Let $\mathcal{C}_k$ be one of the target classes of the task, in this use case one of the possible states the patient can be while he/she is monitored, and let x_t be the observed sample at time instant t, then, for this use case, $P(\mathcal{C}_k \mid x_t)$ represents the *a posteriori* probability that the patient is in the state corresponding to target class $\mathcal{C}_k$ when the sample x_t has been observed.

Applying the Bayes' rule, considering each channel l as independent of the others (a Naive assumption) and expanding the joint probabilities to take into account the clustering, we get the following expression when the clustering is based on a Gaussian Mixture Model (GMM):

$$P(\mathcal{C}_k \mid x_t) = \frac{\pi(\mathcal{C}_k) \cdot p(x_t \mid \mathcal{C}_k)}{\sum_{c=1}^{K} \pi(\mathcal{C}_c) \cdot p(x_t \mid \mathcal{C}_c)} = \frac{\pi(\mathcal{C}_k) \cdot \sum_{l=1}^{L} p(x_t^l \mid \mathcal{C}_k)}{\sum_{c=1}^{K} \pi(\mathcal{C}_c) \cdot \sum_{l=1}^{L} p(x_t^l \mid \mathcal{C}_c)}$$

where

K	is the number of target classes
L	is the number of channels recorded in the EEG
x_t	is the sample at time t including all the channels in the EGG
x_t^l	is the sample at time t corresponding to the l-th channel of the EGG
$\pi(\mathcal{C}_k)$	is the *a priori* probability of the target class $\mathcal{C}_k$
$p(x_t^l \mid \mathcal{C}_k)$	is the *conditional probability density* of generating x_t^l during the period in which the state of the patient corresponds to target class $\mathcal{C}_k$

The *conditional probability density* $p(x_t^l \mid \mathcal{C}_k)$ is computed as follows:

$$p(x_t^l \mid \mathcal{C}_k) = \sum_{j=1}^{J} \pi(w_j) \cdot p(x_t^l \mid w_j, \mathcal{C}_k) \cdot P(w_j \mid \mathcal{C}_k) \simeq \sum_{j=1}^{J} \pi(w_j) \cdot p(x_t^l \mid w_j) \cdot P(w_j \mid \mathcal{C}_k)$$

where

J	is the number of clusters in the clustering, i.e., the number of components of the GMM in use
$\pi(w_j)$	is the weight of Gaussian w_j in the mixture
$p(x_t^l \mid w_j)$	is computed as a normal probability distribution $\mathcal{N}(x_t^l \mid \mu_j, \Sigma_j)$
$P(w_j \mid \mathcal{C}_k)$	is the conditional probability of observing samples generated by the Gaussian component w_j during a period corresponding to target class $\mathcal{C}_k$

then,

$$P(\mathcal{C}_k \mid x_t) \simeq \frac{\pi(\mathcal{C}_k) \cdot \sum_{l=1}^{L} \sum_{j=1}^{J} \pi(w_j) \cdot p(x_t^l \mid w_j) \cdot P(w_j \mid \mathcal{C}_k)}{\sum_{c=1}^{K} \pi(\mathcal{C}_c) \cdot \sum_{l=1}^{L} \sum_{j=1}^{J} \pi(w_j) \cdot p(x_t^l \mid w_j) \cdot P(w_j \mid \mathcal{C}_c)}$$