1. Overview

The 88Q1110/88Q1111 and 88Q2220[M]/88Q2221[M] devices are TC10 Sleep/Wake-capable PHYs. The 88Q5072 Switch also supports TC10 capable integrated PHYs as link partners.

The Marvell 88Q1111x and 88Q222x[M] PHYs and the 88Q5072 and 88Q6113 switches can operate in a low power sleep mode with minimal standby current from the battery voltage with the main supply shut off. During this mode, the device can continuously monitor for an MDI wake up pulse or a pulse presented at the local WAKE_IN pin and respond to this wake-up command as specified in OPEN Alliance Sleep/Wake Specification.

This document comprises the following:

TC10 Sleep/Wake Capable PHY Configurations

- Standalone TC10-capable PHY to standalone TC10 capable PHY
- Multiple TC10-capable PHYs integrated in a switch application
- External TC10-capable PHY with MAC (switch)

Enter Sleep Mode

- Deep Sleep Mode
- T1 Port Sleep Mode
- Considerations of standalone PHY entering sleep versus an integrated PHY (switch) entering sleep

Wake from Sleep

- Local wake is available with WAKE_IN
- Remote wake is available through MDI.

LPSD Circuitry

- The Low Power Signal Detect circuitry can be power by Vbatt through a MOSFET or direct always on supply.

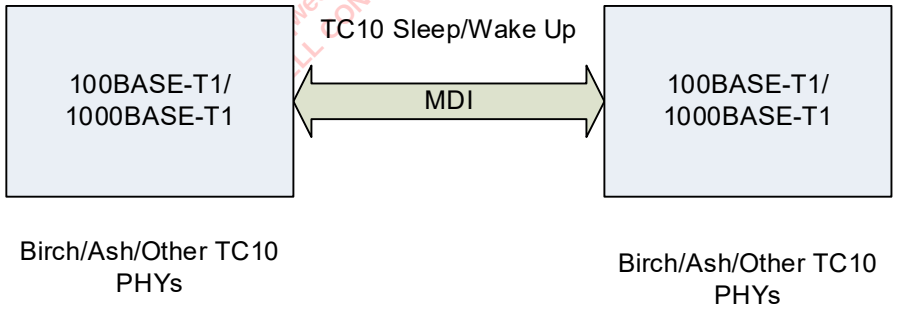
Doc. No. TD-000530 Rev 1

2. TC10 Sleep-/Wake-capable PHY Configurations

2.1 Standalone TC10-capable PHY to Standalone TC10-capable PHY

The Sleep/Wake between two TC10-capable standalone PHYs, such as the 88Q1110/88Q1111 and 88Q222x[M] devices, is accomplished through MDI. Either of the devices can initiate a sleep request via register write.

Figure 1: Sleep/Wake between Two TC10 Standalone PHYs

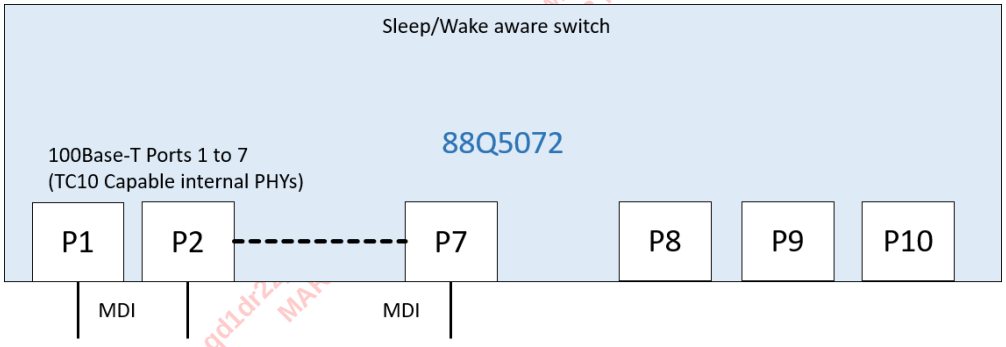


The Sleep/Wake status of 88Q111x/88Q222x[M] PHY devices can be read via register write and both PHYs have an option to generate different TC10 modes.

2.2 TC10-capable PHYs Integrated in a Switch Application

In the case of a switch with a TC10-capable internal application, although a port and its link partner may agree to enter TC10 deep sleep state (where power to the device is totally removed), the switch and remaining internal PHY ports may not be ready to enter the deep sleep state. So, the PHY port will enter a low power state similar to IEEE power down while the remaining switch and others stay active. When all internal ports have agreed to enter the TC10 Sleep state with their link partner, the switch can then decide to enter the Deep Sleep state taking away power to the Switch.

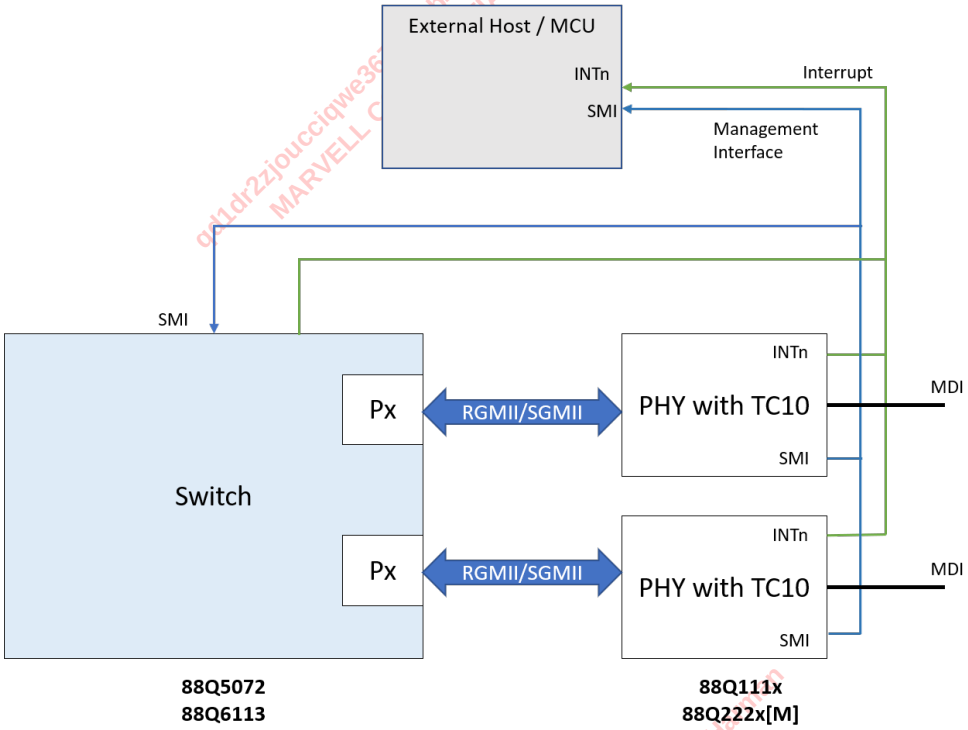
Figure 2: Multiple TC10 PHYs Integrated with a Switch



2.3 Multiple External TC10-capable PHY with a MAC/Switch

For extended applications of PHYs connected with a Marvell Automotive switch, the switch level awareness of the Sleep/Wake events are required so that the switch can determine if the switch is ready to allow itself to enter sleep. The external host can be used to manage the switch and forwarded sleep/wake-up request. This can be achieved with help of an external host as shown in Figure 3.

Figure 3: Sleep/Wake between a TC10 PHY and a Switch



When an external PHY agrees to enter the TC10 Sleep/Wake mode, either by receiving TC10 sleep/wake-up request from the link partner or sleep/wake-up request by the host, interrupt can be generated on one of PHY pins. All interrupts are grouped and connected to the external host. Upon receiving interrupt external host can poll the sleep/wake-up status of all externally connected PHY and based on software-defined sleep/wake forwarding table it can forward sleep/wake-up requests to other PHY in the system.

3. Enter Sleep Modes

There are two low power or sleep modes:

- The traditional LPSD mode, known as the **Deep Sleep Mode**, where the device has supply power completely removed.
- T1 Port **Sleep Mode**, where the device still has power but in a low power state. This is similar to IEEE power down. In some parts of the document we may refer to this sleep mode as TC10 sleep mode because upon completion of TC10 sleep handshake you will enter the T1 Port Sleep Mode.

3.1 T1 Port Sleep Mode (TC10 sleep Mode)

The following are ways to request that the TC10 PHY devices power down in the T1 Port Sleep Mode:

1. The link partner sends a low power sleep command (LPS), which is a specific scrambled idles message included in the normal 100BASE-T1/1000BASE-T1 idles to the TC10 PHY device. This initiates a sleep handshake with it to confirm both would like to be in the T1 Port Sleep Mode low power state. A register bit (88Q111x -> 3.8702.0) is programmed to 1 to initiate a sleep request, which will initiate a sleep handshake with the link partner. Sleep status can be read back by register 3.8073 bits 2:0 where the value '001' indicates the local PHY being in sleep.
2. A sleep request is received at internal PHY from the switch, which initiates the sleep handshake with the link partner. This can be the result of a sleep request being forwarded from 1 port to the others.

3.1.1 TC10 Sleep Handshake between an Integrated PHY and a Switch

The following sleep handshake scheme between the integrated 100BASE-T1 PHY device and an 88Q5072 switch is used when the TC10 sleep is initiated, completed, and the LPSD logic removes power.

1. The TC10 PHY device sends a command to the switch to tell the switch to stop Tx traffic. The command to do this is "PHY Sleep in Progress".
2. When the switch receives this command, the switch immediately stops Tx traffic if no packet is being sent or as soon as the current packet finishes; that is, if there is one being transmitted.
3. If the Tx traffic has stopped, then the Marvell TC10 PHY device will be able to complete the sleep handshake after both the Marvell TC10 PHY device and its LP go into SLEEP_SILENT state. After this, the TC10 PHY device and its LP go into the T1 Port Sleep Mode.
4. If the TX traffic has not stopped from the switch, or activity from the LP has not stopped while the TC10 PHY device and LP are in the SLEEP_SILENT state, then the sleep request fails.
5. If the sleep handshake has completed, then the Marvell TC10 PHY device informs the switch that it is sleeping and ready to have power removed by the LPSD circuit if confirmed by the switch; one of these two commands is sent:
   - A command called "PHY Sleep Complete Remote" is sent if the sleep request was sent in from the LP. This tells the switch that the sleep request should be forwarded to the other ports that the switch logic indicates should receive forwarded sleep commands.
   - A command called "PHY Sleep Complete Local" is sent if the sleep request was sent in from the switch. This command indicates that the switch should not forward the sleep request since it initiated it.
6. If the sleep request is aborted or failed, then a different embedded command called "PHY Sleep Aborted or Failed" is forwarded to the Switch.

7. When the “PHY Sleep In Progress” command is received from the PHY, the switch starts a timer that expires after 20 ms. If there is no “PHY Sleep Aborted or Failed” or “PHY Sleep Completed Local/Remote” command sent from the PHY after 20 ms, then the switch should stop the flow control. This is added for safety reasons to prevent flow control (and the prevention of Tx packets from being sent) from being stuck indefinitely.
8. If the sleep handshake is aborted or failed but the “Sleep Aborted or Failed” command is not seen by the switch and the link is still up, then traffic should be allowed to pass.
9. If the sleep handshake is completed and the “Sleep Complete Remote/Local” command is not seen by the switch then after 20 ms, the switch will no longer expect this command. The link should drop and this will prevent the traffic from flowing.
10. If a wake request comes in when the PHY is in SLEEP SILENT state, then the sleep handshake is failed and a “Sleep Aborted or Failed” command is sent and sleep is terminated. If the wake request comes during a state after the SLEEP SILENT state, then the wake request is processed normally.
11. If the sleep handshake is finished and one of the two commands in #5 has been sent to the switch, then the switch will send the command “Switch Power Removal Request” to the Marvell TC10 PHY device to communicate “drop INH” and remove power (which must happen within another 8 ms) if the switch is OK with this power removal. When started, the command sequence for power removal can be interrupted by a wake request regardless of what is seen at the Host interfaces. If the Marvell TC10 PHY device is able to initiate an LPSD power removal, and once the device is in the LPSD Deep Sleep Mode, only a pulse sent into the WAKE_IN pin for a local wake up or activity on the copper media side (Analog receiver) for a remote wake up can wake up the Marvell TC10 PHY device. Anything else getting power from a regulator controlled by the Marvell TC10 PHY device INH output also will wake up. Note that a local or remote wakeup may be disabled by programming the corresponding register bits in the 3.87xx space in the PHY:
    - 3.8701.12 LPSD Local Wake Up
    - 3.8701.11 LPSD Remote Wake Up
12. If the switch is not OK with power removal, it will not send the “Switch Power Removal Request” command. The Marvell TC10 PHY device and its LP stay in the T1 Port Sleep Mode. For example, if a wake request is seen if from any source, then the switch cannot initiate an LPSD power removal.
13. The switch cannot force a power removal before either the sleep handshake completes or the sleep handshake has failed.
14. By default, the Marvell TC10 PHY device does not get itself out of the T1 Port Sleep Mode.
15. One of the following actions must be performed to progress the Marvell TC10 PHY device out of the T1 Port Sleep Mode if desired:
    - The Marvell TC10 PHY device Wake Request register bit is written to by the Switch.
    - The switch can send the “Switch Wake Request” command to have the Marvell TC10 PHY device wake up from the T1 Port Sleep Mode.
    - A pulse can be sent in the WAKE_IN pin.

After power is reapplied, the switch automatically sends wake requests to whatever ports are designated to have these requests forwarded to them; however, if the PHY receives a remote wake request from the copper media side or from a register bit setting, then the PHY must send a wake request to the switch and the switch must relay this according to its forwarding logic.

The switch can enable flow control after it has power reapplied. Link toggling from 0 to 1 informs the switch that it can send traffic to the PHY Tx side. If link drops, then flow control is enabled; so, flow control may be enabled by the switch when it receives a “Sleep in Progress” command or when link goes down.

3.2 Deep Sleep Mode

There are ways to request a **Deep Sleep Mode** entry:

1. Write register bit (88Q111x -> 3.8700.0) to 1. This puts the device in Deep Sleep Mode immediately where INH is deasserted, without doing a TC10 sleep handshake with the Link Partner.
2. Another scenario would be for the PHY that have already entered T1 Port Sleep, followed by the (controller) writing register bit (88Q111x -> 3.8700.0) to 1, to have the INH deasserted and enter deep sleep.
3. **A Switch Power Removal Request (No external PHYs are connected).** This gives the internal PHY and the switch permission to go into Deep Sleep. This is only allowed when all devices are in the T1 Port Sleep Mode first and then they receive this power removal permission. The switch can instead not grant permission for a PHY to have power removed and it would itself not go into Deep Sleep. Note that there is a register bit that can prevent the Switch from going into Deep Sleep if this is desired by the user.

   The following register needs to be configured to put the switch into Deep Sleep mode:

   - Disable Port Sleep Check for each external port by setting TC10 Port Control Register (Index: 34 of Port Scratch and Miscellaneous on Port 1 to 11 Offset: 0x1A) bit 6 to 1.
   - Enable Deep Sleep by setting TC10 Global Control 1 Register (Index: 32 of Port Scratch and Miscellaneous on Port 0 Offset: 0x1A) bit 3 to 1
   - To Enter into LPSD/Deep Sleep, set TC10 Global Control 1 Register bit 0 to 1.

4. **Power Removal Request for a Switch with External PHYs**:

   When all ports have agreed to enter the TC10 sleep state with their link partner, the external host can then decide to send switch (and PHY) into the Deep Sleep state taking away power from the Switch. During this mode, the device can continuously monitor for a pulse presented at the local wake-up pin and respond to this wake-up pulse.
   The following register needs to be configured to put the switch into Deep Sleep mode:

   - Disable Port Sleep Check for each port by setting TC10 Port Control Register (Index: 34 of Port Scratch and Miscellaneous on Port 1 to 11 Offset: 0x1A) bit 6 to 1.
   - Enable Deep Sleep by setting TC10 Global Control 1 Register (Index: 32 of Port Scratch and Miscellaneous on Port 0 Offset: 0x1A) bit 3 to 1
   - To Enter into LPSD/Deep Sleep, set TC10 Global Control 1 Register bit 0 to 1.

4. Wake from Sleep

As an IEEE and OPEN Alliance TC10 compliant 100BASE-T1 Ethernet PHY, the Marvell TC10 PHY supports wake-up using a Wake-up Pulse (WUP) or supports using a Wake-up Request (WUR) to notify others to potentially wake up Devices further within a network.

Wake-up

The Marvell TC10 PHY can be woken up by a local wake-up pin, a wake-up request command or a wake-up pulse from link partner. Upon detection, a wake-up interrupt may be generated, and the wake-up source is flagged in the Wake-up Status Register. The source bits are cleared when device is in reset mode.

Local Wake-up

When the Device is in a low power mode, a positive pulse presented at the WAKE_IN pin and meeting the minimum duration time (tlocalwkup) triggers a local wake-up.

Remote Wake-up Indication During Link-up by WUR)

A WUR command is encoded in the scrambler stream as defined in Section 7.3 of OPEN TC10 Sleep/Wake-up Specification when a wake request is received after link up, so the device is not in a low power mode. A minimum of 64 bits of Wake-up Request encoded idles are required for a successful detection and passing of the wake request to the other parts of the network.

(For example: with 88Q1110/88Q1111, writing bit 3.8702.4 = '1' to send out Wake Up Request (WUP) to link partner.)

Remote Wake-up by WUP

WUP are link training codes transmitted from the link partner over a passive link. The activity on the MDI lines will be detected as a remote wake-up. The wake-up pulse has a duration of 1 ms (+/- 0.3 ms) to allow a reliable detection.

Low Power Sleep

Low Power Sleep (LPS) is encoded in the scrambler stream as defined in Section 7.3 of the OPEN Sleep/Wake-up Specification. 64 bits of LPS encoded idles must be sent for a sleep request to be successfully detected by the link partner.

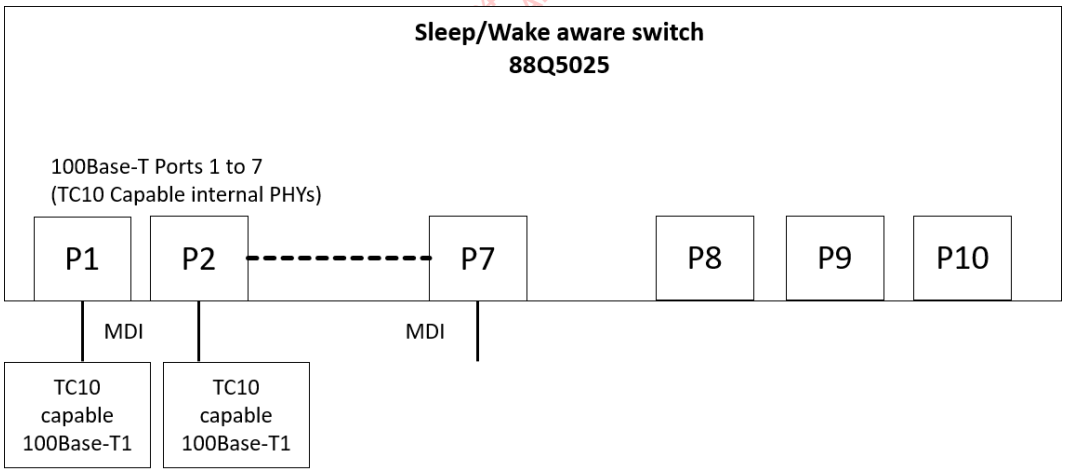
TC10 Sleep/Wake-up Enable

The TC10 Sleep/Wake-up feature for the device is enabled via the configuration pin in the standalone PHYs.

5. Sleep and Wake-up Forwarding

5.1 Switch with Only Integrated PHY in Use

Figure 4: Internal TC10-capable PHYs Connected with TC10 PHY LP



In the switch application, an event of TC10 wake up or TC10 sleep from one port can be propagated automatically to other integrated ports if the sleep and wake up forwarding vectors are set to the intended ports.

Table 1: Sleep Forwarding Vector Register, Index:30 of Port Scratch and Miscellaneous on Port 1 to 11

Offset: 0x1A

Bits	Field	Type	Description
7:1	SleepFwd Vec[7:1]	RWR	TC10 Sleep Forwarding Vector[7:] This indicates to which PHY the port's Sleep signal should forward. To forward to Port 1, bit 1 of this register must be set to one. Setting bit forwarding to its own port does not have any effect. Note: Bit 1 is for port 1, bit 2 is for bit 2, and so on.
0	Reserved	RSVD	Reserved for future use

Table 2: Wake Forwarding Vector Register, Index:32 of Port Scratch and Miscellaneous on Port 1 to 11

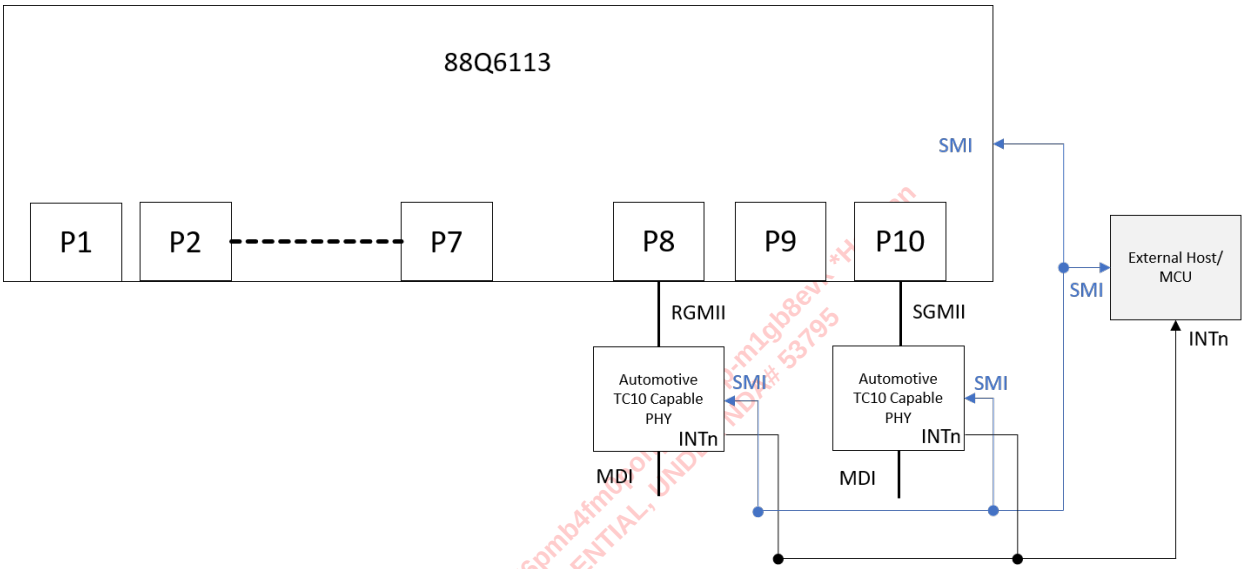
Offset: 0x1A

Bits	Field	Type	Description
7:1	WakeFwd Vec[7:1]	RWR	TC10 Wake Forwarding Vector[7:] This indicates to which PHY the port's Wake signal should forward. To forward to Port 1, bit 1 of this register must be set to one. Setting bit forwarding to its own port does not have any effect. Note: Bit 1 is for port 1, bit 2 is for bit 2, and so on.
0	Reserved	RSVD	Reserved for future use

In the case of external PHYs, software can write to registers to manually forward the WUP or sleep request at the local attached PHY. For example, with 88Q1110/88Q1111, manually write bit 3.8702.4 = '1' to send out Wake Up Request (WUP) to link partner; the next section describes this scenario in detail.

5.2 Switch with External PHY

Figure 5: External TC10-capable PHYs Connected with the Marvell Switch



For extended applications of external TC10-capable PHYs connected with the Marvell switch (88Q6113), the device level awareness of the Sleep/Wake events is required so that the device can determine if the device is ready to allow itself to enter sleep. This can be achieved with help of an external host as shown in Figure 5.

When External PHY agrees to enter the TC10 Sleep/Wake mode, either by receiving TC10 sleep/wake-up request from the link partner or sleep/wake-up request by the host, interrupt can be generated on one of PHY pins. All interrupts are grouped and connected to the external host. Upon receiving the interrupt, the

external host can poll the sleep/wake-up status of all externally connected PHYs and based on software-defined sleep/wake forwarding table it can forward sleep/wake-up requests to other PHYs in the system.

5.3 Sleep Scenarios in Switch Application

Switch Powered while Some or All Ports are in T1 Port Sleep Mode

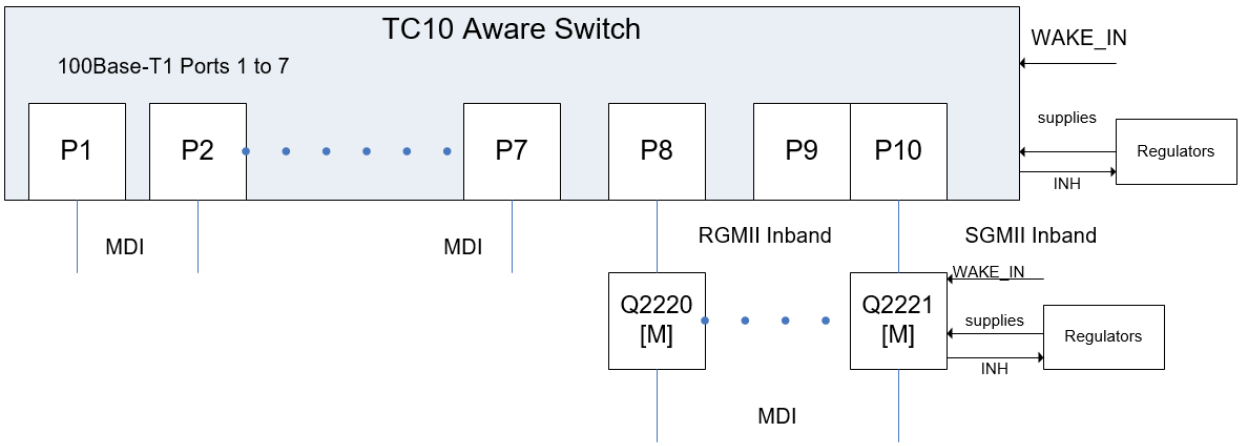
T1 port sleep mode is similar to IEEE power down mode and register access to each of those PHY ports are possible during T1 Port Sleep Mode. In the case of a switch, if the integrated PHY port is in T1 Port Sleep Mode, it means the the switch is still powered. External PHYs that have decided on TC10 sleep will also enter T1 Port Sleep Mode.

Switch Power Removed

Deep Sleep Mode would mean the INH is de-asserted and connected regulators can remove power.

If the switch has power removed, then the switch and its integrated PHYs will be in the deep sleep mode. The external PHYs will have entered deep sleep mode and its power would be removed. Prior to removing power of the external PHY, the switch can query to PHY to determine if the external PHY is in T1 Port Sleep Mode.

Figure 6: Switch TC10 Sleep

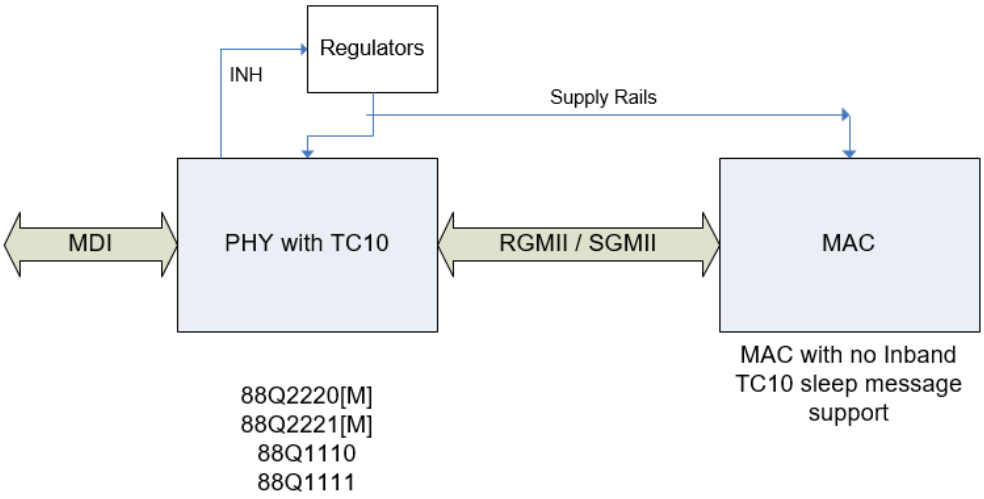


In this figure, separate INH to separate regulators are shown for the case that PHYs and the switch have their own power subsystem. However, it may be more common that a shared power subsystem among the switch and PHYs. Refer to the later section Full System LPSD Configuration for details.

5.4 Standalone PHY Power Removed

When the TC10 PHY is connected with a MAC/switch that is not TC10 aware, upon agreeing to enter TC10 sleep, the PHY will enter T1 Port Sleep Mode. The MAC can query the PHY and then set the PHY into deep sleep mode which results in the INH de-assertion and if connected to the regulators, can remove power.

Figure 7: Standalone TC10 PHY Connected with Non-TC10 Aware MAC/Switch



Wake-up Application

Any of the following ways may be used to wake up a device out of the T1 Port Sleep Mode:

1. Energy is detected at the MDIP/N media interface of TC10-capable PHYs.
2. A wake pulse of at least 40 µs is detected at the Marvell TC10 PHY device's WAKE_IN pin. There is no wake request forwarded at the Host interface in this case.
3. A WUR is sent when link is up to sleeping devices further on in the network.
4. A WUP is sent to the link partner if the sender is in the T1 Port Sleep Mode upon receiving a wake request at its Host interface.

Note that if the link is not up, then a WU will not be sent until link comes up and will not be sent if the link is not up within 195 ms by default.

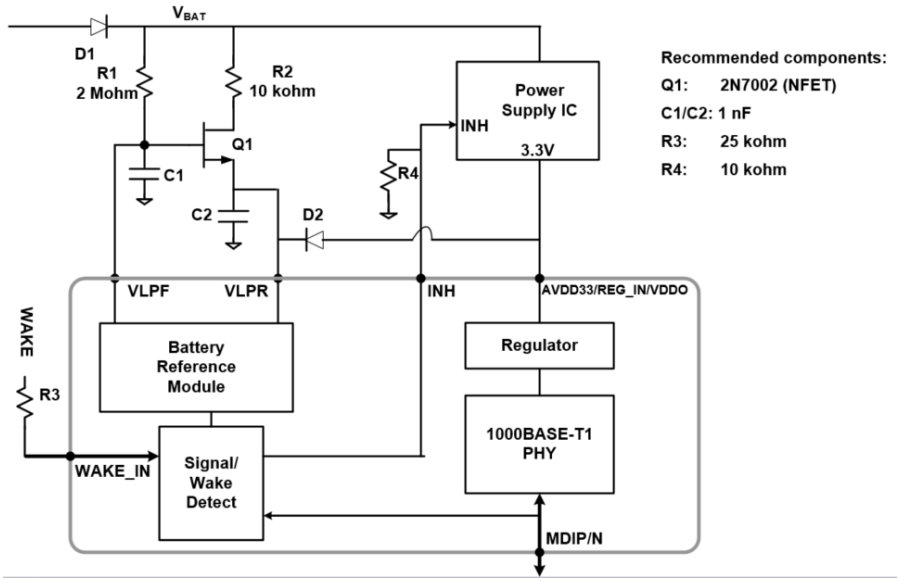
Any of the following ways may be used to wake up a device out of Deep Sleep Mode:

1. Energy is detected at the MDIP/N media interface.
2. A wake pulse of at least 40 us is detected at the Marvell TC10 PHY device's WAKE_IN pin.

Note that in a switch, any port receiving energy to wake up will forward a wake request to other ports where sending a wake request is indicated. A WUP will be sent to the other port link partners if indicated.

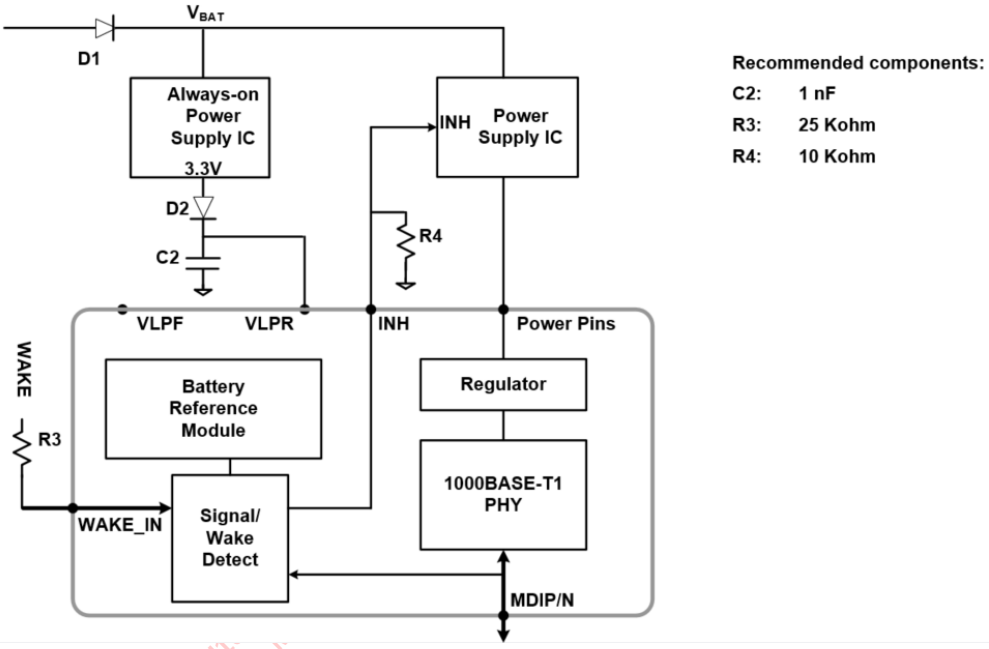
6. LPSD Circuitry Options

Figure 8: Option 1 - Utilizing VBAT with MOSFET to Regulate the Voltage to VLPR



Refer to the datasheet for further details.

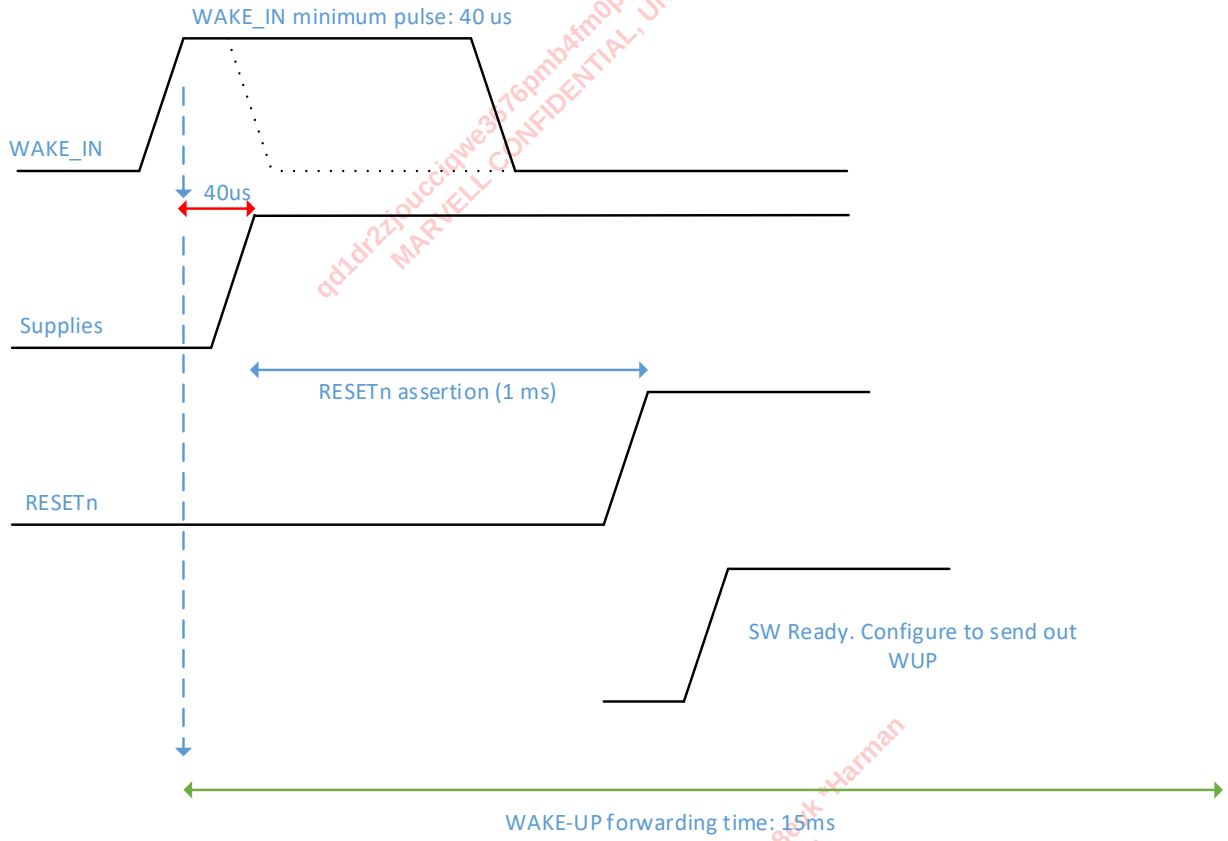
Figure 9: Option 2 - Utilizing a Diode Drop from an Available 3.3V to Feed VLPR



Refer to datasheet for further details. VLPR expects 2.6V (allowable range: min 2.3V to 2.9V max).

6.1 WAKE_IN and POR Sequence Timing

Figure 10: Upon a Wake Event, the Wake-up Forwarding Should Occur within 15 ms



To ensure timing window is uniform across all devices, a WAKE_IN and POR should be initiated by an external host/or microcontroller to each device. Within the 15 ms windows, after full system boot up for the switch and PHY, either automatic wake forwarding or manual wake forwarding via register write is required to send out wake-up pulse to notify TC10 link partners.

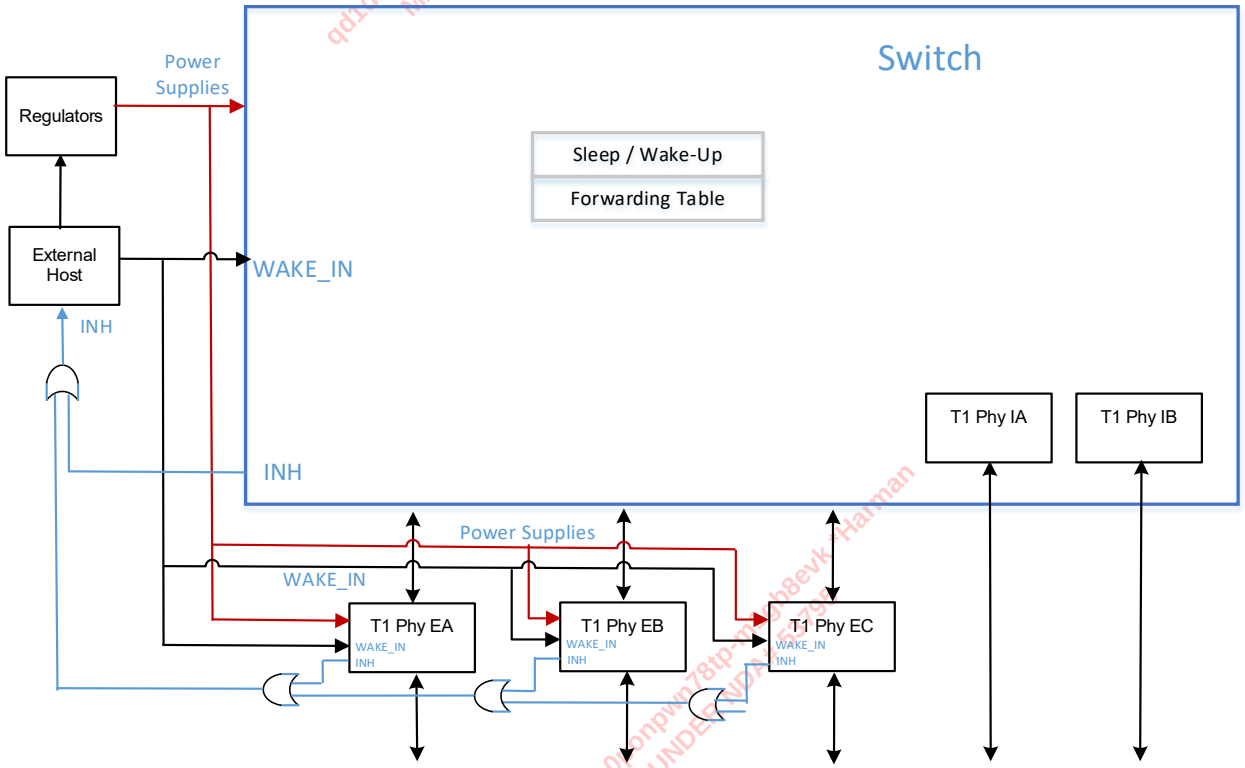
7. Full System LPSD Configuration

Systems where the power subsystem is shared among PHYs and switches, the LPSD connection can be combined, where INH from each device are logically combined.

System-level Sleep/WUP scenarios have the following assumptions:

1. The switch and its external PHYs share the same power supply.
2. The switch must be on if any of its PHYs are on.
3. The external host wakes up individual PHY first, before instructing the PHY to send out Sleep or WUP command to its link partner.
4. Hardware reset signal resets both the switch and PHYs.

Figure 11: Full System LPSD



For the purposes of discussion in this document, integrated PHYs as T1 Phy IA and T1 Phy IB. The external PHYs are referred to as: T1 Phy EA, T1 Phy EB, and T1 Phy EC.

Generally, a security microcontroller (external host) is available in the system and by providing the INH to the microcontroller, the microcontroller can assert the WAKE_IN and enable regulators to the switch and PHY subsystems.

Scenario 1: The whole system is in deep sleep

Remote Wake-up

1. One of the PHY ports receives WUP from its link partner and it wakes up and asserts INH.
2. The INH is received by the microcontroller which provides a WAKE_IN to PHYs and the switch.
3. The microcontroller will enable regulators to the switch and PHYs.
4. The system can send and receive TC10 Sleep and Wake-up commands from that point forward.

Local Wake-up

1. The external host, assuming it's available, assert WAKE_IN to both PHYs and the switch.
2. The switch and PHYs will wake up from sleep.

Scenario 2: When whole system is in wake-up state

1. One of the PHY ports receives the Sleep command from its link partner.
2. The previously described command is forwarded to the switch.
3. The switch forwards such command to other ports depending on port configuration. The sleep request is initiated outbound to all ports that are TC10 sleep capable.
4. The system enters deep sleep if all PHYs agree by completing TC10 handshake with each of its link partner.

Use Case Group 1

Pre-condition: The switch and all associated internal and external PHYs are in TC10 deep sleep.

Case 1.1 Remote Wake-up

Constraint:

Wake-up forwarding time: <=15 ms, including all regulator power up and the switch/PHY boot up time.

Procedure:

1. One (or more) internal/external PHY receive WUP from its link partner, external PHY EA are used as an example, PHY EA drives its internal INH net High. The INH is received by the microcontroller which provides a WAKE_IN to PHYs and switches. The microcontroller will enable regulators to the switches and PHYs.
2. All switches and PHYs receive power. The switch may require additional time to boot up.
3. The PHY EA do not send WUP/WUR to its link partner, unless the switch forwarding vector has configure that MAC port associated with PHY EA and the switch will use CIC inband to initiate external WUP. If inband is not used, then the external host can explicitly instruct the PHY to send WUP via register write.
4. The PHY EB, EC, IA, IB, depending on pre-configured wake-up forwarding table, wakes up and forward WUP to its respective link partners within 15 ms after PHY EA receives WUP.

Note:

a. For the PHY which is configured not to send WUP to its link partner, it remains in TC10 sleep mode (also refer to as T1 port sleep) with all power rails supplied, and is expecting remote WUP or local wake-up to wake up.

b. Unless the external host explicitly instruct to do so, all PHYs do not send additional WUP/WUR aside from initial forwarded one.

Case 1.2 Local Wake-up by WAKE_IN Pin

Constraint:

Wake-up forwarding time: <=15 ms, including all regulator power up and the switch/PHY boot up time.

Procedure:

1. The external host, assumed up and available, asserts WAKE_IN to the switch and all PHYs.
2. The regulator turns on after it receives first INH being High regardless of the source.
3. All switches and PHYs receive power. The switch may need additional time to boot up.
4. All internal/external PHYs, depending on pre-configured wake-up forwarding table, wake up and forward WUP to its respective link partners within 15 ms after WAKE_IN is asserted.

Note:

a. For the PHY which is configured not to send WUP to its link partner, it remains in TC10 sleep mode (also refer to as T1 port sleep) with all power rails supplied and is expecting remote WUP or local WAKE_IN to wake up.

b. Unless the external host explicitly instruct to do so, all PHYs do not send additional WUP/WUR aside from initial forwarded one.

c. TC10 requires forwarding wake-up command to all ports if source is from local WAKE_IN.

Use Case Group 2

Pre-condition: Power is supplied to the switch and all associated internal and external PHYs. Not all internal/external PHY may be in TC10 port sleep mode.

Case 2.1 Remote Wake-up (WUP/WUR)

Constraint:

Wake-up forwarding time: <=2 ms, this is active forwarding case.

Procedure:

1. The PHY receives remote wake signal (WUP/WUR) from its link partner and command is forwarded to the switch forwarding table.
2. All internal/external PHYs, depending on pre-configured wake-up forwarding table, wake up and transmit WUP (if in TC10 sleep mode) or transmit WUR (if in TC10 wake-up mode) to the link partner.

Note:

a. For the PHY which is still in TC10 sleep mode and receives wake-up command from switch, it will be woken up and send WUP to its link partner.

b. Unless the external host explicitly instruct to do so, all PHYs do not send additional WUP/WUR aside from initial forwarded one.

c. For the PHY which is in TC10 sleep mode and configured not to send WUP to its link partner, it remains in TC10 sleep mode with all power rails supplied and is expecting remote WUP or local wake-up to wake up.

Case 2.2 Local Wake-up by WAKE_IN Pin

Constraint:

Wake-up forwarding time: <=2 ms, this is an active forwarding case.

Procedure:

1. The external host, assumed up and available, asserts WAKE_IN to Switch and all PHYs. Note that all WAKE_IN are tied together in the use case.
2. All internal/external PHYs, depending on pre-configured wake-up forwarding table, shall wake up and transmit WUP (if in TC10 sleep mode) or transmit WUR (if in TC10 wake-up mode) to link partner

Note:

a. For the PHY which is still in TC10 sleep mode and receives wake-up command from switch, it will be woken up and send WUP to its link partner.

b. TC10 requires forwarding wake-up command to all ports if source is from local WAKE_IN.

c. For the PHY which is in TC10 sleep mode and configured not to send WUP to its link partner, it shall stay in TC10 sleep mode with all power rails supplied and is expecting remote WUP or local wake-up to wake up.

d. Unless the external host explicitly instruct to do so, all PHY shall not send additional WUP/WUR aside from initial forwarded one.

Case 2.3 Local Wake-up by Register

Constraint:

Wake-up forwarding time: <=2 ms, this is active forwarding case.

Step:

1. External host, assumed up and available,

a. instructs the switch to forward wake-up command to its internal/external PHY according to the forwarding table, or

b. instructs the switch and the external PHY separately to forward the wake-up command to designated PHY.

Note:

a. For the PHY which is still in TC10 sleep mode and receives wake-up command from host, it will be woken up and send WUP to its link partner.

b. Unless the external host explicitly instruct to do so, all PHYs will not send additional WUP/WUR aside from initial forwarded one.

c. For the PHY which is in TC10 sleep mode and configured not to send WUP to its link partner, it remains in TC10 sleep mode with all power rails supplied and is expecting remote WUP or local wake-up to wake up.

Case 2.4 Remote Sleep (LPS Command)

Constraint:

Sleep command forwarding time: <=2 ms

Procedure:

1. One (or more) internal/external PHY receives LPS from its link partner, using an external PHY EA as an example.
2. The PHY EA notifies the switch of ongoing TC10 handshaking status with link partner.
3. After the handshaking completes, the PHY EA notifies the switch of the completion and drive its internal INH net Low.
4. The switch will forward sleep command to other internal/external PHYs according to the sleep forwarding table.

Note:

   a. The switch will not drive INH Low before all PHYs complete TC10 handshaking

Case 2.5 Local Sleep by Register

Constraint:

Sleep command forwarding time: <=2 ms

Procedure:

1. External host, assumed functional,
   a. instructs the switch to forward sleep command to its internal/external PHYs according to the forwarding table, or
   b. instructs the switch and external PHY separately to forward sleep command to designated PHYs.
2. Each PHY notifies the switch of ongoing TC10 handshaking status with link partner.
3. After handshaking completes, each PHY notifies the switch of the completion and drive its internal INH net Low.

Note: The switch does not drive INH Low before all PHY completes TC10 handshaking.

Appendix A: Init Code for TC10

The following device requires a one-time initialization for proper TC10 functionality

88Q222x[M]

The PHY is unable to detect a wake-up pulse when it goes into deep sleep (LPSD sleep) due to a high threshold for the wake-up pulse signal detection.
To lower the signal detection threshold, set the following bits in register 3.802C:

- 3.802C.15 = 1'b1 Enable overwrite.
- 3.802C.14:13 = 2'b01 Set threshold to 1 (Low).

The threshold setting persists until VBAT(12V) is removed. Other power supply rails removal (3.3V, 1.2V, 0.75V) will not clear the threshold setting.

88Q5075

To configure the sleep forwarding vector for a switch internal PHY, set 3.FA38.0=1 for each internal PHY. For an internal PHY, this bit also must be enabled to fully the enable sleep forwarding feature, it is a multi-step process.

Appendix B: Document Revision History

Revision	Date	Description
Rev 1	10/12/2021	Initial release