

13.3 – Distribución de la fmm en el entrehierro del prototipo M-3

Hipótesis 1 (ideal) :

Devanado monofásico con espira de sombra, (bifásico virtual) M-3

$$\begin{aligned}I &= 100 \text{ A} \\I_{es} &= 100 \text{ A} \\ \varphi (I - I_{es}) &= 90^\circ\end{aligned}$$

Nº de espiras = 50

- DEFINICIÓN DE LA MATRIZ C

```
Unprotect[C];  
C[n_]:=Table[If[i<n,If[i==j,-1,If[i==j-1,1,0]],1],  
{i,n},{j,n}]
```

- DEFINICIÓN DE LA MATRIZ DE LOS SIGNOS S

```
S[m_]:=Table[If[i<=m,If[i==j,1,0],If[i-m==j,-1,0]],  
{i,2m},{j,m}]
```

- DEFINICIÓN DE LA MATRIZ DE DEVANADO W

```
w2=Table[0,{i,50},{j,4}];
```

```
w2[[1]]={wa,0,0,0};  
w2[[2]]={0,wb,0,0};  
w2[[3]]={0,0,wa,0};  
w2[[4]]={0,0,0,wb};  
w2[[5]]={wa,0,0,0};  
w2[[6]]={0,wb,0,0};  
w2[[7]]={0,0,wa,0};  
w2[[8]]={0,0,0,wb};  
w2[[9]]={wa,0,0,0};  
w2[[10]]={0,wb,0,0};  
w2[[11]]={0,0,wa,0};  
w2[[12]]={0,0,0,wb};  
w2[[13]]={wa,0,0,0};  
w2[[14]]={0,wb,0,0};  
w2[[15]]={0,0,wa,0};  
w2[[16]]={0,0,0,wb};  
w2[[17]]={wa,0,0,0};  
w2[[18]]={0,wb,0,0};  
w2[[19]]={0,0,wa,0};  
w2[[20]]={0,0,0,wb};  
w2[[21]]={wa,0,0,0};  
w2[[22]]={0,wb,0,0};  
w2[[23]]={0,0,wa,0};  
w2[[24]]={0,0,0,wb};
```

```

w2[[25]]={wa,0,0,0};
w2[[26]]={0,wb,0,0};
w2[[27]]={0,0,wa,0};
w2[[28]]={0,0,0,wb};
w2[[29]]={wa,0,0,0};
w2[[30]]={0,wb,0,0};
w2[[31]]={0,0,wa,0};
w2[[32]]={0,0,0,wb};
w2[[33]]={wa,0,0,0};
w2[[34]]={0,wb,0,0};
w2[[35]]={0,0,wa,0};
w2[[36]]={0,0,0,wb};
w2[[37]]={wa,0,0,0};
w2[[38]]={0,wb,0,0};
w2[[39]]={0,0,wa,0};
w2[[40]]={0,0,0,wb};
w2[[41]]={wa,0,0,0};
w2[[42]]={0,wb,0,0};
w2[[43]]={0,0,wa,0};
w2[[44]]={0,0,0,wb};
w2[[45]]={wa,0,0,0};
w2[[46]]={0,wb,0,0};
w2[[47]]={0,0,wa,0};
w2[[48]]={0,0,0,wb};
w2[[49]]={wa,0,0,0};
w2[[50]]={0,0,0,0};

```

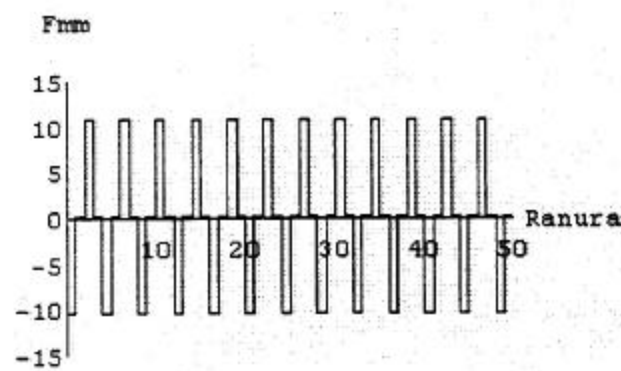
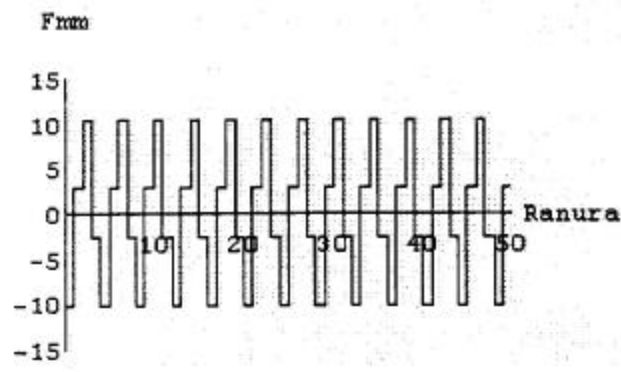
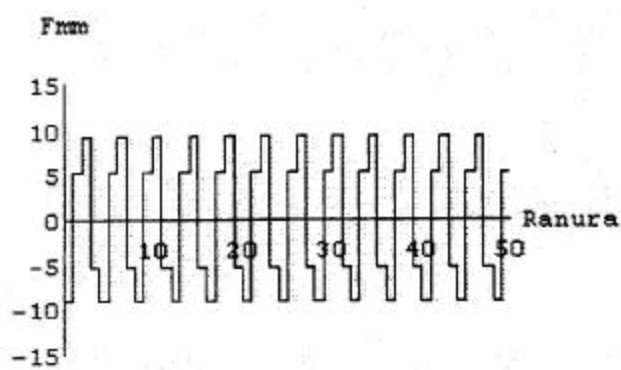
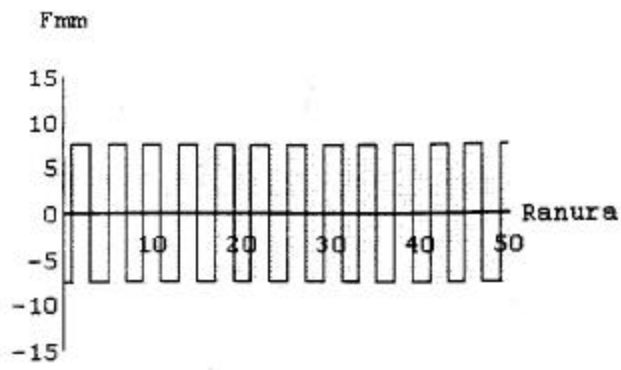
- SOLUCIÓN

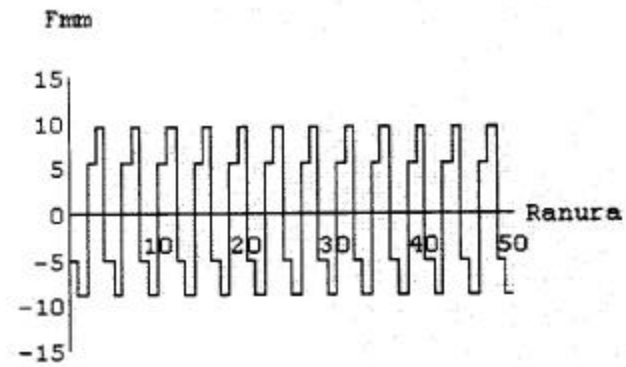
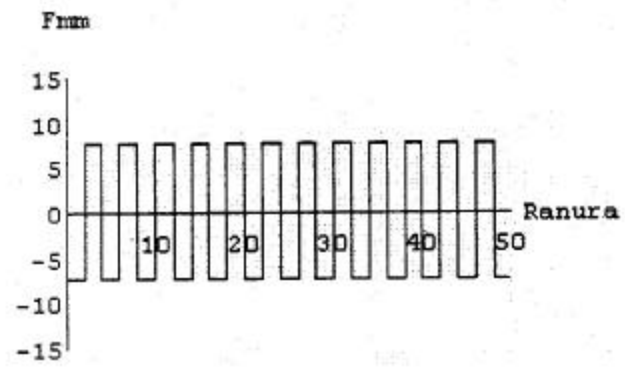
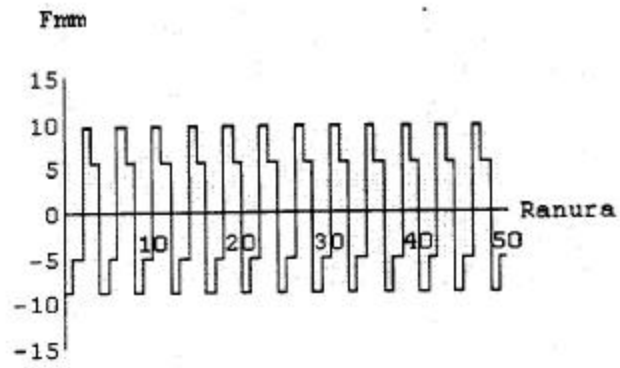
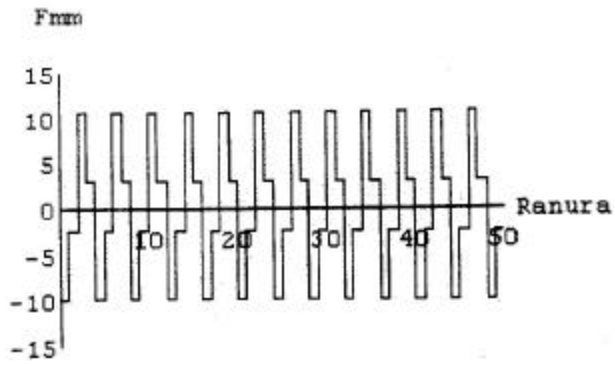
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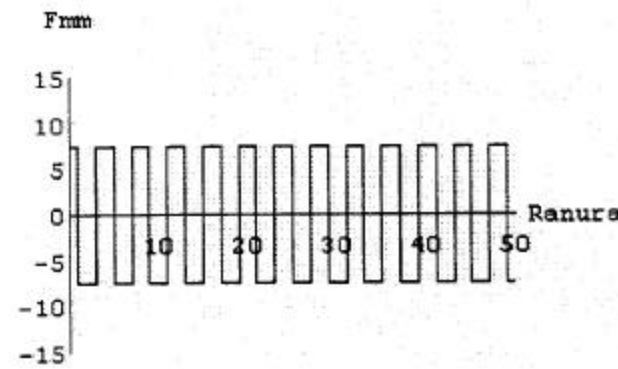
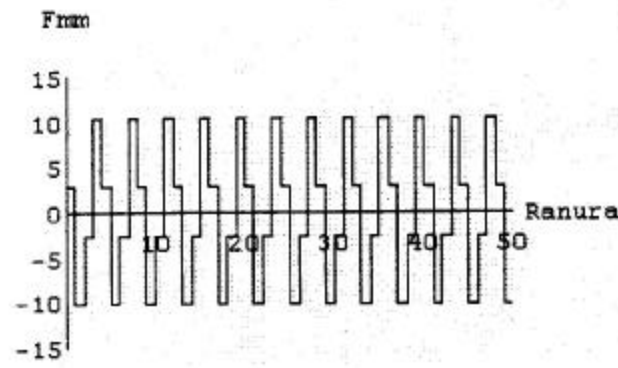
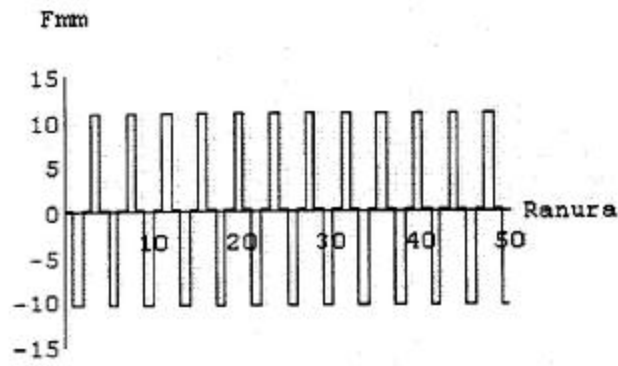
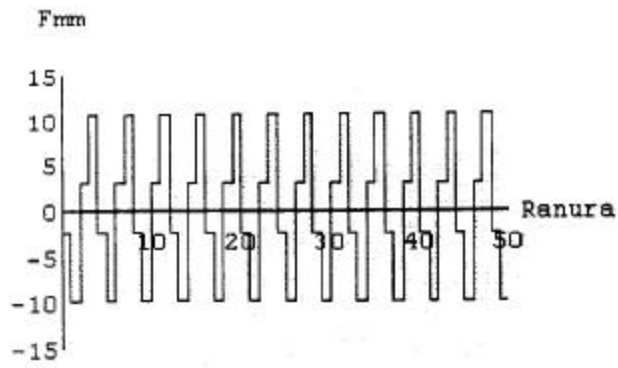
Auxmat2=Inverse[C[50]].w2.S[2];
Fmm[Ia,Ib]:=Auxmat2.{Ia,Ib};
wa=wb=15;
Aux=Table[0,{j,200},{i,200}];
Animcos[Nframe_]:=Do[{
  Ia=N[Cos[2 Pi/Nframe (k-1)]],
  Ib=N[Cos[2 Pi/Nframe (k-1)-Pi/2]],

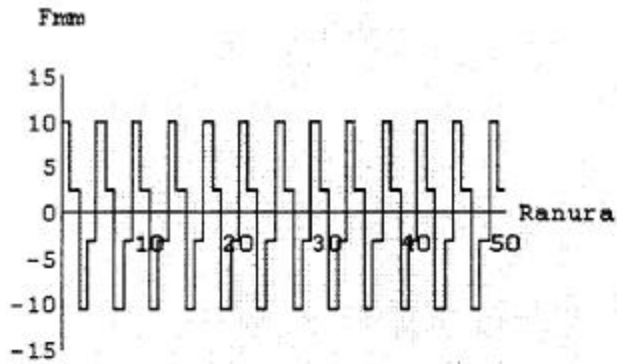
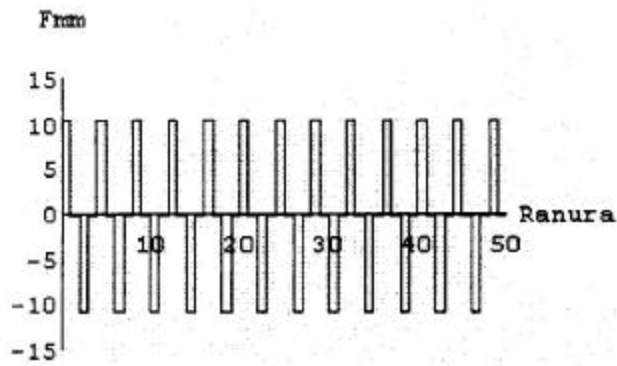
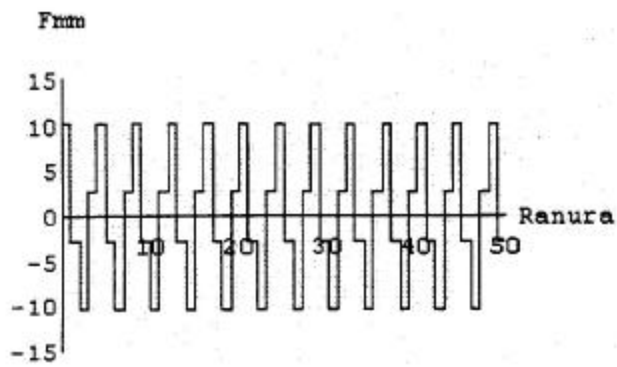
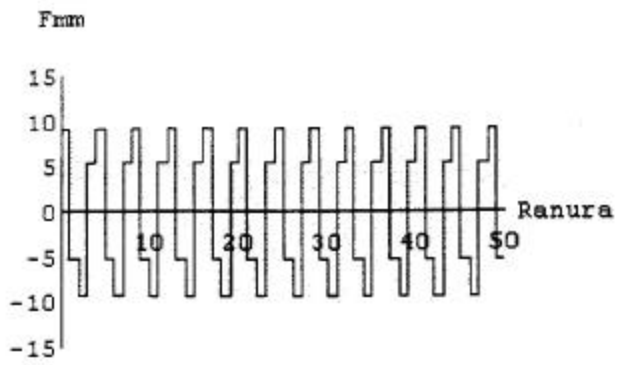
  Aux[[k]]=Fmm[Ia,Ib],
  ListPlot[Table[{
    Table[Floor[(i1/2)],
    Table[Aux[[k,Floor[(i1+1)/2]]]],
    {i1,1,100}],
    PlotJoined->True,
    PlotRange->{{0,50},{-20,20}},
    AxesLabel->{"Ranura","Fmm"}},
    {k,1,Nframe}]
Animcos[24]

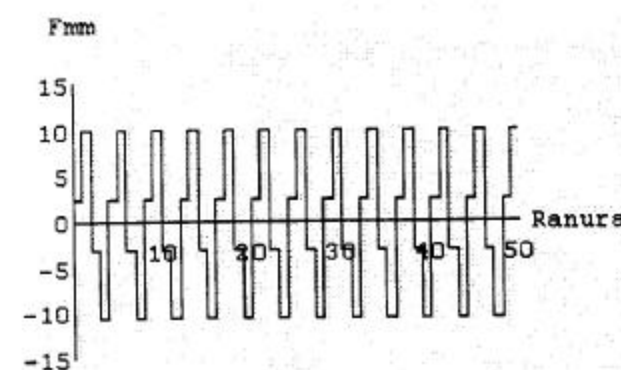
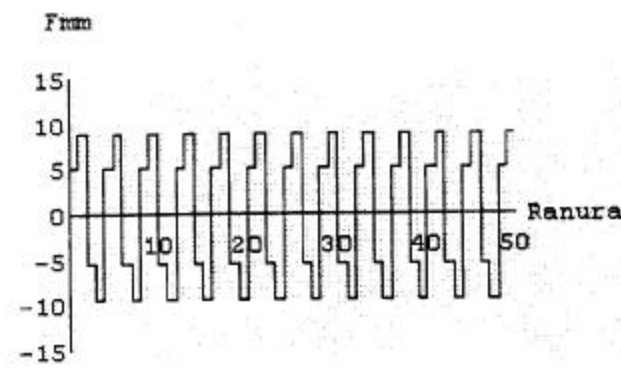
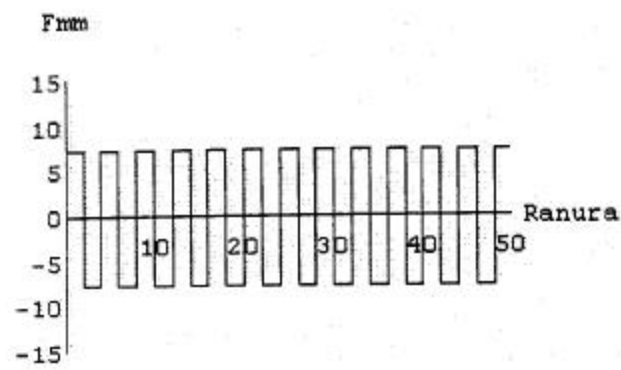
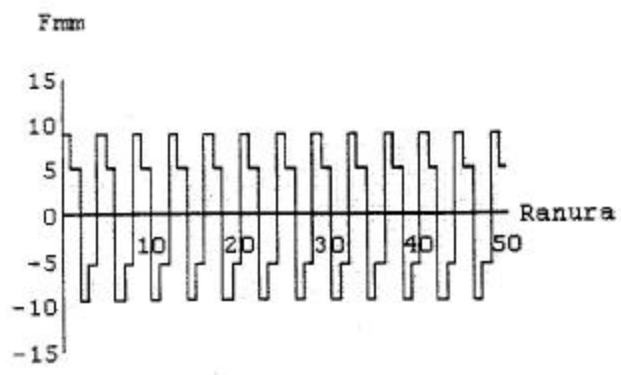
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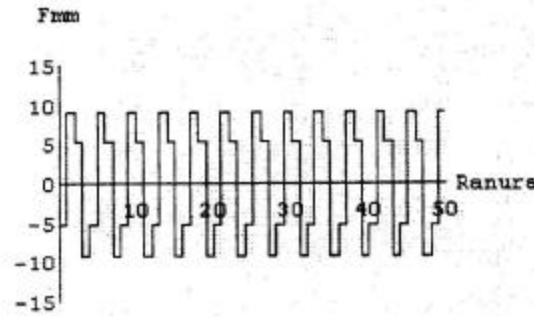
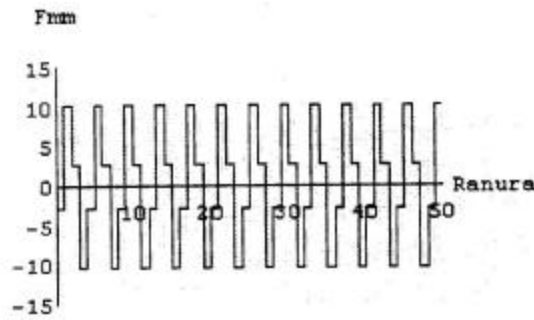
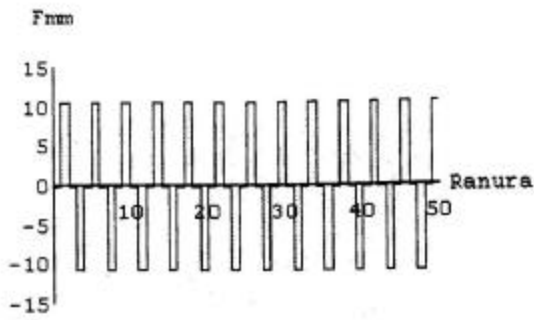












Con la hipótesis mantenida inicialmente, se puede comprobar que cuando el devanado inductor del prototipo M-3 es alimentado, la onda de f.m.m. en el entrehierro es una onda pulsante en amplitud y deslizante en el tiempo.

Prototipo M-3

Hipótesis 2:

Devanado monofásico con espira de sombra, (bifásico virtual) M-3

$$I = 100 \text{ A}$$

$$I_{es} = 10 \text{ A}$$

$$\phi (I - I_{es}) = 90^\circ$$

Nº de espiras = 50

- DEFINICIÓN DE LA MATRIZ C

Unprotect[C];

```
C[n_]:=Table[If[i<n,If[i==j,-1,If[i==j-1,1,0]],1],  
{i,n},{j,n}]
```

- DEFINICIÓN DE LA MATRIZ DE LOS SIGNOS S

```
S[m_]:=Table[If[i<=m,If[i==j,1,0],If[i-m==j,-1,0]],  
{i,2m},{j,m}]
```

- DEFINICIÓN DE LA MATRIZ DE DEVANADO W

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w2=Table[0,{i,50},{j,4}];
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w2[[1]]={wa,0,0,0};
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w2[[8]]={0,0,0,wb};
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w2[[9]]={wa,0,0,0};
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w2[[10]]={0,wb,0,0};
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w2[[11]]={0,0,wa,0};
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w2[[12]]={0,0,0,wb};
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w2[[13]]={wa,0,0,0};
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w2[[14]]={0,wb,0,0};
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w2[[15]]={0,0,wa,0};
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w2[[16]]={0,0,0,wb};
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w2[[17]]={wa,0,0,0};
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w2[[18]]={0,wb,0,0};
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w2[[19]]={0,0,wa,0};
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w2[[20]]={0,0,0,wb};
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w2[[22]]={0,wb,0,0};
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w2[[23]]={0,0,wa,0};
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w2[[24]]={0,0,0,wb};
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w2[[25]]={wa,0,0,0};
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w2[[36]]={0,0,0,wb};
w2[[37]]={wa,0,0,0};
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w2[[40]]={0,0,0,wb};
w2[[41]]={wa,0,0,0};
w2[[42]]={0,wb,0,0};
w2[[43]]={0,0,wa,0};
w2[[44]]={0,0,0,wb};
w2[[45]]={wa,0,0,0};
w2[[46]]={0,wb,0,0};
w2[[47]]={0,0,wa,0};
w2[[48]]={0,0,0,wb};
w2[[49]]={wa,0,0,0};
w2[[50]]={0,0,0,0};

```

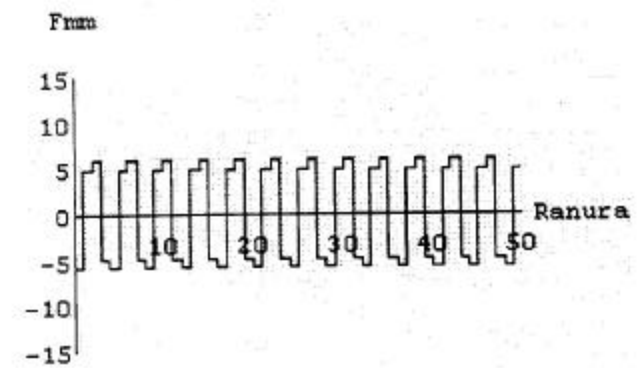
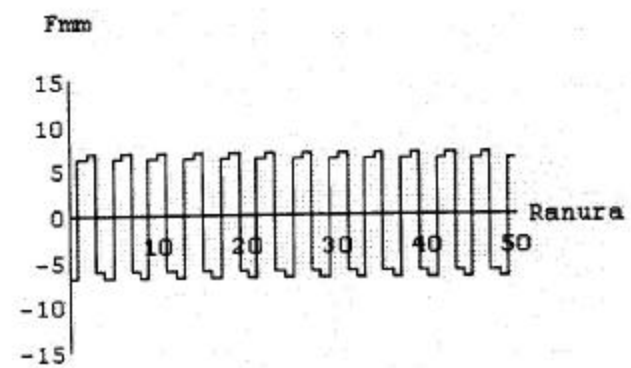
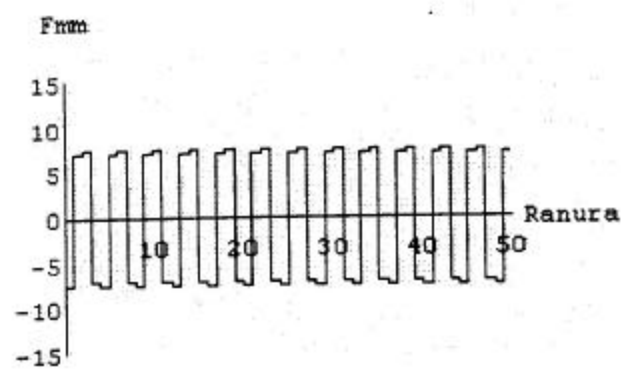
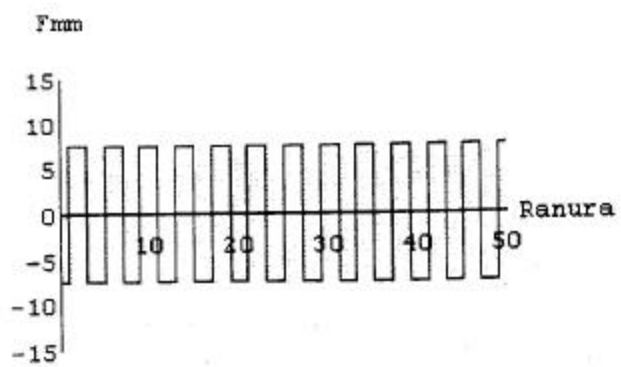
- SOLUCIÓN

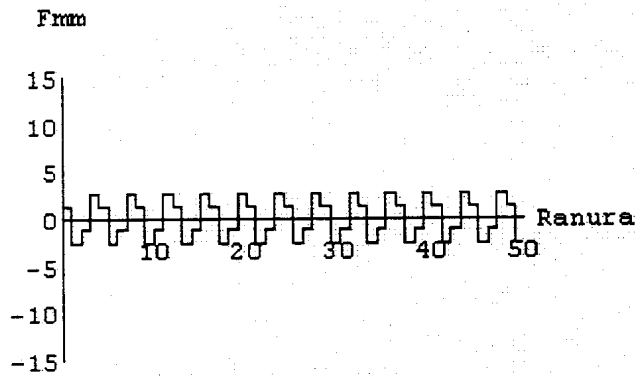
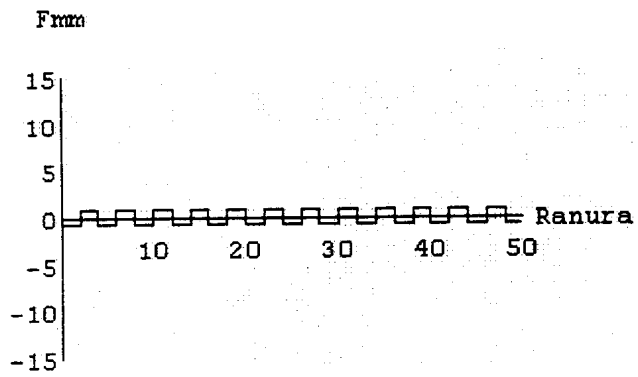
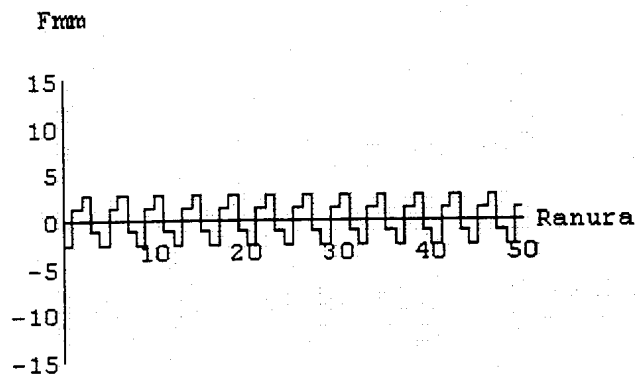
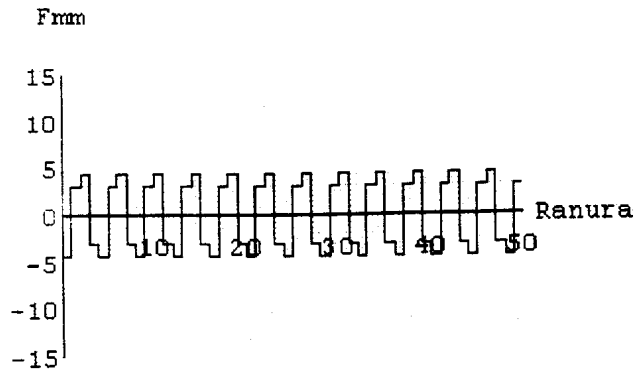
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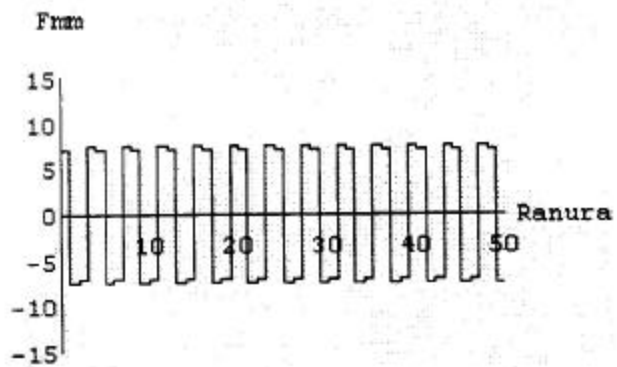
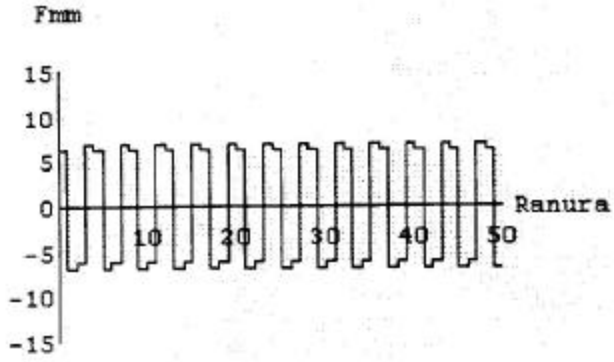
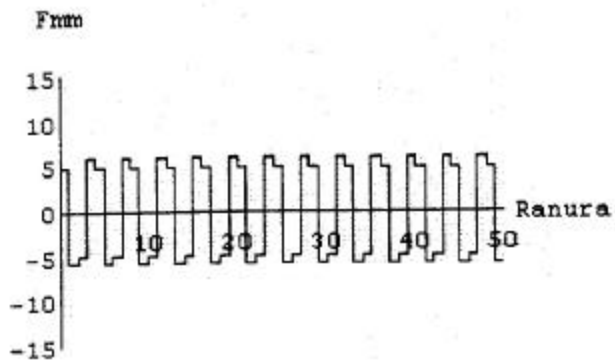
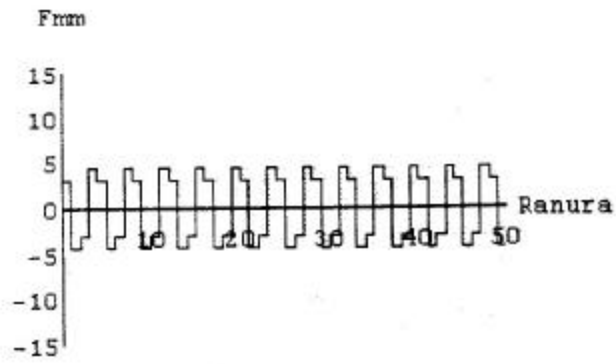
Auxmat2=Inverse[C[50]].w2.S[2];
Fmm[Ia,Ib]:=Auxmat2.{Ia,Ib};
wa=wb=15;
Aux=Table[0,{j,200},{i,200}];
Animcos[Nframe_]:=Do[{
  Ia=N[Cos[2 Pi/Nframe (k-1)]],
  Ib=N[0.1*Cos[2 Pi/Nframe (k-1)-Pi/2]],

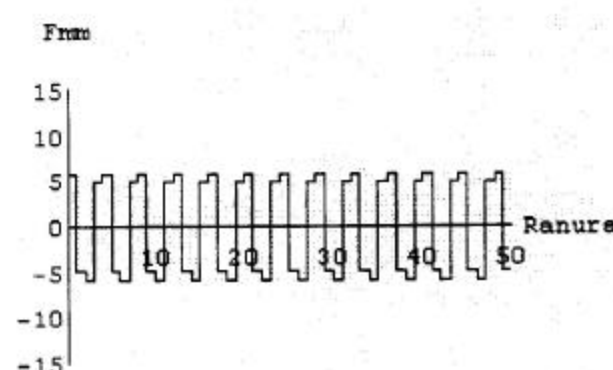
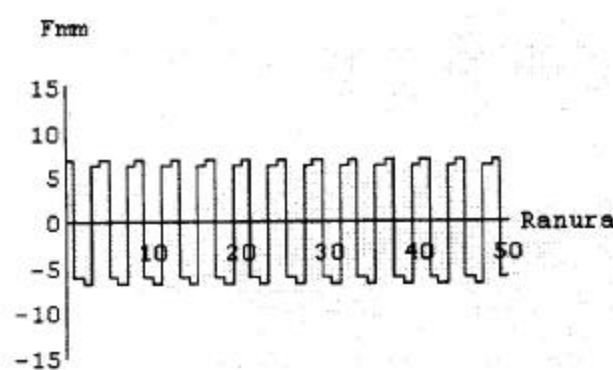
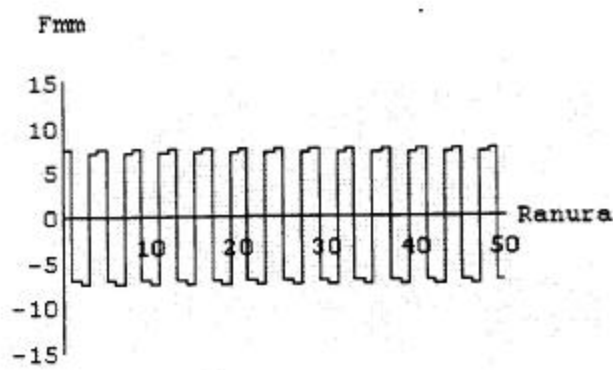
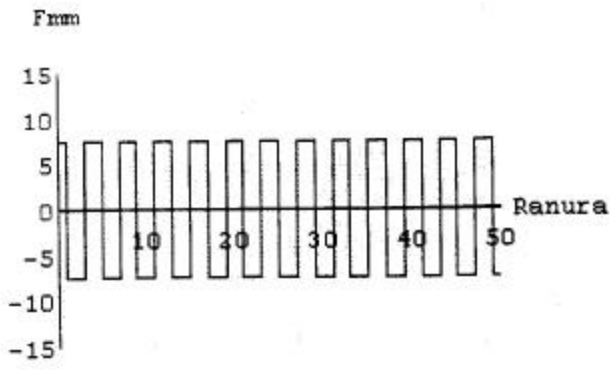
  Aux[[k]]=Fmm[Ia,Ib],
  ListPlot[Table[{
    Table[Floor[(i1/2)],
    Table[Aux[[k,Floor[(i1+1)/2]]]],
    {i1,1,100}],
    PlotJoined->True,
    PlotRange->{{0,50},{-15,15}},
    AxesLabel->{"Ranura","Fmm"}},
    {k,1,Nframe}]
Animcos[24]

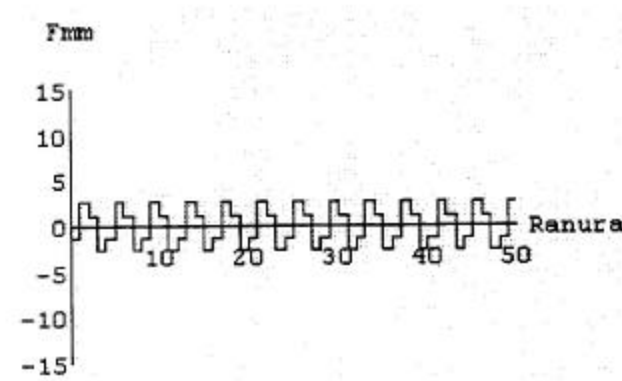
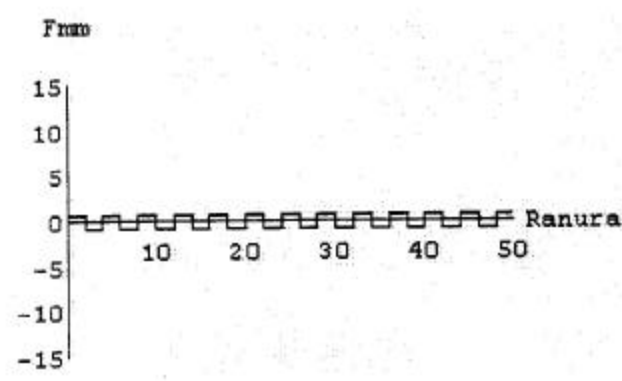
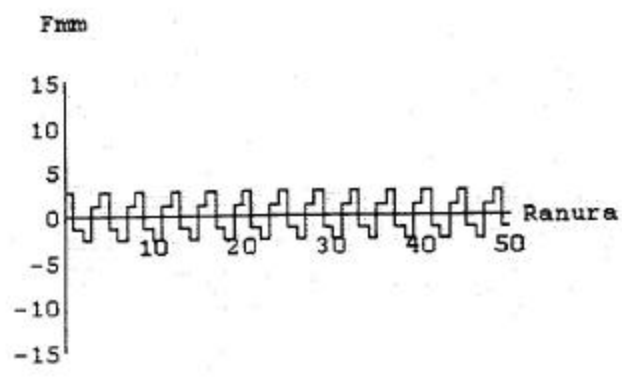
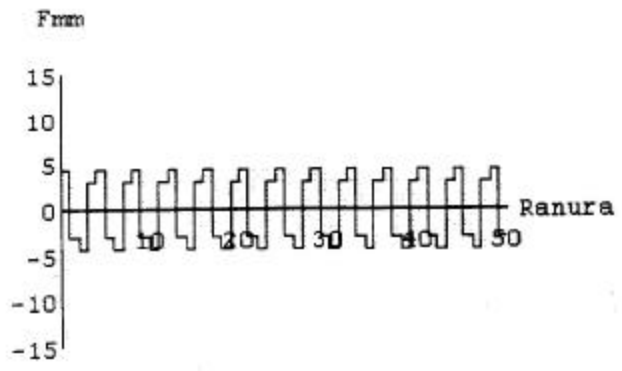
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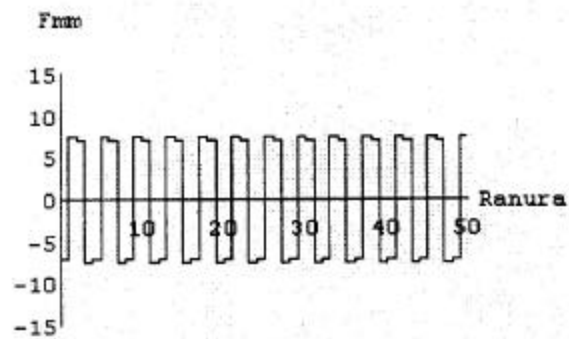
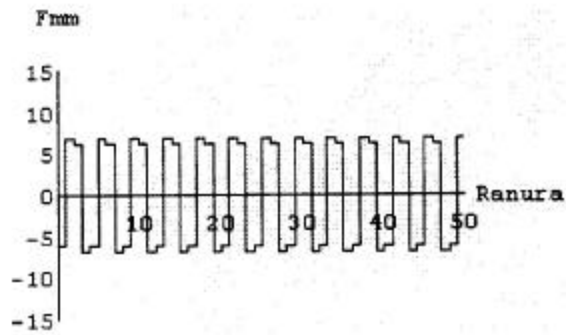
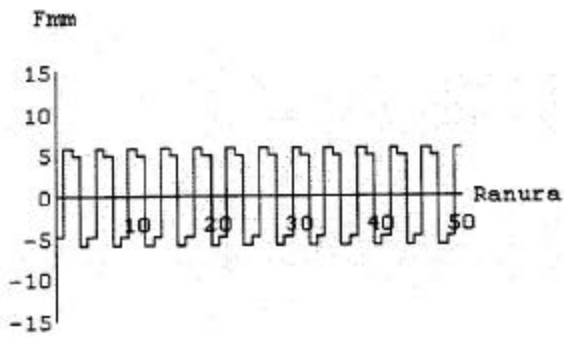
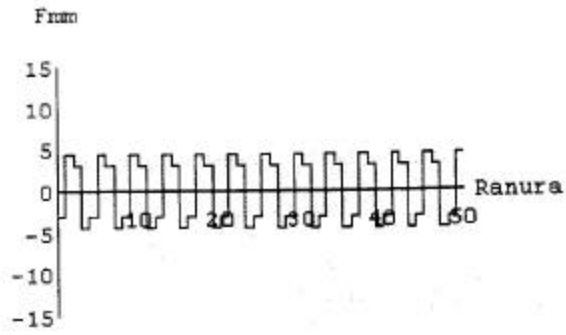












Con la hipótesis mantenida inicialmente, se puede comprobar que cuando devanado inductor del prototipo M-3 es alimentado, la onda de f.m.m. en entrehierro es una onda pulsante en amplitud y deslizante en el tiempo, aunque

carácter deslizante es menor que con la hipótesis 1, por consiguiente la eficiencia eléctrica del prototipo M-3 con esta hipótesis es menor que con la hipótesis 1.

Prototipo M-3

Hipótesis 3 :

Devanado monofásico con espira de sombra, (bifásico virtual) M-3

$$I = 100 \text{ A}$$

$$I_{es} = 10 \text{ A}$$

$$\phi (I - I_{es}) = 72^\circ$$

Nº de espiras = 50

- DEFINICIÓN DE LA MATRIZ C

Unprotect[C];

C[n_]:=Table[If[i<n,If[i==j,-1,If[i==j-1,1,0]],1],
{i,n},{j,n}]

- DEFINICIÓN DE LA MATRIZ DE LOS SIGNOS S

S[m_]:=Table[If[i<=m,If[i==j,1,0],If[i-m==j,-1,0]],
{i,2m},{j,m}]

- DEFINICIÓN DE LA MATRIZ DE DEVANADO W

w2=Table[0,{i,50},{j,4}];

w2[[1]]={wa,0,0,0};

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w2[[44]]={0,0,0,wb};
w2[[45]]={wa,0,0,0};
w2[[46]]={0,wb,0,0};
w2[[47]]={0,0,wa,0};
w2[[48]]={0,0,0,wb};
w2[[49]]={wa,0,0,0};
w2[[50]]={0,0,0,0};

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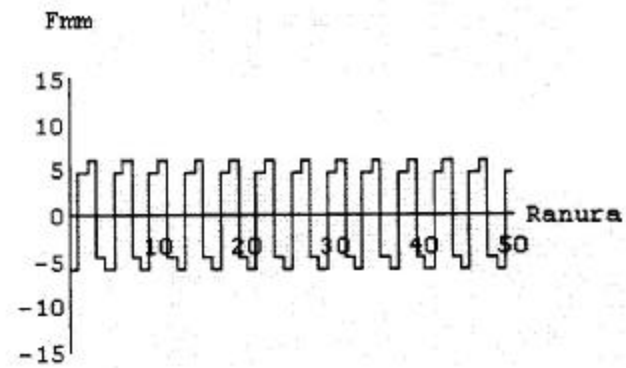
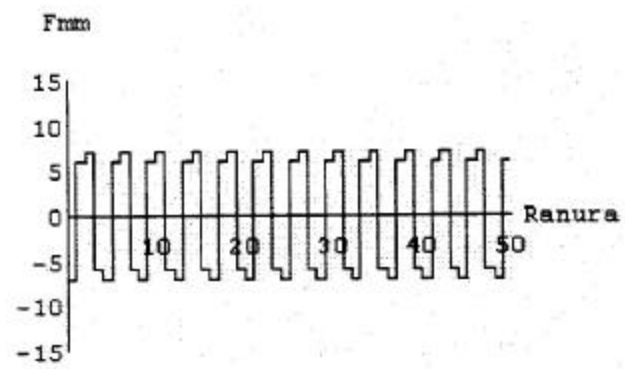
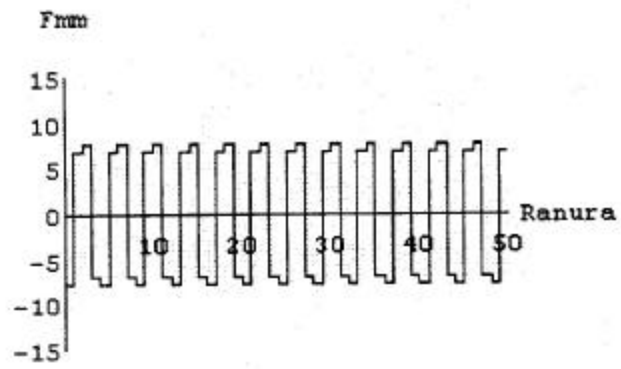
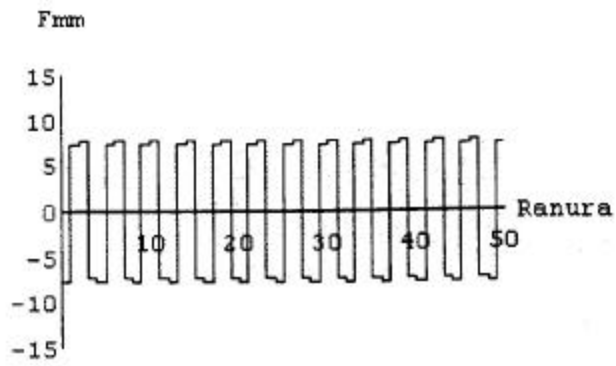
- SOLUCIÓN

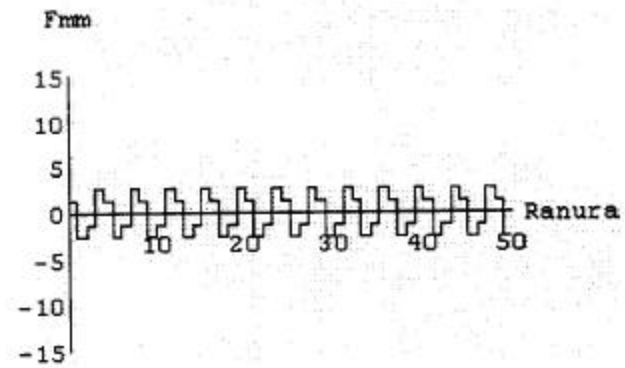
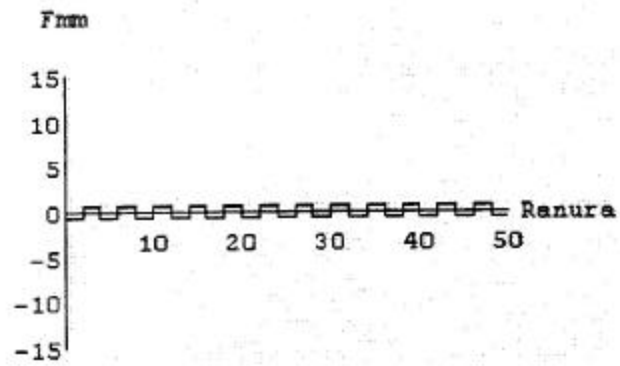
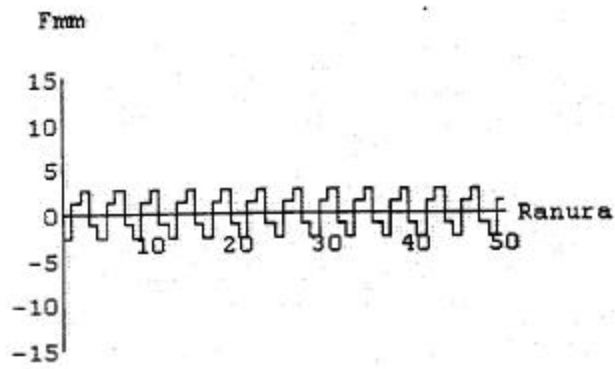
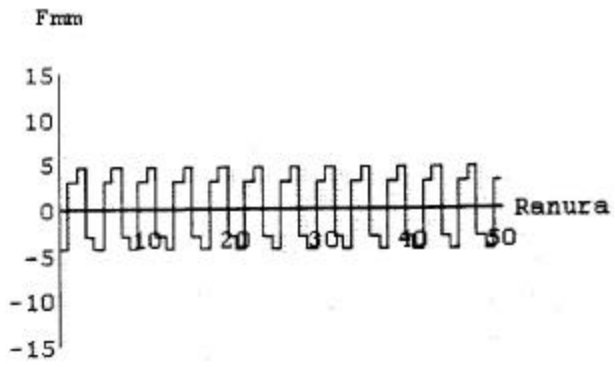
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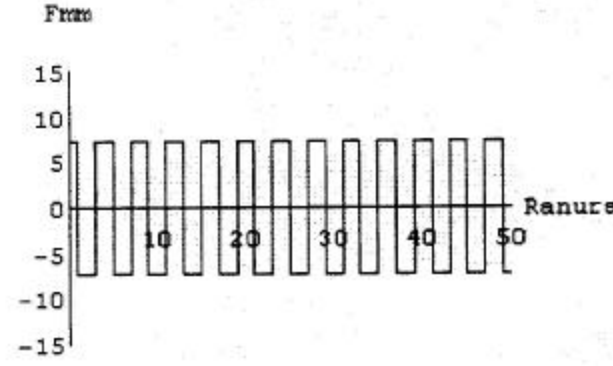
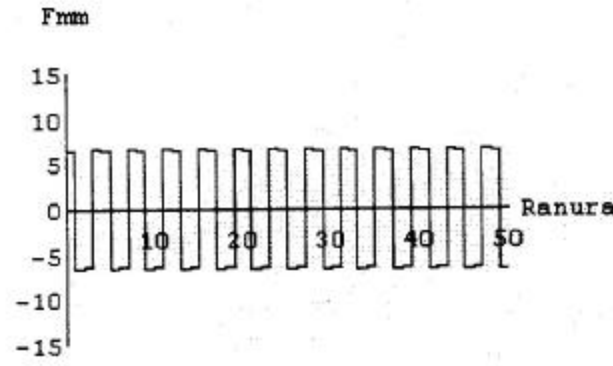
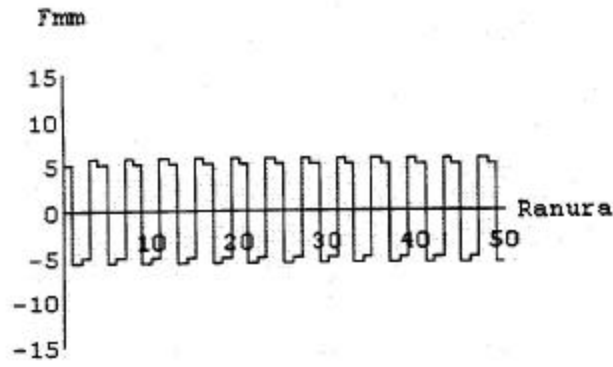
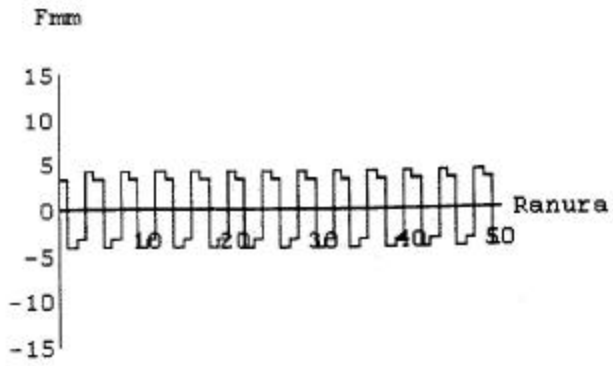
Auxmat2=Inverse[C[50]].w2.S[2];
Fmm[Ia,Ib]:=Auxmat2.{Ia,Ib};
wa=wb=15;
Aux=Table[0,{j,200},{i,200}];
Animcos[Nframe_]:=Do[{
  Ia=N[Cos[2 Pi/Nframe (k-1)]],
  Ib=N[0.1*Cos[2 Pi/Nframe (k-1)-2*Pi/5]],

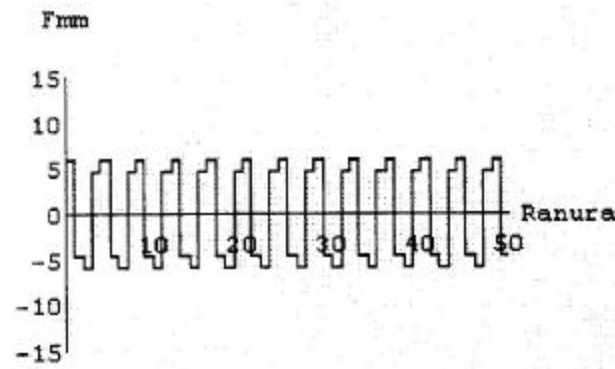
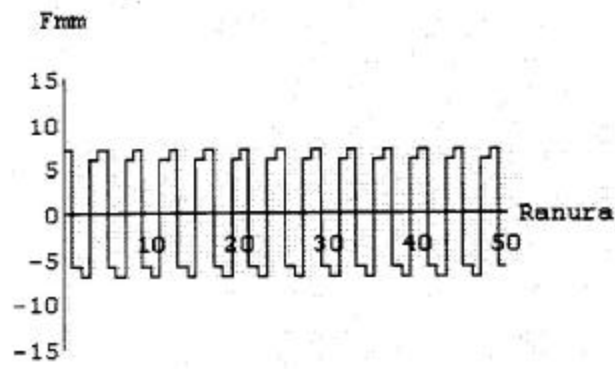
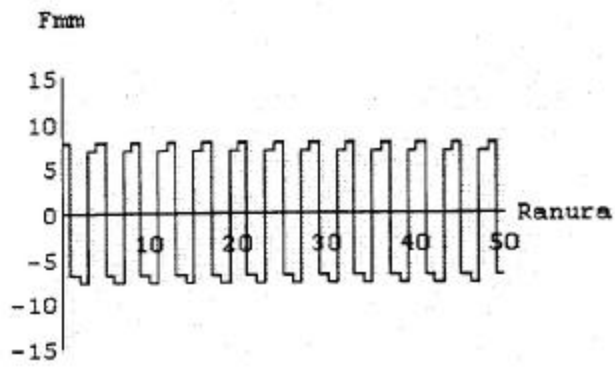
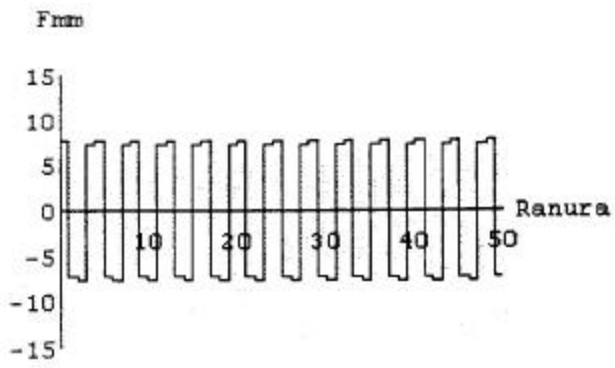
  Aux[[k]]=Fmm[Ia,Ib],
  ListPlot[Table[{
    Table[Floor[(i1/2)],
    Table[Aux[[k,Floor[(i1+1)/2]]]],
    {i1,1,100}],
    PlotJoined->True,
    PlotRange->{{0,50},{-15,15}},
    AxesLabel->{"Ranura","Fmm"}],
    {k,1,Nframe}]
Animcos[24]

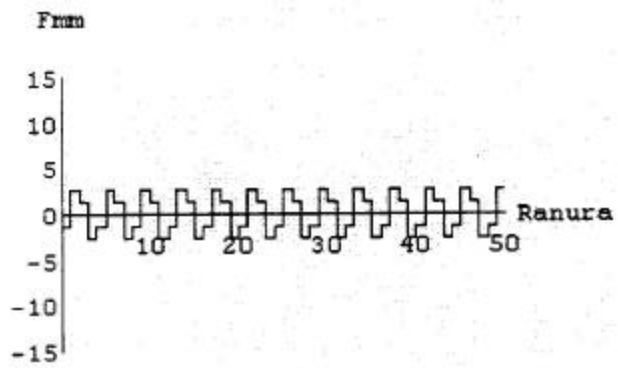
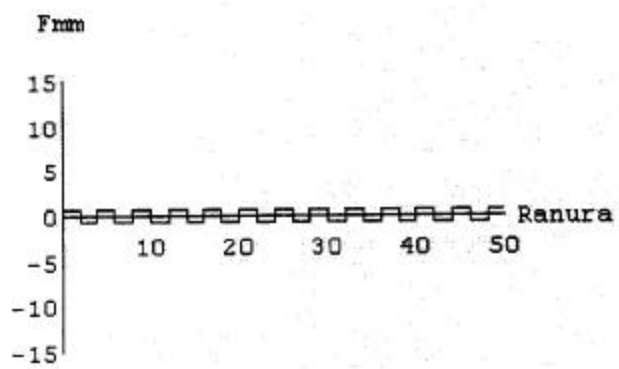
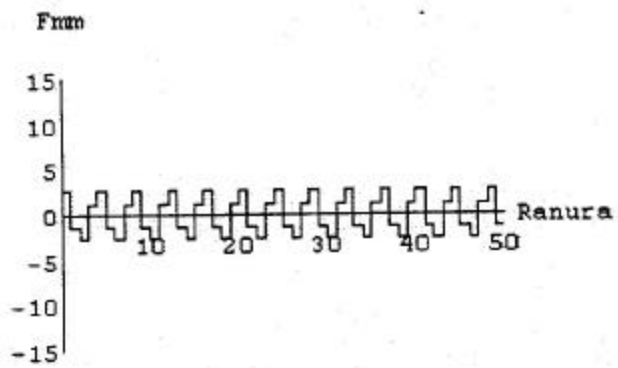
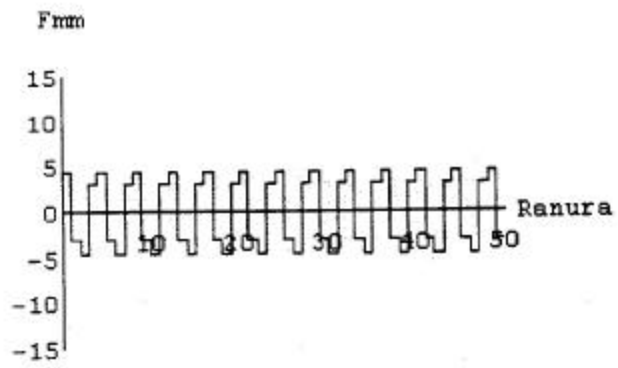
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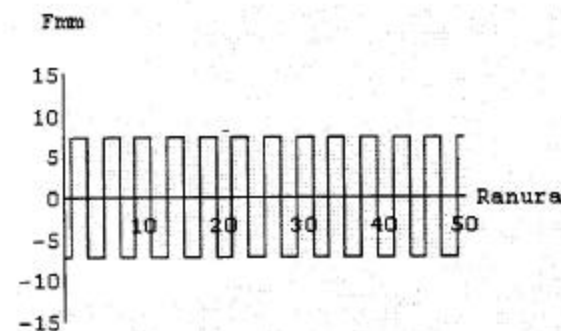
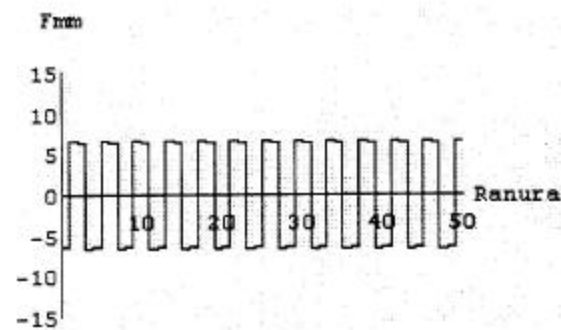
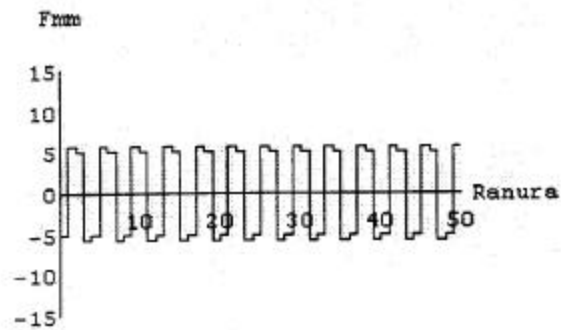
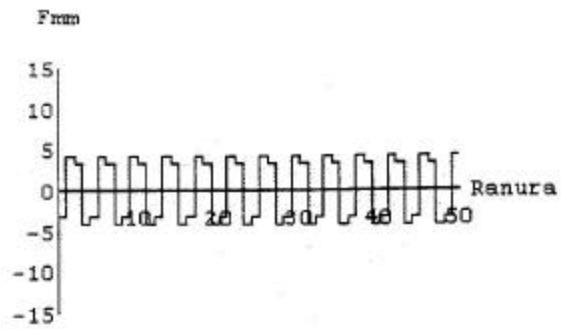












Con la hipótesis mantenida inicialmente, se puede comprobar que cuando el devanado inductor del prototipo M-3 es alimentado, la onda de f.m.m. en el entrehierro es una onda pulsante en amplitud y deslizante en el tiempo, similar a la hipótesis 2.

Prototipo M-3

Hipótesis 4 :

Devanado monofásico con espira de sombra, (bifásico virtual) M-3

$$I = 100 \text{ A}$$

$$I_{es} = 1 \text{ A}$$

$$\varphi (I - I_{es}) = 90^\circ$$

Nº de espiras = 50

- DEFINICIÓN DE LA MATRIZ C

Unprotect[C];

$C[n_]=\text{Table}[\text{If}[i<n,\text{If}[i==j,-1,\text{If}[i==j-1,1,0]],1],$
 $\{i,n\},\{j,n\}]$

- DEFINICIÓN DE LA MATRIZ DE LOS SIGNOS S

$S[m_]=\text{Table}[\text{If}[i<=m,\text{If}[i==j,1,0],\text{If}[i-m==j,-1,0]],$
 $\{i,2m\},\{j,m\}]$

- DEFINICIÓN DE LA MATRIZ DE DEVANADO W

$w2=\text{Table}[0,\{i,50\},\{j,4\}];$

$w2[[1]]=\{wa,0,0,0\};$

$w2[[2]]=\{0,wb,0,0\};$

$w2[[3]]=\{0,0,wa,0\};$

$w2[[4]]=\{0,0,0,wb\};$

$w2[[5]]=\{wa,0,0,0\};$

$w2[[6]]=\{0,wb,0,0\};$

$w2[[7]]=\{0,0,wa,0\};$

$w2[[8]]=\{0,0,0,wb\};$

$w2[[9]]=\{wa,0,0,0\};$

$w2[[10]]=\{0,wb,0,0\};$

$w2[[11]]=\{0,0,wa,0\};$

$w2[[12]]=\{0,0,0,wb\};$

$w2[[13]]=\{wa,0,0,0\};$

$w2[[14]]=\{0,wb,0,0\};$

$w2[[15]]=\{0,0,wa,0\};$

$w2[[16]]=\{0,0,0,wb\};$

$w2[[17]]=\{wa,0,0,0\};$

$w2[[18]]=\{0,wb,0,0\};$

$w2[[19]]=\{0,0,wa,0\};$

$w2[[20]]=\{0,0,0,wb\};$

$w2[[21]]=\{wa,0,0,0\};$

$w2[[22]]=\{0,wb,0,0\};$

$w2[[23]]=\{0,0,wa,0\};$

$w2[[24]]=\{0,0,0,wb\};$

$w2[[25]]=\{wa,0,0,0\};$

$w2[[26]]=\{0,wb,0,0\};$

$w2[[27]]=\{0,0,wa,0\};$

```

w2[[28]]={0,0,0,wb};
w2[[29]]={wa,0,0,0};
w2[[30]]={0,wb,0,0};
w2[[31]]={0,0,wa,0};
w2[[32]]={0,0,0,wb};
w2[[33]]={wa,0,0,0};
w2[[34]]={0,wb,0,0};
w2[[35]]={0,0,wa,0};
w2[[36]]={0,0,0,wb};
w2[[37]]={wa,0,0,0};
w2[[38]]={0,wb,0,0};
w2[[39]]={0,0,wa,0};
w2[[40]]={0,0,0,wb};
w2[[41]]={wa,0,0,0};
w2[[42]]={0,wb,0,0};
w2[[43]]={0,0,wa,0};
w2[[44]]={0,0,0,wb};
w2[[45]]={wa,0,0,0};
w2[[46]]={0,wb,0,0};
w2[[47]]={0,0,wa,0};
w2[[48]]={0,0,0,wb};
w2[[49]]={wa,0,0,0};
w2[[50]]={0,0,0,0};

```

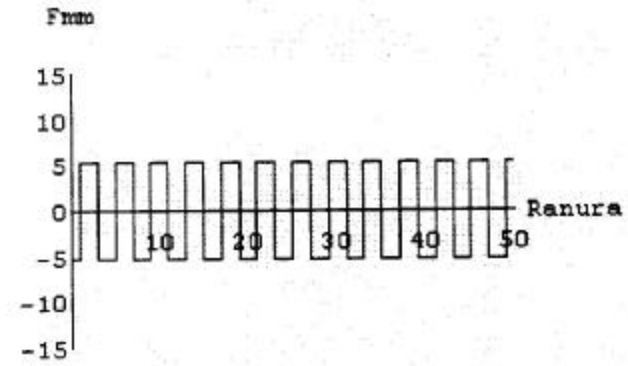
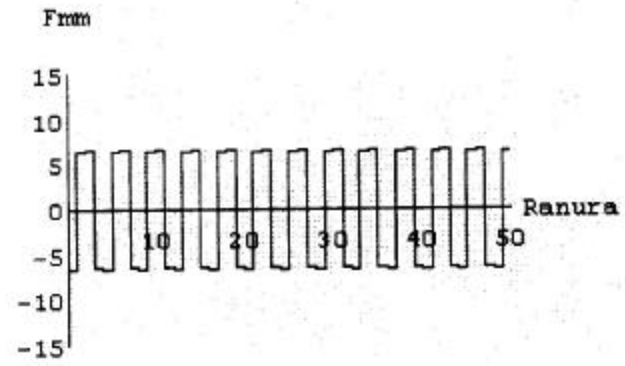
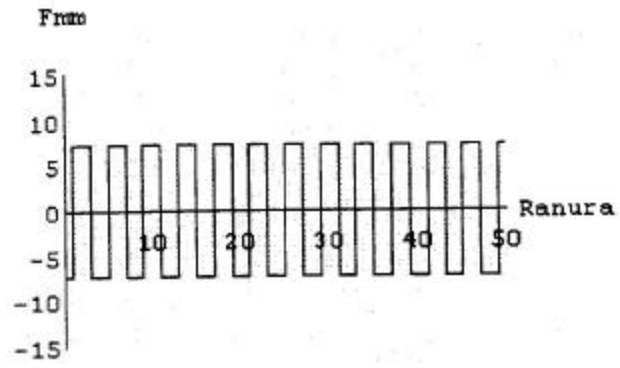
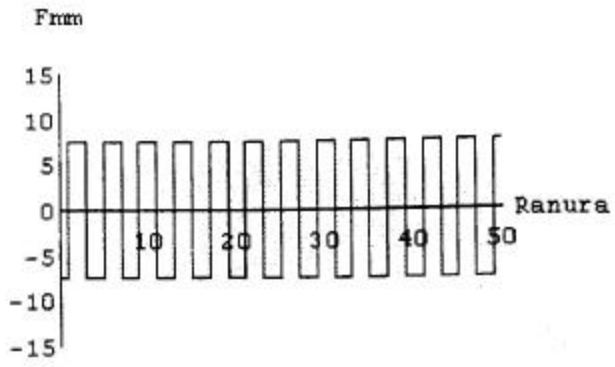
- SOLUCIÓN

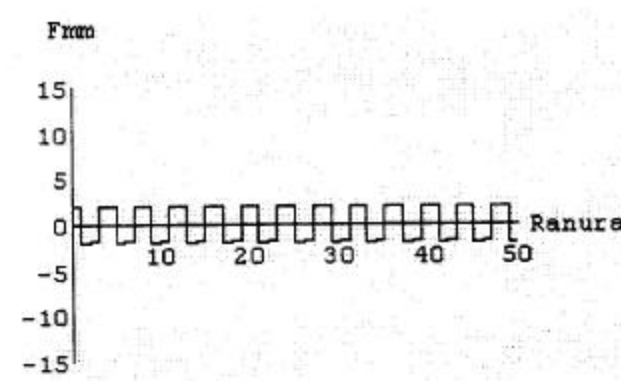
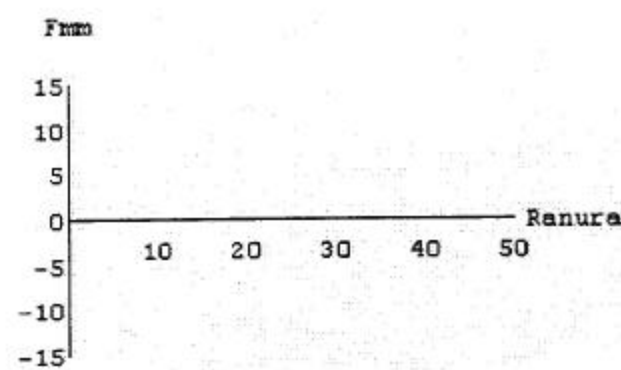
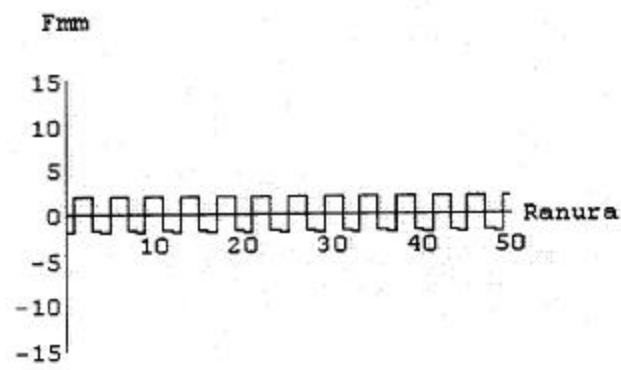
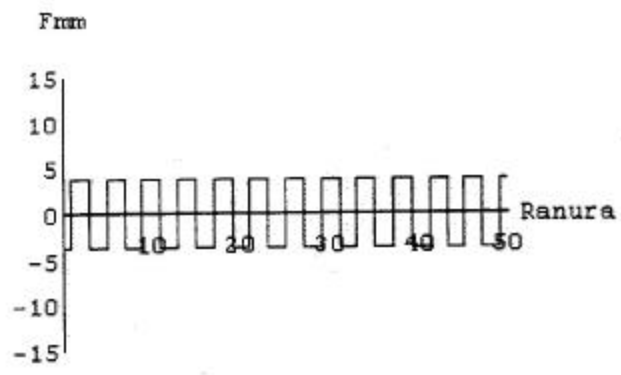
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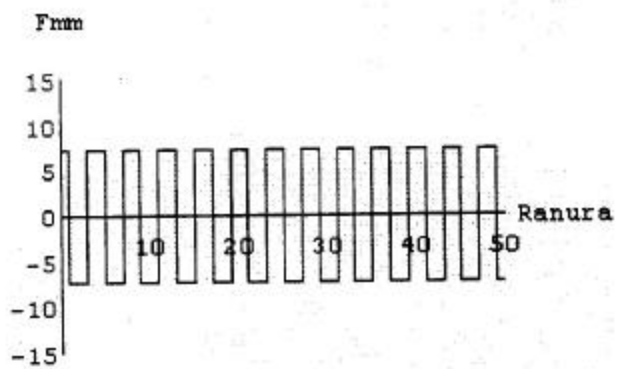
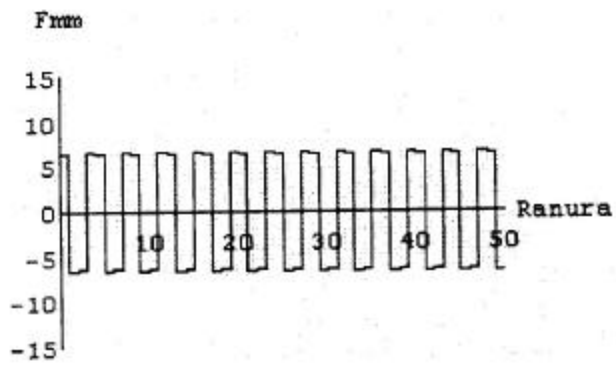
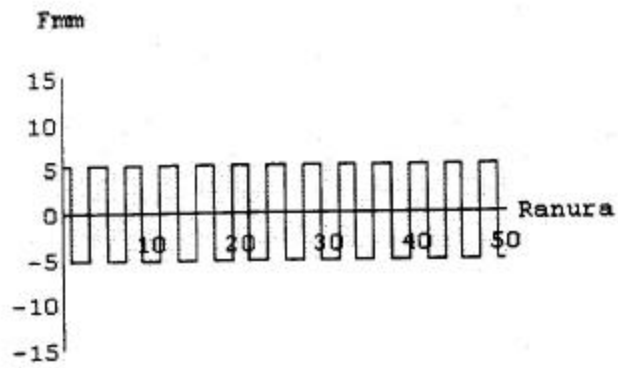
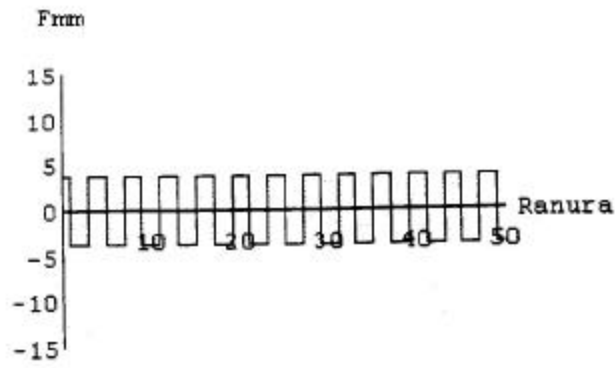
Auxmat2=Inverse[C[50]].w2.S[2];
Fmm[Ia,Ib]:=Auxmat2.{Ia,Ib};
wa=wb=15;
Aux=Table[0,{j,200},{i,200}];
Animcos[Nframe_]:=Do[{
  Ia=N[Cos[2 Pi/Nframe (k-1)]],
  Ib=N[0.01*Cos[2 Pi/Nframe (k-1)-Pi/2]],

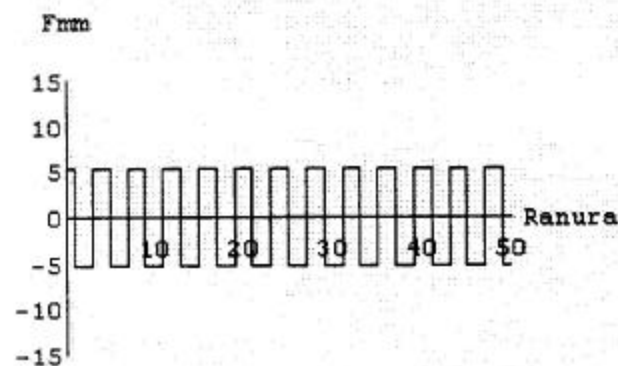
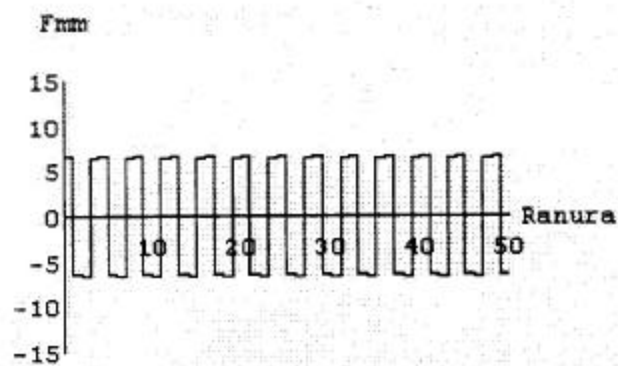
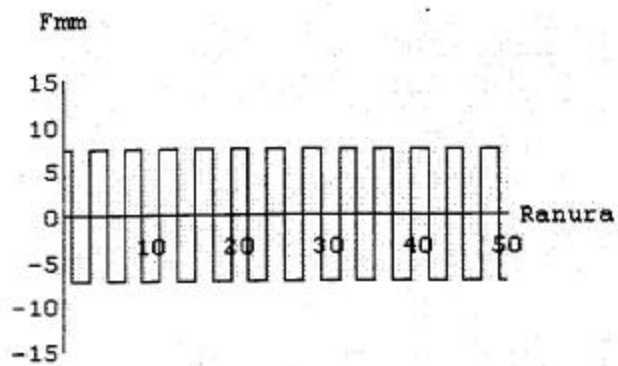
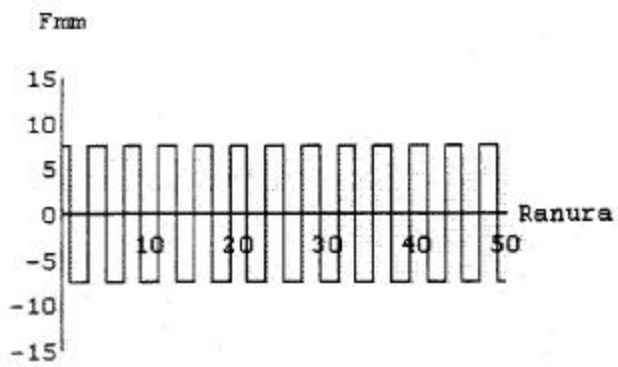
  Aux[[k]]=Fmm[Ia,Ib],
  ListPlot[Table[{
    Table[Floor[(i1/2)],
    Table[Aux[[k,Floor[(i1+1)/2]]]],
    {i1,1,100}],
    PlotJoined->True,
    PlotRange->{{0,50},{-15,15}},
    AxesLabel->{"Ranura","Fmm"}},
    {k,1,Nframe}]
Animcos[24]

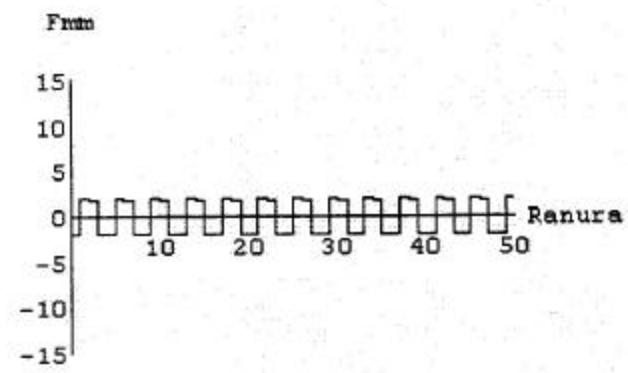
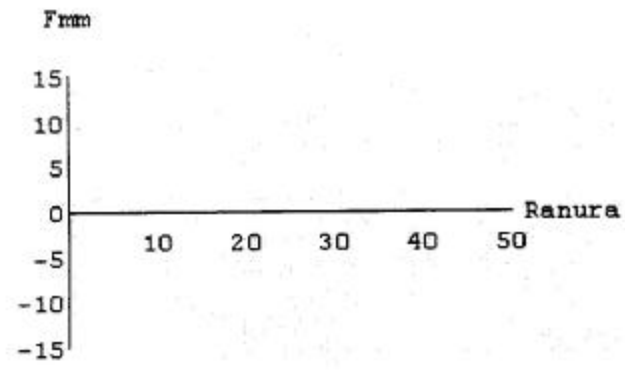
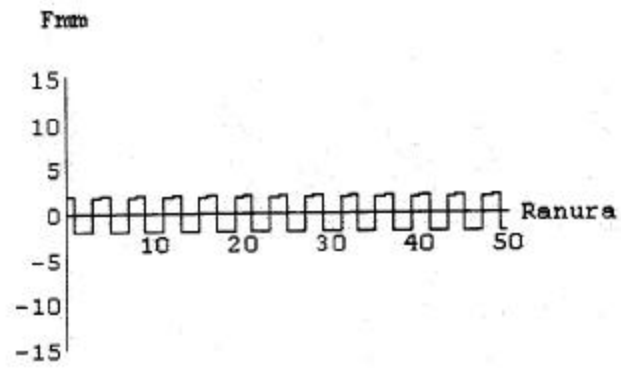
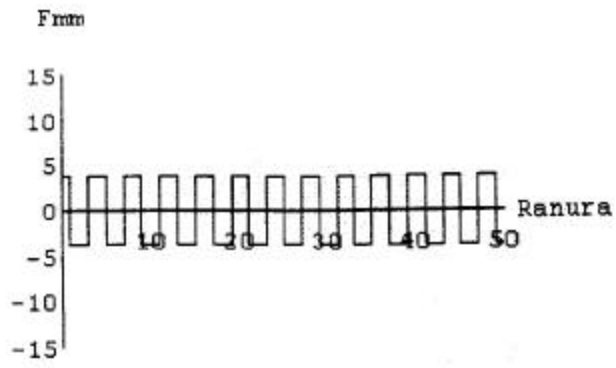
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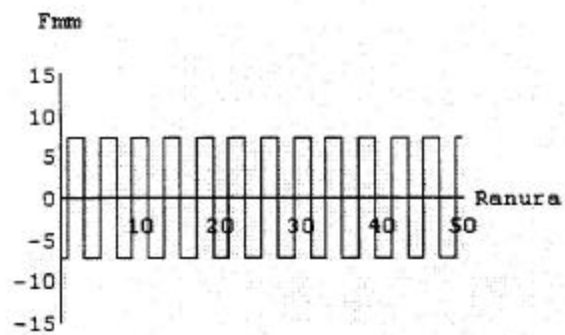
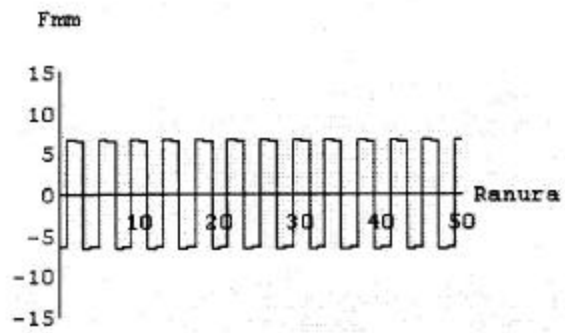
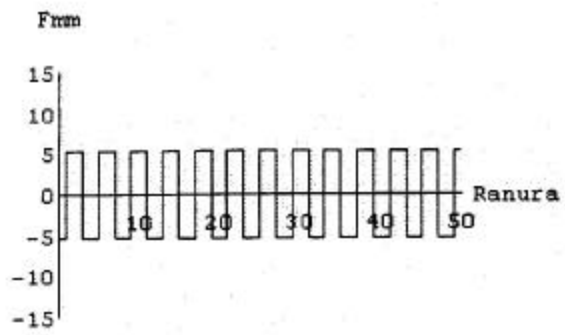
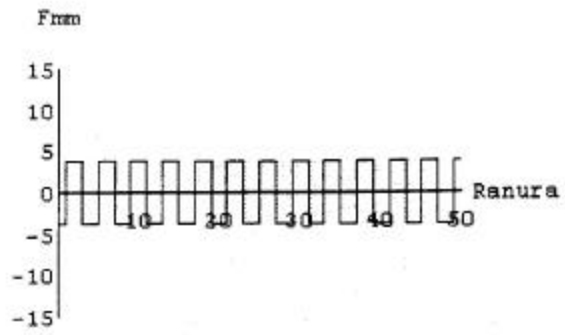












Con la hipótesis mantenida inicialmente, se puede comprobar que cuando el devanado inductor del prototipo M-3 es alimentado, la onda de f.m.m. en el entrehierro es una onda pulsante en amplitud y el carácter deslizante está muy minimizado.