Cos(ϕ) compensation

P	3000	Load Power [Watt]
U	230	Load rms Line-Neutral voltage
cos(ϕ)	0.75	Load cos(ϕ)
Rcable/meter	0.01	Cable resistance per meter[Ω per meter]
Lcable/meter	1.0E-5	Cable inductance per meter[H per meter]
Cable length	100	Cable length [meter]

Calculate

Calculate nominal power

Load parameters P and cos(ϕ) are defined for U without cable

Apparent power per phase S[VA] = P/cos(ϕ)=4000[VA]
Q[VAR] = sqrt(S^2-P^2)=sqrt(4000*4000-3000*3000)=2646[VAR]
Inom[A] = S/U=4000/230=17.391[A]

Calculate load resistance
From P and I the load resistance is calculated:
R_{load}[ohm]=P/I^2=3000/(17.391*17.391)=10[ohm]

Calculate load inductance
From reactive power, the load inductance is calculated
X_{load}=Q/I^2=2646/(17.391*17.391)=8.748[ohm]
L_{load}[mH]=X_{load}/(2 π f)=9/314.15927=27.8[mH]

Calculate cable resistance and inductance
R_{cable}[mΩ]=R_{cable}[per meter]* length [per phase]=10*100=1000[mΩ]
L_{cable}[mH]=L_{cable}[per meter]* length [per phase]=0.01*100=1[mH]
X_{cable}[Ω]=L_{cable}*2 π f=1*314.15927=0.314[Ω]
Z_{cable}[Ω]=sqrt(R_{cable}^2+X_{cable}^2)=sqrt(1*1+0.314*0)=1.048[Ω]

Calculate total resistance and inductance seen from the source
R_{tot}[Ω]=R_{cable}+R_{load}=1+10=10.919[Ω]

$L_{tot}[mH]=L_{cable}+L_{load}=1+0=28.844[mH]$
$X_{tot}[\Omega]=L_{tot}*2\ \pi\ f=28.844*314.15927=9.062[\Omega]$
$Z_{tot}[\Omega]=sqrt(R_{tot}^2+X_{tot}^2)=sqrt(10.919*11+9.062*9)=14.189[\Omega]$

Calculate new current
$Inew=U/Z_{tot}= 230/14.189=16.21[A]$

Calculate apparent power
$S=U*I_{new}= 230*16.21=3728[VA]$

Calculate Cable loss
$R_{cable}*Inew^2= 1*16.21*16.21=263[Watt]$

Calculate power delivered to the load
$R_{load}*Inew^2= 10*16.21*16.21=2606[Watt]$

Calculate Load voltage
$U_{load}new=U-Zcable*Inew = 230-1*16.21=213[Volt]$

Calculate new cos(ϕ)
$Cos(\phi) =(Pcable+Pload)/S = (263+2606)/3728=0.77$

Calculate Reactive power for calculating the compensation capacitor
$Q[VAR] = sqrt(S^2-(Pcable+Plaod)^2)=sqrt(3728*3728-2868.89*2868.89)=2381[VAR]$

Calculate compensation capacitor
$Xc = U^2/Q = 230*230/2381=22[\Omega]$
$C = 1/(2\pi*f*Xc) = 1/(314.15927*22=143[\mu F]$