Ford Suspend to RAM Function Requirement(China)-U718

1.Overview

1.1 Overview

The purpose of this document is to describe the feature function requirements for “STR” (Suspend To RAM)Feature. This document describes the usage of the STR Feature in the vehicle from different actor’s perspective. Put all devices into low power mode before shutdown, device and system status is saved in RAM memory, DDR memory is set to self-refresh mode to maintain content; When starting up, you only need to exit the self-refresh mode and restore the state of the device and system to complete the startup.

- All CPU cores, peripherals and IP Cores received Power collapsed status.
- The internal bus clock is down to its lowest frequency.
- The source crystal (XO) is turned off.
- Most open PMIC regulators close.

1.2 Goal

STR feature is a power state offering quick start infotainment system. It's between Standby and Sleep mode. It takes less time to boot up than sleep mode and has less battery consumption than standby mode. It is power management that achieves a balance between power consumption and startup.

1.3 Acronyms, Abbreviations, Terminology

Abbreviation	Definition
CAN	Controller area network, A feature - rich bus standard for vehicles. Designed to allow a single chip computer on a bus network to communicate with the instrument without the need for a host computer. (ISO 11898)

SoC	System On a Chip, Similar to a mobile phone chip, a complete embedded system is integrated on a single chip.
AP	Low-power multifunctional processors used in the Internet of Things are generally VLSI that expand audio and video capabilities and dedicated interfaces on the basis of low-power cpus. It's part of the system-on-chip SoC.
GPIO	General-purpose input/output, A miniature processing chip with pins that can write and read high and low levels.
SPI	Serial Peripheral Interface Bus, A specification for synchronous serial ports for chip communication.
VMCU	Vehicle Microcontroller Unit
CPM	Onboard power management API for exposing the operating interface to the application to manipulate power status.
CPMS	The on-board power management service implements the on-board power state machine, provides the VHAL interface, and simultaneously performs the final call for suspension and shutdown.
CPPD	Expose the native AIDL interface to register a power management policy listener
Suspend	This is called Suspend to RAM(STR). The SoC will enter S3 power mode, where the CPU is powered down but the RAM is still powered on. Storage to RAM.
Hibernate	This is called Suspend to disk (STD/S4). The SoC will enter the S4 power mode, i.e. sleep, while RAM memory will be written to a non-volatile medium such as hard disk, and the system will be powered off. STD refers to Storage to Disk, and S4 is the power mode.
BSP	The BSP is the support layer between the hardware and the operating system that is used to initialize the hardware and load the system boot.
PMIC	A chip used to manage the power requirements of the host system.
VHAL	The HAL layer is the hardware abstraction layer, between the hardware (driver) layer and the application layer, and provides the hardware operation interface for the application. V is for Vehicle.
VIP	Vehicle Interface Processor

2.General Requirement

2.1 Performance Requirement

2.1.1 System timing

Initial State	Target State	Duration(s)	Note
STR mode	Functional mode	2~4	If times out, a retry mechanism is required. If the retry still fails, go to sleep mode.
Functional mode	STR mode	25	

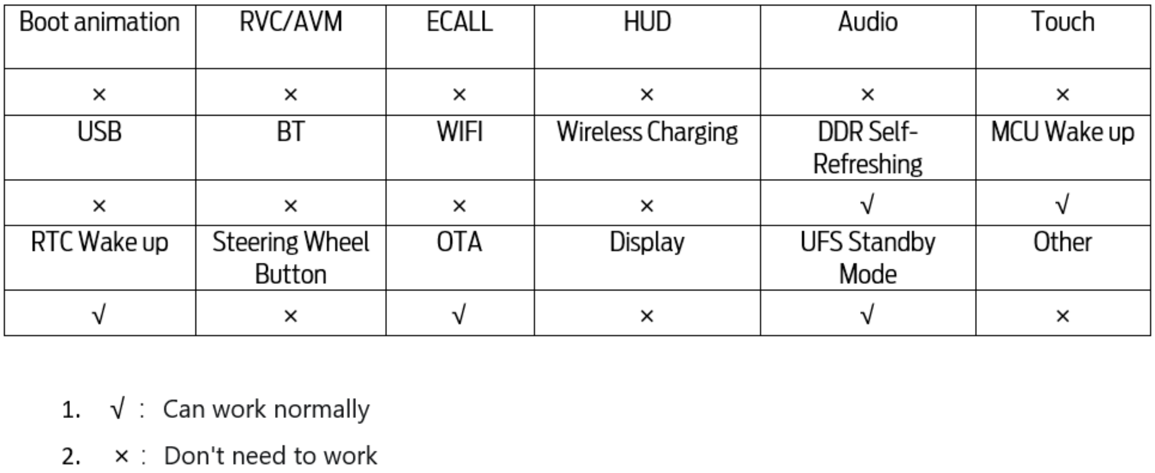
2.1.2 Current&Voltage Consumption

After APIM enters STR mode, APIM current and voltage consumption data is as follows:

Current	Voltage
• The APIM current consumption at STR at normal temperature is less than or equal to 7mA • The APIM current consumption at STR at -30 is less than or equal to 3.7mA • The APIM current consumption at STR at 45 is less than or equal to 6.8mA • The APIM current consumption at STR at 65 is less than or equal to 10.3mA • The APIM current consumption at STR of 75 is less than or equal to 18.7mA	The voltage of APIM at STR ranges from 10v to 16v.(If it is out of range, the infotainment system will enter sleep power mode)

2.1.3 Peripherals State

The following table describes the working state of the peripherals in STR mode:



Boot animation	RVC/AVM	ECALL	HUD	Audio	Touch
×	×	×	×	×	×
USB	BT	WIFI	Wireless Charging	DDR Self-Refreshing	MCU Wake up
×	×	×	×	√	√
RTC Wake up	Steering Wheel Button	OTA	Display	UFS Standby Mode	Other
√	×	√	×	√	×

1. √ : Can work normally
2. × : Don't need to work

2.1.4 Memory management

- Android application memory garbage clearance strategy Usually, when APIM enters the sleep state normally, the system and application layer will go through the complete shutdown sequence, and its app internal cache/and generated memory garbage will be cleared. After the STR function is added, APIM will usually enter STR mode/exit STR mode. In this scenario, the app internal cache/memory garbage in APIM will be saved into RAM and loaded again when STR exits. If the memory piles up a lot, this will bring trouble to the system startup time and the functional completeness of the app.
- APIM vendors need to implement an android system/app memory cleaning mechanism, especially for cars with STR.
- In order to reduce the running of apps in the background and prevent the risk of system crash due to excessive memory usage, the system will automatically shut down when the number of STR entries reaches the threshold(Recommended 30 times).
- Triggering condition of the memory clearing mechanism: If the system memory reaches the specified threshold or the App memory reaches the specified threshold, the system detects that the system is in the shutdown sequence, and the system automatically triggers memory clearing.
- Memory leak: It is recommended to do a memory leak pressure test for 2 weeks in the development process of the APP adapted to STR to ensure that the memory increase of the APP does not exceed specified threshold value after 2 weeks of operation
- crash/NE It is recommended to do a 2-week stress test in the development process of the APP adapted to STR to ensure that there is no crash and JE/NE/ANR in the 2-week running time of the APP.

2.2 Configuration Requirement

Configuration Name	Default Duration(Days)	Description	Note
STR mode	5	0: Disable STR 1-7: Enable STR	DE06 Start byte = 10, Start Bit = 7 Size=8 bit

Note: The configuration bit is modified by DET. The value of STR duration can be modified. To facilitate debug, advised to set the unit to minute in engineering mode(add 5 minutes, 10 minutes option).

2.3 Data Tagging Requirement

In order to ensure the effective reporting of STR entry and exit events, we need to define some buried events to monitor the working pattern of STR, so as to ensure that the normal operation of STR can be effectively identified in the cloud.

Example:(Final definition shall prevail)

Event ID	Description	Attach Information
Entry	Record the entry time, string format: 2021-04-26 18:05:33, upload the next startup	turnofftime|string|turnofftime|required
Exit	Record whether the user is in STR mode or sleep when starting the vehicle	turnonmode|string|turnonmode|required
Entry Exception	Description An exception occurred when entering STR. Report the cause of the exception	entryexception|string|entryexception|required
Exit Exception	Description An exception occurred when exiting STR. Report the cause of the exception	exitexception|string|exitexception|required

2.4 CAN Module indications

- After the APIM module enters STR mode, APIM cannot affect the normal conversion of power management state machines of other modules of CAN network nodes.

- After the APIM module exits STR mode, because APIM starts quickly, for the scenario that other CAN nodes on the vehicle network need to shake hands to work normally, the APIM supplier needs to identify and confirm in advance to ensure that APIM has corresponding countermeasures to ensure that APIM can also shake hands with rival parts smoothly even when it starts earlier.
- Once you enter STR, it behaves like the standard Ford Info power management sleep mode, except that the system's DDR memory is in self-refresh mode to preserve the context.

3.General Functions

The basic functions of STR mainly include entry and exit. The following describes the timing of each state in detail.

3.1 STR Entrance and Exit

STR Entrance

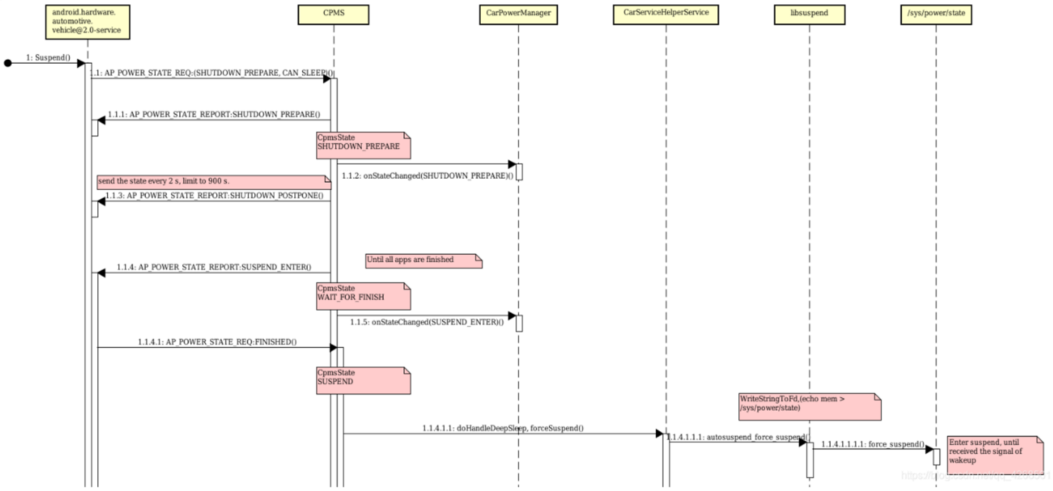

android.hardware.
automotive.
vehicle@2.0-service
CPMS
CarPowerManager
CarServiceHelperService
libsuspend
/sys/power/state
1: Suspend()
1.1: AP_POWER_STATE_REQ:(SHUTDOWN_PREPARE, CAN_SLEEP)()
1.1.1: AP_POWER_STATE_REPORT:SHUTDOWN_PREPARE()
CpmsState
SHUTDOWN_PREPARE
1.1.2: onStateChanged(SHUTDOWN_PREPARE)()
send the state every 2 s, limit to 900 s.
1.1.3: AP_POWER_STATE_REPORT:SHUTDOWN_POSTPONE()
Until all apps are finished
1.1.4: AP_POWER_STATE_REPORT:SUSPEND_ENTER()
CpmsState
WAIT_FOR_FINISH
1.1.5: onStateChanged(SUSPEND_ENTER)()
1.1.4.1: AP_POWER_STATE_REQ:FINISHED()
CpmsState
SUSPEND
WriteStringToFd,(echo mem >
/sys/power/state)
1.1.4.1.1: doHandleDeepSleep, forceSuspend()
1.1.4.1.1.1: autosuspend_force_suspend()
1.1.4.1.1.1.1: force_suspend()
Enter suspend, until
received the signal of
wakeup

Figure 1 STR enters the logic block diagram

- The MCU notifies the SOC to enter suspend
- The SOC Power Manager notifies the app to suspend
- App Finished(close dependent peripherals)
- The kernel of the peripherals closed
- The SOC notifies the MCU that it can proceed to suspend
- The MCU disconnects the peripheral power supply
- MCU goes to sleep

STR Exit

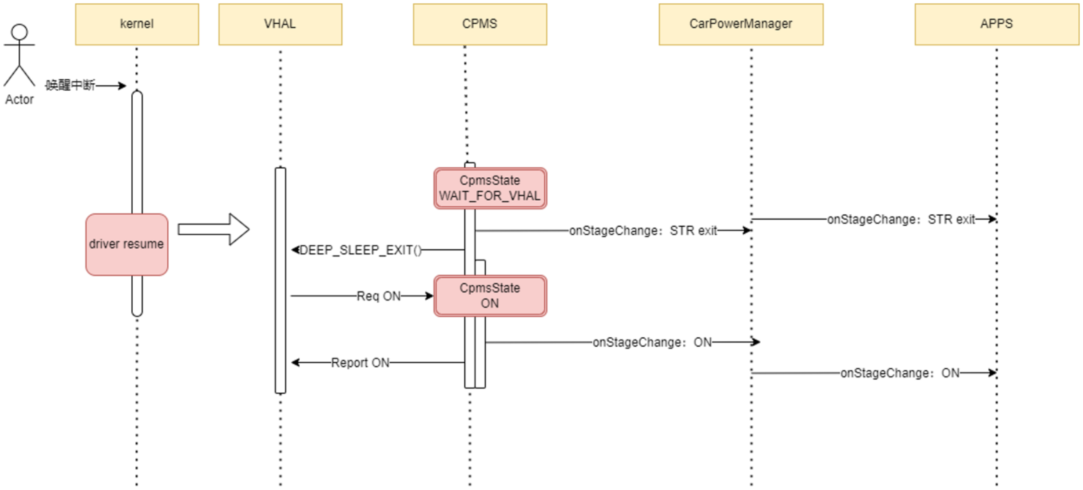


Figure 2 STR exit logic diagram

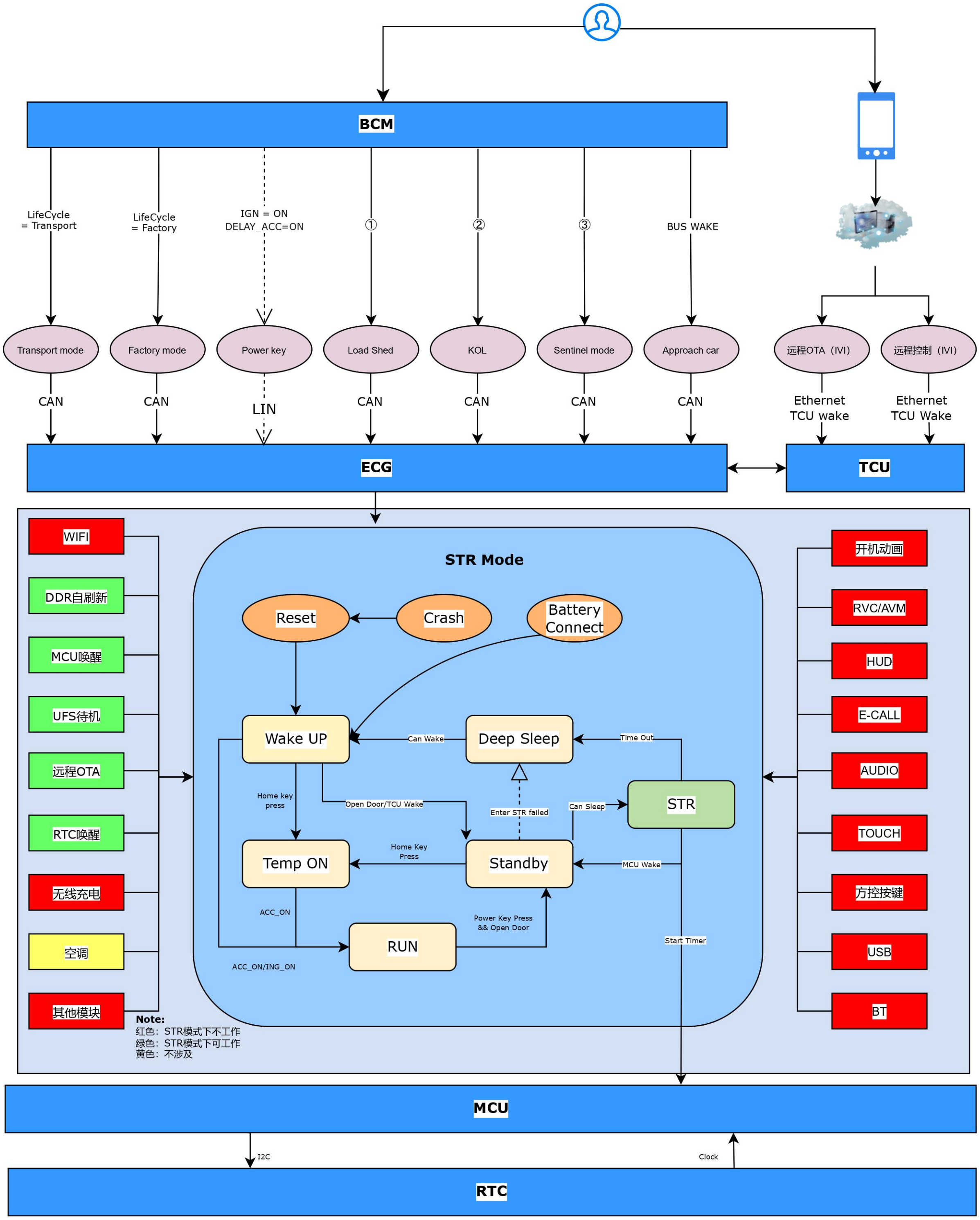
- MCU wakes up/powers on peripherals
- Notify the SOC resume
- SOC CPU wakes up/exits DDR self-refresh
- Kernel peripheral initialization
- The Android system resume
- Android app resume
- The system function returned to normal

4.General Design

The following describes the basic design in STR mode.

4.1 B-Diagram

The following is a B-Diagram in STR modeIt describes the physical modules and abstract modules involved in the function, which can effectively help us identify the boundary range of the function



Note:

① Battery_Mgmt_2 : Batt_Crit_SoC_B = Active' AND 1. '_Battery_Mgmt_2 : Shed_Level_Req = SOON_ENG_OFF' OR 2. '_Battery_Mgmt_2 : Shed_Level_Req = SHED_ENG_OFF'

OR Battery_Mgmt_2 : Shed_Drain_Eng_Off_B = Active' AND 1. '_Battery_Mgmt_2 : Shed_Level_Req = SOON_ENG_OFF' OR 2. '_Battery_Mgmt_2 : Shed_Level_Req = SHED_ENG_OFF

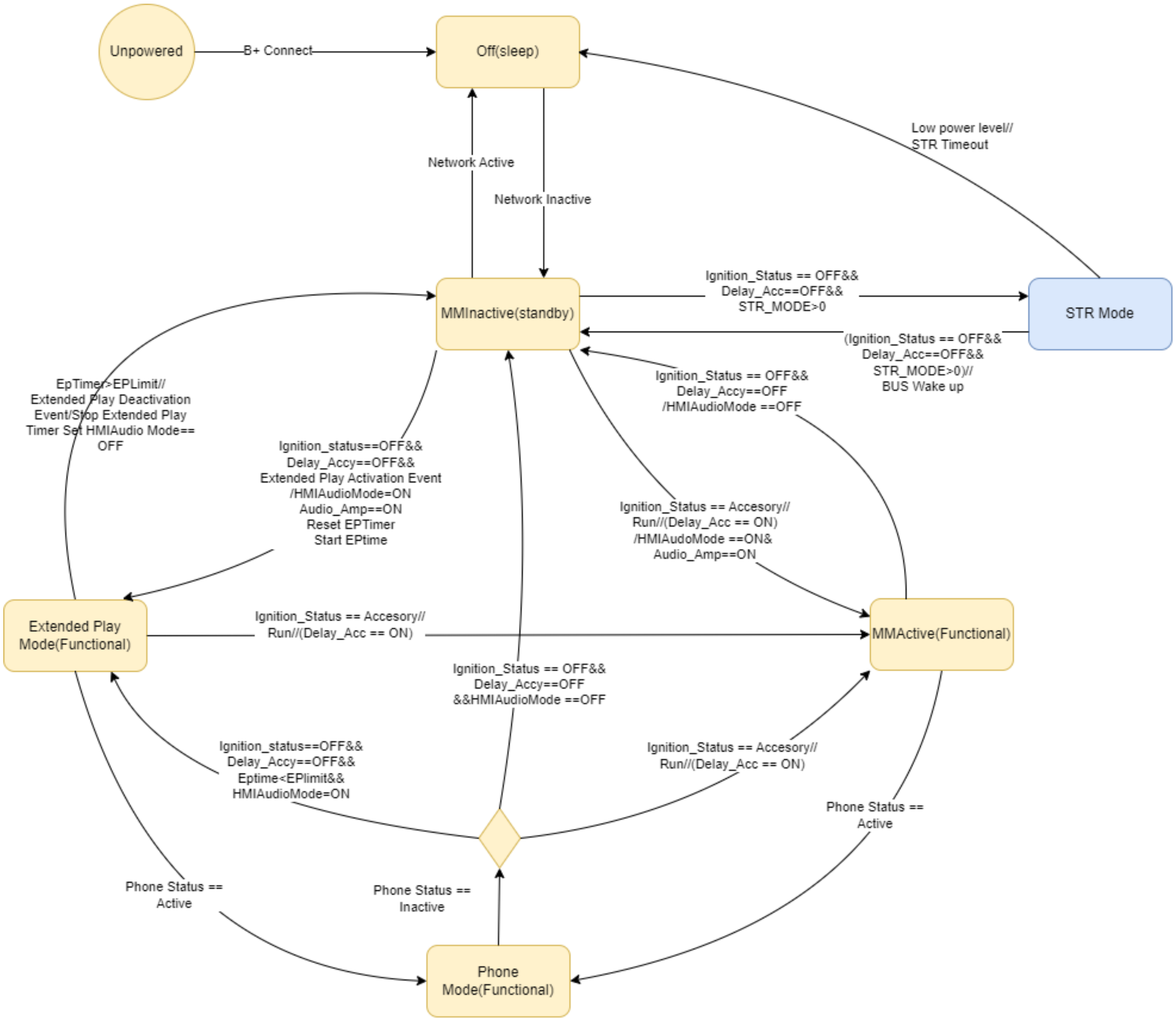
OR Battery_Mgmt_2 : Shed_T_Eng_Off_B = Active' AND 1. '_Battery_Mgmt_2 : Shed_Level_Req = SOON_ENG_OFF' OR 2. '_Battery_Mgmt_2 : Shed_Level_Req = SHED_ENG_OFF

② KeyOffMde_D_Actl =CriticalBattery(40% electric charge) or Hibernate

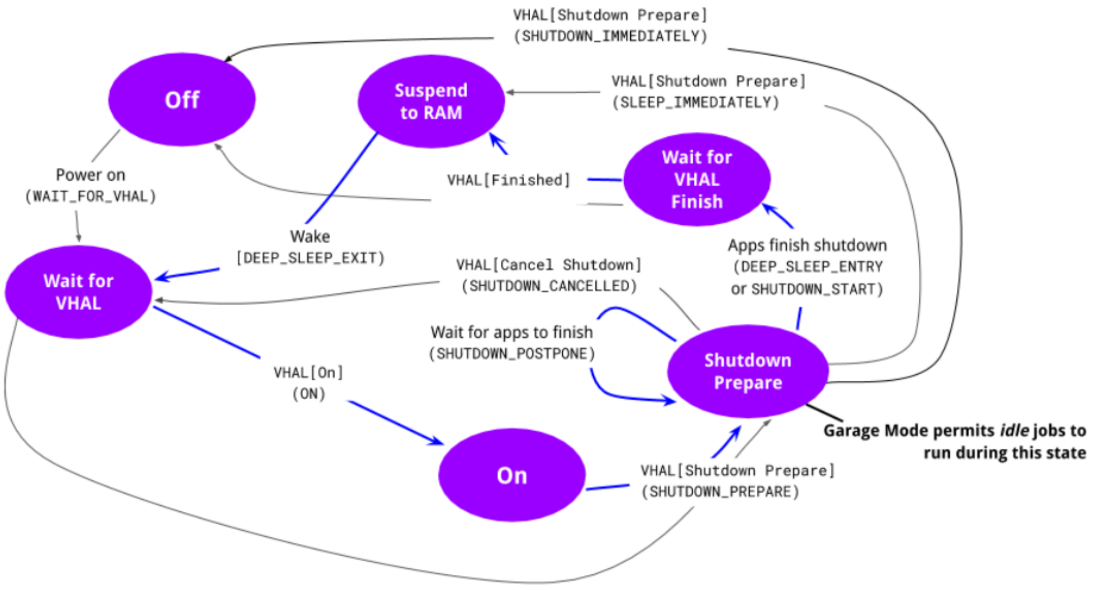
③ Perimeter_Alarm_Status_ET =Activated && PrmtrAlrmEvnt_D_Stat = DF_DOOR

4.2 Generic Diagram

The following is a state flow diagram in STR modebased on the power module's original power mode state machine, it adds a new STR substate



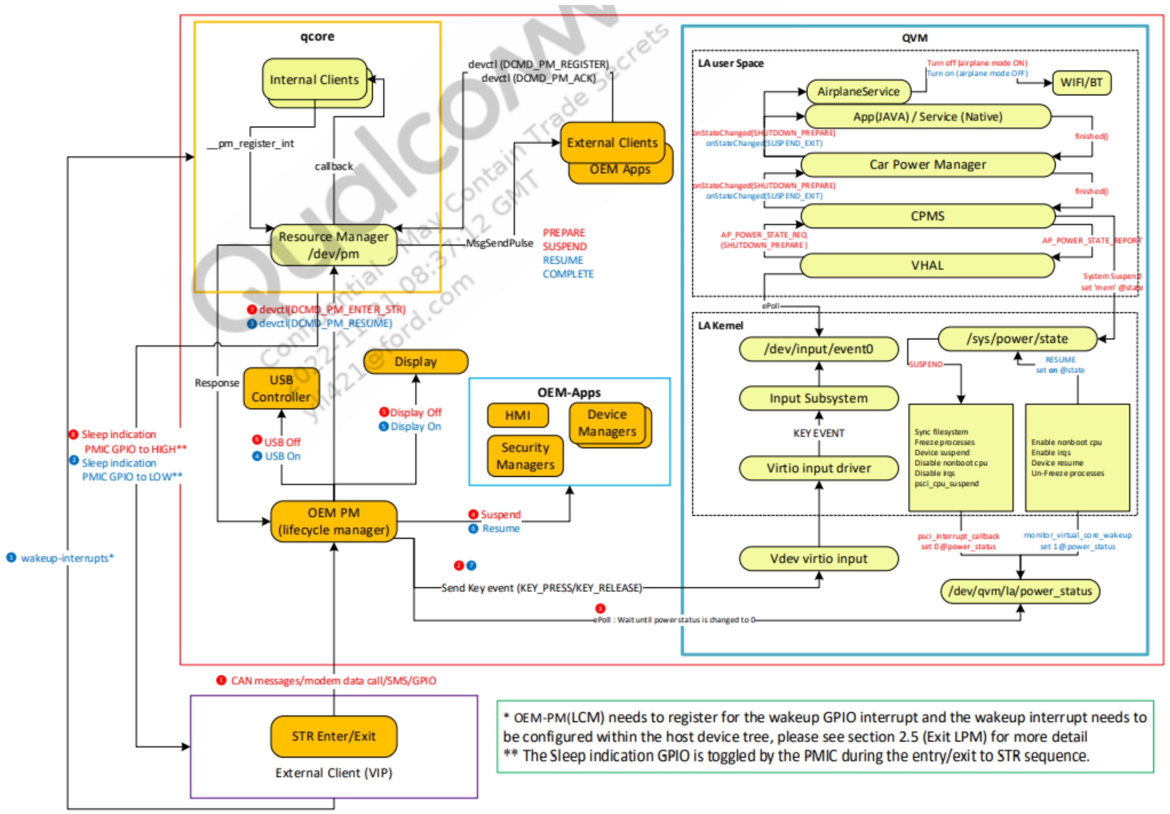
Here is the power management state machine after adding STR mode. The most common state transitions are highlighted in blue.



State	Description
Suspend to RAM	Vehicle and SoC power down. No code is executed. The SoC RAM is still powered on. 1. When the state machine is in the WAIT_FOR_FINISH state, VHAL returns a Finished signal and migrates the state machine to SUSPEND 2. When the state machine is in SHUTDOWN_PREPARE, VHAL returns SLEEP_IMMEDIATELY and the state should be moved to SUSPEND immediately
Wait for VHAL	When the driver interacts with the vehicle (for example, by opening the door), the VMCU supplies power to the SoC. AAOS recovers from the "Hang to RAM" state and enters the "wait for VHAL" state, where it waits to coordinate with VHAL. In addition, when the state machine is in SHUTDOWN_PREPARE, the WAIT_FOR_VHAL state is also re-entered if VHAL tells you to cancel the shutdown.
On	When VHAL returns to the On state, that is, the hardware starts successfully and the state machine enters the ON state to complete power start.
Shutdown Prepare	1. When waiting for VHAL failure, that is, hardware startup failure, directly enter the shutdown preparation state. 2. When VHAL returns to prepare for shutdown, the state machine enters SHUTDOWN_PREPARE. 3. When AAOS still has an application running, CMPS notifies the application to shut down and the state machine stays in SHUTDOWN_PREPARE until there is no more application to shut down. Note 1: When in garage mode, the closed ready state allows idle jobs to be performed. Note 2: When VHAL is unturned, the state moves to WAIT_FOR_VHAL state Note 3: In this state, VHAL will return SLEEP_IMMEDIATELY and SHUTDOWN_IMMEDIATELY signals, and the state machine should change immediately.
Wait for VHAL Finish	At this point, AAOS informs the VHAL that it is ready to shut down. The VMCU is expected to place the SoC in Deep Sleep and to remove power from the Application Processor. AAOS is then in the Suspend-to-RAM state, although no code is being executed.

4.3 Architecture

The following diagram shows a complete sequence of STR entry or exit within QNX and Android. The blue path depicts the wake-up path and red path depicts the suspend path.



* OEM-PM(LCM) needs to register for the wakeup GPIO interrupt and the wakeup interrupt needs to be configured within the host device tree, please see section 2.5 (Exit LPM) for more detail
** The Sleep indication GPIO is toggled by the PMIC during the entry/exit to STR sequence.

Red Zone: QNX&Android   Blue Zone: Android

4.4 Software Design

4.4.1 Android Software Design

To implement shut down and Suspend-to-RAM (STR), Android provides a `CarPowerManagementService` service and a `CarPowerManager` interface.

State transitions are triggered by the Vehicle Master Control Unit (VMCU). To communicate with the VMCU, integrators must implement several components. Integrators are responsible for integrating with the Vehicle Hardware Abstraction Layer (VHAL) and the kernel implementation. Integrators are also responsible for disabling wake sources and ensuring that shutdowns are not postponed indefinitely.

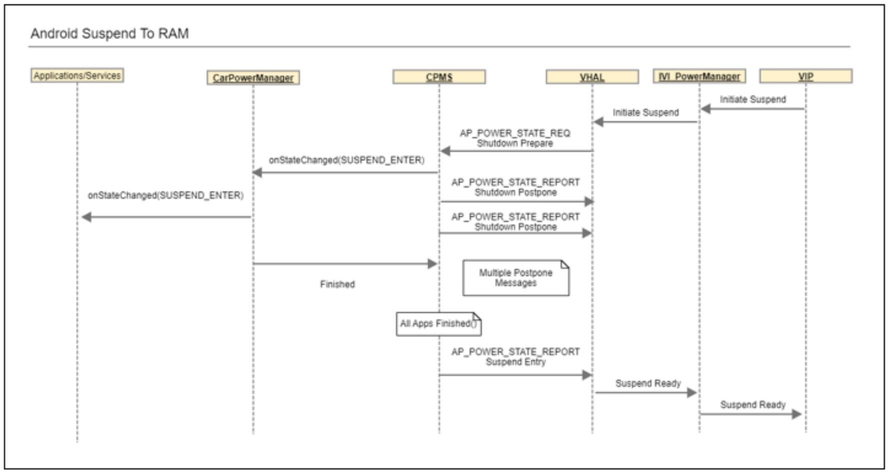
The STR function is implemented in the kernel. This feature is exposed to the user space as a special file located at /sys/power/state. AAOS is suspended by writing mem to this file.

libsuspend is a native library that implements forcesuspend(). This function uses /sys/power/state to suspend AAOS. forcesuspend() can be called from system services, including CPMS.

Only the VIP can initiate deep sleep. Once deep sleep is initiated, the VIP sends a notification to the IVI_PowerManager, IVI_PowerManager sends the notification to CPMS via the VHAL. The CPMS changes the state to SHUTDOWN PREPARE and broadcasts this state transition to all observers (the applications and services that monitor CPMS) by calling the `onStateChanged()` method with a new state ID provided by the CPM.

The CPM mediates between the applications/services and the CPMS. The `onStateChanged()` method for the applications/services is synchronously invoked in the CPM's `onStateChanged()` method. Most applications and services are required to complete their preparation before returning from this call. Privileged services are allowed to continue their preparations asynchronously after returning. In this case, the privileged service calls finish() on the provided CompletableFuture object when it finishes its preparation. While waiting for all preparations to complete, the CPMS periodically sends shutdown postpone requests to the VHAL.

When all CPM objects have completed shutdown preparations, the CPMS sends `AP_POWER_STATE_REPORT` to the VHAL, which then notifies the VIP that the AP is ready to suspend. The CPMS also calls its suspend method, which suspends the kernel with a feature provided by `libsuspend`. This will occur once the SoC-PowerManager instructs the IVI-PowerManager to transition to the suspend state from WAIT_FOR_VHAL.



4.4.2 QNX Software Design

All CPU cores, peripherals, and IP cores are power collapsed, and internal bus clocks are reduced to the lowest frequency. Source crystal (XO) is turned off. All active PMIC regulators are turned off, and only a small range of regulators are active at this moment. Internal VDD_CX and VDD_MX rails are put in Retention mode. Retention mode is the lowest possible voltage level to ensure that the internal memories can retain their contents over the duration of deep sleep. The DDR is put into a Self Refresh mode. System can resume from Suspend to RAM (STR) by a small subset of interrupts. This mode provides the maximum power savings, see SA8155 Current Consumption Data (80-PE986-7) for power consumption numbers on native to-the-metal Android. An important note on QTI's STR implementation is that the contents of IP hardware register states are retained across deep sleep, allowing for fast exit from STR since all IP cores go through a warm-boot instead of a cold-boot sequence. Thus, one or more drivers running on these cores need not perform the expensive step to reprogram the hardware. Typical latencies are in the order of a few ~100 ms. Entry into STR is carried out via PM framework.

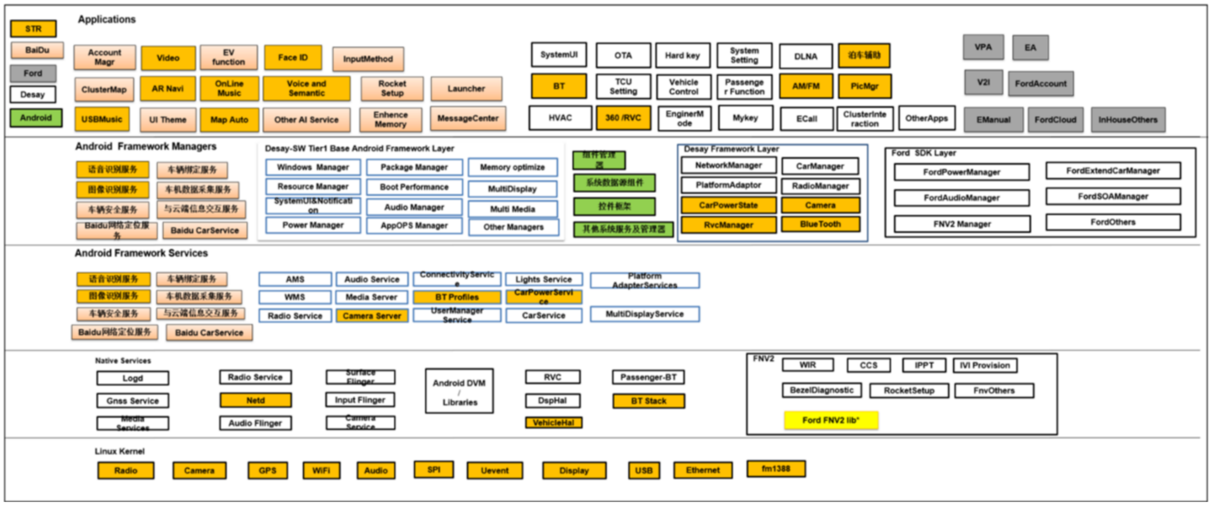
Since the 8155 retains its IP hardware register states during this deep sleep it allows the SOC to execute a warm reset and thus resulting in much faster (a few hundred milliseconds) boot sequence.The process to enter and exit the Suspend-to-RAM (STR) mode is initiated by request to the life cycle manager (LCM) which requests the GVM to suspend, and then passing control to the the qcore power manager interface file devctl (DCMD_PM_ENTER_STR) calls to /dev/pm.

Power Managers on both QNX and Android need to properly shutdown from Suspend To RAM, in order to do so they must wake up from sleep and properly change/transition from SLEEP state to SHUTDOWN state so that the kernel can shutdown gracefully. During normal operations, where Suspend to RAM timer expires and SoC must shutdown:

1. The VIP Must wakeup the SoC
2. The VIP must shutdown the SoC Following the Normal Shutdown sequence as follows:
    a. GPIO identifications:
        i. VIP_PS_HOLD_LOGIC : Low : Used to determine the CCPU has powered down the PMIC.
        ii. VREG_S10C_OP752: 0V , Used to determine the CCPU has powered down the PMIC and the power has reached a low.
    a. Assert a GPIO for few seconds letting SoC know STR to Shutdown is going to happen and then follow hardware power shutdown sequence

4.5 Software Change Scope

According to the evaluation of current Sync+2.0 APIM vendors, the scope of software changes is shown in the following figure:



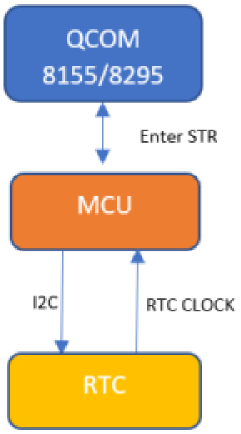
Sync+2.0 APIM vendors comb STR software change scope

As can be seen from the above diagram, STR software changes involve a wide range, including application level, Android Framework service level, and Linux kernel level.

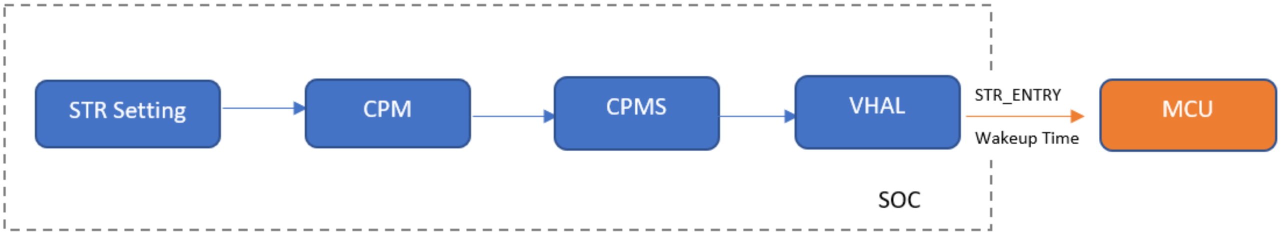
4.6 Hardware Change Scope

To develop STR mode, You need to switch to a chip that supports the related functions, It involves the change of the chip unit module. After entering the STR, a timer is needed to ensure that the STR exits normally within the specified time. The RTC plays a key role as the timing crystal.

4.6.1 RTC architecture



4.6.2 Timing interface



5.Test

Suppliers need to provide relevant test methods, test cases, and test tools (software/hardware) to assist testers to properly test the system into/out of STR mode.

- For abnormal scenarios involved in the test process and those that cannot pass the normal scenario test, relevant methods can be provided to simulate test verification.
- In the process of software development, log specifications need to be formulated to guide the daily development of developers. For key logic /modules, valid logs are recorded and can be output to provide a basis for later problem locating.
- For hardware-related tests, test methods (current and voltage tests) should be provided to guide testers to carry out hardware tests.
- For software performance related testing, it can provide relevant testing tools to monitor performance data and help quickly find performance problems.

5.1 Test Case

The following table is a list of test cases for STR-related functions, mainly includes the following scope:

- Basic Function
- Error Handling
- Configuration
- Interaction
- DTC
- Performance

Ford ICA2..._STR.xlsx

5.2 Scenario Reference

The following table is a list of scenario reference for STR-related functions:

No	Type	Scenario	Handling
1	Special	Enter the STR (sleep) process, Suddenly the door of the ignition/unlock/drive/CAN network activation	MCU immediately reset system Interrupt response, not in the process of current STR scheme into into the time more than 7 s, unable to meet the demand of ignition such as bright screen/wake immediately. To be optimized. For ignition bright screen requirements immediately, strategy is MCU immediately reset system.
2	Special	Guarantee system for a long time don't shutdown system stability	STR automatic shutdown condition persists for more than 30 hours & Enter the STR (sleep) more than 20 times automatic shutdown "shutdown" on a regular basis to ensure the stability of the system. Can be customized according to customer's requirements.
3	Special	The battery supply, Car parking lot outdoor long-term exposure	STR automatic shutdown condition persists for more than 30 hours Under the environment of high temperature, the DDR from refresh consumption current is bigger. High temperature environment will run out of battery power for a long time, need to shutdown strategy control. Can be customized according to customer's requirements.
4	Special	State of the STR, DDR data corruption/change	Can't wake up. Should the system exceptions or actual not met, For verification.
5	FAQ	STR state misjudgment Normal mode of the ADC threshold voltage and STR mode of the ADC ceiling voltage difference is too small	Reduce the judgment STR mode and normal mode of the ADC voltage precision
6	FAQ	STR S10C voltage to 0.5 V System sleep without any exception or error logs, or wake up, but not S10C voltage down to 0.5 V, namely the whole Soc SiP into low power mode	Some equipment resources did not release, causing some subsystem is not idle or gets stuck, but fails to notify the PMIC into low power mode. Need to grab Ramdump to QCOM parsing card where it is. Now encountered this kind of problem scenarios: 1. QNX Kanzi process without releasing the GPU resources; 2. New UART driver instance, link chain UART peripherals occasionally send which UART data when suspend, led to the suspension of UART driver stuck in processing function;

7	FAQ	Enter the STR appear ADSP busy failure QNX qcore dormancy fails, an error waitfor_drv_idle (ADSP) failed, rc = 16	Android has application in the use of ADSP resources or QNX end, cause ADSP subsystem can't enter the idle. Now encountered this problem scenario: the Android unreleased PCM equipment; QNX alarm sound broadcast alarm sound when it enters the STR;
8	Suspend Abnormal	The peripheral power-on sequence is abnormal, causing the Suspend function to fail	Internal STR power timing review, strictly control the timing
9	Suspend Abnormal	Some peripheral drives are abnormal, resulting in excessive static current of STR	You need to consider whether the peripheral supports the low power mode. If it does not support the low power mode, you need to switch the peripheral to the PMIC Separate power control
10	Suspend Abnormal	Related status of the IPCL communication module, such as handshake, is lost, resulting in abnormal Resume status	The state before entering the STR is stored in Retention RAM for data recovery when the MCU exits the STR to wake up
11	Suspend Abnormal	SOC resources are not released in time, resulting in failure to enter STR (such as I2C, file handle, GPU, network, etc.)	Check the resource usage of each application and service and adjust the resource usage according to the actual situation during debugging
12	Resume Abnormal	The peripheral power-on sequence is abnormal, causing the resume to fail	Internal STR power timing review, strictly control the timing
13	Resume Abnormal	kernel crash or panic is caused by bit inversion or unknown abnormal transfer, causing the system to fail to start	Bit flipping is theoretically possible in DRAM with very strong interference, but the probability is very small. You need to pass the super Time mechanism notifies MCU to restart
14	Resume Abnormal	Session recover abnormal	Based on the MCU side, the SoC side application service synchronizes state/mode operation
15	Resume Abnormal	Data synchronization Exception	Body data information shall be subject to MCU data, and synchronous operation shall be performed on SoC side User data, subject to SoC data, will be synchronized to MCU

6.API

System applications and services can be realized through CarPowerManager. CarPowerStateListener state change notification to receive the power. This interface defines a method onStateChanged(), which is a callback function that is invoked when the CPMS power level has changed. The following example defines a new anonymous class that implements this interface:

Example:

```
private final CarPowerManager.CarPowerStateListener listener =
  new CarPowerManager.CarPowerStateListener () {
    @Override
     public void onStateChanged(int state) {
       Log.i(TAG, "onStateChanged() state = " + state);
     }
};
```

When the power state changes, the system calls the onStateChanged() method of the listener object and uses a value to indicate the new power state. The link between the actual value and the state of power supply in CarPowerManager. CarPowerStateListener are defined, as shown in the list below:

Name	Description
ON	Enter the open state. The system is fully functioning.
SHUTDOWN_CANCELLED	The shutdown has been cancelled and the power supply has returned to normal.
SHUTDOWN_ENTER	Shutdown preparations are complete. Enter the shutdown state.
SHUTDOWN_PREPARE	The application should be cleaned up and ready to suspend or close.
SUSPEND_ENTER	Shutdown preparations are complete. Enter the suspended state.
SUSPEND_EXIT	Wake up from a suspended state or resume from a cancelled suspended state.
WAIT_FOR_VHAL	The system is starting, but it is still waiting for the communication with VHAL to be established. After the communication is established, the system can enter the enabled state.

6.1 CarPowerStateListenerWithCompletion description

When this CarPowerStateListener is executed on onStateChange, it notifies the CPMS that the current change has been executed. This is usually used in the SHUTDOWN_PREPARE state, because the Listener of CPMS waits for all WithCompletion completion to complete when the handle shutdown prepare is used.

6.2 Application adaptation

In STR mode, app software adaptation must follow the following principles:

No	Item	Description
1	Interface design	• Interfaces must be encapsulated based on CarPowerManager. • All apps obtain STR power status from the Ford SDK and apply for/release resources. • Interface design requires project compatibility.
2	Recent task clearing policy	Recent Task Cleanup is a built-in feature on Android designed to clear background tasks and free up memory. After entering STR mode, the system needs to use this policy to process the app to ensure that STR mode is entered. Note: System side preferentially covers the adaptation of STR (by killing processes or destroying interfaces)
3	Performance	Ensure that the memory meets the performance requirements of each APP during the STR cycle.
4	UI processing	Exit STR mode, IVI interface starts, car home page back to Launcher application.
5	Abnormal case	Abnormal scenarios in the limit state need to be considered (the rival component state cannot be reached, the interface needs to be refreshed, and the rival component needs to be operated failure, etc.).
6	Compatibility	After the STR is adapted, Applications (whether system applications or third-party applications) can be compatible up or down without compatibility issues. In order to avoid crash, Applications need to catch exceptions on related interfaces.
7	Standard interface adaptation	Some focus state handling (Media, etc.) is handled uniformly by the system side. The application side must comply with standard native interface adaptation.
8	Shutdown strategy	In order to reduce the risk of system crash caused by memory occupation caused by continuous running of apps in the background, defined a clear System memory management scheme. The tentative scheme is: **the infotainment system enter STR mode for 30 times** (this is the tentative scheme, will be based on adjust the system performance test.) Shut down the system, enter the sleep mode, and clear the system memory in a timely manner.
9	Log management	During STR mode adaptation, key logic logs must be embedded and output to the log system.

Here are the strategies to follow for each module.

Module	Pre State	Exit State
USB music	Play	Play is resumed when the conditions are met. Otherwise, there is no audio source by default
	Pause	Pause (this is the logic in the app, hold the pause)
USB video	Play	The video cannot be played in the background and will not be restored
	Pause	The video cannot be played in the background and will not be restored
USB picture	Play	The picture cannot be played in the background and will not be restored
	Pause	The picture cannot be played in the background and will not be restored
FM/AM	Play	The playback will be resumed when the conditions are met
	Search	Interrupt the search and resume the last broadcast
BT	The switch is off	Keep off
	The switch is on	Keep on
	Connect BT	If the conditions for connection back are met, the connection is automatically reconnected
	Incoming Call	Restoring the Call Status
	Outgoing Call	Restoring the Call Status

	On the phone	Call status is restored, but private/speaker mode depends on the phone
	Three-way call	Call status is restored, but private/speaker mode depends on the phone
	BT music playing	Play is resumed when the conditions are met. Otherwise, there is no audio source by default
	BT music pausing	Pause (this is the logic in the app, hold the pause)
Navigation	Navigation broadcast in progress	The navigation information is displayed on the home page card. The navigation application is rolled back to the background and needs to be evaluated
Voice	Voice broadcast in progress	Non-restoring
Instrument	Instrument warning	According to the current vehicle CAN signal triggered, the instrument does not actively recover, regardless of STR
Carplay	CP music playing	The playback will be resumed when the conditions are met
	CP music pausing	The playback will be paused when the conditions are met
	CP on the phone	When the playing conditions are met, the call is resumed, and the private speaker mode is undetermined
	CP Navigation broadcasting	Resume navigation when playback conditions are met
	Cp siri playing	Non-restoring
Online music	Music playing	The playback will be resumed when the conditions are met
	Music pausing	The playback will be paused when the conditions are met
	Video playing	Non-restoring
	Video pausing	Non-restoring
DVR	Recording	External parts, not controlled by the host
	Video playing	Non-restoring
WIFI	Switch off	Keep off
	Switch on	Keep on
	wifi connect	If the conditions are met, the connection is automatically connected
	AP open	Keep open
	AP connect	The behavior of external devices is not controlled by the host
	wifi searching	The behavior of external devices is not controlled by the host
Screensaver	Screensaver interface	Restore to screensaver, exit from screensaver, restore to home page
Front seat/rear seat Bluetooth	Off	Keep off
	On	keep on
	Connect	If the conditions are met, the connection is automatically reconnected
Upgrade	USB upgrade process	During the USB upgrade process, first look at the current performance and then discuss the solution
	OTA upgrade process	OTA upgrade cannot enter STR mode. This scenario does not exist
AVM/RVC	Activate AVM/RVC	The engine cannot be turned off when RVC cannot enter STR. AVM exits after entering STR and does not restore AVM

Here are the examples to follow for some modules(for reference only).

Module	Pre-Condition	Expected Result
Navigation	1. Start the vehicle: Ignition= on, delay acc= on 2. Open the map APP, navigation broadcast 3. Turn off the engine, stop the car, open the door and get off the car	1. Open the car door, get in and light it 2. Start the engine within 4-5s 3.Launcher back to the foreground 4. Click the map menu in the launcher. The map displays the last navigation scene

BT phone	1. Start the vehicle: Ignition= on, delay acc= on 2. Connect the Bluetooth of the mobile phone and make a Bluetooth call 3. Turn off the engine, stop the car, open the door and get off the car	1. Open the car door, get in and light it 2. Start the engine within 4-5s 3. If no Bluetooth phone event occurs at this time, send the Launcher to the front desk. If a Bluetooth phone event occurs at this time, keep the BT phone in the foreground
BT Music	1. Start the vehicle: Ignition= on, delay acc= on 2. Connect the Bluetooth of the mobile phone and make a Bluetooth call 3. Turn off the engine, stop the car, open the door and get off the car	1. Open the car door, get in and light it 2. Start the engine within 4-5s 3. Automatically connect the launcher to the foreground and restore the last source (relying on the status of the mobile phone music player)
E-Manual	1. Start the vehicle: Ignition= on, delay acc= on 2. Open the electronic manual, click the trunk door on the car body, and the pop up window will appear 3. Turn off the engine, stop the car, open the door and get off the car	1. Open the car door, get in and light it 2. Start the engine within 4-5s 3. Send launcher to the foreground, click the electronic manual again, and expect unnecessary pop-ups to disappear (depending on the business logic of each APP)

Application Kill Strategy

The system processes applications according to the latest task clearing policy. The current policy mainly divides apps into three categories:

- System not processing: The system does not remove the UI or destroy the process.
- The UI to be removed: UI removed and the process still alive.
- System kill process: The system will destroy the process.

Each business party needs to calculate the current scope of their own application, Based on the premise that the system processes application policies, applications that still do not meet the STR specification need to be individually adapted.

7.Signal

The following is how typical signals in power mode work in STR mode.

7.1 Load Shed and KOL Strategy

- When the APIM is in load shed mode, STR should not be requested.
- After APIM entering STR mode, if the vehicle low battery event occurred, BCM sets KeyOffMde_D_Actl = CriticalBattery during ignition off when SOC falls below calibratable value (e.g. KOL:30%/LoadShed:40%). When this is set, BCM wakes up CAN bus to Tx this signal to other modules, then APIM will exit STR mode and enter deep sleep when CAN bus stop.
- CAN Message:

  Load Shed:
  Battery_Mgmt_2 : Batt_Lo_SoC_B = Active' AND
  1. '_Battery_Mgmt_2 : Shed_Level_Req = SOON_ENG_OFF' OR
  2. '_Battery_Mgmt_2 : Shed_Level_Req = SHED_ENG_OFF'

  OR
  Battery_Mgmt_2 : Batt_Crit_SoC_B = Active' AND
  1. '_Battery_Mgmt_2 : Shed_Level_Req = SOON_ENG_OFF' OR
  2. '_Battery_Mgmt_2 : Shed_Level_Req = SHED_ENG_OFF'

  OR
  Battery_Mgmt_2 : Shed_Drain_Eng_Off_B = Active' AND
  1. '_Battery_Mgmt_2 : Shed_Level_Req = SOON_ENG_OFF' OR
  2. '_Battery_Mgmt_2 : Shed_Level_Req = SHED_ENG_OFF

  OR
  Battery_Mgmt_2 : Shed_T_Eng_Off_B = Active' AND
  1. '_Battery_Mgmt_2 : Shed_Level_Req = SOON_ENG_OFF' OR
  2. '_Battery_Mgmt_2 : Shed_Level_Req = SHED_ENG_OFF

  KOL :Body_Info_7 : KeyOffMde_D_Actl = CriticalBattery or Hibernate

7.2 Life Cycle Strategy

- When the life cycle of the vehicle is transport or factory, STR should not be requested.
- CAN Message:

Body_Info_3:LifeCycMde_D_Actl = Factory or Transport

8.Other

8.1 OTA Capability

- The introduction of STR function involves the coordinated change of hardware and software (SOC/MCU) side. APIM suppliers need to ensure that STR function can be implemented in stages, adopting hardware first/embedded, software with STR/ without STR function can be compatible with hardware and can be executed through configuration opening.
- In addition to STR hardware, other MCU/SOC firmware and software components, APIM vendors need to ensure that software updates /configuration updates can be done over the OTA to enable STR functionality in both user and factory vehicles.

Pre-Condition	Evaluation of key modules	Demand
• The hardware itself supports STR-related design requirements • The software does not support STR mode • Make the software support STR function through OTA	• MCU ◦ All modification modules involved in STR can be OTA upgraded • SOC ◦ Partition table cannot be OTA upgraded: STR is not involved ◦ DATA partitions cannot be OTA upgraded: STR/ non-STR compatibility can be maintained by software logic design, and DATA can be clarified by post-OTA master reset if necessary ◦ MAP partition cannot be OTA upgraded: STR is not involved ◦ BSP: All modules can be upgraded OTA ◦ Framework: All modules can be upgraded OTA ◦ APP: All modules can be upgraded OTA • OTA ◦ When MCU and SOC are upgraded separately, power management design needs to be reserved in advance to ensure normal operation after unilateral access to STR	• The overall risk is manageable and STR functionality can be supported through OTA upgrades

For OTA support, developers need to consider the following scenarios. In these upgrade scenarios, ensure that there is no compatibility problem after the upgrade. If the upgrade fails, you need to roll back the version:

- Single SoC OTA upgrade
- Single MCU OTA upgrade
- SoC+MCU combined with OTA upgrade

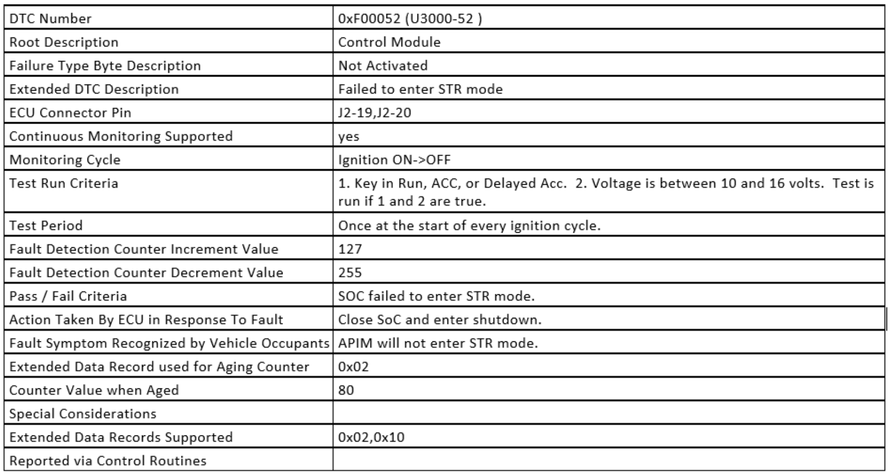
For OTA, the order is to update MCU first and then SoC.

8.2 DTC

When the STR fails to enter or exit, the DTC error code and the cause of the error are reported, which can help users quickly identify the current status of the vehicle and effectively solve the problem. (Part spec prevails, See the Part spec documentation for details)

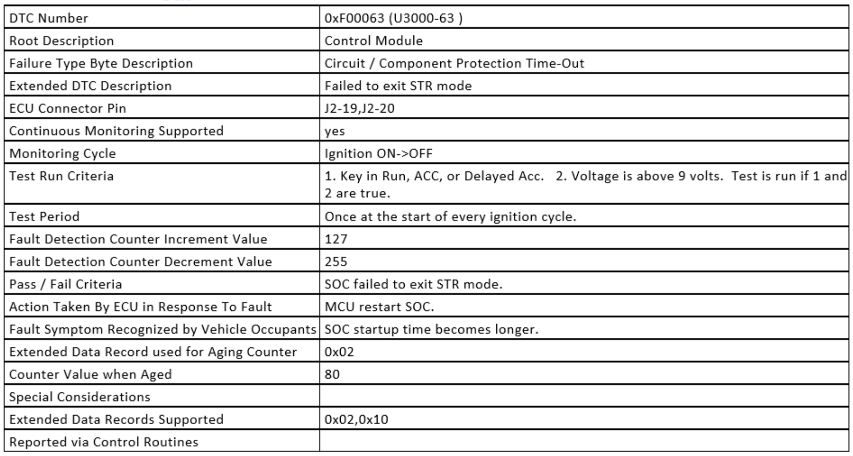
Number	Display Number	Name	Extended Name
0xF00052	U3000-52	Control module system internal failure	STR entered failure
0xF00063	U3000-63	Control module circuit/protection time out	STR exited failure

3.5.7.116. DTC 0xF00052 - Control Module Not Activated



DTC Number	0xF00052 (U3000-52)
Root Description	Control Module
Failure Type Byte Description	Not Activated
Extended DTC Description	Failed to enter STR mode
ECU Connector Pin	J2-19,J2-20
Continuous Monitoring Supported	yes
Monitoring Cycle	Ignition ON->OFF
Test Run Criteria	1. Key in Run, ACC, or Delayed Acc. 2. Voltage is between 10 and 16 volts. Test is run if 1 and 2 are true.
Test Period	Once at the start of every ignition cycle.
Fault Detection Counter Increment Value	127
Fault Detection Counter Decrement Value	255
Pass / Fail Criteria	SOC failed to enter STR mode.
Action Taken By ECU in Response To Fault	Close SoC and enter shutdown.
Fault Symptom Recognized by Vehicle Occupants	APIM will not enter STR mode.
Extended Data Record used for Aging Counter	0x02
Counter Value when Aged	80
Special Considerations	
Extended Data Records Supported	0x02,0x10
Reported via Control Routines	

3.5.7.117. DTC 0xF00063 - Control Module Circuit / Component Protection Time-Out



DTC Number	0xF00063 (U3000-63)
Root Description	Control Module
Failure Type Byte Description	Circuit / Component Protection Time-Out
Extended DTC Description	Failed to exit STR mode
ECU Connector Pin	J2-19,J2-20
Continuous Monitoring Supported	yes
Monitoring Cycle	Ignition ON->OFF
Test Run Criteria	1. Key in Run, ACC, or Delayed Acc. 2. Voltage is above 9 volts. Test is run if 1 and 2 are true.
Test Period	Once at the start of every ignition cycle.
Fault Detection Counter Increment Value	127
Fault Detection Counter Decrement Value	255
Pass / Fail Criteria	SOC failed to exit STR mode.
Action Taken By ECU in Response To Fault	MCU restart SOC.
Fault Symptom Recognized by Vehicle Occupants	SOC startup time becomes longer.
Extended Data Record used for Aging Counter	0x02
Counter Value when Aged	80
Special Considerations	
Extended Data Records Supported	0x02,0x10
Reported via Control Routines	

Revision logs

No	Person	Date	Change description
1	Li Yongcun (YLI421)	2022-11-01	Draft 1st version of Ford STR SPSS
2	GaoLing(LGAO31)/Li Yongcun(YLI421)/Liu Shiwang(SLIU141)	2022-11-21	Update the STR adaptation policy
3	GaoLing(LGAO31)/Li Yongcun(YLI421)/Liu Shiwang(SLIU141)	2022-12-06	Added DTC description and updated adaptation policy
4	GaoLing(LGAO31)/Li Yongcun(YLI421)/Liu Shiwang(SLIU141)	2023-01-10	STR scheme update
5	GaoLing(LGAO31)/Li Yongcun(YLI421)/Liu Shiwang(SLIU141)	2023-02-09	• Added the description of APP processing policy • Define the final DTC