

HL7900 Low Power Modes

APPLICATION NOTE

1 Introduction

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1.1 Overview

The HL7900 supports 3GPP power saving features (PSM, eDRX), implements low power modes, and provides configuration settings to optimize power consumption.

This document supplements the "3GPP Power Saving Features" section of the HL7900 Product Technical Specification. It provides detailed descriptions, usage instructions and use cases for the following features and low power modes:

- [3GPP Power Saving Features](#):
 - [eDRX](#) (extended DRX) — Low power consumption DRX extension for host applications that must be reachable but can tolerate extended sleep cycles (e.g. long receive latency periods).
 - [PSM](#) (Power Saving Mode) — Low power consumption feature for host applications that send mobile originated (MO) data at extended intervals (e.g. several hours, days, or weeks) and do not need to be reachable during those intervals.
- Low Power Modes:
 - [Sleep Mode](#) — Basic low power mode
 - [Lite Hibernate Mode](#) — Intermediate low power mode
 - [Hibernate Mode](#) — Lowest power mode

1.2 Differences Between HL78xx and HL7900

There are some differences between HL78xx and HL7900, including:

1. Semiconductor difference and CPU efficiency instructions used — HL7900 is ARM-based while HL78xx is MIPS-based, so the current consumption is lower in the HL7900. For power measurement details, see [Current Consumption](#).
2. System Resource Management (SRM) component introduced — In HL78xx, user can set the lowest system power mode setting. In HL7900, users can only control application processor power mode setting and SRM decides the system power mode.

- Improved HL7900 AT commands compatible with HL78xx — Please see the HL7900 AT Command Reference Guide for details.

2 3GPP Power Saving Features

HL7900 modules support 3GPP advanced power saving features — eDRX (extended DRX) and PSM (Power Saving Mode).

2.1 eDRX

Extended Idle DRX (I-eDRX) is a 3GPP-specified extension of the Discontinuous Reception (DRX) low power consumption feature. This extension reduces the number of paging messages the module must monitor while remaining in idle state, resulting in a corresponding decrease in power consumption at the cost of increasing receive latency.

In eDRX, the module monitors only the paging opportunities that occur in a Paging Time Window (PTW) and then enters eDRX Sleep before the next PTW. During eDRX Sleep, the module may enter a very low power state for power savings. This sequence (eDRX PTW followed by eDRX Sleep) comprises a single eDRX cycle.

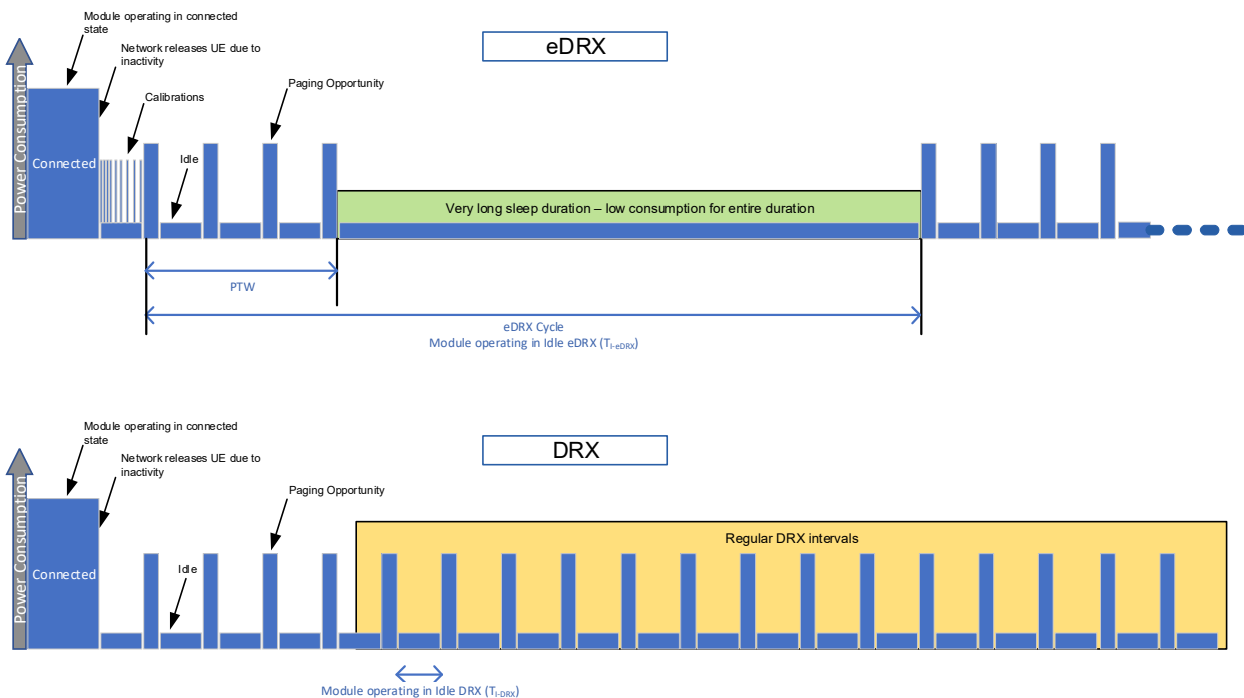


Figure 1: eDRX vs DRX comparison

The eDRX cycle length (T_{I-eDRX}) is negotiated between the module and the network during Attach and TAU procedures. The module requests a preferred cycle when enabling eDRX, and the network replies with two parameters:

- T_{I-eDRX} – Actual eDRX cycle length to be used

T_{I-eDRX} can be set from 5.12–2621.44 seconds (~44 minutes) in LTE M and from 20.48-10485.76 seconds (~175 minutes) in NB IoT. The requested value is configured by the customer using the +CEDRXS command, and the negotiated eDRX values (T_{I-eDRX} and T_{P-TW}) are read using the +CEDRXRDP command.

Note: While the module is in I eDRX, it periodically wakes very briefly to calibrate its internal clock with the network. These calibrations are much shorter than a regular paging opportunity and the module is not reachable during the calibration. After RRC is released, calibrations initially occur at ~10 s intervals, increasing slowly up to T_{I-eDRX} , whichever is shorter. See [Calibration Procedure](#) for details.

The length of time a network holds data for the module is network-dependent. If it is determined that the network is not holding some data for the module, use AT+CEDRXS to set a shorter T_{I-eDRX} value.

- T_{P-TW} – Paging time window length

The module remains in I-eDRX until it detects a paging message from the network during a paging opportunity, or needs to access the network (to make a data connection, send a mobility TAU or periodic TAU, etc.), at which time it returns to the connected state.

Note: Low power modes (i.e. Sleep, Lite Hibernate, Hibernate) do not affect eDRX settings and functionality.

2.2 PSM

PSM (Power Save Mode) is a 3GPP feature that allows the module to minimize power consumption by entering a very low power state while remaining registered with an LTE network. This mode is useful for applications that do not need to be reachable by the network, or can tolerate extremely high receive latency.

PSM behavior depends on two timers – the PSM Timer (Extended T3412 – extended periodic TAU timer) and the PSM Active Timer (T3324). The module requests PSM (with its preferred Extended T3412 and T3324 values) in an ATTACH or TAU (Tracking Area Update) procedure to the network, and the network either accepts the request (using the module's preferred values or network-specified ('negotiated') values) or rejects it (in which case PSM is not enabled).

If the network accepts the PSM request:

1. The network saves module state information and the module remains attached (registered) to the network.
2. The network releases the RRC session, which starts the Extended T3412 and T3324 timers.
3. The module enters the PSM active state. In this state, it can receive/send packets from/to the network. The module stays in PSM Active State until T3324 expires.

Note: If T3324 is long enough, enabling eDRX may result in additional power savings during Active time.

4. The module enters the PSM dormant state. In this state:
 - The module is not reachable by the network.
 - The module can enter a very low power state mode (e.g. Lite Hibernate, Hibernate) for improved power savings.
 - The host application can wake the module to send mobile-originated data. If this happens:
 - i. The host application must wait until it receives a %CPSMSU URC before attempting data transmission.
 - ii. The module enters the connected state to send the data. After the data session finishes, the module moves back to step 2.

- The module can disable PSM or change PSM parameters , which triggers a TAU procedure. If this happens, the module enters the connected state, does the TAU procedure, and then:
 - If PSM is disabled, the PSM operation is terminated.
 - If PSM is still enabled, the module moves back to step 2.

Note: While in dormant state, the network does not hold any data packets being sent to the module (i.e. mobile-terminated packets).

5. If the host application does not send data or perform any network activity before Extended T3412 expires, the module automatically sends a periodic TAU to the network:
 - If the network receives the TAU, the module enters the connected state. After the TAU procedure completes, the module moves back to step 2.
 - If the network does not receive the TAU, it detaches the module (the module's state information is removed) and the module must reattach to the network before sending data.

A host application enables and configures PSM using the AT+CPSMS command (see [+CPSMS \(Power Saving Mode Setting\) AT Command](#)). This configuration is persistent on the module. The module requests the PSM configuration in its ATTACH or TAU request. The host application only needs to configure once (or to change the configuration).

Table 2 describes characteristics of the PSM timers.

Table 2: PSM Timer Characteristics

Timer/ Characteristics	Details
T3324 (Active Timer)	Duration the module must be idle (eDRX or DRX mode with no Rx/Tx activity) before it enters PSM dormant state.
Timer starts (at 0)	The timer (re)starts at 0 s each time the module enters idle state (after the network releases the RRC session).
Timer stops	The timer stops in the following ways: <ul style="list-style-type: none"> ▪ Before it expires, when any data transfer (Rx/Tx) interrupts the idle state. The RRC session begins. ▪ When it expires. The module enters PSM dormant state.
Selecting appropriate timer value	Considerations: <ul style="list-style-type: none"> ▪ The requested timer value should be long enough to allow the module to send a packet to a server and receive a reply before entering PSM dormant state. If the timer is too short, the module will enter PSM dormant state before receiving the reply and the packet will be lost (since networks typically do not hold mobile-terminated packets for later transmission). ▪ Select the shortest suitable timer to reduce current consumption.
Extended-T3412 (Extended Periodic TAU Timer)	Maximum duration the module can remain attached to the network without transmitting (i.e. in a data session or TAU procedure). <i>Note: For DRX and eDRX, the network typically specifies the basic periodic TAU timer (T3412) value to use. However, if the network instead provides the extended-T3412, the module will use that value.</i> When enabling PSM, the module specifies the preferred extended-T3412 value and the network replies with both the negotiated extended-T3412 and the basic network-specified T3412. The module will always use the extended-T3412 for PSM.
Timer starts (at 0)	The timer (re)starts at 0 s each time the module enters idle state (after the network releases the RRC session).

Table 2: PSM Timer Characteristics (Continued)

Timer stops	<p>The timer stops in the following ways:</p> <ul style="list-style-type: none"> ▪ Before the timer expires, if the host application wakes the module to request that it send mobile-originated data to the network. ▪ Before the timer expires, if the host application uses the +CPSMS AT command to update the configuration with new preferred values. The module sends the new preferred values to the network to negotiate the new values and update the timers. ▪ When the timer expires, the module automatically wakes and sends a periodic TAU message to the network. <p>In each case, the timer restarts at 0 when the module re-enters idle state.</p>
Selecting appropriate timer value	<p>Considerations:</p> <ul style="list-style-type: none"> ▪ Requested timer value should typically be much longer than the expected interval for sending mobile-originated data to the network. This ensures the module does not waste current by waking to send a periodic TAU and then waiting in RRC idle mode before returning to PSM dormant state. ▪ There is no problem with requesting a very long (or maximum) duration. If the network does not support the requested value, it may use a shorter 'negotiated' value. ▪ Networks may not support abnormally short requested timer values. If the network does not support the requested value, it may use a longer 'negotiated' value or not enable PSM.

2.2.1 Typical PSM Operations

A typical PSM use case is a host application that infrequently sends mobile-originated data to the network and does not need to be reachable for long periods. One example would be a battery-powered device that collects data from a remote sensor and then transmits it to the network.

For the purpose of this use case, assume:

- Maximum time expected between remote sensor data reports — 34 hours
- Maximum idle time (the longest period the module should remain reachable from the network (after RRC is released) without being contacted) — 20 seconds

Based on those parameters, the module must set appropriate preferred PSM values:

- Active Timer (T3324) — Set to 20 seconds. A longer timer would increase power consumption by remaining in idle mode longer than necessary to receive a possible data transmission from the network.
- Periodic TAU cycle timer (Extended T3412) — Set to maximum allowed value and the network will return the negotiated value. Setting a shorter timer (close to expected sensor reporting period) could result in the timer expiring, forcing a TAU transmission. Setting a longer timer results in the host application waking up and transmitting only when sensor data is received.

Note: In a typical PSM use case, the extended T3412 should be configured much longer than the data transaction interval so that no TAU procedure is needed (since each TAU increases total power consumption).

Figure 3 illustrates this use case:

Time T0 — Module boots and attaches to network.

Time T1 — Module drops to Idle state, T3324 and Extended T3412 start at 0.

Time T2 — Nothing received from network, T3324 expires, module drops to PSM dormant state.

(Note – WAKEUP is low.)

Time T3 — Host application receives sensor data that is to be sent to the network server.

Time T4 — Host application asserts WAKEUP (High). Module wakes and Extended T3412 stops. After UART1_CTS signal is active, module issues AT commands (e.g. +KTCPSND, +KUDPSND) to send data to network. (Refer to the HL7900 AT Command Reference Guide for examples.)

Time T5 — Module drops to Idle state, T3324 and Extended T3412 restart at 0.

Time T6 — Nothing received from network, T3324 expires, module drops to PSM dormant state.

Note: WAKEUP is deasserted (low) after AT commands are complete.

Time T7 — Remote sensor had no data to send, no data received. Extended T3412 expires, module wakes up and sends TAU to network.

Time T8 — Module drops to Idle state, T3324 and Extended T3412 restart at 0.

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For signal state details of this use case, see [PSM Typical Use Case – Data Transmission Initiated by Host](#).

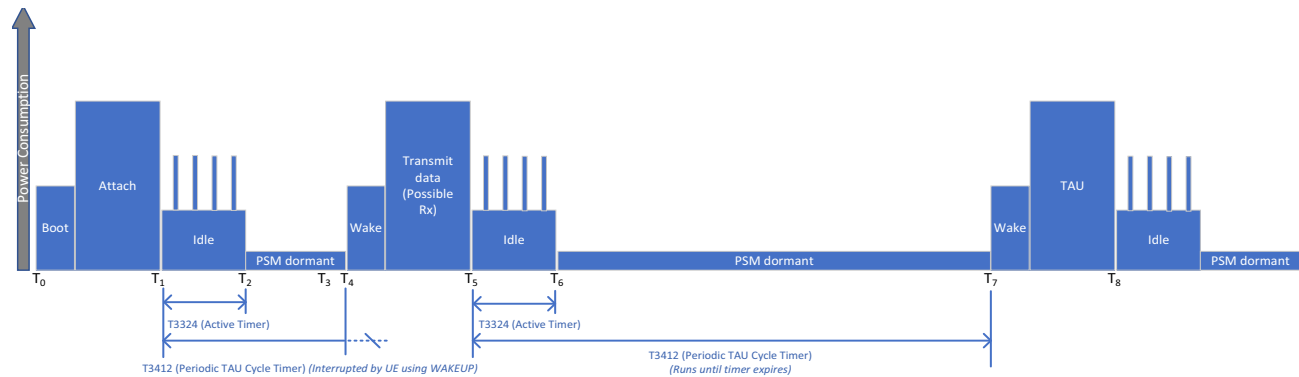


Figure 3: Power Saving Mode – Typical Use Case Example

A variation of this use case is to have the host application periodically wake the module (before the Extended T3412 timer expires) to send a polling packet to the network to check if the network requires the module to be accessible. (The packet could contain sensor data, host application and/or module diagnostic information, or other useful information.) If the network responds that it needs the module to leave PSM mode and remain accessible, the module can then switch to eDRX mode, which provides low-power benefits but remains accessible (unlike PSM).

2.3 Concurrent PSM and eDRX

eDRX and PSM can be concurrently enabled to further decrease the module's current consumption, as compared with the current consumption of the module operating with only PSM enabled. In this configuration, when the module transitions from the connected state to the idle state, it enters eDRX for the duration of the Active Timer (T3324) window of PSM.

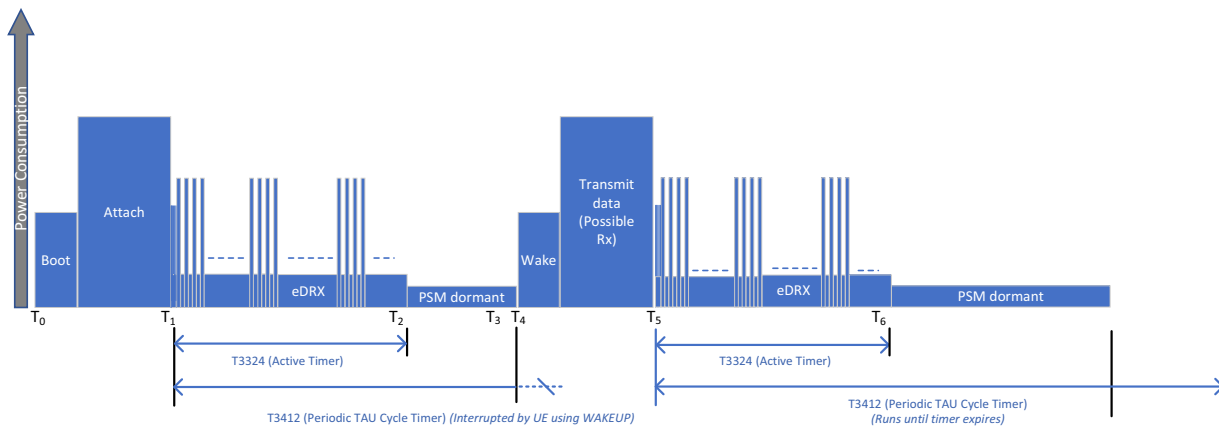


Figure 4: Concurrent PSM and eDRX

For example, if PSM and eDRX are configured with the following settings:

- PSM:
 - T3412 (PSM Timer) — 86400s (24 hours)
 - T3324 (Active Timer) — 327.68s (~5.5 minutes)
- eDRX:
 - eDRX cycle time — 81.92s

Assuming the network does not attempt to contact the module after the module leaves the connected state and enters PSM idle state:

- The module will stay in the idle state for 327.68 seconds (the Active Timer).
- While in the idle state, the module will:
 - a. Remain in eDRX power saving mode for 4 cycles of 81.92 seconds each.
 - b. Go to PSM dormant state for ~23h55m until the T3412 timer expires.
 - c. Wake and send a periodic TAU, and then the PSM process repeats.

2.4 RAI

In 3GPP, Release Assistance Indication (RAI) is a 3GPP feature that indicates network release in the RRC connection. The RAI feature can improve module power consumption. In HL7900, a provision was made to indicate RAI combined with the UDP transmission. Note that the RAI function works when CIOT CP is used to transfer user data (in HL7900, CIOT CP is default disabled for Cat-M and default enabled for NB-IoT).

In the default settings, the RAI feature is disabled. The host can enable the RAI feature by the AT command `AT%RAISET=x` before the UDP sending AT command. When enabling RAI, the network will send RRC release to the module after the last UDP packet sending (Last UL) or last UDP packet receiving (Last UL and single DL) depending on what `AT%RAISET` sets. The module immediately goes to sleep.

2.4.1 AT Command Examples showing RAI Features

CAT-M

/* CloT EPS optimization for Cat-M as it is default disabled, need to be run each time upon bootup*/

```
AT+CCIOTOPT=0,1
```

NB-IoT

```
AT+CGDCONT=1,"IP","internet"
```

```
AT+KCNXCFG=1,"GPRS","internet"
```

```
AT+KUDPCFG=1,0,0,1
```

Last UL

/* Below are pair command, AT%RAISET=1 need to be run every time before +KUDPSND */

```
AT%RAISET=1 /* Last UL */
```

```
AT+KUDPSND=1,"flake.legato.io",6005,10
```

Last UL and single DL

/* Below are pair command, AT%RAISET=2 need to be run every time before +KUDPSND */

```
AT%RAISET=2 /* Last UL and single DL */
```

```
AT+KUDPSND=1,"flake.legato.io",6000,10 /* port 6000 is echo server*/
```

NB-IoT:

```
AT+KUDPCFG=1,0,0,1
```

Last UL:

/* Below are pair command, AT%RAISET=1 need to be run every time */

```
AT%RAISET=1 /* Last UL */
```

```
AT+KUDPSND=1,"flake.legato.io",6005,10
```

Last UL and single DL:

/* Below are pair command, AT%RAISET=2 need to be run every time */

```
AT%RAISET=2 /* Last UL and single DL */
```

```
AT+KUDPSND=1,"flake.legato.io",6000,10 /* port 6000 is echo server*/
```

3 Power Modes

The HL7900 module operates in the following power modes – Running (i.e. active), and low power modes (Sleep, Lite Hibernate, Hibernate, OFF), as described in 6.1 Power Mode Descriptions. Power consumption is greatly reduced by integration of the 3GPP power saving features (PSM and eDRX) with the low power modes.

3.1 Power Mode Descriptions

The HL7900 module supports operation in the following power modes:

- Running ([Running Mode](#))
- Low power modes
 - Sleep ([Sleep Mode](#))
 - Lite Hibernate ([Lite Hibernate Mode](#))
 - Hibernate ([Hibernate Mode](#))
 - OFF ([OFF Mode](#))

The AT+KSLEEP command is used to enable the lowest possible power mode that the module can enter – for example:

- If Lite Hibernate is enabled, the module could go to Sleep or Lite Hibernate, but never Hibernate.
- If Hibernate is enabled, the module could go to any low power mode (Sleep, Lite Hibernate, Hibernate).

For details, refer to the HL7900 AT Command Reference Guide.

3.2 Module Subsystems

The HL7900 is composed of three main subsystems:

- Modem
- Application
- System Resource Manager (SRM)

3.2.1 Modem Subsystem

The modem subsystem runs the LTE M/NB IoT protocol stack, physical layer and RF.

The subsystem will be in one of the following states, as defined by the 3GPP specification:

- OFF — Modem is turned off, SIM is not powered (AT+CFUN=0)
- Flight mode — Modem is turned off, SIM is powered (AT+CFUN=4)
- Connected — Modem has an active connection with the network for signaling or data exchanges.
- C-DRX/C-eDRX — Modem maintains active connection while entering short sleep cycles to reduce power consumption.
- DRX sleep — Modem is registered to the network but with no active connection and periodically listens to the network for paging.
- eDRX sleep — Same as DRX sleep state but modem listens less frequently to the network for paging.
- PSM dormant state — Module is registered to the network with a successful PSM negotiation and is in a dormant state.
- Out of coverage — Modem is not registered to the network due to lack of coverage.
- Searching mode — Modem performs periodic scans to find a suitable network after power on or after network coverage is lost.

3.2.2 Application Subsystem

The application subsystem runs services such as TCP/IP stack, AT commands service and controls the host interfaces such as UART1 and GPIOs. The application subsystem will be in one of the following states:

- Active — Data or AT commands are being processed.
- Stop — The processor becomes idle and the processor is running at 32KHz.
- Standby — RTC, I/O states, 32KHz crystal are ON. Others are OFF.
- Shutdown — RTC, 32KHz crystal are ON. Others are OFF.

3.2.3 System Resource Manager

The system resource manager manages all the power saving activities and decide which the system power mode is used. It also controls which power domain is powered or not powered (see [System Power Domains](#) for power domain list). The system power mode will be in one of the following modes:

- Active — running
- Sleep — medium system power, very fast entry and recovery time.
- Lite hibernate — low system power, GPIO logic is retained, system can be woken up by UART1_DTR.
- Hibernate — lowest system power, GPIO logic is not retained.

Voting Mechanism

Application and modem subsystem have their own power states. The system resource manager (SRM) evaluates the power mode voting requested by application and modem, selects the required power mode, and configure the power domain accordingly. [Table 5](#) shows the modem and application voting and the SRM decides the final power mode:

Table 5: Modem and Application Voting

	Modem active	Modem DRX	Modem eDRX	Modem PSM
Application run	Active	Active	Active	Active
Application stop	Active	Sleep	Sleep	Sleep
Application standby	Active	Lite hibernate	Lite hibernate	Lite hibernate
Application shutdown	Active	Hibernate	Hibernate	Hibernate

Memory Retention

Before entering hibernation, the necessary memory context is saved to retention memory and to a specific partition of flash memory. Upon exit from hibernation, the saved memory context is restored to allow cores in the subsystem to continue to run. Since necessary memory context is restored, system wake up from hibernation avoids the reboot process and significantly reduces power consumption.

Before entering long hibernation, the memory context is saved to flash. Saving to flash cost much less power due to the retention memory is off. Therefore, the module's floor current can go to approximately 1 μA . But the resume time costs more time since flash is much slower than retention memory. Besides, due to the flash wearing, the module only saves to flash only when long hibernation (see [Flash Wearing Protection](#) for long hibernation time threshold)

If the expected hibernation time is not long, the memory context is saved to retention memory before entering hibernation. Since retention memory is powered, the module's floor current will go to more than 5 μA , much more than retaining to flash.

Flash Wearing Protection

Although memory context saving to flash costs much less power. Flash is only guaranteed about 100,000 erase/write operations in 10 years of operation. Therefore, the module has to prevent frequently erasing and writing to flash.

Due to the wear leveling protection, the current minimal sleep time for retaining to flash is 10 minutes in modem off, 10 minutes in long eDRX and 20 minutes in PSM. If the minimum duration was not met, the protection may trigger the module to fall back and retain in retention memory until the minimum duration is met.

4 System Power Domains

The HL7900 has several power domains that are supplied independently via VBATT. This allows the module to operate with some domains unpowered in supported low power modes. For HL7900 hardware architecture details, refer to the HL7900 Product Technical Specification.

The HL7900's power domains include:

- **Low Power** — This domain is ON in all power modes. It includes the RTC (32 KHz clock), a RAM retention memory (not available in long hibernate) and the following I/Os:
 - RESET_IN_N — (Active state – Low) Resets the module
 - WAKEUP — (Active state – High) Wakes the module up from low power modes
- **I/O** — This domain is ON in all power modes except Hibernate and OFF. When this domain is powered, VGPIO output is available, which indicates that the module is active and running.
- **Core** — This domain is ON in Running and Sleep power modes. It includes the main system.
- **Fast Clock** — This domain is ON in Running mode only. It includes the main (26 MHz) system clock.
- **RF** — This domain is ON in Running mode only, during RX/TX activity.

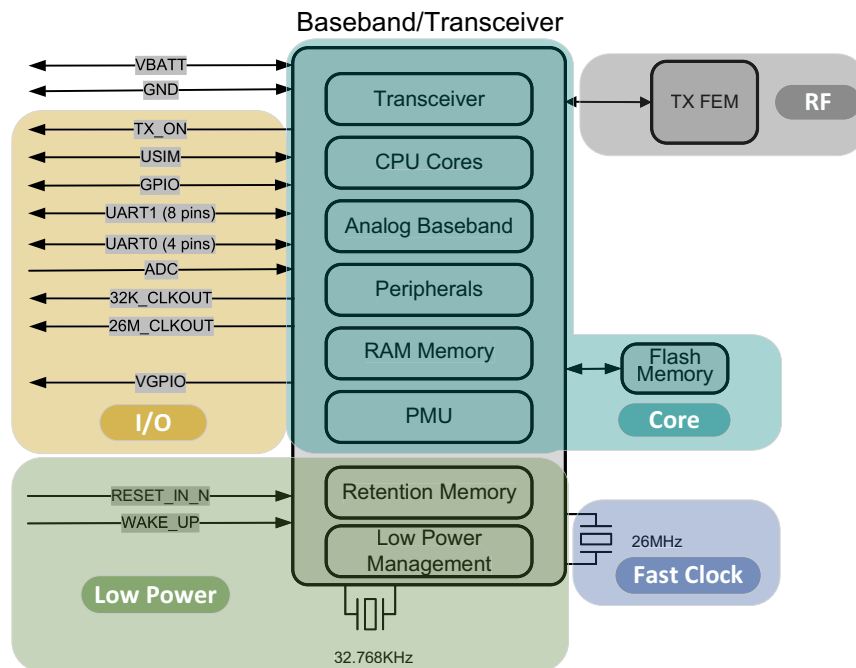
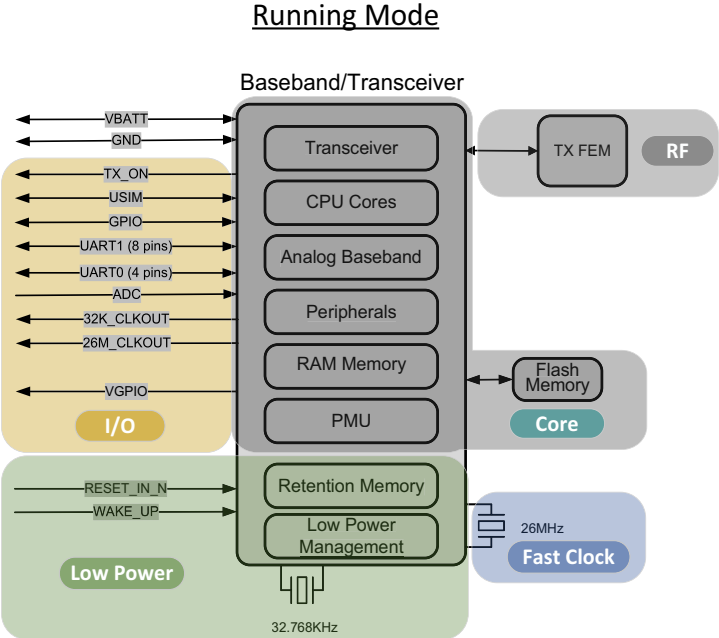


Figure 6: Modem Power Domains

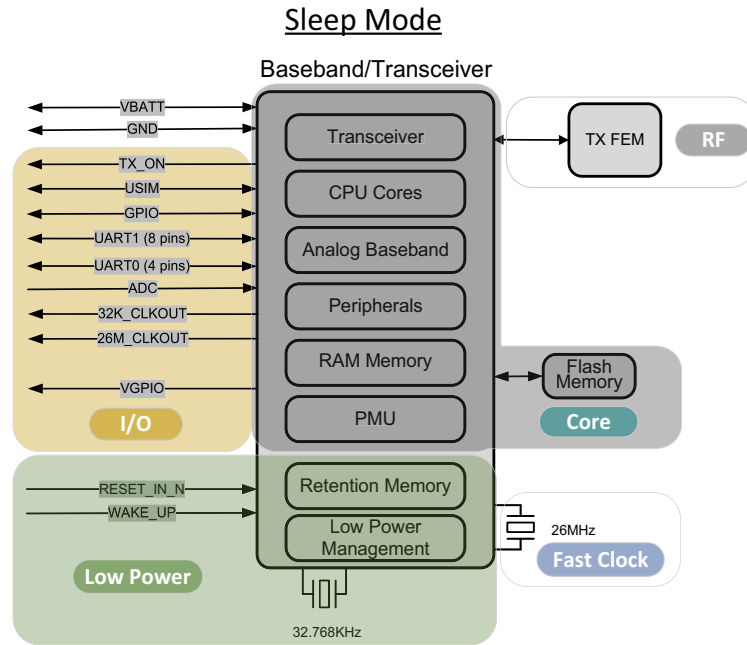
4.1 Running Mode

In running mode, all module power domains are powered. Note that RF power is only on during Rx/Tx activity.



4.2 Sleep Mode

In Sleep mode (+KSLEEP <level> = 0), the Fast Clock and RF power domains are not powered. All other domains are powered.



Power mode: Sleep

App processor sleeping; Modem out-of-coverage, sleeping, or off

The module enters this mode if all the following conditions are met:

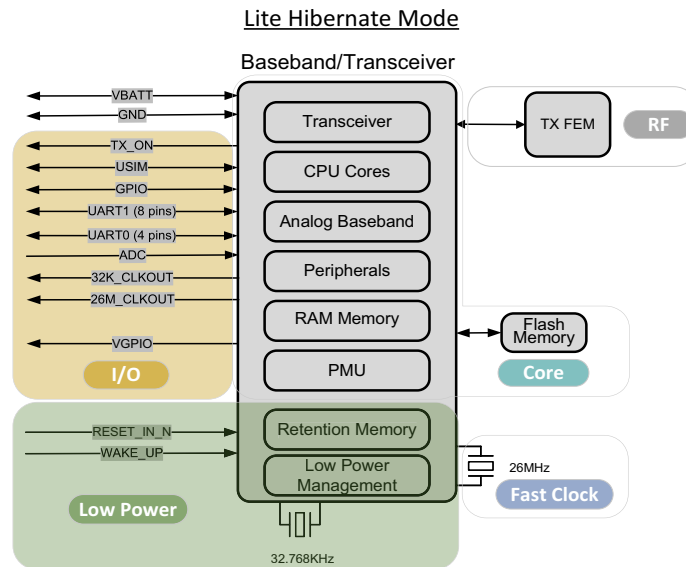
- Sleep mode is allowed (+KSLEEP <level> is set to 0 – Sleep, 1 – Lite Hibernate or 2 – Hibernate).
- +KLSLEEP <delay> timer is not running.
- The application subsystem is in sleep state.
- The modem subsystem is in DRX or in eDRX sleep, OFF, in PSM dormant state, or in out of coverage mode.
- UART1_DTR is not active (only if +KSLEEP <mngt> parameter is set to 0).
- WAKEUP pin is set to inactive (Low).
- RESET_IN_N pin is set to inactive (High).

The module's subsystems can be woken by any of the following:

- WAKEUP signal transition to active (High) – Wakes application subsystems.
- UART1_DTR signal transition to active (Low) – Wakes application subsystems (only if +KSLEEP <mngt> is set to 0, and <level> is set to 0 – Sleep or 1 – Lite Hibernate).
- Module events such as SMS or IP data reception – Wakes application and modem subsystems. (Note - IP wakes the application layer to check for a socket, and SMS wakes the application layer to save the message in NV memory.)
- All unsolicited result codes that are activated by the customer application (as module state changes (+CREG, +CEREG, etc.) – Wakes the application layer. (The modem subsystem is already on – the +CEREG URC is created by the modem subsystem.)
- Internal processing needs such as internal timer expiration, interrupts, etc. – One or more subsystems will wake, depending on the processing requirements. (e.g. [a] only the modem subsystem wakes in receive mode during PTW in eDRX mode, or upon TAU timer expiry; [b] when a flash write is required, the modem subsystem is already on and wakes the application subsystem)

4.3 Lite Hibernate Mode

In Lite Hibernate mode, only the I/O and Low Power domains are powered – the Core, Fast Clock, and RF domains are not powered. Applications that require I/Os to be retained must use either Lite Hibernate mode (recommended) or Sleep mode.



App processor off; Modem out-of-coverage, sleeping, or off

In this mode, the application subsystem is OFF. The modem subsystem may wake up periodically to listen to paging or to perform a periodic Tracking Area Update procedure while in eDRX, but the application subsystem stays OFF.

The module enters this mode if all the following conditions are met:

- Lite Hibernate mode is allowed (+KSLEEP <level> is set to 1 – Lite Hibernate or 2 – Hibernate).
- UART1_DTR is not active (only if +KSLEEP <Mngt> parameter is set to 0).
- +KLSLEEP <delay> timer is not running.
- The application subsystem is in standby or shutdown state (note that once the module enters Lite Hibernate mode, the application subsystem state changes to OFF).
- The modem subsystem is in one of the following states: DRX sleep, eDRX sleep, OFF, PSM dormant, or out of coverage.
- WAKEUP pin is set to inactive (Low).
- RESET_IN_N pin is set to inactive (High).

The module's subsystems can be woken by any of the following:

- WAKEUP signal transition to active (High) – Wakes application subsystems.
- UART1_DTR transitions to active (only if +KSLEEP <Mngt> parameter is set to 0).
- Performing a TAU procedure (triggered by T3412 expiration in eDRX mode or extended T3412 expiration in PSM dormant state) – Wakes the modem subsystem. In some cases (e.g. when LWM2M is enabled), the application subsystem also wakes.
- Enabling receiver during PTW in eDRX mode – Wakes the modem subsystem.
- Receiving data during PTW in eDRX mode – Wakes the application subsystem.
- Modem subsystem state change as network coverage is lost or recovered – May wake the application subsystem (e.g. if +CEREG URCs are enabled, if the recovered service requires an MRU (Most Recently Used cell) table update, etc.).

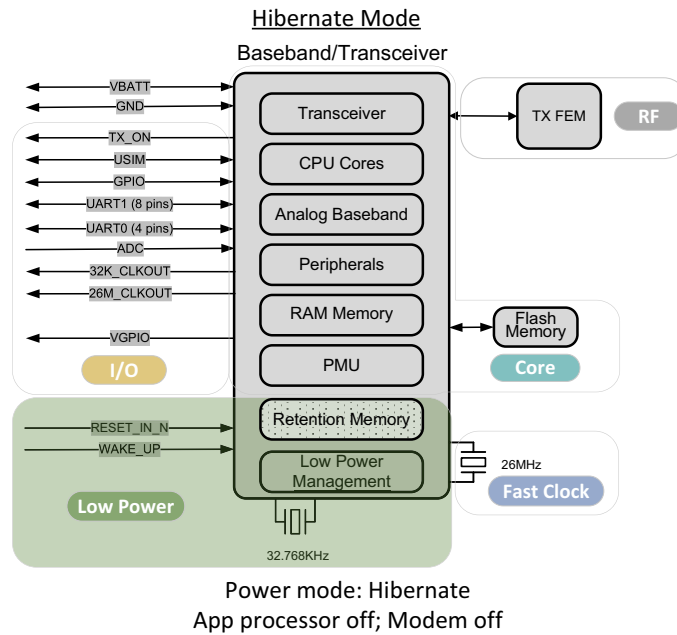
4.4 Hibernate Mode

Hibernate mode (+KSLEEP <level> = 2) is recommended for applications targeting the lowest power consumption.

With this mode enabled, the module can achieve its minimal power consumption:

- eDRX sleep
- PSM dormant

In Hibernate mode, only the Low Power power domain is powered, all other domains are not powered. Note that in long hibernate, the Retention memory contexts are backed up to flash and then the Retention memory is not powered.



In this mode, the application subsystem is OFF. The modem subsystem may wake up periodically to listen to paging or to perform a periodic Tracking Area Update procedure while in eDRX, but the application subsystem stays OFF.

The module enters this mode if all the following conditions are met:

- Hibernate mode is allowed (+KSLEEP <level> is set to 2 – Hibernate).
- +KLSLEEP <delay> timer is not running.
- The application subsystem is in sleep state (note that once the module enters Hibernate mode, the application subsystem state changes to OFF).
- The modem subsystem is in PSM dormant state, or is in eDRX sleep state and the UICC deactivation feature is enabled for eDRX.

Note that UICC deactivation mechanism is a release 13 feature (refer to ETSI TS 131 102 V13.4.0 clause 5.1.10 and 5.1.11):

- In PSM, UICC deactivation can be done if PIN code is disabled.
- In eDRX, UICC deactivation can be done if PIN code is disabled and deactivation of UICC is authorized in EFAD.

Note that if the modem subsystem is in eDRX and UICC deactivation is not enabled, then the lowest power mode the module can enter is Lite Hibernate.

Support of this feature by the UICC may be retrieved by reading the SIM's EFAD file using AT+CRSM=176,28589,0,0,4 and checking the response. The feature is supported if the first bit of Byte 1 and the fourth bit of Byte 3 are '1' in the <response> parameter.

e.g. +CRSM: 145,15,01000802

The <response> is "01000802" (B4B3B2B1). Byte 1 ("01") = 0001 and byte 3 ("08") = 1000.

- WAKEUP pin is set to inactive (Low).
- RESET_IN_N pin is set to inactive (High).

The module's subsystems can be woken by any of the following:

- WAKEUP signal transition to active (High) – Wakes application subsystems.
- Performing a TAU procedure (triggered by T3412 expiration in eDRX mode or extended T3412 expiration in PSM dormant state) – Wakes the modem subsystem. In some cases (e.g. to send URCs due to changes in RF conditions), the application subsystem also wakes.
- Wake up the receiver during PTW in eDRX mode – Wakes the modem subsystem.
- Receiving data during PTW in eDRX mode – Wakes the application subsystem.
- Modem subsystem state change as network coverage is lost or recovered – May wake the application subsystem (e.g. if +CEREG URCs are enabled, if the recovered service requires an MRU table update, etc.).

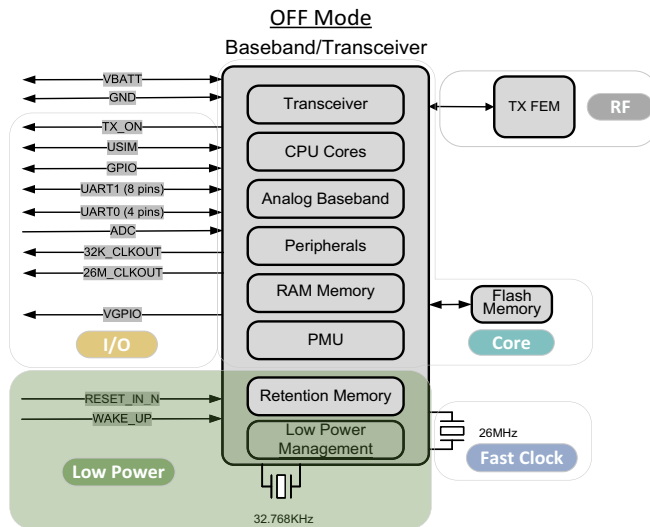
Note: In eDRX mode, the module enters Hibernate mode between paging opportunities whether in a paging time window or between paging time windows.

In both eDRX and PSM modes, when the module enters Hibernate, I/Os are not retained. If the module is in eDRX, the modem subsystem periodically partially wakes to listen to the paging. During this short wake-up, certain I/Os are configured with reset values as described in the PTS, so some I/O toggling will occur (and can be ignored).

4.5 OFF Mode

In OFF mode, most of the Low Power domain is powered (retention memory are not powered). All other domains are not powered.

In this mode, the application subsystem and the modem subsystem are OFF. Retention memory contexts is not saved. The module enters this mode if it is switched off by the +CPOF or +CPWROFF command. The module can be woken by the WAKEUP signal (high).



5 Low Power Mode Operation

The lowest power mode that the module can possibly enter is configured using the +KSLEEP command. Then, when operating, the module automatically selects the best power mode based on the +KSLEEP configuration and the current module state as shown in [Table 7](#).

Table 7: Module Power Mode Details

+KSLEEP configuration		Module state	Best achievable power mode	Signal states to enter power mode (All required)	Hardware wakeup sources (Any) ^a	Modem Subsystem-Related Wakeup Sources from Lite Hibernate or Hibernate	
<mngt>	<level> ^b						
Sleep disabled (<mngt>=2)	N/A	Connected	No power save mode	N/A	N/A	-	
Sleep enabled (<mngt>=0 or <mngt>=1)	Stop (<level>=0)	DRX, eDRX, Flight Mode, PSM, out of coverage	Sleep	WAKEUP: inactive UART1_DTR: inactive ^c	WAKEUP: active RTC timer timeout event UART1_DTR: active**	-	
		Standby (<level>=1)	DRX	Lite Hibernate	WAKEUP: inactive UART1_DTR: inactive ^c	WAKEUP: active RTC timer timeout event UART1_DTR: active**	-
	Flight Mode		Lite Hibernate	-			
	Back-off period during network coverage recovery		Lite Hibernate	Expiry of back-off period			
	eDRX		Lite Hibernate	SMS or IP reception Network coverage lost			
	PSM		Lite Hibernate	Extended-T3412 (Periodic TAU timer)			
	Shutdown (<level>=2)	DRX	DRX	Lite Hibernate	WAKEUP: inactive UART1_DTR: inactive ^c	WAKEUP: active RTC timer timeout event	-
			Flight Mode	Lite Hibernate			-
		Back-off period during network coverage recovery	Lite Hibernate	Expiry of back-off period			
		eDRX (UICC deactivation disabled)	Lite Hibernate	SMS or IP reception Network coverage lost			
		eDRX (UICC deactivation enabled)	Hibernate	SMS or IP reception Network coverage lost			
		PSM	Hibernate	Extended-T3412 (Periodic TAU Timer)			
		+CFUN=0	Hibernate				WAKEUP: active

- UART1 data reception by the module does not trigger a module wake up from any low power mode.
- Lowest possible power saving mode that module can enter.
- Only if configured with +KSLEEP <mngt> parameter set to 0.

The figure below is an example of the module's low power mode state transition graph with the following configuration:

- +KSLEEP <level> parameter is set to 2 – Shutdown mode,
- +KSLEEP <Mngt> parameter is set to 1 – Standalone sleep mode, and
- UICC deactivation feature is supported by the SIM card.

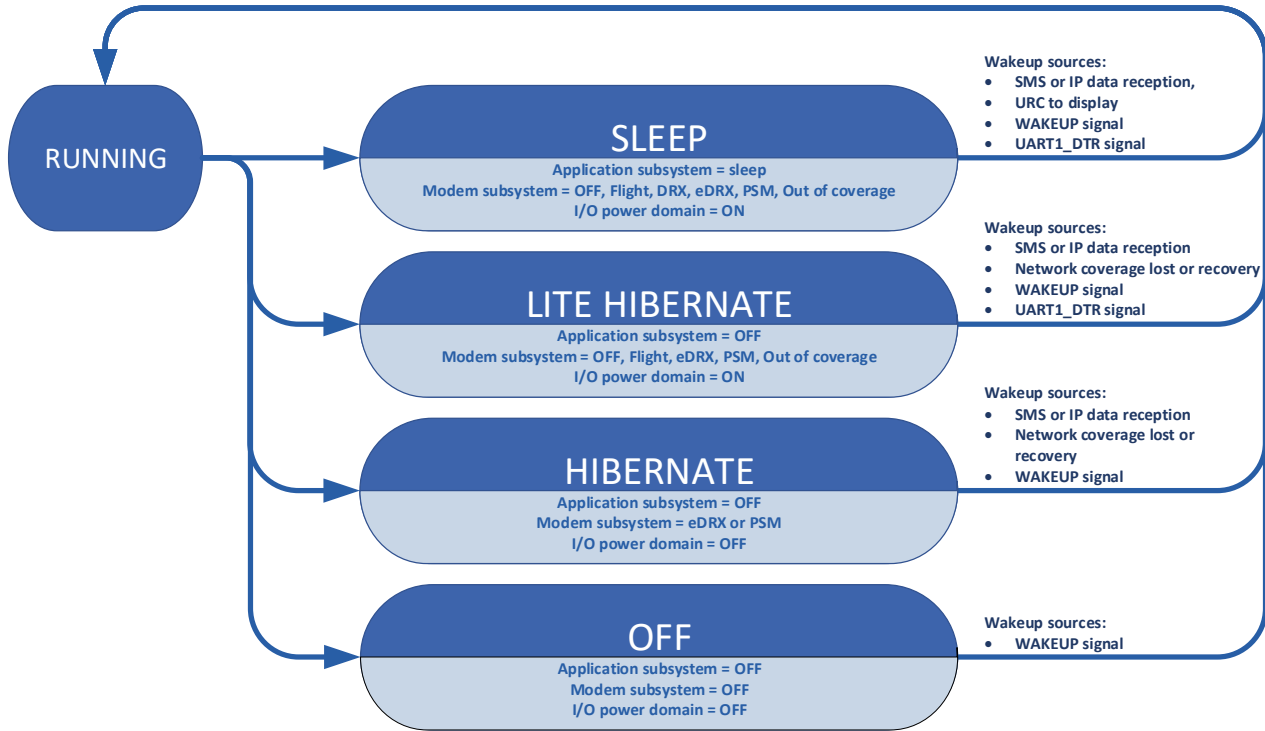


Figure 8: Low Power Mode Transition Graph Example

6 Host Application Interface

6.1 Monitoring Low Power Modes

The host application can detect when the module enters/exits lite hibernate and hibernate modes by monitoring the following signals:

- GPIO6 – The host application can use AT+KHWIOCFG=3,1,6 to enable monitoring (via GPIO6) of lite hibernate mode entry/exit. GPIO6 is pulled low when the module enters eDRX sleep state, and set high when the module wakes.
- VGPIO – The host application can use VGPIO as an indirect indicator of hibernate mode entry/exit. When the module enters hibernate mode, VGPIO is not powered and most I/Os are not defined and cannot be driven by the host application.

Since VGPIO is not powered in Hibernate mode, its output voltage may be used to monitor Hibernate mode entry/exit – when the voltage is low, the module has entered Hibernate; when the voltage is high (1.8 V), the module is awake (not in Hibernate).

Note – While in Hibernate mode, external I/O input may affect the actual voltage of VGPIO as VGPIO is not powered internally. For additional details, refer to the HL7900 Product Technical Specification.

- EXT_ALARM – If the device is active or in sleep mode, this pin is high. If device is in lite hibernate mode, this pin is low. If device is in hibernate mode, this pin is floating.

6.2 Host Application Wake Up Signal (Ring Indicator)

If a host application is designed to enter into low power mode by itself, and needs to be woken only when the module receives data for the host application to process (SMS or IP packets), the module must send a ring indicator signal to wake the host application.

The HL7900 provides UART1_RI (a standard active-low ring indicator tied to VGPI0) and an option (+KRIC command) to configure an active-high GPIO as an alternative ring indicator that is driven high only for specific types of incoming data (otherwise, the signal is always kept low).

If the module's lowest power mode is configured as:

- Lite Hibernate or Sleep — UART1_RI can be used to wake the host application from low power mode.
- Hibernate — UART1_RI cannot be used because VGPI0 is not powered in Hibernate mode. This is because when the module enters into Hibernate mode, UART1_RI changes to low (its active state) and would incorrectly wake the host application. Therefore, the alternative ring indicator must be used.

To configure GPIO2 to function as a ring indicator, use the +KRIC command. Refer to the HL7900 AT Command Reference Guide for details.

6.3 IP Server Mode

To allow time for IP packet reception and processing after the module exits from Lite Hibernate or Hibernate mode, the +KSLEEP <delay> parameter should be configured to satisfy the host application's performance requirements. This delay prevents the module from immediately re-entering Lite Hibernate or Hibernate mode, and lets the host application processor wake up and raise the WAKEUP pin (High) or UART1_DTR. (Note — UART1_DTR is available only in Lite Hibernate mode, not Hibernate, and only if configured with +KSLEEP <mngt> parameter set to 0.)

When the module receives data in Lite Hibernate or Hibernate mode:

6. The modem subsystem wakes the application subsystem to process the data.
7. The application subsystem asserts the CTS to wake the host application to process the data.

When the host application wakes in response to the CTS:

1. The host application immediately asserts WAKEUP (High) keep the module awake.
However, if the host application does not wake quickly enough, the module may re-enter Lite Hibernate/Hibernate before WAKEUP is asserted. To prevent this, configure the +KSLEEP <delay> parameter with a duration long enough to allow the host application to wake and assert WAKEUP (High).

Note: If the +KSLEEP <mngt> parameter was set to 0 and the module is in Lite Hibernate, the host application can assert UART1_DTR instead of WAKEUP. (UART1_DTR is not available in Hibernate mode.)

2. The host application receives the incoming data and communicates with the back-end server as needed. If the application is aware that no more data will be transferred, +CNMPD can be used to shorten the RRC connected state. See [RAI](#) for details.
3. The host application de-asserts WAKEUP (Low) when communication with the back-end server is finished. This enables the module to enter Lite Hibernate/Hibernate state when all module subsystems allow it.
4. The module resumes eDRX operations with maximum power savings.

Note: If the host application does not deassert WAKEUP (Low) when communication is finished, the module resumes eDRX operation in active state with high current consumption.

7 Module–Host Application Handshake on Wakeup from Low Power Modes

This section describes the handshake sequences between the module and host application when the module wakes from Lite Hibernate or Hibernate mode, for both host-initiated and module-initiated wakeup.

7.1 Host-initiated Module Wakeup

Host-initiated wakeup is required when the host application needs the module to send data (i.e. mobile-originated (MO)), or needs to execute an AT command on the module.

(Note – In these sequences, the host application asserts either WAKEUP or UART1_DTR, depending on +KSLEEP configuration.)

- Handshake sequence to send MO data in PSM or eDRX:
 - a. The host application asserts WAKEUP or UART1_DTR.
 - b. The host application asserts UART1_RTS and waits for the module to assert UART1_CTS.
 - c. If the module is in PSM, it waits to receive a %CPSMS URC.
 - d. The module sends the data.
- Handshake sequence to process a non-data AT command:
 - a. The host application asserts WAKEUP or UART1_DTR.
 - b. The host application asserts UART1_RTS and waits for the module to assert UART1_CTS.
 - c. The host application sends the AT commands, and the module processes it.

7.2 Module-initiated Host Wakeup

Module-initiated host wakeup is required when the module wakes autonomously due to received data (e.g. mobile-terminated (MT) SMS or IP data in eDRX, a network state change, etc.)

Note: In this sequence, the signal(s) used by the module depend on its configured lowest power mode, and on the +KRIC configuration. If the lowest power mode is Hibernate, the module uses the alternative ring indicator (GPIO2, configured via +KRIC). If the lowest power mode is Lite Hibernate or Sleep, the module can use UART1_RI or the alternative ring indicator (if configured).

- Handshake sequence:
 - a. The module toggles GPIO2 or UART1_RI, and asserts UART1_CTS.
 - b. The host application asserts WAKEUP, before the GPIO2/UART1_RI pulse ends, to keep the module awake while the host communicates with the backend server.
 - c. The host application asserts UART1_RTS.
 - d. The module sends all URCs, and the host application reads and processes incoming data.

(Note – MT data in PSM mode is not a recommended/supported use case.)

8 Low Power Mode Use Cases

This section describes typical PSM and eDRX use cases.

8.1 UDP vs. TCP – Considerations for Low Power Operation

The HL7900 supports both TCP and UDP transmission protocols.

While TCP provides for higher-reliability data transmission than UDP, the messaging overhead associated with establishing / terminating TCP connections and optimizing data transfer can result in greater power consumption than UDP.

Under good network conditions, both TCP and UDP work well as latency is short and consistent, similar to wired networks. However, as conditions worsen, LPWA networks (LTE-M and NB-IOT) use mitigation methods/reliability mechanisms (repetitions and slower peak data rates) to deal with wireless communication uncertainty, allowing the module to continue to operate. These mitigations/mechanisms add latencies and jitter to packet transfers, which impact TCP protocol operations to a point that might make TCP unusable. For battery powered devices, the extra packets used by TCP for connection establishment/disconnection and TCP retransmissions will consume more power.

LPWA applications typically send or receive small data packets (up to ~10kB). For these smaller packets, the additional overhead from TCP for connection establishment/disconnection has a relatively larger impact. Given that LPWA has its own reliability mechanisms to deal with uncertainty, the TCP messaging overhead is essentially 'pure overhead'. The additional reliability provided by TCP should not be needed for smaller data transmissions. Applications can use UDP and include a UDP reply (ACK) packet for simple reliability and, if necessary, resend packets.

In summary,

- Low-latency (good conditions) – Both TCP and UDP are suitable.
- High-latency (poor conditions) – UDP is suitable. TCP is not suitable, since LPWA networks use mitigation techniques that make TCP less effective or unusable (the techniques make TCP's messaging overhead unmanageable).
- Battery-powered devices – UDP is suitable. TCP is not suitable, since TCP overhead (extra packets for connect/transmit/disconnect), especially with correspondingly small packets for LPWA, consumes more power.

Therefore, UDP (with the application using reply packets) is recommended.

8.2 PSM Use Cases

The recommended Low Power mode for PSM is Hibernate mode. When configured for PSM, the module enters PSM dormant state (in Hibernate mode) once the Active Timer (T3324) expires. It is then woken by the host application to send host-initiated data packets.

In Hibernate mode, the I/Os are not retained and the module can be only be woken up from the WAKEUP pin (High).

Table 9 describes the AT commands used to configure a module (that expects to send mobile-originated data every 24 hours) for PSM with a 20 second Active Timer and 320 hour (~2 weeks) Periodic TAU Timer.

Table 9: PSM Use Case – Related AT Command Configurations

Description	Command
PSM configuration: <ul style="list-style-type: none"> Extended-T3412 = 320 hours T3324 = 20 seconds 	AT+CPSMS=1,,,“11000001”,“00001010” OK
Sleep Mode configuration <ul style="list-style-type: none"> Hibernate Mode Managed via WAKEUP pin 	AT+KSLEEP=1,2 OK

8.2.1 PSM Typical Use Case – Data Transmission Initiated by Host

The host application may want to send data over the network while the module is in PSM mode and Hibernate Low Power mode. Before sending data, the host application will first wake the module up using the WAKEUP signal (High). Once the UART1_CTS signal is active, the host application wakes completely.

As PDN/PDP context is saved in PSM mode, these procedures are executed rapidly. Once data is sent, Extended T3412 and T3324 timers are rearmed with their initial values.

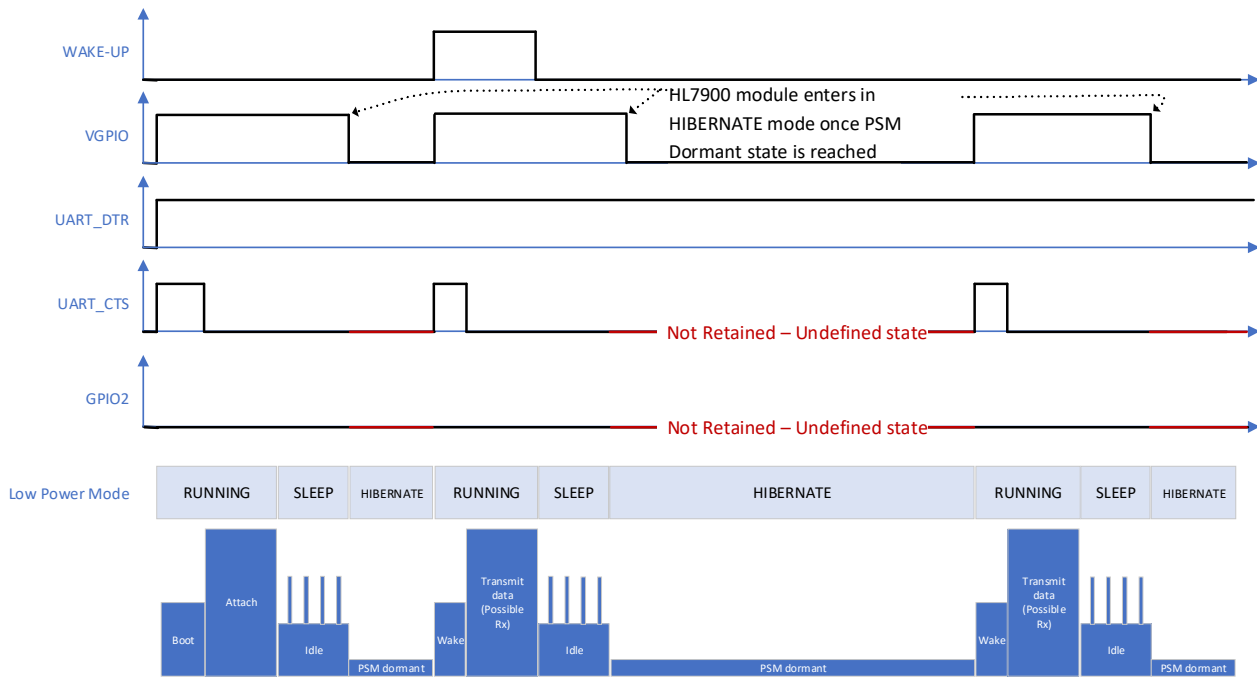


Figure 10: PSM Mode – Typical Use Case

8.3 eDRX Use Case

The recommended Low Power state to achieve the best power consumption saving while the module is in eDRX mode is Hibernate mode. When configured in eDRX mode, the module enters the lowest power consumption mode during eDRX sleep period. In particular, this mode depends on the UICC configuration as explained previously:

- If the UICC does not allow UICC deactivation in eDRX mode, the module enters Lite Hibernate mode during eDRX sleep period.
- If the UICC allows UICC deactivation in eDRX mode, the module enters Hibernate mode during eDRX sleep period.

The module periodically wakes up to listen to the paging as described previously. This wake up is a partial wake up meaning that only the modem subsystem of the module is awake.

8.3.1 Calibration Procedure

For the first few minutes after entering Lite Hibernate or Hibernate mode (note – not the lowest power PSM dormant state), the module repeatedly wakes to calibrate the internal clock and maintain synchronization with the network. It is due to the internal clock might drift according to the temperature.

The calibration starts when state from CONNECTED to IDLE with a wake-up cycle 1.28 seconds, then increases from 2.56, 5.12 ... seconds to the eDRX cycle time (TI eDRX). Some steps can be skipped according to the environmental conditions. Therefore, different temperature cause different calibration time. For example, under room temperature the calibration time is about 50 seconds (see [Figure 11](#)) and under high temperature the calibration time is 100 seconds (see [Figure 12](#)).

The calibration procedure relaunches after each RRC connection (TAU or Data) or if network synchronization is lost. If a sudden large drift is detected during calibration, it may restart the calibration.

After calibration is done, the wake-up cycle to maintain synchronization with the network still depends on the setting and environment. The cycles are listed in the table below.

Mobility Mode	RAT	eDRX Cycle [s]	Sync Wake-up Cycle [s]	Temperature Range
Mobile	CAT-M / NB-IoT	≤ 81.92	=eDRX cycle	All
		All other	81.92	
Static	CAT-M	All cycles	=eDRX cycle	15 °C ≤ T ≤ 35 °C
		NB-IoT	≤ 327.68	
	CAT-M / NB-IoT	All other	655.36	T < 15 °C or T > 35 °C
		≤ 81.92	=eDRX cycle	
	163.84	81.92		
	CAT-M	All other	=eDRX cycle	
NB-IoT	327.68	=eDRX cycle		
	All other	655.36		

For example, if the eDRX cycle is 102.4 seconds under mobile mode, the HL7900 wakes up after 81.92 seconds and then wakes up at paging opportunity, which is $102.4 - 81.92 = 20.48$ seconds after first wake-up. See Figure 4-4 for details.

About the mobility mode, there are two modes, mobile and static. If the device is not moving, switch to static mode for longer wake-up cycles. If the device is moving, the device should be switched to dynamic mode. AT command can switch the setting. `%setcfg="PS_DEV_MOB_TYPE"` is for persistence setting and `%LTECMD=1,"EXTMOBILITY"` is for non-persistent setting. Please refer to HL7900 AT Command Reference Guide for detailed command descriptions.

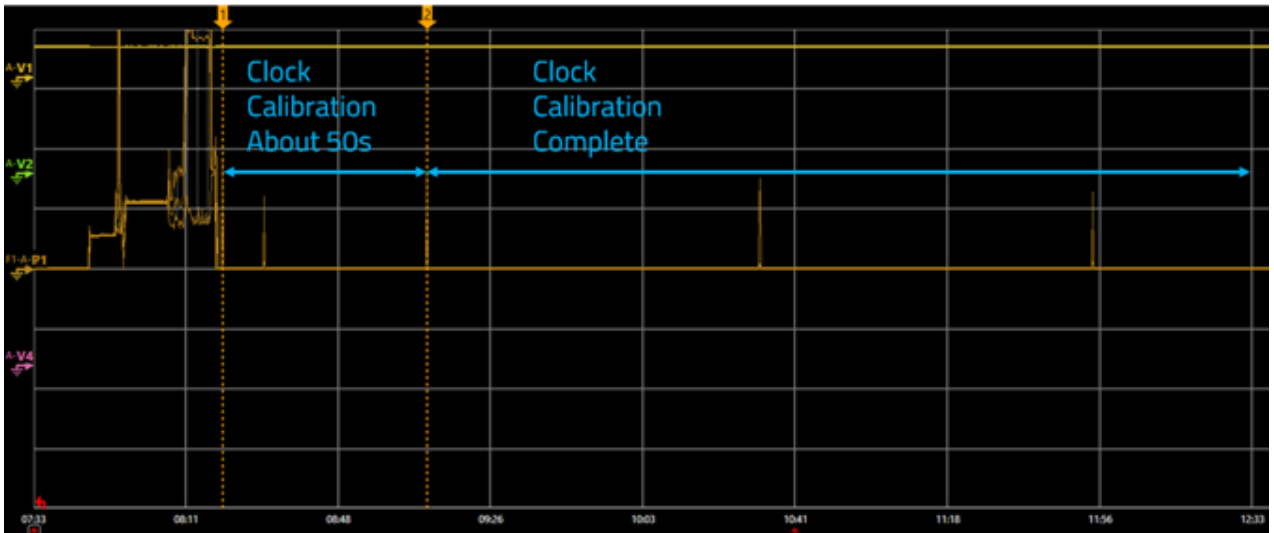


Figure 11: eDRX Mode – Calibration Procedure of eDRX cycle 81.92 seconds under room temperature (25 ° C)

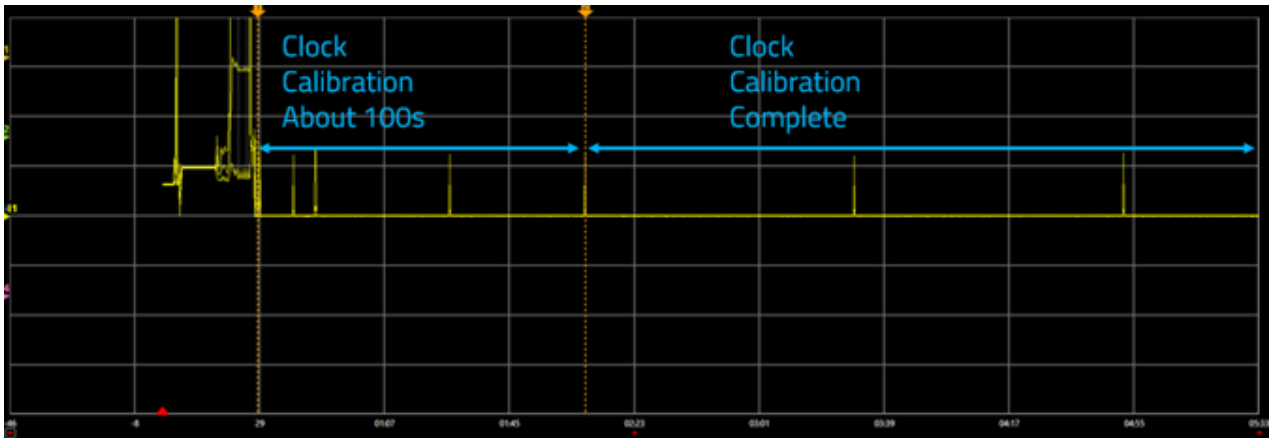


Figure 12: eDRX Mode – Calibration Procedure of eDRX cycle 81.92 seconds under high temperature (55 ° C)

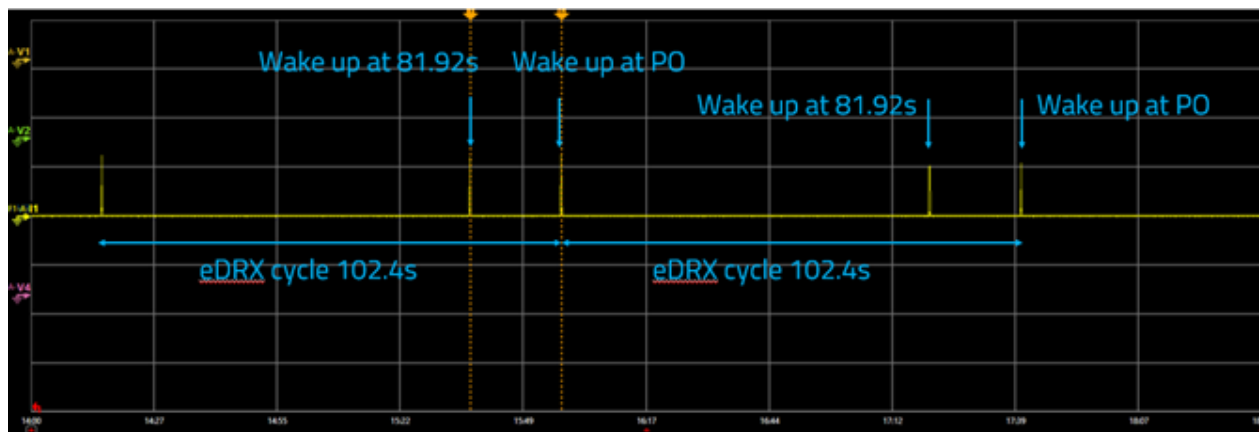


Figure 13: eDRX Mode – wake-up cycle limit to 81.92 seconds when on mobile mode

8.3.2 eDRX/Hibernate Mobile-Terminated Use Case

Table 14 describes the AT commands used to configure a module for eDRX and setting it to use UDP server. The example following the table describes how an incoming UDP packet is managed in this configuration.

Table 14: eDRX Use Case – Related AT Command Configurations

Description	Command
eDRX configuration: eDRX cycle = 81.92 seconds	AT+CEDRXS=1,4,"0101" OK <i>Note: The second parameter is the RAT (<Act-Type>). Use '4' for LTE-M (as shown), or '5' for NB-IoT.</i>
Sleep Mode configuration <ul style="list-style-type: none"> Standalone Hibernate mode 10 seconds delay 	AT+KSLEEP=1,2,10 OK
RING indicator configuration: <ul style="list-style-type: none"> Active on incoming UDP data Pulse = 1 second GPIO2 	AT+KRIC=128,0,1,2 OK
UDP socket configuration: UDP Server listening	AT+KUDPCFG=1,1,5000,,,,,1
Hardware Flow Control: Active	AT&K3

When the module is in eDRX/Hibernate mode:

1. The modem subsystem listens periodically to the network paging channel.
2. If the backend server sends an incoming UDP packet, the network first buffers this packet until the next paging opportunity of the module.
3. At the paging opportunity, the network sends a paging message to request the establishment of an RRC connection.
4. The modem subsystem receives the paging message and:

- initiates an RRC connection to receive and buffer the UDP packet, and
 - wakes up the application subsystem.
5. The modem subsystem sends the buffered UDP packet to the application subsystem for processing.
 6. The application subsystem wakes the host application to receive and process the UDP packet (and additional packets, if necessary). For a detailed description of the wakeup handshaking process, see [Module-initiated Host Wakeup](#).
 7. When the host application finishes communicating with the backend server, the host application de-asserts WAKEUP (low) to signal the module that it can go to eDRX/hibernation mode.
 8. The network releases the RRC connection after it has idled (no data transfer) for the required period (RRC_INACTIVITY_TIMER).
 9. The module goes to eDRX/hibernation mode, and this process repeats (i.e. go back to Step 1).

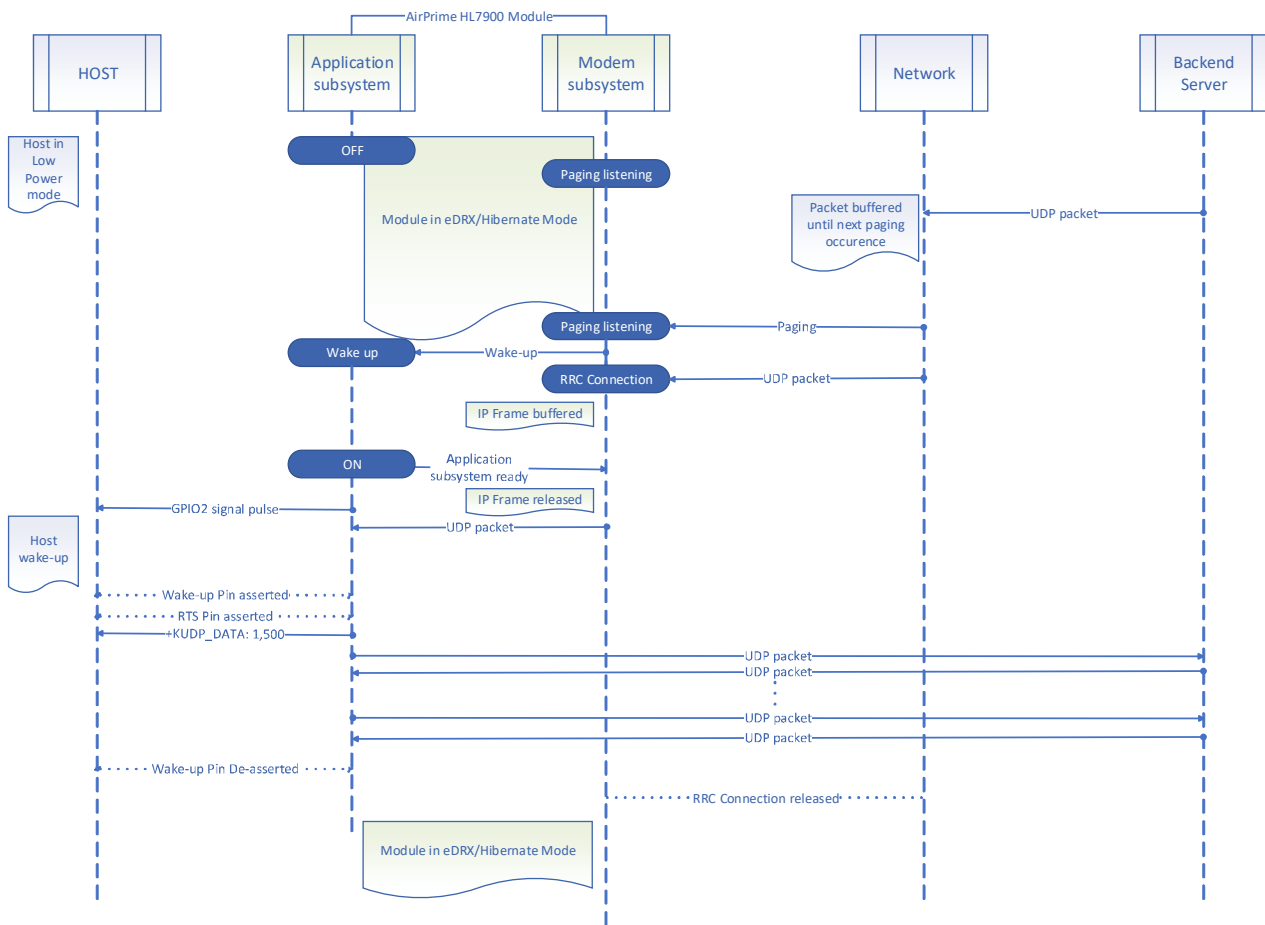


Figure 15: eDRX/Hibernate Mobile-Terminated Use Case Flow Chart

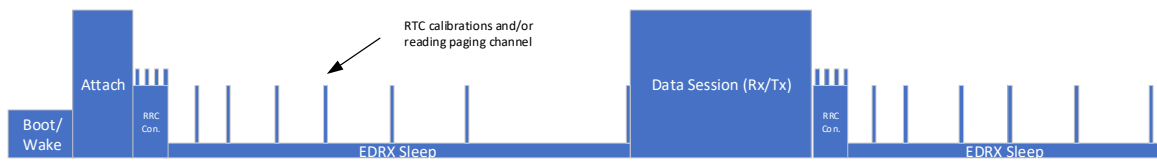
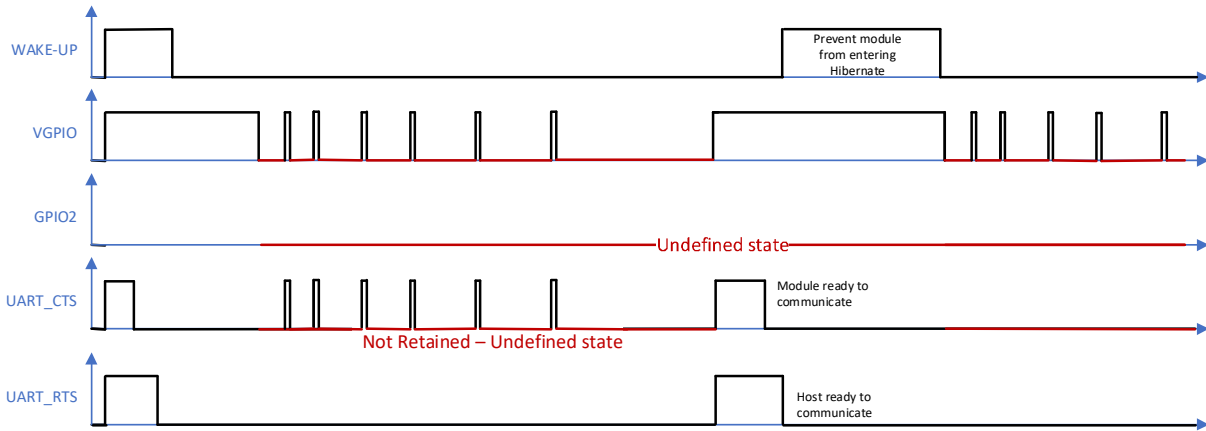


Figure 16: eDRX/Hibernate Mobile-Terminated Use Case Sequence Diagram

9 Current Consumption

For typical current consumption measurements, refer to the HL7900 Product Technical Specification that can be downloaded via the [Source](#).

For current consumption measurements under other conditions, contact Support.

10 AT Commands

Note: Commands in this section are presented in alphabetical order.

10.1 +CEDRXRDP (eDRX Read Dynamic Parameters) AT Command

Refer to the HL7900 AT Command Reference Guide for detailed command descriptions.

10.1.1 Syntax

AT+CEDRXRDP

+CEDRXRDP: <AcT-type>[,<Requested_eDRX_value>[,<NW-provided_eDRX_value>

[,<Paging_time_window>]]]

OK

10.1.2 Description

The execute command returns <AcT-Type> and <Requested_eDRX_value>, <NW-provided_eDRX_value> and <Paging_time_window> if eDRX is used for the cell that the module is currently registered to.

10.1.3 Defined Values

Table 17: Parameters

Parameter	Value	Description
<AcT-type>		Access technology type as defined in the +CEDRXS command (see Table 20)
<Requested_eDRX_value>		Requested eDRX cycle time as defined in the +CEDRXS command (see Table 20)
<Paging_time_window>	See table below	Paging Time Window size

Table 18: <Paging_time_window> Values

<Act-type>=5 – NB-IoT					<Act-type>=4 – LTE-M				
Bit				Paging Time Window Length	Bit				Paging Time Window Length
8	7	6	5		4	3	2	1	
0	0	0	0	2.56 seconds	0	0	0	0	1.28 seconds
0	0	0	1	5.12 seconds	0	0	0	1	2.56 seconds
0	0	1	0	7.68 seconds	0	0	1	0	3.84 seconds
0	0	1	1	10.24 seconds	0	0	1	1	5.12 seconds
0	1	0	0	12.8 seconds	0	1	0	0	6.4 seconds
0	1	0	1	15.36 seconds	0	1	0	1	7.68 seconds
0	1	1	0	17.92 seconds	0	1	1	0	8.96 seconds
0	1	1	1	20.48 seconds	0	1	1	1	10.24 seconds
1	0	0	0	23.04 seconds	1	0	0	0	11.52 seconds
1	0	0	1	25.6 seconds	1	0	0	1	12.8 seconds
1	0	1	0	28.16 seconds	1	0	1	0	14.08 seconds
1	0	1	1	30.72 seconds	1	0	1	1	15.36 seconds
1	1	0	0	33.28 seconds	1	1	0	0	16.64 seconds
1	1	0	1	35.84 seconds	1	1	0	1	17.92 seconds
1	1	1	0	38.4 seconds	1	1	1	0	19.20 seconds
1	1	1	1	40.96 seconds	1	1	1	1	20.48 seconds

10.1.4 Examples

Send the following command to request an eDRX cycle of 81.92 s.

```
AT+CEDRXS=1,4,5
```

```
OK
```

```
AT+CEDRXRDP
```

```
+CEDRXRDP: 4,5,5,0
```

```
OK
```

In this example, the network accepted the 81.92 s eDRX cycle and provided a PTW of 1.28 seconds.

10.2 +CEDRXS (eDRX Setting) AT Command

Refer to the HL7900 AT Command Reference Guide for detailed command descriptions.

10.2.1 Syntax

AT+CEDRXS=[<mode>[,<AcT-type>[,<Requested_eDRX_value>]]]

10.2.2 Description

The set command controls the setting of the module’s eDRX parameters. The command controls whether the module wants to apply eDRX or not, as well as the requested eDRX value for each specified type of access technology.

10.2.3 Defined Values

Table 19: Parameters

Parameter	Value	Description
<mode>	Integer type	Indication to disable or enable the use of eDRX in the module
	0	Disable the use of eDRX (default value)
	1	Enable the use of eDRX
	2	Enable the use of eDRX and enable unsolicited result code: +CEDRXRDP: <AcT-type>[,<Requested_eDRX_value>[,<NW-provided_eDRX_value>[,<Paging_time_window>]]]
	3	Disable the use of eDRX and discard all parameters for eDRX or, if available, reset to the manufacturer specific default values
<AcT-type>	Integer type	Access technology type
	4	E-UTRAN (WB-S1 mode) = LTE-M
	5	E-UTRAN (NB-S1 mode) = NB-IoT
<Requested_eDRX_value>	String type "b4b3b2b1"	Requested eDRX cycle time 3GPP specification defines this parameter as a string type using the indicated format.
	Integer type 0-15	The HL7900 extends the parameter definition to allow values to be entered as the integer equivalent. See table below for values.

Table 20: <Requested_eDRX_value> Values

Integer	String (bits: "b4b3b2b1")				T _{eDRX}	Description
	b4	b3	b2	b1		
0	0	0	0	0	5.12 seconds	For LTE-M only
1	0	0	0	1	10.24 seconds	For LTE-M only
2	0	0	1	0	20.48 seconds	For LTE-M AND NB-IoT
3	0	0	1	1	40.96 seconds	For LTE-M AND NB-IoT
4	0	1	0	0	61.44 seconds	For LTE-M only
5	0	1	0	1	81.92 seconds	For LTE-M AND NB-IoT
6	0	1	1	0	102.4 seconds	For LTE-M only
7	0	1	1	1	122.88 seconds	For LTE-M only
8	1	0	0	0	143.36 seconds	For LTE-M only
9	1	0	0	1	163.84 seconds	For LTE-M AND NB-IoT
10	1	0	1	0	327.68 seconds	For LTE-M AND NB-IoT
11	1	0	1	1	655.36 seconds	For LTE-M AND NB-IoT
12	1	1	0	0	1310.72 seconds	For LTE-M AND NB-IoT
13	1	1	0	1	2621.44 seconds	For LTE-M AND NB-IoT
14	1	1	1	0	5242.88 seconds	For NB-IoT only
15	1	1	1	1	10485.76 seconds	For NB-IoT only

10.3 +CEREG (EPS Network Registration Status) AT Command

Refer to document the HL7900 AT Command Reference Guide for detailed command description.

10.3.1 Syntax

AT+CEREG=<n>

OK

AT+CEREG?

OK

10.3.2 Example

```
AT+CEREG=1
OK
AT+CEREG?
+CEREG=1,1
OK
```

10.3.3 Description

The execute format of this command enables unsolicited result codes.

Both the query format of this command and the unsolicited result codes return the negotiated values for the PSM Active Timer (T3324) and Periodic TAU PSM cycle timer (Extended T3412).

When <n>=4, the unsolicited result code will provide the module with the Active Timer value and optionally the extended periodic TAU value if there is a change of the network cell in E-UTRAN.

If the Active Timer value is returned, it means the network allows the use of PSM.

10.3.4 Defined Values

Table 21: Parameters

Parameter	Value	Description
<Active-Time>		Negotiated Active Timer as defined in the +CPSMS command (see Table 24).
<Periodic-TAU>		Negotiated Periodic TAU cycle timer as defined in the +CPSMS command (see Table 23).

10.4 +CPSMS (Power Saving Mode Setting) AT Command

Refer to document the HL7900 AT Command Reference Guide for detailed command description.

10.4.1 Syntax

```
AT+CPSMS=[<mode>[,<Requested_Periodic-RAU>[,<Requested_GPRS-READY-timer>
[,<Requested_Periodic-TAU>[,<Requested_Active-Time>]]]]]
```

10.4.2 Description

The set command controls the setting of the module’s PSM parameters. It controls whether the module wants to apply PSM or not, as well as the requested extended periodic TAU value in E-UTRAN and the requested Active Timer value.

See the unsolicited result codes provided by +CEREG for the Active Timer value and the extended periodic TAU value that are allocated to the module by the network in E-UTRAN.

10.4.3 Defined Values

Table 22: Parameters

Parameter	Value	Description
<mode>	Integer type	Indication to disable or enable the use of PSM in the module
	0	Disable the use of PSM
	1	Enable the use of PSM
<Requested_Periodic-RAU>		Not used
<Requested_GPRS-READY-timer>		Not used
<Requested_Periodic-TAU>		Requested extended periodic TAU (Extended-T3412) value (see Table 24)
<Requested_Active-Time>		Requested Active Timer (T3324) value (see Table 23)

Table 23: <Extended_Periodic-TAU> Values

Bit								Description	
8	7	6	5	4	3	2	1		
0	0	0	Timer Value						Value is incremented in multiples of 10 minutes Periodic TAU = Timer Value × 10 minutes
0	0	1							Value is incremented in multiples of 1 hour Periodic TAU = Timer Value × 1 hour
0	1	0							Value is incremented in multiples of 10 hours Periodic TAU = Timer Value × 10 hours
0	1	1							Value is incremented in multiples of 2 seconds Periodic TAU = Timer Value × 2 seconds
1	0	0							Value is incremented in multiples of 30 seconds Periodic TAU = Timer Value × 30 seconds
1	0	1							Value is incremented in multiples of 1 minute Periodic TAU = Timer Value × 1 minute
1	1	0							Value is incremented in multiples of 320 hours Periodic TAU = Timer Value × 320 hours
1	1	1							Value indicates that the timer is deactivated Periodic TAU timer deactivated

Table 24: <Requested_Active-Time> Values

Bit								Description	
8	7	6	5	4	3	2	1		
0	0	0	Timer Value						Value is incremented in multiples of 2 seconds Active Timer = Timer Value × 2 seconds
0	0	1							Value is incremented in multiples of 1 minute Active Timer = Timer Value × 1 minute
0	1	0							Value is incremented in multiples of decihours Active Timer = Timer Value × 6 minutes (<i>decihours</i>)
1	1	1							Value indicates that the timer is deactivated Active Timer deactivated

10.4.4 Example

The following command sets T3324 to 20 seconds and T3412 to 1 hour:

AT+CPSMS=1,,,"00000110";"00001010"

OK

10.5 +CRSM (Restricted SIM Access) AT Command

Refer to document the HL7900 AT Command Reference Guide for detailed command description.

10.5.1 Syntax

```
AT+CRSM=176,28589,0,0,4
```

```
+CRSM: <sw1>,<sw2>[,<response>]
```

10.5.2 Description

This command (with the specific indicated parameter values) reads the SIM's EFAD file.

10.5.3 Example

```
AT+CRSM=176,28589,0,0,4
```

```
+CRSM: 144,0,"81000803"
```

```
OK
```

11 Terms and Abbreviations

Term / Abbreviation	Definition
CE Level	The Coverage Enhancement Level is the number (1-4) assigned to the module by the network to indicate signal coverage level at the module's position. Higher numbers indicate a higher UL repetition factor will be used in communications. For details, refer to AT+CRCEs in the HL7900 AT Command Reference Guide
C-DRX / C-eDRX	Connected mode DRX
Connected mode	Modem state when a connection is established with the network for data or signaling exchange.
Domain	See System Power Domains
eDRX	See eDRX
E-UTRAN modes	WB-S1 mode — LTE-M (Cat-M1); NB-S1 mode — NB-IoT (NB1)
Flight mode	Modem subsystem is OFF, and SIM is powered. Synonyms: Airplane mode, offline mode, standalone mode
Host application	Device incorporating the HL7900 module
I-eDRX	Extended Idle DRX
Idle mode	Modem state when it has no dedicated channel allocated and it listens periodically to the paging channel according to its DRX or eDRX cycle.
MO	Mobile Originated – Data transfer initiated by the module (i.e. "IP pull")
MT	Mobile Terminated – Data transfer initiated by the network-side server (i.e. "IP push")
MRU	Most Recently Used cell
Power Domain	A set of hardware modules that share the same power source.
PSM	Power Saving Mode
PSM dormant	Modem state when it is registered to the network and not listening to the paging channel.
PTW	Paging Time Window
Receive latency	The length of time required for the module to receive a message sent from the network
RRC	Radio Resource Control protocol
TAU	Tracking Area Update
UE	User Equipment (i.e. the HL7900 module)
URC	Unsolicited Result Code
SRM	system resource manager

12 Document History

Revision number	Release date	Changes
1	August 2024	Document creation, preliminary release
2	February 2025	Changed to numbered headings Updated 2.4 RAI Updated 6.2 Host Application Wake Up Signal (Ring Indicator) Revised and added note under 7.2 Module-initiated Host Wakeup and revised steps a and b Revised Figure 15 eDRX/Hibernate Mobile-Terminated Use Case Flow Chart Added Ring indicator configuration under Table 14 Updated #6 under 8.3.2 eDRX/Hibernate Mobile-Terminated Use Case

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