as set to 0 in SLEEP/AWAKE (CMD5) argument.

The Sleep command is used to initiate the state transition from Standby state to Sleep state. The memory device indicates the transition phase busy by pulling down the DAT0 line. No further commands should be sent during the busy. The Sleep state is reached when the memory device stops pulling down the DAT0 line.

The Awake command is used to initiate the transition from Sleep state to Standby state. The memory device indicates the transition phase busy by pulling down the DAT0 line. No further commands should be sent during the busy. Standby state is reached when the device stops pulling down the DAT0 line.

Sleep Description

During the Sleep state the V_{CC} power supply may be switched off. This is to enable even further system power consumption saving. The V_{CC} supply is allowed to be switched off only after the Sleep state has been reached (the memory device has stopped to pull down the DAT0 line). The V_{CC} supply have to be ramped back up at least to the min operating voltage level before the state transition from Sleep state to Standby state is allowed to be initiated (Awake command).

The host may issue SLEEP_AWAKE (CMD5) to enter or to exit from Sleep state if POWER_OFF_NOTIFICATION byte is set to POWERED_ON. Before moving to Standby state and then to Sleep state, the host sets POWER_OFF_NOTIFICATION to SLEEP_NOTIFICATION and waits for the DAT0 line de-assertion. While in Sleep (slp) state V_{CC} (Memory supply) may be turned off as defined in 6.6.21. Removing power supplies other than V_{CC} while the device is in the Sleep (slp) state may result in undefined device behavior. Before removing all power supplies, the host should transition the device out of Sleep (slp) state back to Transfer state using CMD5 and CMD7 and then execute a power off notification setting POWER_OFF_NOTIFICATION byte to either POWER_OFF_SHORT or POWER_OFF_LONG.

While POWER_OFF_NOTIFICATION is set to POWERED_ON, the device expects the host to :

- Keep the device power supplies alive (both V_{CC} and V_{CCQ}) and in their active mode,
- Not power off the device intentionally before changing POWER_OFF_NOTIFICATION to either POWER_OFF_LONG or POWER_OFF_SHORT, and
- Not power off V_{CC} intentionally before changing POWER_OFF_NOTIFICATION to SLEEP_NOTIFICATION and before moving the device to Sleep state.

Pay Attention for Sleep Operation

There is no requirement for flush due to switching between the partitions. (Note: This also implies that the cache data shall not be lost when switching between partitions). Cached data may be lost in SLEEP state, so host should flush the cache before placing the device into SLEEP state.

Sleep/PON Setting

Read/Write

7.4.110 POWER_OFF_NOTIFICATION [34]

This field allows host to notify the device before the device is powered off. Values not in Table 183 are invalid and setting them will result in SWITCH_ERROR.

NOTE *e*•MMC device should be able to guard against sudden power loss even when POWER_OFF_NOTIFICATION is set to 0x01 (POWER_ON) since unintentional power loss event may still occur.

Table 183 — Valid POWER_OFF_NOTIFICATION values

Value	Name	Description
0x00	NO_POWER_NOTIFICATION	Power off notification is not supported by host, device shall not assume any
0x02	POWER_OFF_SHORT	Host is going to power off the device, The device shall respond within GENERIC_CMD6_TIME.
0x03	POWER_OFF_LONG	Host is going to power off the device The device shall respond within POWER_OFF_LONG_TIME.
0x04	SLEEP_NOTIFICATION	Host is going to put the device in Sleep Mode. The device shall respond within SLEEP_NOTIFICATION_TIME

Use CMD6 to Write 0x04 in Ext_CSD[34] for Sleep-Notification before turn off VCC

Read Only

7.4.51 SLEEP_NOTIFICATION_TIME [216]

This field indicates the maximum timeout for the SWITCH command (CMD6) when notifying the device that it is about to be move to sleep state (slp) by writing SLEEP_NOTIFICATION to POWER_OFF_NOTIFICATION [34] byte. Time is expressed in units of 10-millimicroseconds. The formula to calculate the max timeout value is:

CMD6 Sleep-Notification busy wait time

reserved.

Table 130 — Sleep Notification timeout values

Value	Timeout Values
0x00	Not defined
0x01	$10us \times 2^1 = 20us$
0x02	$10us \times 2^2 = 40us$
:	:
0x17	$10us \times 2^{23} = 83.88s$
0x18–0xFF	Reserved

7.4.50 S_A_TIMEOUT [217]

This register defines the max timeout value for state transitions from Standby state (stby) to Sleep state (slp) and from Sleep state (slp) to Standby state (stby). The formula to calculate the max timeout value is:

Sleep/A

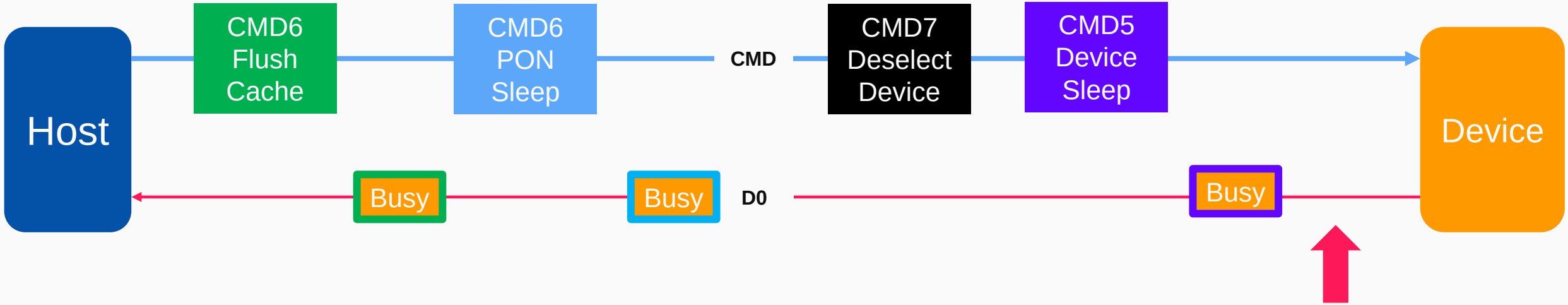
CMD5 Sleep busy wait time

Max register val and 0xFF are reserved.

Table 129 — Sleep/awake timeout values

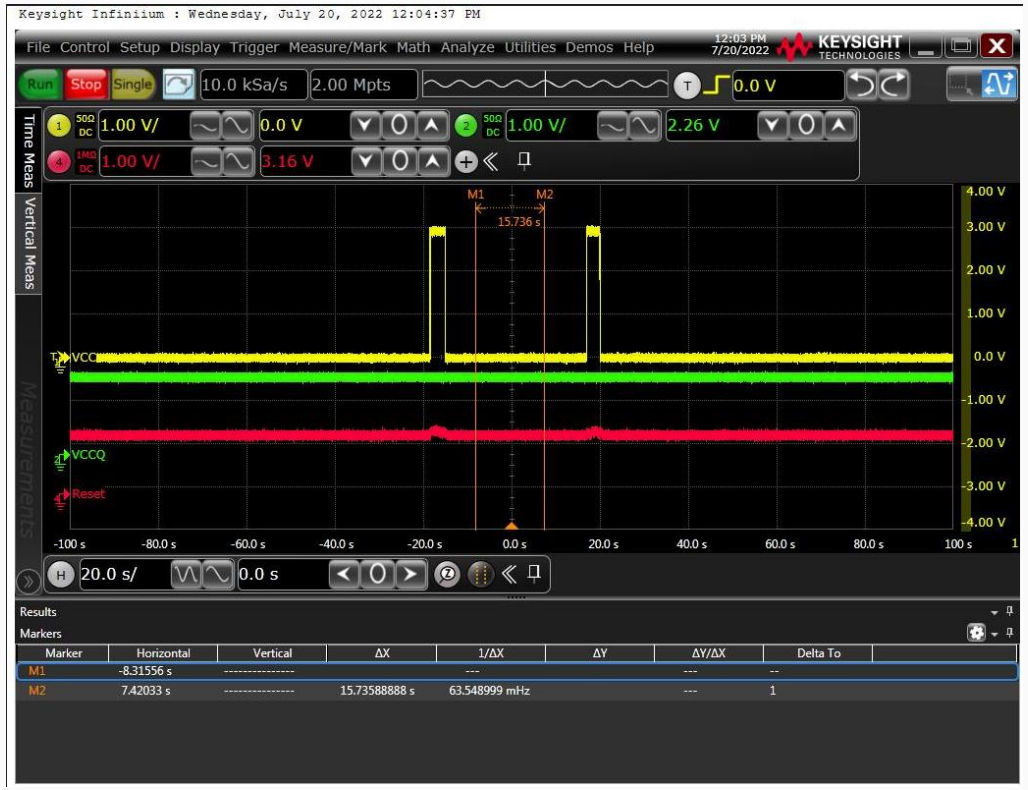
Value	Timeout Values
0x00	Not defined
0x01	100ns × 21 = 200ns
0x02	100ns × 22 = 400ns
:	:
0x17	100ns × 223 = 838.86ms
0x18–0xFF	Reserved

eMMC Sleep with VCC turn-off flow



VCC waveform from customer's platform

PON (Short) is sent after MTK Modified Driver



No	Time	EVENT	DATA	Information	Bus	Clock
72...	979s:448ms:344...	R1	RSP:0D000000E005D [47:0]	-	MMC:-	Ncr:33
72...	979s:448ms:378...	CMD13(SEND_ST...	ARG:00010000 CRC:29	-	MMC:198....	Nrc:6545
72...	979s:448ms:379...	R1	RSP:0D000000E005D [47:0]	-	MMC:-	Ncr:33
72...	979s:448ms:413...	CMD13(SEND_ST...	ARG:00010000 CRC:29	-	MMC:198....	Nrc:6568
72...	979s:448ms:414...	R1	RSP:0D000000E005D [47:0]	-	MMC:-	Ncr:33
72...	979s:448ms:448...	CMD13(SEND_ST...	ARG:00010000 CRC:29	-	MMC:198....	Nrc:6505
72...	979s:448ms:448...	R1	RSP:0D000000E005D [47:0]	-	MMC:-	Ncr:33
72...	979s:448ms:482...	CMD13(SEND_ST...	ARG:00010000 CRC:29	-	MMC:198....	Nrc:6539
72...	979s:448ms:483...	R1	RSP:0D000000E005D [47:0]	-	MMC:-	Ncr:33
72...	979s:448ms:517...	CMD13(SEND_ST...	ARG:00010000 CRC:29	-	MMC:198....	Nrc:6550
72...	979s:448ms:518...	R1	RSP:0D000000E005D [47:0]	-	MMC:-	Ncr:33
72...	979s:448ms:545...	BUSY END	-	BUSY 1329 us	MMC:-	-
72...	979s:448ms:552...	CMD13(SEND_ST...	ARG:00010000 CRC:29	-	MMC:186....	Nrc:6564
72...	979s:448ms:553...	R1	RSP:0D000009003F [47:0]	-	MMC:-	Ncr:33
72...	979s:448ms:588...	CMD06(SWITCH)	ARG:03220201 CRC:00	Host is going to power off (SHORT)	MMC:198....	Nrc:6805
72...	979s:448ms:589...	BUSY START	-	-	MMC:-	-
72...	979s:448ms:589...	R1b	RSP:0600000800CB [47:0]	-	MMC:-	Ncr:34
72...	979s:451ms:214...	BUSY END	-	BUSY 2625 us	MMC:-	-
72...	993s:069ms:112...	CMD00(GO_IDLE...	ARG:00000000 CRC:4A	-	MMC:0.4MHz	Nrc:Over...
72...	993s:071ms:297...	CMD01(SEND_OP...	ARG:40030000 CRC:44	-	MMC:0.4MHz	Ncc:826
72...	993s:083ms:802...	CMD01(SEND_OP...	ARG:40030000 CRC:44	-	MMC:4MHz	Nrc:4901

Figure#3: PON (SHORT) was sent before power off

Abnormal Vcc drop during power up

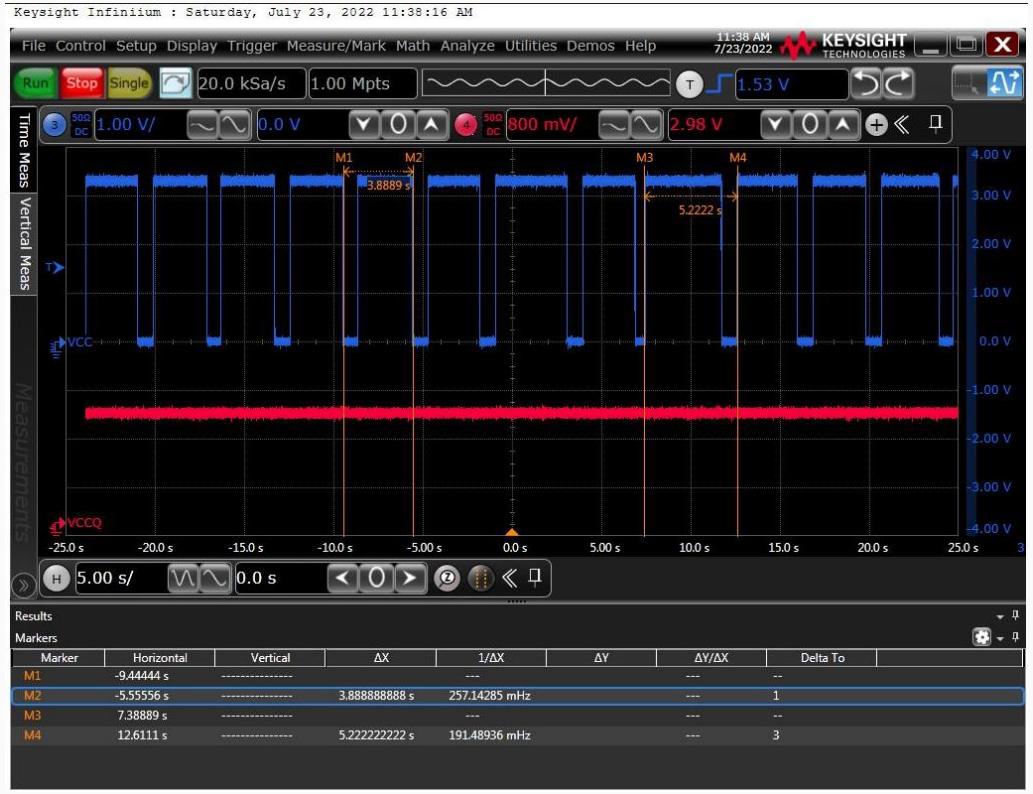
Figure#4: Platform#1—Anormal Vcc drop was found after power up 15s

Figure#5: Platform#2—Anormal Vcc drop was found after power up after 9s

Suggestions:
Platform to disable Vcc drop during power up.

VCC waveform from customer's platform

Final Patch after MTK Modification



23225	032s:332ms:006us 042 us	CMD13(SEND_STATUS)	ARG:00010000 CRC:29	-	MMC:198.0MHz Nrc:8105
23226	032s:332ms:007us 000 us	R1	RSP:0D00000E005D [47:0]	-	MMC:- Ncr:33
23227	032s:332ms:031us 024 us	CMD13(SEND_STATUS)	ARG:00010000 CRC:29	-	MMC:186.4MHz Nrc:4585
23228	032s:332ms:031us 000 us	R1	RSP:0D00000E005D [47:0]	-	MMC:- Ncr:33
23229	032s:332ms:075us 043 us	CMD13(SEND_STATUS)	ARG:00010000 CRC:29	-	MMC:198.0MHz Nrc:8277
23230	032s:332ms:075us 000 us	R1	RSP:0D00000E005D [47:0]	-	MMC:- Ncr:33
23231	032s:332ms:099us 023 us	CMD13(SEND_STATUS)	ARG:00010000 CRC:29	-	MMC:198.0MHz Nrc:4545
23232	032s:332ms:099us 000 us	R1	RSP:0D00000E005D [47:0]	-	MMC:- Ncr:33
23233	032s:332ms:123us 023 us	CMD13(SEND_STATUS)	ARG:00010000 CRC:29	-	MMC:198.0MHz Nrc:4408
23234	032s:332ms:123us 000 us	R1	RSP:0D00000E005D [47:0]	-	MMC:- Ncr:33
23235	032s:332ms:165us 042 us	CMD13(SEND_STATUS)	ARG:00010000 CRC:29	-	MMC:198.0MHz Nrc:8029
23236	032s:332ms:166us 000 us	R1	RSP:0D00000E005D [47:0]	-	MMC:- Ncr:33
23237	032s:332ms:191us 025 us	CMD13(SEND_STATUS)	ARG:00010000 CRC:29	-	MMC:186.4MHz Nrc:4909
23238	032s:332ms:192us 000 us	R1	RSP:0D00000E005D [47:0]	-	MMC:- Ncr:33
23239	032s:332ms:233us 041 us	CMD13(SEND_STATUS)	ARG:00010000 CRC:29	-	MMC:198.0MHz Nrc:7869
23240	032s:332ms:233us 000 us	R1	RSP:0D00000E005D [47:0]	-	MMC:- Ncr:33
23241	032s:332ms:258us 024 us	CMD13(SEND_STATUS)	ARG:00010000 CRC:29	-	MMC:198.0MHz Nrc:4602
23242	032s:332ms:258us 000 us	R1	RSP:0D00000E005D [47:0]	-	MMC:- Ncr:33
23243	032s:332ms:301us 043 us	CMD13(SEND_STATUS)	ARG:00010000 CRC:29	-	MMC:198.0MHz Nrc:8223
23244	032s:332ms:302us 000 us	R1	RSP:0D00000E005D [47:0]	-	MMC:- Ncr:33
23245	032s:332ms:326us 024 us	CMD13(SEND_STATUS)	ARG:00010000 CRC:29	-	MMC:198.0MHz Nrc:4590
23246	032s:332ms:326us 000 us	R1	RSP:0D00000E005D [47:0]	-	MMC:- Ncr:33
23247	032s:332ms:369us 042 us	CMD13(SEND_STATUS)	ARG:00010000 CRC:29	-	MMC:198.0MHz Nrc:8191
23248	032s:332ms:370us 000 us	R1	RSP:0D00000E005D [47:0]	-	MMC:- Ncr:33
23249	032s:332ms:394us 024 us	CMD13(SEND_STATUS)	ARG:00010000 CRC:29	-	MMC:186.4MHz Nrc:4602
23250	032s:332ms:394us 000 us	R1	RSP:0D00000E005D [47:0]	-	MMC:- Ncr:33
23251	032s:332ms:436us 041 us	BUSY END	-	BUSY 1324 us	MMC:- -
23252	032s:332ms:439us 003 us	CMD13(SEND_STATUS)	ARG:00010000 CRC:29	-	MMC:198.0MHz Nrc:8577
23253	032s:332ms:440us 000 us	R1	RSP:0D000009003F [47:0]	-	MMC:- Ncr:33
23254	032s:332ms:465us 025 us	CMD06(SWITCH)	ARG:03220401 CRC:3A	Host is going to put the device in Sleep Mode	MMC:198.0MHz Nrc:4856
23255	032s:332ms:465us 000 us	BUSY START	-	-	MMC:- -
23256	032s:332ms:465us 000 us	R1b	RSP:0600000800CB [47:0]	-	MMC:- Ncr:34
23257	032s:333ms:169us 703 us	BUSY END	-	BUSY 703 us	MMC:- -
23258	032s:333ms:178us 009 us	CMD07(SELECT/DESELECT_CARD)	ARG:00000000 CRC:41	-	MMC:198.0MHz Nrc:Over...
23259	032s:333ms:191us 012 us	CMD05(SLEEP_AWAKE)	ARG:00018000 CRC:51	-	MMC:198.0MHz Ncc:2283
23260	032s:333ms:191us 000 us	BUSY START	-	-	MMC:- -
23261	032s:333ms:191us 000 us	R1b	RSP:0500000600BB [47:0]	Busy	MMC:- Ncr:34
23262	032s:334ms:187us 996 us	BUSY END	-	BUSY 996 us	MMC:- -
23263	033s:002ms:838us 668 ms	CMD00(GO_IDLE_STATE)	ARG:00000000 CRC:4A	-	MMC:0.4MHz Nrc:Over...
23264	033s:005ms:011us 002 ms	CMD01(SEND_OP_COND)	ARG:40200000 CRC:06	-	MMC:0.4MHz Ncc:821
23265	033s:005ms:143us 132 us	R3	RSP:3F40FF8080FF [47:0]	-	MMC:- Ncr:5
23266	033s:017ms:543us 012 ms	CMD01(SEND_OP_COND)	ARG:40200000 CRC:06	-	MMC:0.4MHz Nrc:4912
23267	033s:017ms:676us 132 us	R3	RSP:3FC0FF8080FF [47:0]	-	MMC:- Ncr:5
23268	033s:017ms:866us 190 us	CMD02(ALL_SEND_CID)	ARG:00000000 CRC:26	-	MMC:0.4MHz Nrc:28
23269	033s:017ms:998us 132 us	R2	RSP:3F450100444136 30...	-	MMC:- Nid:5
23270	033s:018ms:396us 397 us	CMD03(SET_RELATIVE_ADDR)	ARG:00010000 CRC:3F	-	MMC:0.4MHz Nrc:23
23271	033s:018ms:546us 150 us	R1	RSP:0300000500FB [47:0]	-	MMC:- Ncr:12
23272	033s:018ms:981us 434 us	CMD07(SELECT/DESELECT_CARD)	ARG:00010000 CRC:6E	-	MMC:0.4MHz Nrc:126
23273	033s:019ms:131us 150 us	R1b	RSP:070000070075 [47:0]	-	MMC:- Ncr:12
23274	033s:019ms:316us 184 us	CMD06(SWITCH)	ARG:03220101 CRC:1D	Host shall notify before powering off	MMC:0.4MHz Nrc:26
23275	033s:019ms:441us 124 us	BUSY START	-	-	MMC:- -
23276	033s:019ms:466us 025 us	R1b	RSP:0600000800CB [47:0]	-	MMC:- Ncr:12
23277	033s:019ms:663us 197 us	CMD13(SEND_STATUS)	ARG:00010000 CRC:29	-	MMC:0.4MHz Nrc:31
23278	033s:019ms:758us 095 us	BUSY END	-	BUSY 317 us	MMC:- -
23279	033s:019ms:796us 037 us	R1	RSP:0D000009003F [47:0]	-	MMC:- Ncr:5
23280	033s:019ms:998us 202 us	CMD06(SWITCH)	ARG:03B70201 CRC:02	8bit data bus	MMC:0.4MHz Nrc:33

Figure#6: PON (SLEEP) was sent before power off: *CMD06 (0X04 means the device will enter sleep mode) → CMD07 (Deselect) →CMD05 (SLEEP)*

1
4