144.3.6 MPCPDU structure and encoding

The MPCPDU structure shall be as shown in Figure 144–26, and is further defined as follows:

a) Destination Address (DA). The DA in MPCPDU is the MAC Control Multicast address as specified in the annexes to Clause 31, or the individual MAC address associated with the port to which the MPCPDU is destined.

b) Source Address (SA). The SA in MPCPDU is the individual MAC address associated with the port through which the MPCPDU is transmitted. For MPCPDUs originating at the OLT end, this can be the address any of the individual MACs. These MACs may all share a single unicast address, as explained in 144.1.2.

c) Length/Type. The Length/Type in MPCPDUs carries the MAC_Control_Type field value as specified in 31.4.1.3.

d) Opcode. The opcode identifies the specific MPCPDU being encapsulated. Values are defined in Table 31A–1.

e) Timestamp. The timestamp field conveys the content of the *LocalTime* variable (see 144.2.2.2) at the time of transmission of the MPCPDUs. This field is 32 bits long and counts time in the units of 1 EQ.

f) Data/Reserved/PAD. These 40 octets are used for the payload of the MPCPDUs. When not used they are filled with zeros on transmission, and ignored on reception.

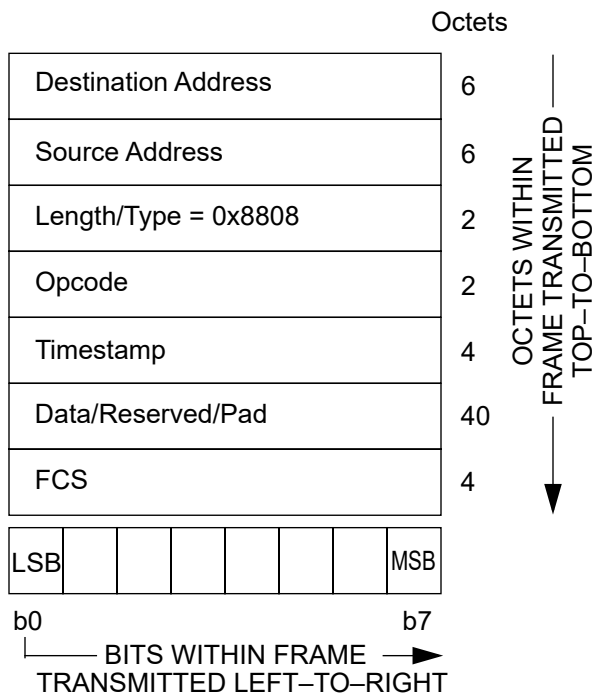g) FCS. This field is the Frame Check Sequence, typically generated by the underlying MAC.

Figure 144–26—Generic MPCPDU

144.3.6.1 GATE description

The purpose of GATE message is to grant transmission windows to ONUs for normal transmission. Up to seven grants can be included in a single GATE MPCPDU. Only grants with non-zero value within the *Grant*

Length #n field are processed by the ONU. If the number of grants with non-zero value in the *Grant Length #n* field in the GATE MPCPDU is zero, such a GATE MPCPDU is used as an MPCP keep alive from the OLT to the ONU.
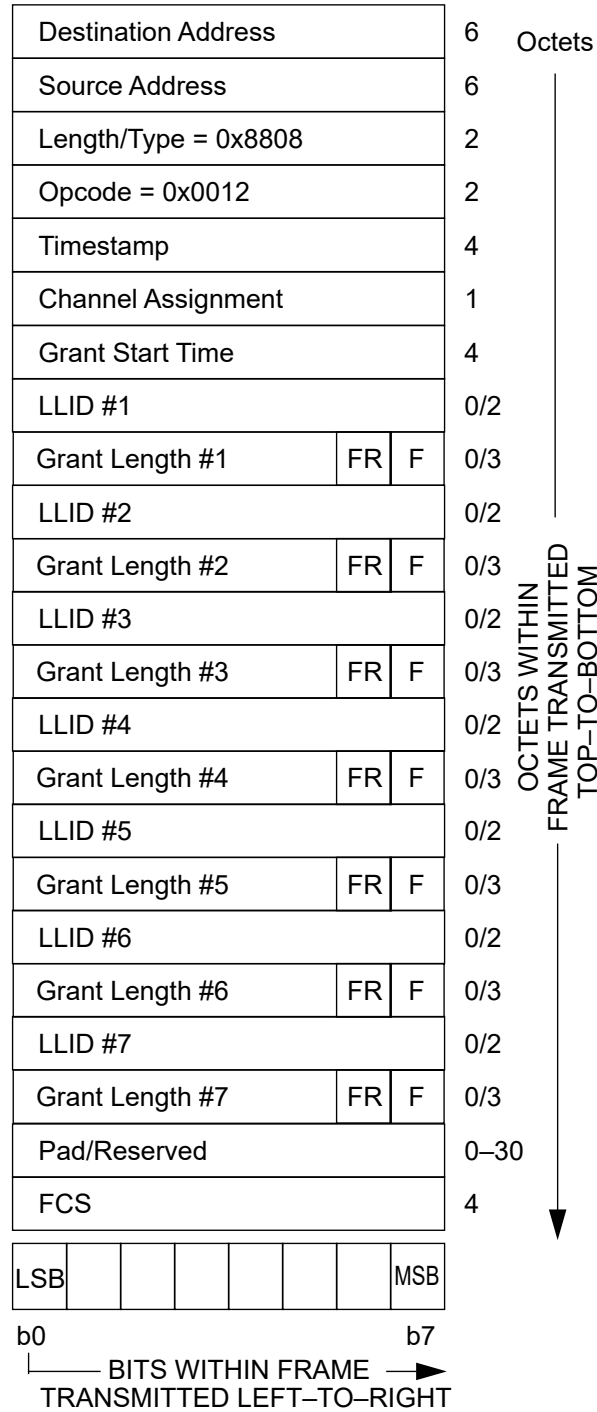
Field	Octets
Destination Address	6
Source Address	6
Length/Type = 0x8808	2
Opcode = 0x0012	2
Timestamp	4
Channel Assignment	1
Grant Start Time	4
LLID #1	0/2
Grant Length #1 · FR · F	0/3
LLID #2	0/2
Grant Length #2 · FR · F	0/3
LLID #3	0/2
Grant Length #3 · FR · F	0/3
LLID #4	0/2
Grant Length #4 · FR · F	0/3
LLID #5	0/2
Grant Length #5 · FR · F	0/3
LLID #6	0/2
Grant Length #6 · FR · F	0/3
LLID #7	0/2
Grant Length #7 · FR · F	0/3
Pad/Reserved	0–30
FCS	4

OCTETS WITHIN FRAME TRANSMITTED TOP–TO–BOTTOM

LSB ... MSB

b0 ... b7

BITS WITHIN FRAME TRANSMITTED LEFT–TO–RIGHT

Figure 144–27—GATE MPCPDU

The GATE MPCPDU is an instantiation of the Generic MPCPDU, and is further defined as follows:

a) Opcode. The opcode for the GATE MPCPDU is 0x0012.
b) Channel Assignment: This 8-bit flag register, where bits 0-3 contain a bitmap representing the wavelength channel(s) on which to transmit on during the assigned transmission slot. Bits 4-7 are reserved. Table 144–1 shows the mapping between individual bits and upstream channels.

Table 144–1—Channel Assignment flags

Bit	Channel field	Values
0	Upstream channel 0	0 – do not use upstream channel 0 for transmission 1 – use upstream channel 0 for transmission
1	Upstream channel 1	0 – do not use upstream channel 1 for transmission 1 – use upstream channel 1 for transmission
2	Upstream channel 2	0 – do not use upstream channel 2 for transmission 1 – use upstream channel 2 for transmission
3	Upstream channel 3	0 – do not use upstream channel 3 for transmission 1 – use upstream channel 3 for transmission
4-7	Reserved	Reserved

c) Grant Start Time: This 32-bit unsigned integer value represents the start time of the transmission grant, expressed in the units of 1 EQ. The start time is compared to the local clock, to correlate the start of the grant.
d) LLID #n: This 16-bit unsigned integer value represents the logical link that is being granted a transmission slot.
e) Grant Length #n: This 22-bit unsigned value represents the length of the grant assigned to LLID #n. The length of the granted transmission slot is expressed in the units of 1 EQ. Up to 7 grants may be packed into a single GATE MPCPDU. All transmission overhead components (see TBD) are included in and thus consume part of the granted transmission slot.
f) Fragmentation (F): (TBD)
g) Forced Report (FR): When the respective bit is set to 0, no action is required from the ONU. When the respective bit is set to 1, the ONU should issue a REPORT MPCPDU during the transmission grant indicated by the *Grant Length #n* field associated with this *Forced Report* flag.
h) Pad/Reserved. This is an empty field that is transmitted as zeros, and ignored on reception. The size of this field depends on the used *Grant Length #n / LLID #n* entry-pairs as well as the presence of any optional fields, and varies in length from 0-30 accordingly.

Editor's Note (to be removed prior to publication): if the number of grants is always fixed at 7, pad size is not variable and should be fixed. The same with the presence of individual fields -they are marked as 0/2 size at this time, implying they may be absent. However, parsing at the ONU requires either knowledge of grant count (absent right now) or a fixed pattern (known number of grants). Right now, we are in the middle requiring contextual parsing in the ONU.

144.3.6.2 REPORT description

REPORT MPCPDU has several functionalities, i.e.:
— Time stamp carried in the *Timestamp* field in each REPORT MPCPDU is used for round trip time (RTT) calculation,
— ONUs use the REPORT MPCPDUs to indicate the amount of data queued in individual LLIDs, and
— REPORT MPCPDUs are also used as keep–alives from ONU to the OLT.

The REPORT MPCPDU is an instantiation of the Generic MPCPDU, and is further defined as follows:
a) Opcode. The opcode for the REPORT MPCPDU is 0x0013.
b) Number of Non-empty Queues (LLIDs): (TBD)

c)   Report Time: (TBD)

Destination Address	6	Octets
Source Address	6	
Length/Type = 0x8808	2	
Opcode = 0x0013	2	
Timestamp	4	
Number of Non-empty Queues (LLIDs)	1	
Report Time	4	
LLID #1	2	
Queue Length #1	3	
LLID #2	2	
Queue Length #2	3	
LLID #3	2	
Queue Length #3	3	
LLID #4	2	
Queue Length #4	3	
LLID #5	2	
Queue Length #5	3	
LLID #6	2	
Queue Length #6	3	
LLID #7	2	
Queue Length #7	3	
Pad	0...35	
FCS	4	

OCTETS WITHIN FRAME TRANSMITTED TOP–TO–BOTTOM

LSB | | | | | | MSB

b0   b7

└──── BITS WITHIN FRAME ──→
TRANSMITTED LEFT–TO–RIGHT

Figure 144–28—REPORT MPCPDU

d)   LLID #n: This 16-bit unsigned integer value represents the logical link that is reporting the queue occupancy.

e) Queue Length #n: This 24-bit unsigned value represents the occupancy of the queue assigned to LLID #n, at time *Report Time*. The value of the queue occupancy is expressed in the units of 1 EQ. Up to 7 queues may be packed into a single REPORT MPCPDU.

f) Pad/Reserved. This is an empty field that is transmitted as zeros, and ignored on reception. The size of this field depends on the used *Queue Length #n / LLID #n* entry-pairs as well as the presence of any optional fields, and varies in length from 0-35 accordingly.

Editor's Note (to be removed prior to publication): REPORT MPCPDU figure shows all Queue / LLID fields as mandatory and then pad field size is marked as 0 ... 35 which makes no sense.

The REPORT MPCPDU shall be generated by a MAC Control instance mapped to an active ONU, and as such shall be marked with a unicast type of LLID (see TBD).

144.3.6.3 REGISTER_REQ description

The REGISTER_REQ MPCPDU is an instantiation of the Generic MPCPDU, and is further defined as follows:

a) Opcode. The opcode for the REGISTER_REQ MPCPDU is 0x0014.

b) Flags. This is an 8 bit flag register that indicates special requirements for the registration, as presented in Table 144–2.

Table 144–2—REGISTER_REQ MPCPDU Flags fields

Value	Indication	Comment
0	Reserved	Ignored on reception.
1	Register	Registration attempt for ONU.
2	Reserved	Ignored on reception.
3	Deregister	This is a request to deregister the ONU. Subsequently, the MAC is deallocated and the LLID may be reused.
4–255	Reserved	Ignored on reception.

c) Pending Grants. This is an unsigned 8 bit value signifying the maximum number of future grants the ONU is configured to buffer. The OLT should not grant the ONU more than this maximum number of *Pending grants* vectors comprised of {llid, grant length, force_report, fragmentation} into the future.

d) Discovery Information. This is a 16 bit flag register. Table 144–3 presents the structure of the Discovery Information flag.

Table 144–3—Discovery Information Fields

Bit	Flag field	Values
0	ONU is 1G upstream capable	0 – ONU transmitter is not capable of 1 Gb/s 1 – ONU transmitter is capable of 1 Gb/s
1	ONU is 10G upstream capable	0 – ONU transmitter is not capable of 10 Gb/s 1 – ONU transmitter is capable of 10 Gb/s
2	ONU is 25G upstream capable	0 – ONU transmitter is not capable of 25 Gb/s 1 – ONU transmitter is capable of 25 Gb/s
3	Reserved	Ignored on Reception
4	1G registration attempt	0 – ONU transmitter is not capable of 1 Gb/s 1 – ONU transmitter is capable of 1 Gb/s

Table 144–3—Discovery Information Fields

Bit	Flag field	Values
5	10G registration attempt	0 – ONU transmitter is not capable of 10 Gb/s 1 – ONU transmitter is capable of 10 Gb/s
6	25G registration attempt	0 – ONU transmitter is not capable of 25 Gb/s 1 – ONU transmitter is capable of 25 Gb/s
7-15	Reserved	Ignored on Reception

e) Laser On Time. This field is 1 octet long and carries the Laser On Time characteristic for the given ONU transmitter. The value is expressed in the units of 1 EQ.

f) Laser Off Time. This field is 1 octet long and carries the Laser Off Time characteristic for the given ONU transmitter. The value is expressed in the units of 1 EQ.

g) Pad/Reserved. This is an empty field that is transmitted as zeros, and ignored on reception. The size of this field is fixed and equal to 34.

The REGISTER_REQ MPCPDU shall be generated by a MAC Control instance mapped to an undiscovered ONU, and as such shall be marked with a broadcast type of LLID (see TBD).

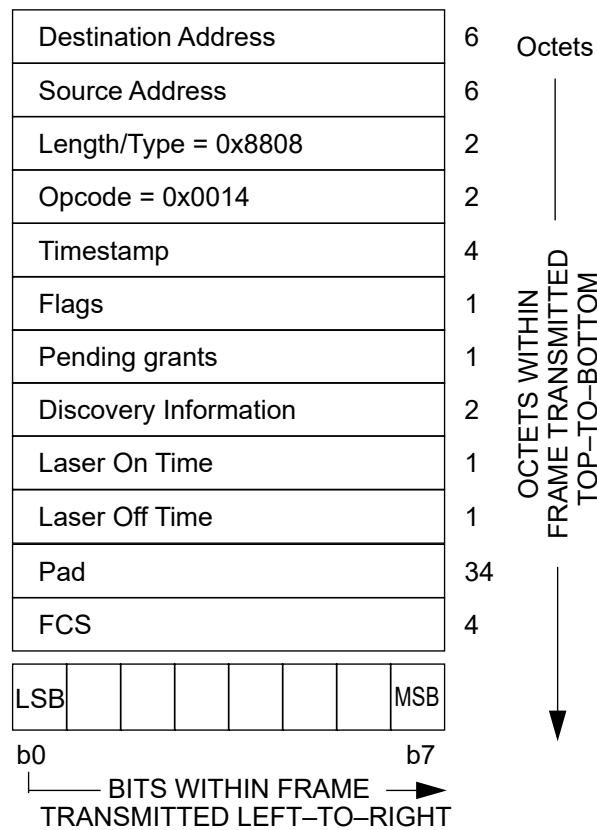|	
Destination Address	6 Octets
Source Address	6
Length/Type = 0x8808	2
Opcode = 0x0014	2
Timestamp	4
Flags	1
Pending grants	1
Discovery Information	2
Laser On Time	1
Laser Off Time	1
Pad	34
FCS	4

OCTETS WITHIN FRAME TRANSMITTED TOP–TO–BOTTOM

LSB ... MSB

b0   b7

└── BITS WITHIN FRAME ──▶
TRANSMITTED LEFT–TO–RIGHT

Figure 144–29—REGISTER_REQ MPCPDU

144.3.6.4 REGISTER description

The REGISTER MPCPDU is an instantiation of the Generic MPCPDU, and is further defined as follows:

a) DA. The destination address used shall be an individual MAC address.

b) Opcode. The opcode for the REGISTER MPCPDU is 0x0015.

c) Assigned Port (PLID). This field holds a 16 bit unsigned value reflecting the Physical LLID (see 143.2.1.1) of the port assigned following registration.

d) Assigned Port (MLID). This field holds a 16 bit unsigned value reflecting the Management LLID (see 143.2.1.2) of the port assigned following registration.

e) Flags. this is an 8 bit flag register that indicates special requirements for the registration, as presented in Table 144–4.

Table 144–4—REGISTER MPCPDU Flags field

Value	Indication	Comment
0	Reserved	Ignored on reception.
1	Reregister	The ONU is explicitly asked to re-register.
2	Deregister	This is a request to deallocate the port and free the LLID. Subsequently, the MAC is deallocated.
3	Ack	The requested registration is successful.
4	Nack	The requested registration attempt is denied by the MAC Control Client.
5–255	Reserved	Ignored on reception.

f) Sync Time. This is an unsigned 16-bit value signifying the required synchronization time of the OLT receiver. The ONU calculates the effective grant length by subtracting the SyncTime, LaserOnTime, LaserOffTime, and END_BURST_DELIMITER from the grant length it received from the OLT. The value is counted in 1 EQ increments. The advertised value includes synchronization requirement on all receiver elements including PMD, PMA, and PCS.

g) Echoed Pending Grants. This is an unsigned 8-bit value signifying the number of future grants the ONU may buffer before activating. The OLT should not grant the ONU more than this number of grants into the future.

h) Laser On Time. This is an unsigned 8-bit value, expressed in the units of 1 EQ, signifying the Laser On Time for the given ONU transmitter. This value may be different from Laser On Time delivered by the ONU in the REGISTER_REQ MPCPDU during the Discovery process. The ONU updates the local *LaserOnTime* variable per state diagram in Figure 144–19.

i) Laser Off Time. This is an unsigned 8-bit value, expressed in the units of 1 EQ, signifying the Laser Off Time for the given ONU transmitter. This value may be different from Laser Off Time delivered by the ONU in the REGISTER_REQ MPCPDU during the Discovery process. The ONU updates the local *LaserOffTime* variable per state diagram in Figure 144–19.

j) Pad/Reserved. This is an empty field that is transmitted as zeros, and ignored on reception. The size of this field is fixed and equal to 30.

The REGISTER MPCPDU shall be generated by a MAC Control instance mapped to all ONUs and such frame is marked by the broadcast LLID (see TBD).
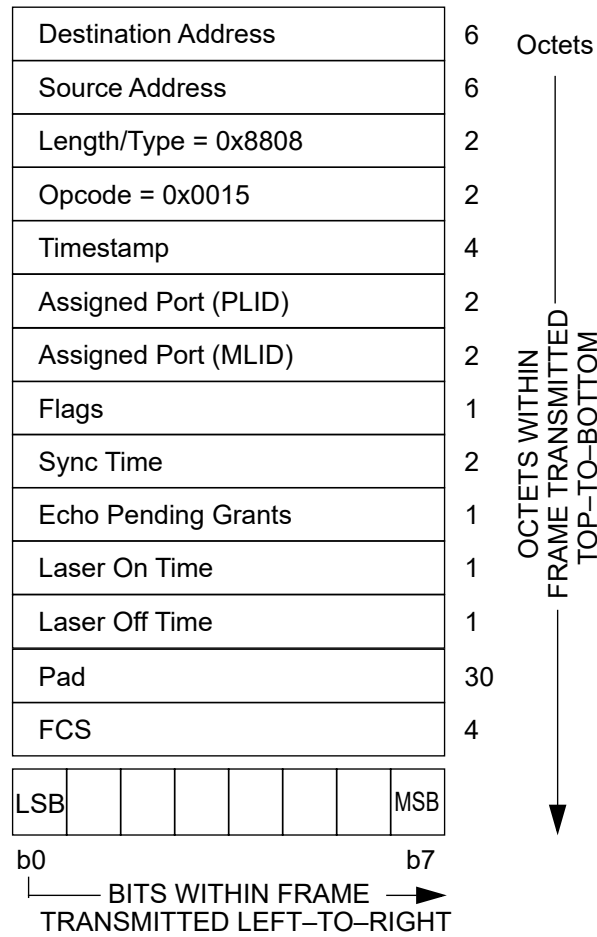
Destination Address	6	Octets
Source Address	6	
Length/Type = 0x8808	2	
Opcode = 0x0015	2	
Timestamp	4	
Assigned Port (PLID)	2	
Assigned Port (MLID)	2	
Flags	1	
Sync Time	2	
Echo Pending Grants	1	
Laser On Time	1	
Laser Off Time	1	
Pad	30	
FCS	4	

OCTETS WITHIN
FRAME TRANSMITTED
TOP–TO–BOTTOM

LSB | | | | | MSB

b0   b7

BITS WITHIN FRAME →
TRANSMITTED LEFT–TO–RIGHT

Figure 144–30—REGISTER MPCPDU

144.3.6.5 REGISTER_ACK description

The REGISTER_ACK MPCPDU is an instantiation of the Generic MPCPDU, and is further defined as follows:

   a)   Opcode. The opcode for the REGISTER_ACK MPCPDU is 0x0016.

   b)   Flags. This is an 8-bit flag register that indicates special requirements for the registration, as presented in Table 144–5.

Table 144–5—REGISTER_ACK MPCPDU Flags fields

Value	Indication	Comment
0	Nack	The requested registration attempt is denied by the MAC Control Client.
1	Ack	The registration process is successfully acknowledged.
2–255	Reserved	Ignored on reception.

   c)   Echoed Assigned Port (PLID). This field holds a 16-bit unsigned value reflecting the Physical LLID (see 143.2.1.1) for the port assigned following registration.

d) Echoed Assigned Port (MLID). This field holds a 16-bit unsigned value reflecting the Management LLID (see 143.2.1.2) for the port assigned following registration.

e) Echoed Sync Time. This is an unsigned 16-bit value echoing the required synchronization time of the OLT receiver as previously advertised (144.3.6.4).

f) Pad/Reserved. This is an empty field that is transmitted as zeros, and ignored at reception. The size of this field is fixed and equal to 33.

The REGISTER_ACK MPCPDU shall be generated by a MAC Control instance mapped to an active ONU, and as such shall be marked with a unicast type of LLID (see TBD).
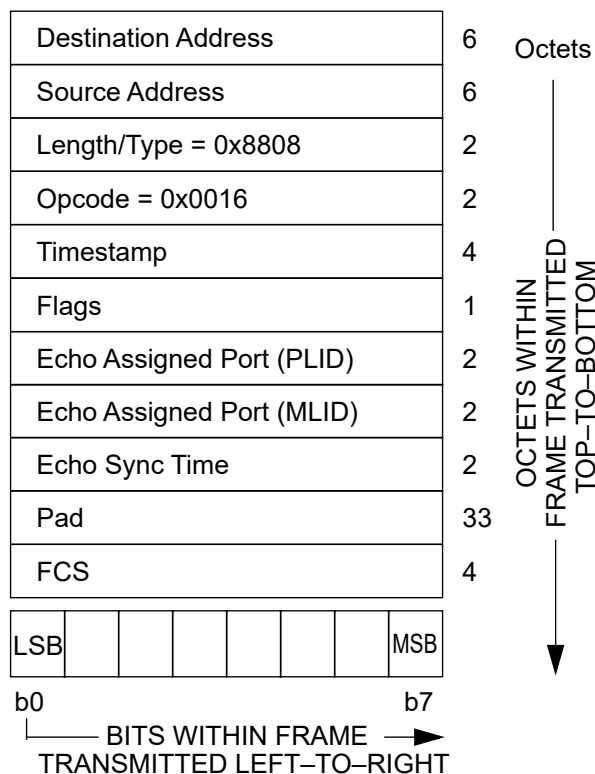
Field	Octets
Destination Address	6
Source Address	6
Length/Type = 0x8808	2
Opcode = 0x0016	2
Timestamp	4
Flags	1
Echo Assigned Port (PLID)	2
Echo Assigned Port (MLID)	2
Echo Sync Time	2
Pad	33
FCS	4

OCTETS WITHIN FRAME TRANSMITTED TOP–TO–BOTTOM

LSB | | | | | MSB
b0   b7
└── BITS WITHIN FRAME ──►
TRANSMITTED LEFT–TO–RIGHT

Figure 144–31—REGISTER_ACK MPCPDU

144.3.6.6 DISCOVERY GATE description

The DISCOVERY GATE MPCPDU is an instantiation of the Generic MPCPDU, and is further defined as follows:

a) Opcode. The opcode for the DISCOVERY GATE MPCPDU is 0x0017.

b) Channel Assignment: This 8-bit flag register, where bits 0-3 contain a bitmap representing the wavelength channel(s) on which to transmit on during the assigned transmission slot. Bits 4-7 are reserved. Table 144–1 shows the mapping between individual bits and upstream channels.

c) Start Time: This 32-bit unsigned integer value represents the start time of the transmission grant, expressed in the units of 1 EQ. The start time is compared to the local clock, to correlate the start of the grant.

d) Discovery Grant Length: This 24-bit unsigned field represents the length of the discovery grant, expressed in the units of 1 EQ.

e) Sync Time. This is an unsigned 16-bit value signifying the required synchronization time of the OLT receiver. The ONU calculates the effective grant length by subtracting the SyncTime, LaserOnTime, LaserOffTime, and END_BURST_DELIMITER from the grant length it received from the OLT. The value is counted in 1 EQ increments. The advertised value includes synchronization requirement on all receiver elements including PMD, PMA, and PCS.

f) Discovery Information. This is a 16-bit flag register. Table 144–6 presents the internal structure of the Discovery Information flag field.

Table 144–6—Discovery Information Fields

Bit	Flag field	Values
0	Reserved	Ignored on Reception
1	OLT is 10G upstream capable	0 – OLT does not support 10 Gb/s reception 1 – OLT supports 10 Gb/s reception
2	OLT is 25G upstream capable	0 – OLT does not support 25 Gb/s reception 1 – OLT supports 25 Gb/s reception
3-4	Reserved	Ignored on Reception
5	OLT is opening 10G discovery window	0 – OLT cannot receive 10 Gb/s data in this window 1 – OLT can receive 10 Gb/s data in this window
6	OLT is opening 25G discovery window	0 – OLT cannot receive 25 Gb/s data in this window 1 – OLT can receive 25 Gb/s data in this window
7-15	Reserved	Ignored on Reception

	Octets
Destination Address	6
Source Address	6
Length/Type = 0x8808	2
Opcode = 0x0017	2
Timestamp	4
Channel Assignment	1
Start Time	4
Discovery Grant Length (EQ)	3
Sync Time	2
Discovery Information	2
Pad	28
FCS	4

OCTETS WITHIN FRAME TRANSMITTED TOP–TO–BOTTOM
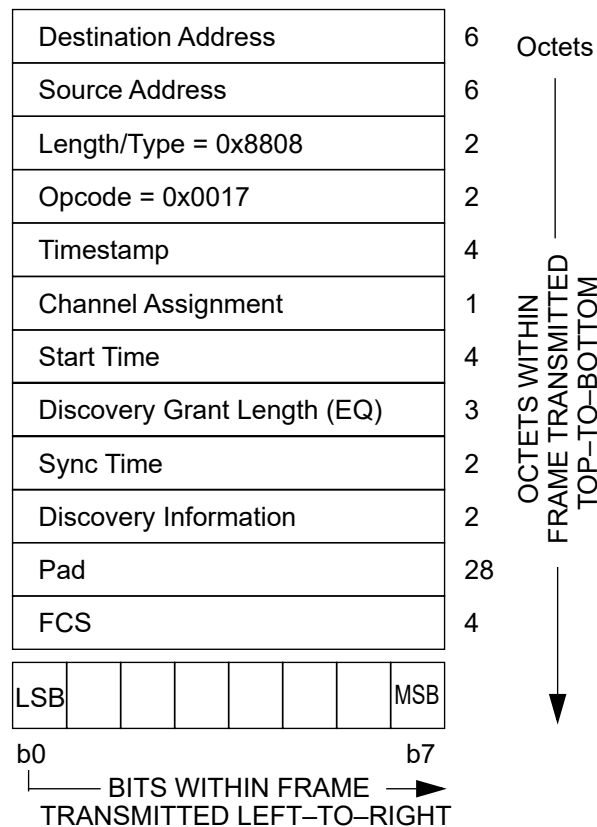
LSB | | | | | | MSB

b0   b7

BITS WITHIN FRAME → TRANSMITTED LEFT–TO–RIGHT

Figure 144–32—DISCOVERY GATE MPCPDU