

1 SchemeIBPRME

This scheme is only applicable to symmetric groups of prime orders.

1.1 Setup() \rightarrow (*mpk*, *msk*)

```

 $q \leftarrow \|\mathbb{G}\|$ 
 $g \leftarrow 1_{\mathbb{G}_1}$ 
generate  $h \in \mathbb{G}_1$  randomly
generate  $x, \alpha \in \mathbb{Z}_r$  randomly
 $H_1 : \{0, 1\}^* \rightarrow \mathbb{G}_1$ 
 $H_2 : \{0, 1\}^* \rightarrow \mathbb{G}_1$ 
 $H_3 : \{0, 1\}^* \rightarrow \mathbb{Z}_r$ 
 $H_4 : \{0, 1\}^* \rightarrow \mathbb{G}_1^2$ 
 $H_5 : \{0, 1\}^* \rightarrow \mathbb{G}_1$ 
 $H_6 : \{0, 1\}^* \rightarrow \mathbb{G}_1$ 
 $H_7 : \{0, 1\}^* \rightarrow \mathbb{G}_1$ 
 $y \leftarrow g^x$ 
 $mpk \leftarrow (G, G_T, q, g, e, h, H_1, H_2, H_3, H_4, H_5, H_6, H_7, y)$ 
 $msk \leftarrow (x, \alpha)$ 
return (mpk, msk)

```

1.2 DKGen(*id_R*) \rightarrow *dk_{id_R}*

```

 $dk_{id_R,1} \leftarrow H_1(id_R)^x$ 
 $dk_{id_R,2} \leftarrow H_1(id_R)^\alpha$ 
 $dk_{id_R} \leftarrow (dk_{id_R,1}, dk_{id_R,2})$ 
return dkidR

```

1.3 EKGen(*id_S*) \rightarrow *ek_{id_S}*

```

 $ek_{id_S} \leftarrow H_2(id_S)^\alpha$ 
return ekidS

```

1.4 ReEKGen(*ek_{id₂}*, *dk_{id₂}*, *id₁*, *id₂*, *id₃*) \rightarrow *rk*

```

generate  $N \in \{0, 1\}^\lambda$  randomly
generate  $\bar{x} \in \mathbb{Z}_r$  randomly
 $rk_1 \leftarrow g^{\bar{x}}$ 
 $rk_2 \leftarrow dk_{id_2,1} h^{\bar{x}} H_6(e(y, H_1(id_3))^{\bar{x}})$ 
 $K \leftarrow e(ek_{id_2}, H_1(id_3))$ 
 $rk_3 \leftarrow e(H_2(id_1), H_7(K || id_2 || id_3 || N) \cdot dk_{id_2,2})$ 
 $rk \leftarrow (N, rk_1, rk_2, rk_3)$ 
return rk

```

1.5 Enc(*ek_{id₁}*, *id₂*, *m*) \rightarrow *ct*

```

generate  $\sigma \in \mathbb{G}_1$  randomly
generate  $\eta \in \mathbb{G}_T$  randomly
 $r \leftarrow H_3(m || \sigma || \eta)$ 

```

```

 $ct_1 \leftarrow h^r$ 
 $ct_2 \leftarrow g^r$ 
 $ct_3 \leftarrow (m || \sigma) \oplus H_4(e(y, H_1(id_2))^r) \oplus H_4(\eta)$ 
 $ct_4 \leftarrow \eta \cdot e(ek_{id_1}, H_1(id_2))$ 
 $ct_5 \leftarrow H_5(ct_1 || ct_2 || ct_3 || ct_4)^r$ 
 $ct \leftarrow (ct_1, ct_2, ct_3, ct_4, ct_5)$ 
return  $ct$ 

```

1.6 ReEnc(ct, rk) $\rightarrow ct'$

```

if  $e(ct_1, g) = e(h, ct_2) \wedge e(ct_1, H_5(ct_1 || ct_2 || ct_3 || ct_4)) = e(h, ct_5)$  then
   $ct'_4 \leftarrow \frac{ct_4}{rk_3}$ 
   $ct_6 \leftarrow rk_1$ 
   $ct_7 \leftarrow \frac{e(rk_2, ct_2)}{e(ct_1, rk_1)}$ 
   $ct' \leftarrow (ct_2, ct_3, ct'_4, ct_6, ct_7, N)$ 
else
   $ct' \leftarrow \perp$ 
end if
return  $ct'$ 

```

1.7 Dec₁(dk_{id_2}, id_1, ct) $\rightarrow m$

```

if  $e(ct_1, g) = e(h, ct_2) \wedge e(ct_1, H_5(ct_1 || ct_2 || ct_3 || ct_4)) = e(h, ct_5)$  then
   $V \leftarrow e(dk_{id_2, 2}, H_2(id_1))$ 
   $\eta' \leftarrow \frac{ct_4}{V}$ 
   $m || \sigma \leftarrow ct_3 \oplus H_4(e(dk_{id_2, 1}, ct_2)) \oplus H_4(\eta')$ 
   $r \leftarrow H_3((ct_3 \oplus H_4(e(dk_{id_2, 1}))) \oplus H_4(\eta')) || \eta'$ 
  if  $g^r = ct_2$  then
     $m \leftarrow \perp$ 
  end if
else
   $m \leftarrow \perp$ 
end if
return  $m$ 

```

1.8 Dec₂($dk_{id_3}, id_1, id_2, id_3, ct'$) $\rightarrow m'$

```

 $V \leftarrow e(dk_{id_3, 2}, H_2(id_2))$ 
 $\eta' \leftarrow ct'_4 \cdot e(H_2(id_1), H_7(V || id_2 || id_3 || N))$ 
 $R \leftarrow \frac{ct_7}{e(H_6(e(dk_{id_3, 1}, ct_6), ct_2))}$ 
 $r \leftarrow H_3((ct_3 \oplus H_4(R)) \oplus H_4(\eta')) || \eta'$ 
if  $g^r \neq ct_2$  then
   $m \leftarrow \perp$ 
end if
return  $m$ 

```