# Low Power Support: Coherency Components

Gemini low-power support has additional requirements and considerations. This section will describe these in more details.

## Coherent IP and their Master Ports must share a power domain

The CCC, IOCB, and LLC hosts must share a power domain with their master port bridges. This is to ensure that these agents can always issue a request to the master port without having to check if the master bridge is powered on, or to go through a sequence to power it on.

## Coherency Connect/Disconnect

ACE masters and ACE-lite+DVM masters must go through a special sequence in order to be powered down. Each of these agents can receive snoops from either CCC or DVM. In order to shut-down, they must get into a state where they no longer need to accept snoops and the CCC and DVM know that they shouldn’t send them. This is implemented in the coherency connect/disconnect protocol. Only when these agents are successfully disconnected can they be powered down.

When these agents attempt to connect to coherency, the CCC, DVM and all paths to and from those agents must be either powered up, or allowed to be powered up with an auto-wake. If one of these elements was in a decode-error type of power domain and not powered up, the connect sequence would get stuck and the agent could hang. Either software needs to be very careful about controlling these power domains and ensuring they are available before any ACE or ACE-lite+DVM is powered on, or they system should choose to place these elements in an auto-wake domain.

ACE-lite, ACE-lite+DVM, and ACE-lite-converted agents all send their IO coherent requests to IOCB. When the requests arrive at IOCB, if it is not already connected to coherency, it will start the process of connecting. Just as with the ACE agents, the CCC must be powered on or auto-wake before the IOCB can connect. This means it must be available before any IO coherent traffic can be issued, or the system could hang.

## DVM Power Domain as Decode Error

The DVM protocol has unique properties. DVM requests cannot handle decode-errors like other requests. The DVM sync request, for instance, requires that a snoop is sent from the DVM to indicate the synchronization has taken place. If the DVM were powered down and was in a decode-error type of power domain when a DVM request is made, the master could hang. For this reason, either the PMU must ensure the DVM is powered up before any ACE or ACE-lite+DVM agents are enabled, or the DVM must be part of an auto-wake domain.

## IOCB Power Down

The IOCB can be powered down whenever it is inactive, as it doesn’t hold state. This makes it a useful candidate for an auto-wake power domain. If the IOCB is requested to power down while it still has requests outstanding, it will reject the power down request with a QDENY.

## CCC Power Down

The CCC stores directory state for coherent masters and so it can’t be turned off at random times, even if no traffic is outstanding. CCC can only be powered off when all coherent masters are disconnected from it, including IOCB. When there are no connected agents, any information in the directory will be stale, and the CCC can be powered down. If the CCC is part of an auto-wake domain and is requested to shut down, it will produce a QDENY to reject the power down if it detects that there are connected agents.

## LLC Power Down

The LLC has unique power domain requirements. It holds a significant amount of data in the cache. It may also be configured as a ScratchPad RAM. In order to power down without data loss, the cache must be flushed first.

To flush the LLC of dirty data, the LLC ways must all be disabled for allocation, to avoid new lines being added to the cache. After that, a flush engine must be initiated that pushes all dirty data to memory, invalidating the cache as it goes. The invalidation is to ensure that write requests don’t hit in the cache and modify a line that was already cleaned. Once the flush engine is completed, and traffic is disabled to the LLC, those LLC ways should be marked as disabled.

If any of the ways are set up as ScratchPad RAM, the LLC will reject a power down sequence. This is because the data will be lost. If the data is no longer needed, software should reprogram those ways as disabled. Power down of the LLC can only happen if all ways are disabled as cache and disabled as RAM. This tells the LLC that no data is currently stored.

If the LLC is part of an auto-wake domain, it will reject any power down request until the entire cache is disabled.

## Restrictions

Gemini Low Power configurations have the following restrictions.

* Gemini IP hosts (CCC, IOCB, DVM and LLC) and their master bridge ports must be under the same power domain
* Gemini IP (CCC, IOCB, DVM and LLC) does not support the voltage domain crossing between itself and bridge ports
* In low power mode, Gemini IP auto-wake mode must be enabled. Not doing so, some coherent transaction will fail. For instance, DVM currently can’t handle decode error