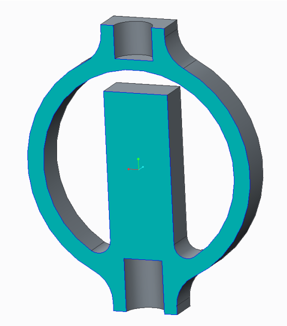
ANEXOS

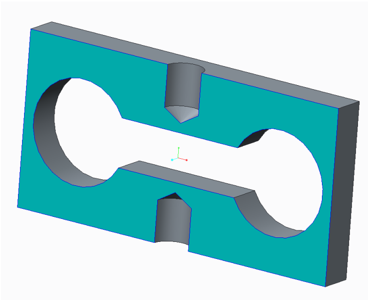
ÍNDICE

ANEXO 1: DISEÑO DE LA CÉLULA DE CARGA

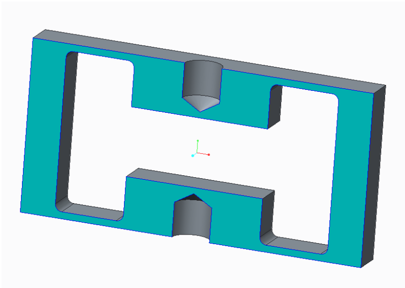
1.1 Geometrías estudiadas con PTC CREO Pro/Engineer



Anillo



Binocular



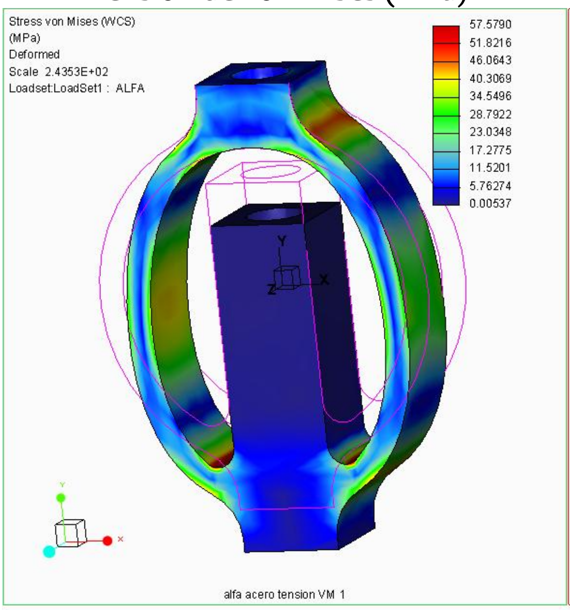
A flexión múltiple

Condiciones del estudio:

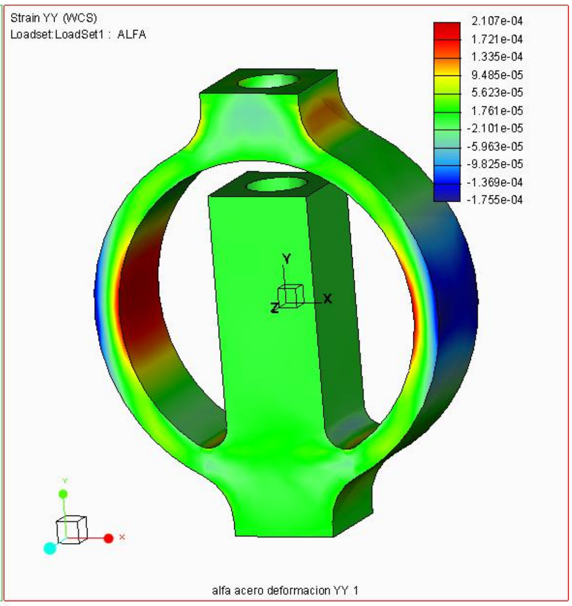
- Fuerza: 20kg-f, dirección YY, en el agujero roscado inferior
- Restricción al desplazamiento en el agujero roscado superior

Resultados del análisis:

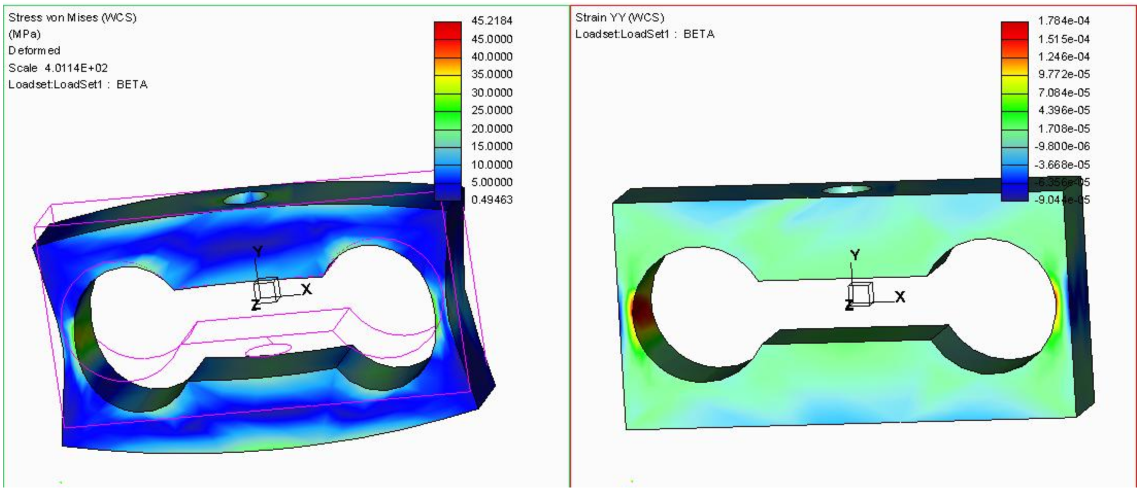
Tensión de von Mises (MPa)



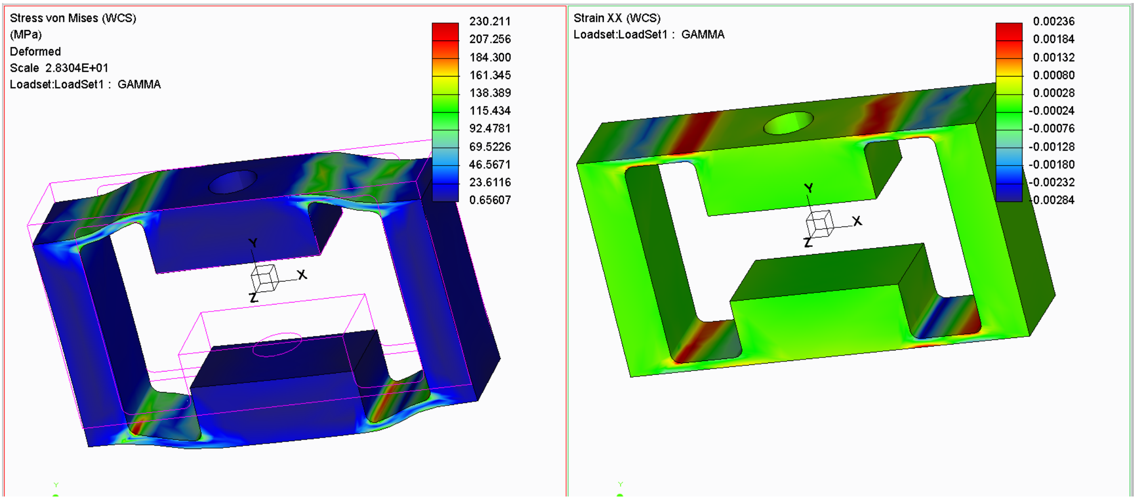
Deformación



Anillo

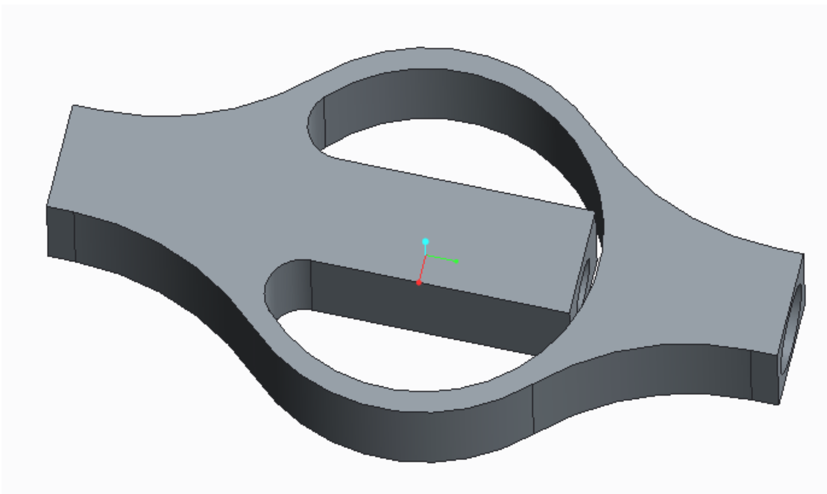


Binocular



Flexión múltiple

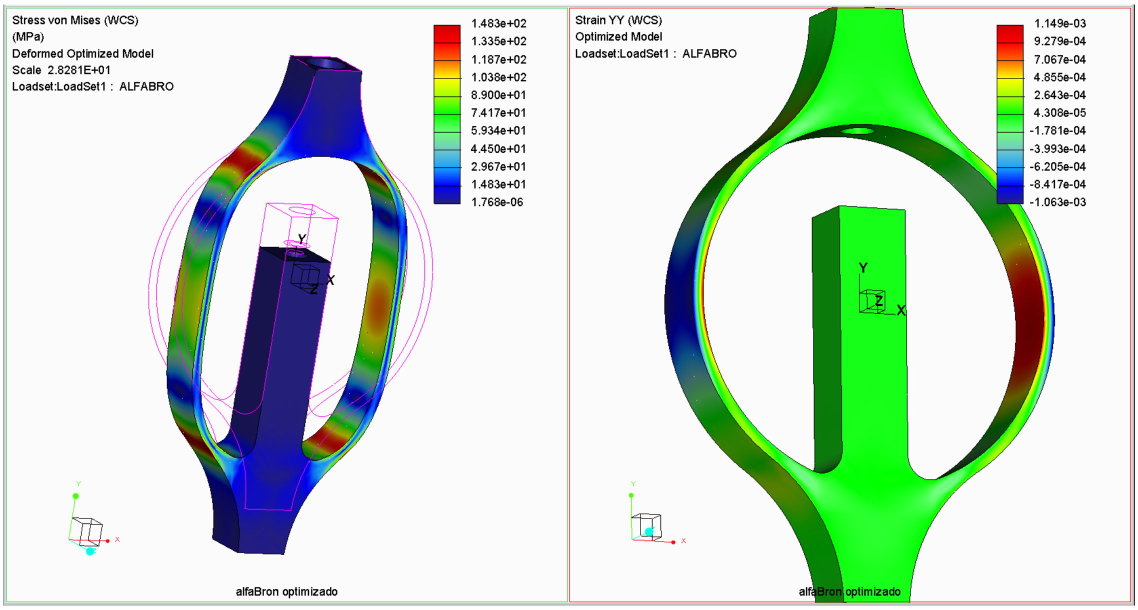
1.2 *Geometría elegida: Anillo*



1.3 *Elección del material*

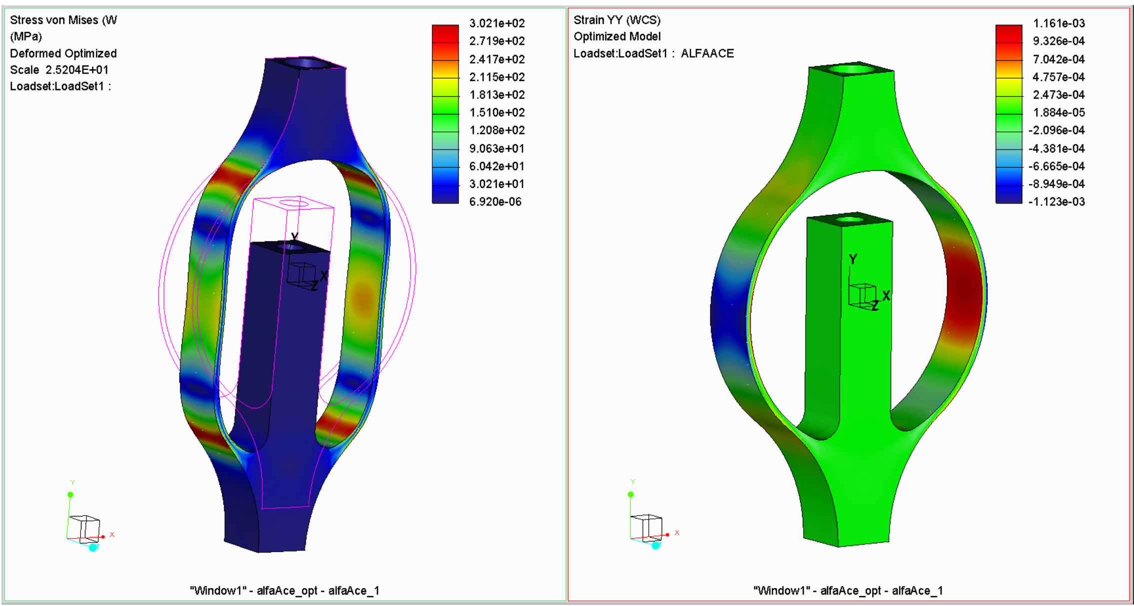
Los análisis efectuados considerando diferentes materiales arrojaron los siguientes resultados:

Bronce



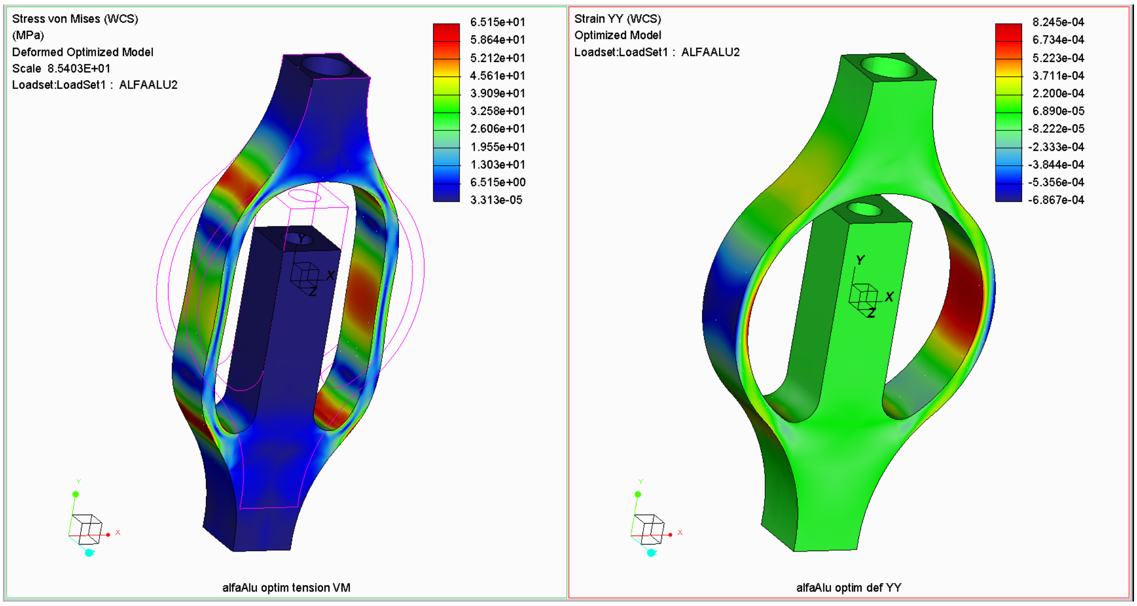

```
Status of Optimization Limits:
1. max_stress_vm      1.4807e+02 =  1.4800e+02
2. Def_Inte           1.1490e-03 >  1.0000e-04

Best Design Found:
Parameters:
   D                       55.0368
   P                       1.68225
Goal:  8.9508e-04
```

Acero



```
Best Design Found:
Parameters:
   D                       47.5131
   P                       1.04559
Goal:  9.2518e-04

Status of Optimization Limits:
1. max_stress_vm      3.0012e+02 =  3.0000e+02
2. Def_Inte           1.1609e-03 >  1.0000e-03
```

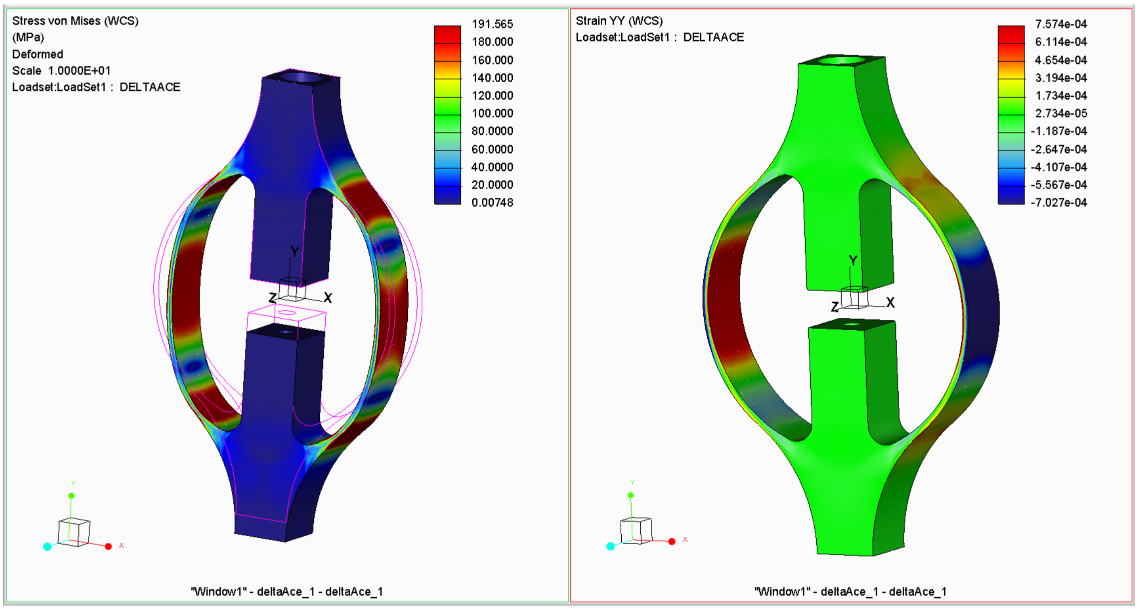
Aluminio




```
Best Design Found:
Parameters:
   D                       40.6756
   P                             2
Goal:  5.7973e-04

Status of Optimization Limits:
1. max_stress_vm      6.5107e+01 =  6.5000e+01
```

1.4 Simulación previa a la optimización

Una vez modificada la geometría de anillo de tal manera que el tope tenga dos partes, se realizó una simulación del efecto de una carga de 20kg-f sobre la pieza. Los resultados se muestran en la figura siguiente:



En la parte izquierda se muestran las tensiones de von Mises, que en ningún punto de la pieza superan los 300MPa, la mitad del límite elástico considerado para el acero. En la parte derecha, las deformaciones en la dirección YY (tracción-compresión) obtenidas aun son inferiores a las deseadas: aproximadamente 750 microdeformaciones frente a las 1000 que son el objetivo.

1.5 Optimización de la geometría escogida

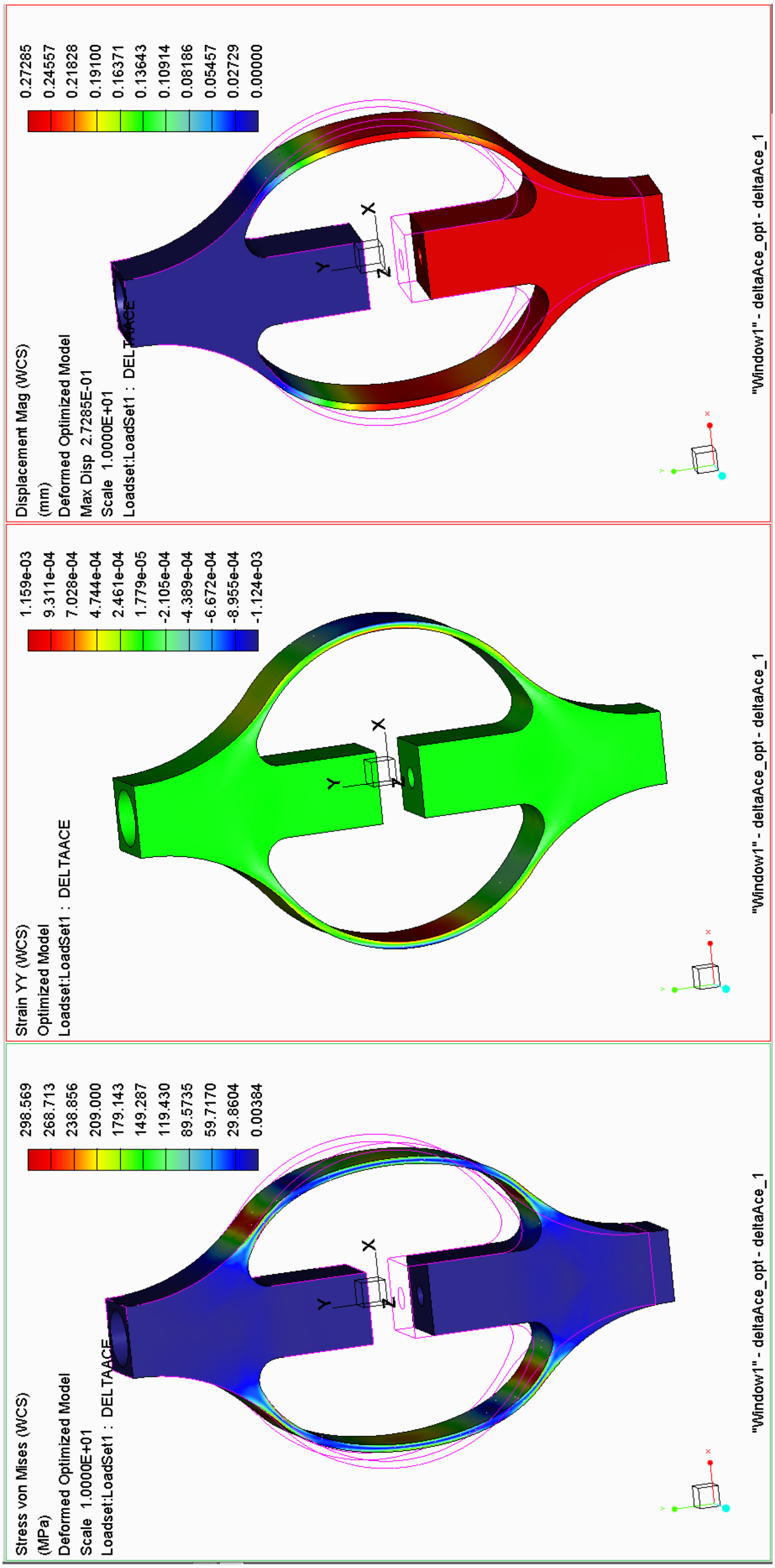
Se realizaron a continuación diversos estudios de sensibilidad de la deformación frente a los diferentes parámetros geométricos de la pieza, concluyendo que los más influyentes son el espesor del arco (diferencia entre radios exterior e interior) así como el diámetro.

Posteriormente se llevó a cabo un estudio de optimización del diseño, permitiendo finalmente alcanzar los objetivos marcados dentro de los rangos previstos.

Resultados del estudio de optimización con el software PTC CREO Pro/Engineer se muestran a continuación.

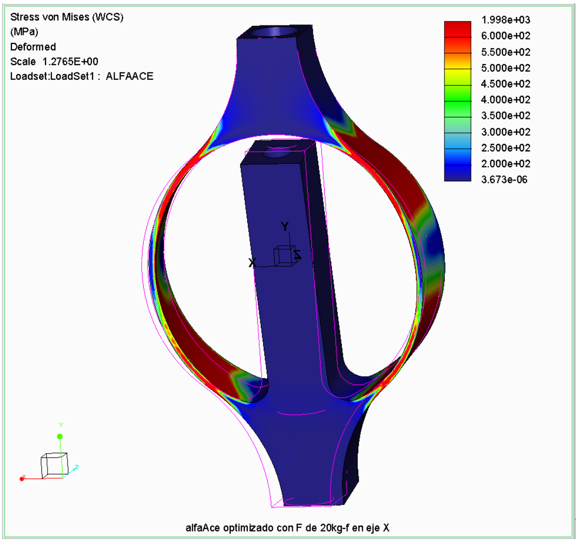
```
Optimization Design Study

Using Sequential Quadratic Programming Optimization
Algorithm
Fri Jul 25, 2014   11:32:03

Goal
   Analysis: deltaAce_1
   Load Set: LoadSet1
   Maximize: Def_ext (absolute value)

Limit: 1
   Analysis: deltaAce_1
   Load Set: LoadSet1
   max_stress_vm < 3.0000e+002

Limit: 2
   Analysis: deltaAce_1
   Load Set: LoadSet1
   Def_Inte > 1.0000e-003

Parameter           Min. Value   Initial Value  Max. Value
D                           40            45            5
P                            1             1            2

Optimization Convergence Tolerance: 1        %
Maximum Number of Optimization Iterations: 20

Begin Analysis of Goal and Limits of            (11:32:03)
Initial Design
------------------------------------------------------------
```

```
Initial Design Status
Parameters:
   D                           45
   P                            1

Goal:  9.1939e-04
Status of Optimization Limits:

1. max_stress_vm     2.9979e+02 <  3.0000e+02 (satisfied within
tolerance)
2. Def_Inte          1.1605e-03 >  1.0000e-03 (satisfied within
tolerance)

Resource Check                                   (11:34:52)
   Elapsed Time     (sec):     174.53
   CPU Time         (sec):     105.91
   Memory Usage      (kb):     673818
   Wrk Dir Dsk Usage (kb):      37891

Begin Optimization Iteration 1                   (11:34:52)

Result of Optimization Iteration 1
Parameters:
   D                      45.0086
   P                            1

Goal:  9.1940e-04


Status of Optimization Limits:
1. max_stress_vm     2.9800e+02 <  3.0000e+02 (satisfied within
tolerance)
2. Def_Inte          1.1594e-03 >  1.0000e-03 (satisfied within
tolerance)

Resource Check                                   (11:37:59)
   Elapsed Time     (sec):     361.90
   CPU Time         (sec):     238.80
   Memory Usage      (kb):     702838
   Wrk Dir Dsk Usage (kb):      35848

Begin Optimization Iteration 2                   (11:37:59)

Converged to optimum design.

Best Design Found:
Parameters:
   D                      45.0086
   P                            1

Goal:  9.1940e-04

Optimization study statistics:
Number of Base Analyses: 8
Number of Perturbation Analyses: 10
```

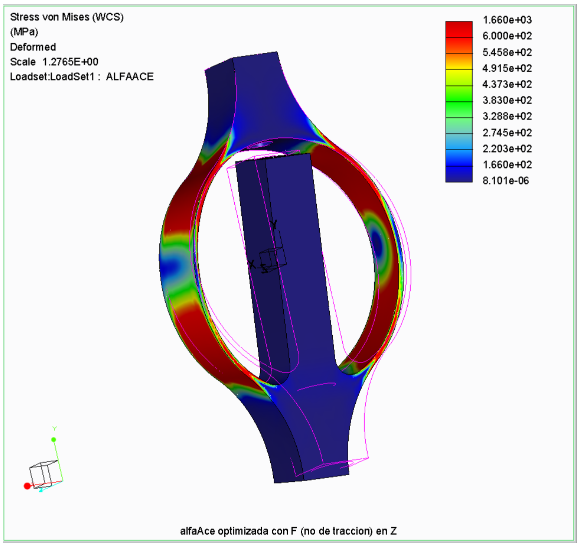


Resultados del estudio de optimización

1.6 *Efecto de fuerzas en direcciones no de tracción pura*



Fuerza en X



Fuerza en Z

Las tensiones de von Mises máximas son superiores a 1500Mpa, más del doble del límite elástico del material.

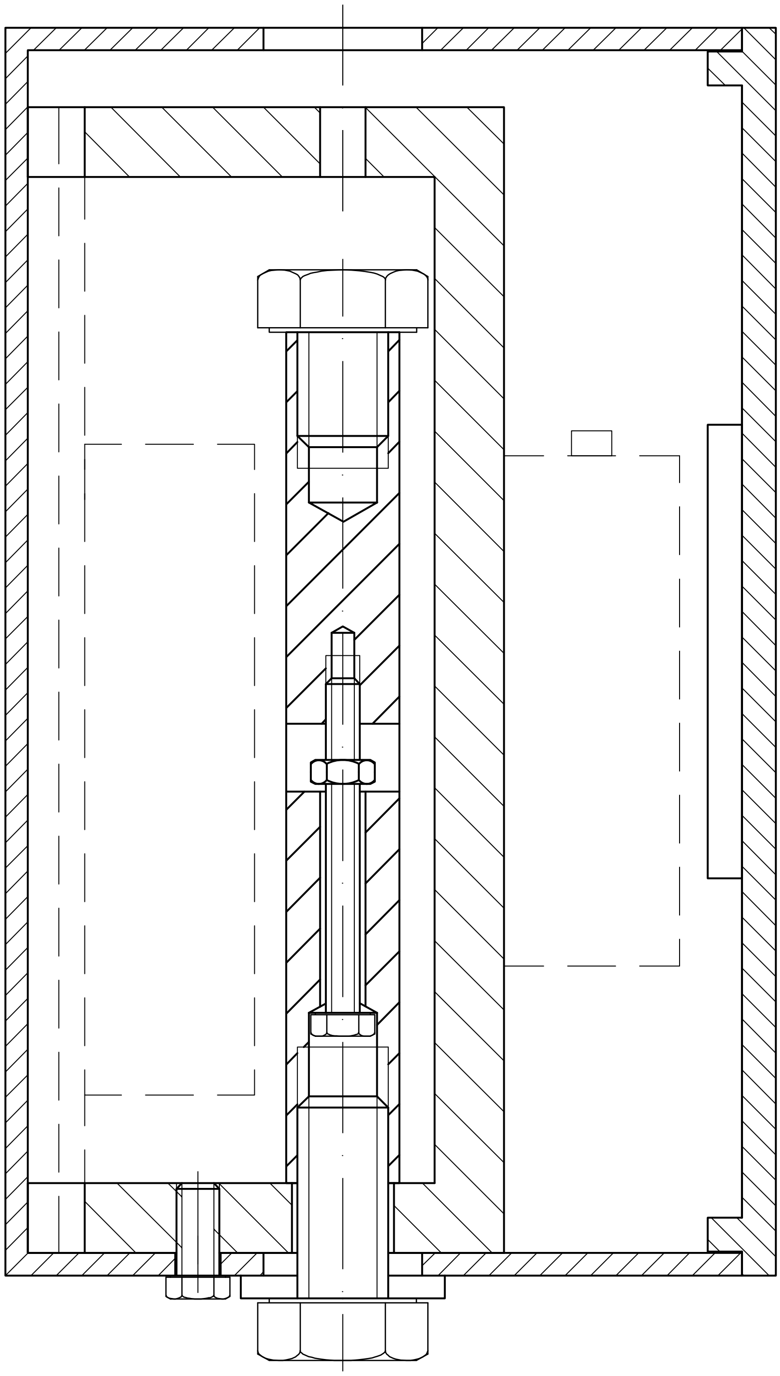
1.7 *Planos De Célula De Carga*

Nº Plano

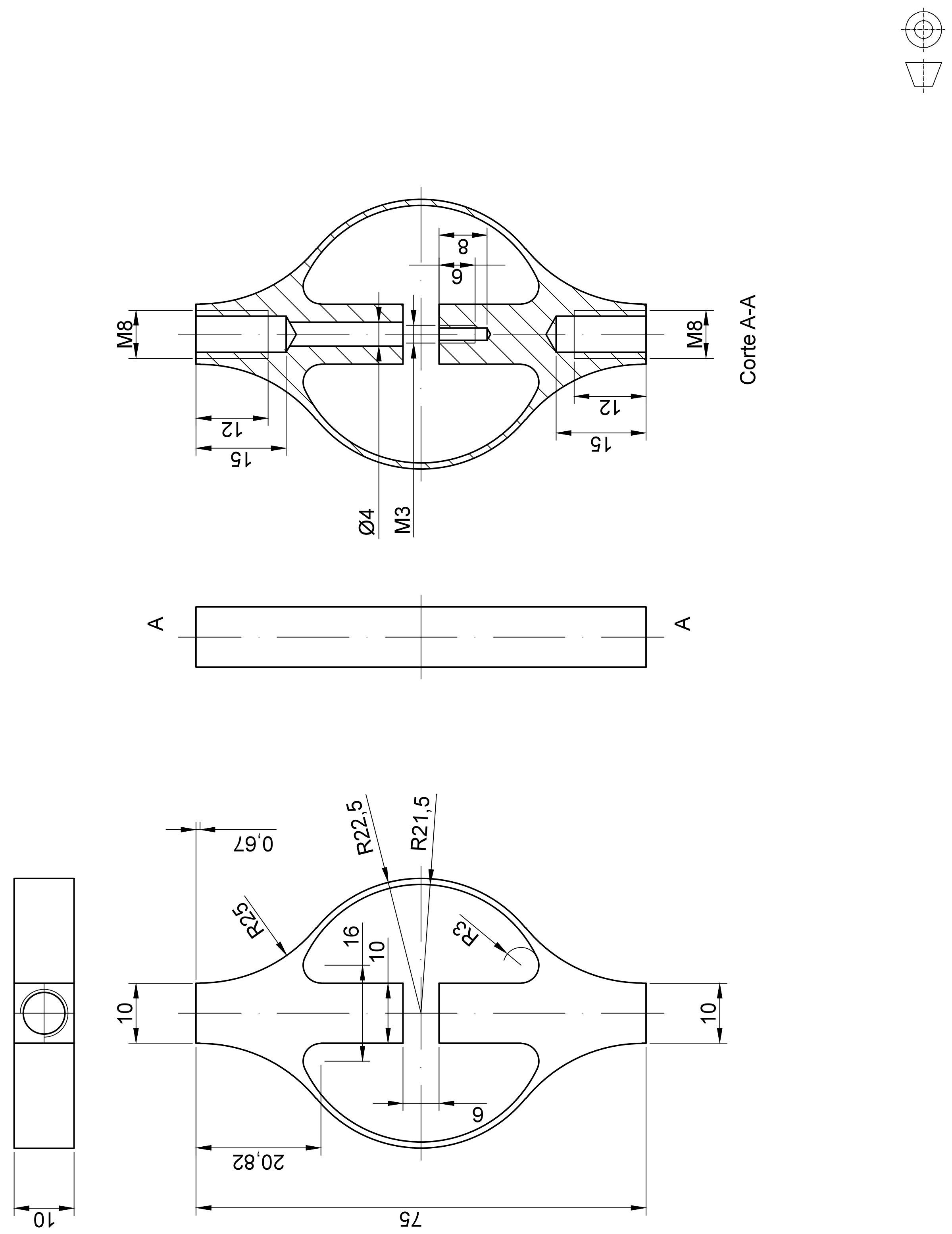
1	Célula de carga
2	Soporte
3	Caja
4	Tapa

Lista de piezas del conjunto mecánico:

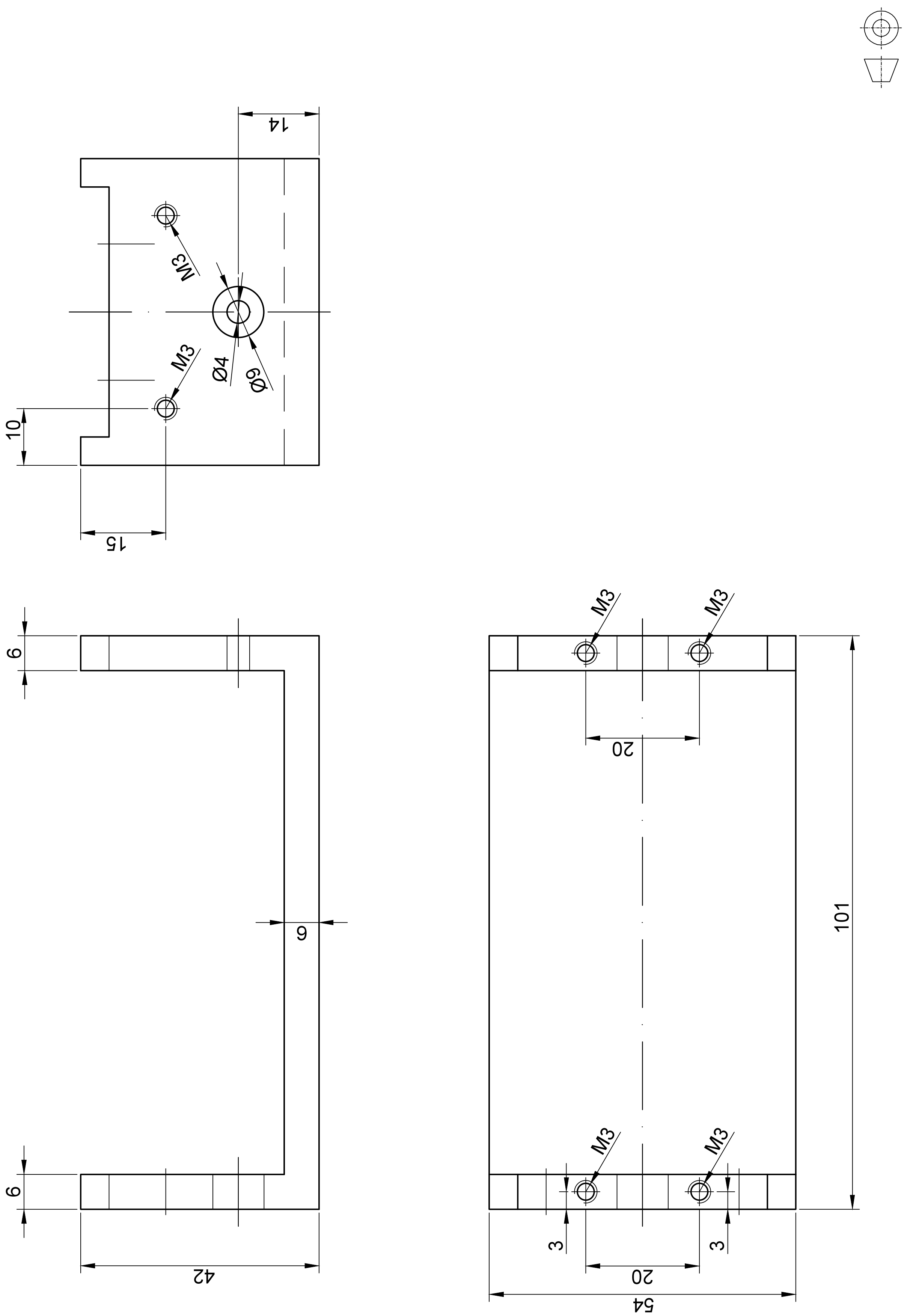
1	Célula de carga
1	Soporte
1	Caja
1	Tapa
2	Tornillo M8
2	Arandela
6	Tornillo M3
2	Cable metálico Ø1,5mm



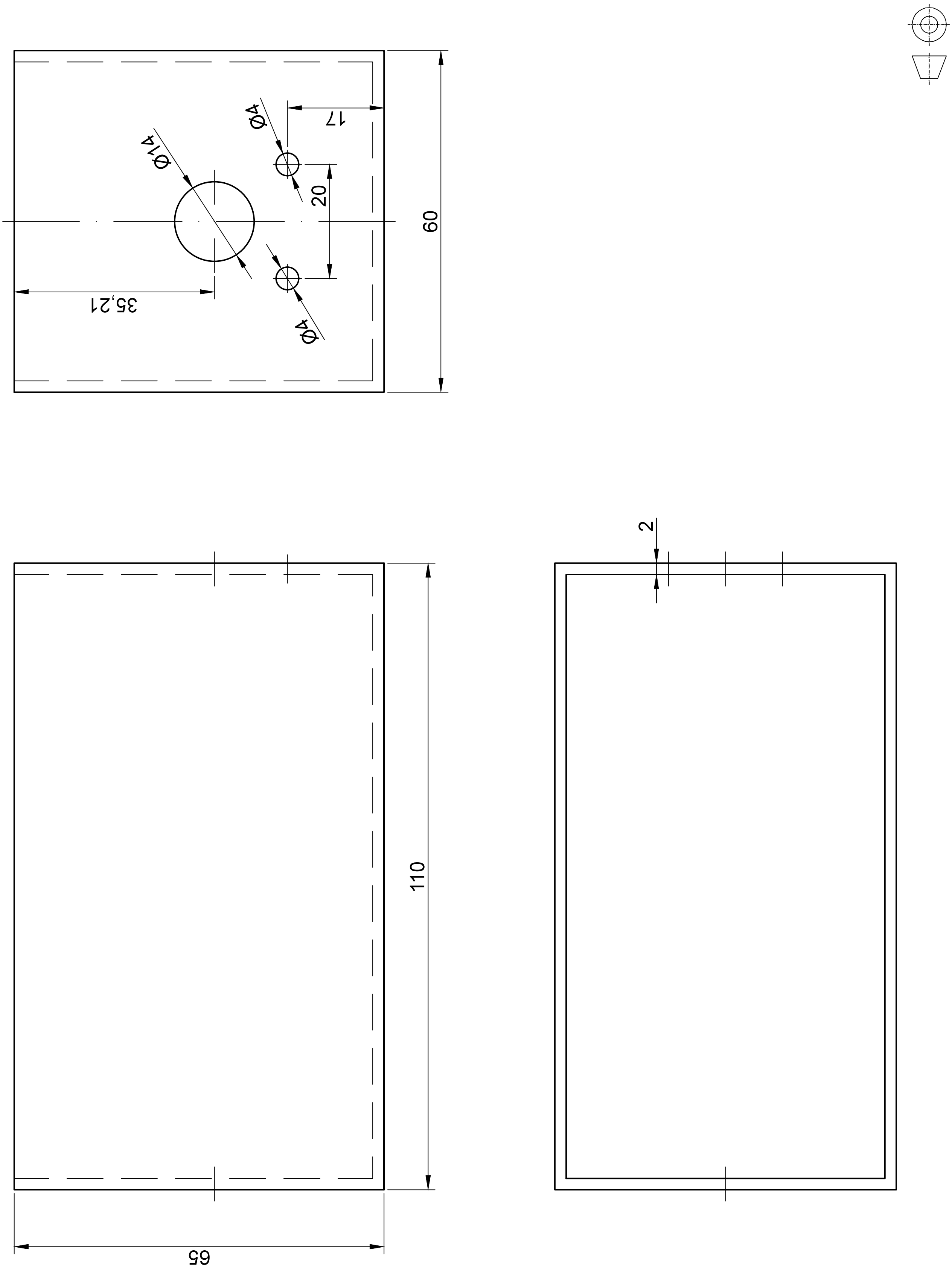
FECHA	AUTOR	PROYECTO	
13-09-14	Adrián Miqueo	DISEÑO Y FABRICACIÓN DE UN DINAMÓMETRO INALÁMBRICO	
Escala: 3:2	PLANO Plano de Conjunto	PLANO Nº	



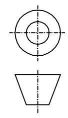
FECHA	AUTOR	PROYECTO	
13–09–14	Adrián Miqueo	PLANTA DE FABRICACIÓN DE TEJAS DE HORMIGÓN	
Escala: 1:1	**PLANO** Célula de Carga	**PLANO Nº** 1	

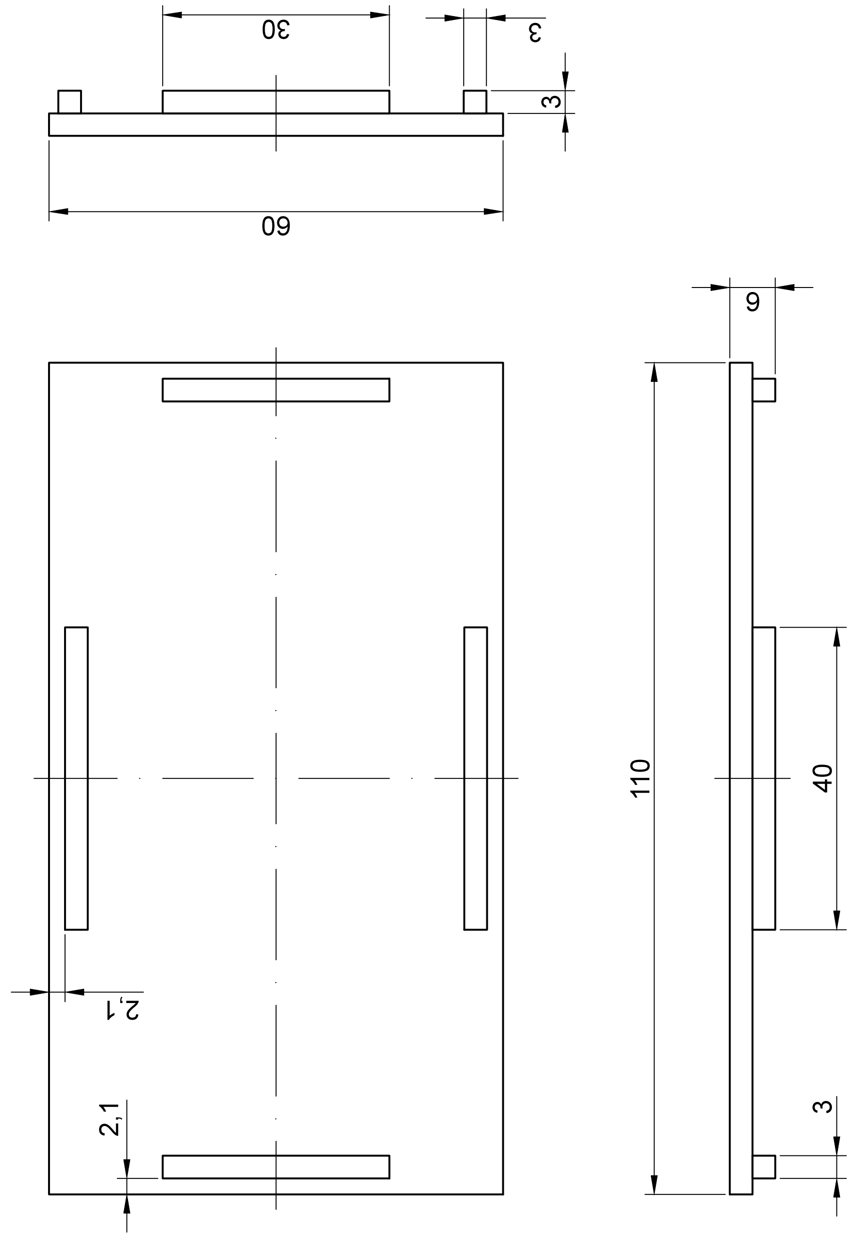


FECHA 13–09–14	AUTOR Adrián Miqueo	PROYECTO DISEÑO Y FABRICACIÓN DE UN DINAMÓMETRO INALÁMBRICO
Escala: 1:1	PLANO Soporte	PLANO Nº 2



FECHA	AUTOR	PROYECTO	
13–09–14	Adrián Miqueo	DISEÑO Y FABRICACIÓN DE UN DINAMÓMETRO INALÁMBRICO	
Escala: 1:1	PLANO: Caja	PLANO Nº 3	

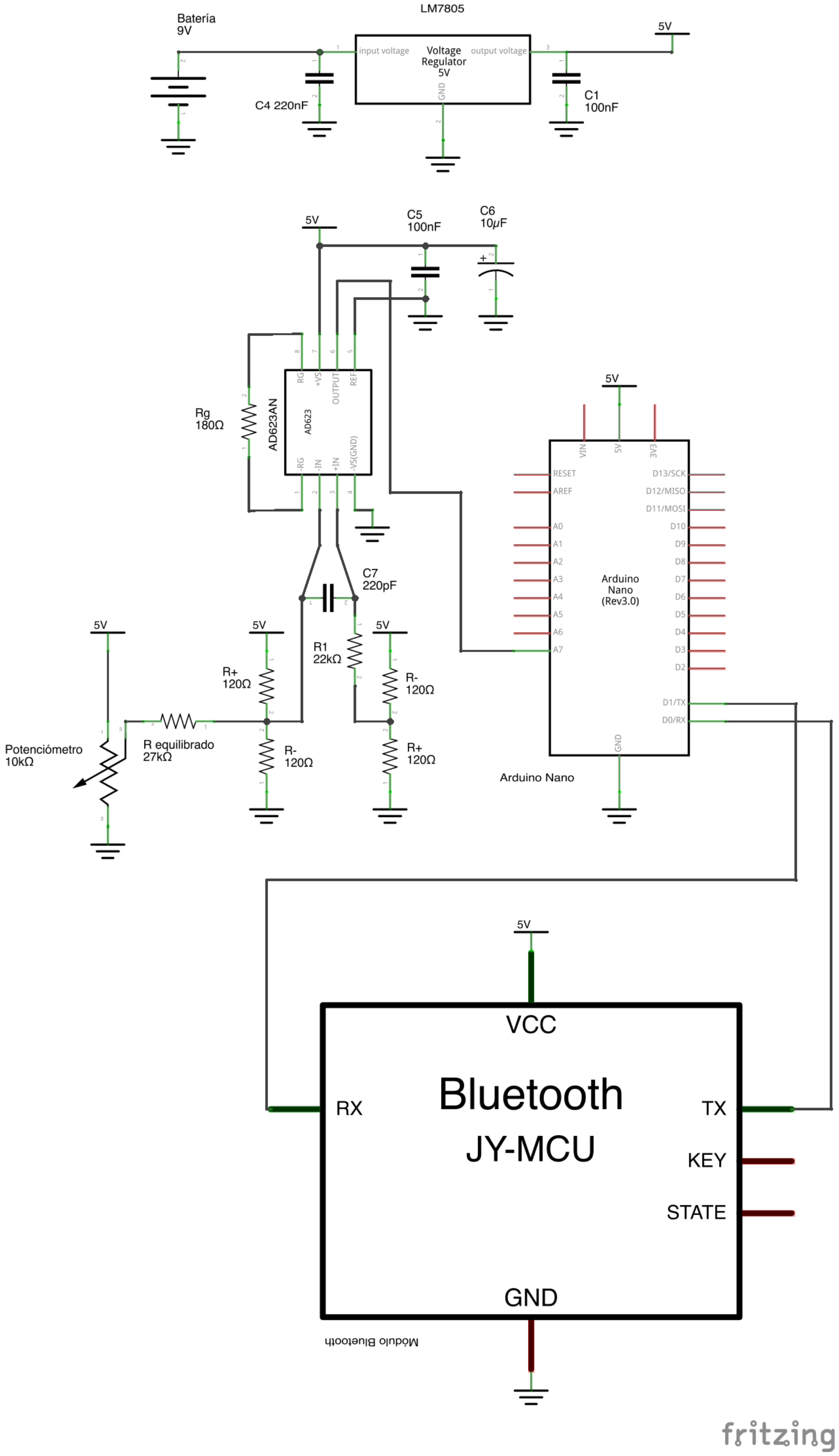




FECHA	AUTOR	PROYECTO
13–09–14	Adrián Miqueo	DISEÑO Y FABRICACIÓN DE UN DINAMÓMETRO INALÁMBRICO

Escala:	PLANO	PLANO Nº	
1:1	Tapa	4	

ANEXO 2: ESQUEMAS ELECTRÓNICA



ANEXO 3: Código de Arduino

```
int pin_pot = 7;
int variable = 0;
int variable0 = 0;
int periodo = 50;
int frecuencia = int (1000/periodo);

void setup()
{
   Serial.begin(9600);
}

void loop()
{
  leer_frecuencia();

  unsigned int valor = analogRead(pin_pot);

  Serial.write(255);
  Serial.write (255);
  Serial.write (lowByte(valor));
  Serial.write (highByte(valor));
  delay(periodo);
}

void leer_frecuencia()  {
  int inicio = 0;
  if (Serial.available() > 3 )  {
    while (inicio<2)  {
      if(Serial.read()==255)  {
        inicio++;
      }
      else  {
        inicio=0;
      }
    }
    if (Serial.available()>0 && inicio==2)  {
      variable=Serial.read();
      inicio++;
    }
    if (Serial.available()>0 && inicio==3)  {
      variable0=Serial.read();
      frecuencia=variable+variable0*256;
      periodo = int(1000/periodo);
      inicio=0;
    }
  }
}
```

ANEXO 4: Código del Programa en Processing

```
/* 16 sep  PROGRAMA COMPLETO

*/

//Colores
color negro = (0);
color blanco = (255);
color gris = (210);
color rojo = color(255,0,0);
color rojoO = color(125,0,0);
color verde = color(0,255,0);
color verdeO = color(0,125,0);
color azul = color(0,0,255);
color azulO = color(0,0,125);
color amarillo = color(255,255,0);
color amarilloO = color(125,125,0);
color fucsia = color(255,0,255);
color fucsiaO = color(125,0,125);
color cyan = color(0,255,255);
color cyanO = color(0,125,125);

//Variables para menú
int sobreBoton = 0;
int x[] = new int[12];
int y[] = new int[12];
int b[] = new int[12];
int h[] = new int[12];

import processing.serial.*;
Serial miPuerto;

int variable=0;
int variable0=0;
int medida;
boolean modo_guardar = false;

//Variables para medida Unica
boolean modo_medidaU = false;
boolean medidaU_lista = false;
String texto_imprimir;

//Variables para medida continua
boolean modo_medidaC = false;
PrintWriter folio;
int xPos; //posicion horizontal inicial del gráfico
float peso = 0;
String nombre_archivo = "";
String nombre = "";
boolean modo_nombrar = false;

//Variables para media aritmética de filtrado
int cont_media = 0;
float datosC[] = new float[16];
int puntero_media = 0;

//Variables para elección de frecuencia de muestreo
boolean modo_frecuencia = false;
```

```
int frecuencia = 100;
int numero = 0;
String numero_string = "";
int contador_frecuencia = 0;

void setup()
{
  miPuerto = new Serial(this, Serial.list()[3],115200);
//COM3=USB,COM4=BlueTooth,Serial.list()[3]=Mac

  size(500,600);
  background(gris);

  x[1]=25;  y[1]=25; b[1]=75;  h[1]=75; //modo guardar
  x[2]=125; y[2]=25; b[2]=250; h[2]=75; //título
  x[3]=400; y[3]=25; b[3]=75;  h[3]=75; //botón Cerrar
  x[4]=25;  y[4]=125;b[4]=350; h[4]=350;//ventana grafica
  x[5]=400; y[5]=125;b[5]=75;  h[5]=75; //medida única
  x[6]=400; y[6]=225;b[6]=75;  h[6]=100;//título medida cont
  x[7]=400; y[7]=325;b[7]=75;  h[7]=75; //comenzar medida
  x[8]=400; y[8]=400;b[8]=75;  h[8]=75; //terminar medida
  x[9]=25;  y[9]=500;b[9]=350; h[9]=75; //ventana de comandos
  x[10]=400;y[10]=500;b[10]=75;h[10]=75;//elección frecuencia
  x[11]=270;y[11]=520;b[11]=75;h[11]=30;//boton RESET

  xPos = x[4];
  for (int i=0; i < 16; i++)  {datosC[i] = 0;}
  cont_media = 0;
  puntero_media = 0;

  enviar_byte(frecuencia);
  puesta_cero();
}

void draw()  {
  sobre_boton();
  if (modo_medidaC == false && modo_nombrar == false)  {
    background(gris);
  }
  pintar_botones();
}


void pintar_botones()  {
  pintar_1();
  pintar_2();
  pintar_3();
  pintar_4();
  pintar_5();
  pintar_6();
  pintar_7();
  pintar_8();
  pintar_9();
  pintar_10();
}

void pintar_1()  {
  if (sobreBoton == 1){
    if(mousePressed){
      fill(negro);
      modo_guardar = !modo_guardar;
      delay(100);
    }
```

```
    else {fill(fucsia);}
  }
  if (modo_guardar == true)  {fill(fucsia);}
  else if (modo_guardar == false)  {fill(fucsiaO);}
  rect(x[1],y[1],b[1],h[1]);
  fill(negro);
  textSize(14);
  text(" Guardar", x[1]+5, y[1]+30);
  text(" datos ", x[1]+5, y[1]+50);
}

void pintar_2()  {
  fill(blanco);
  rect(x[2],y[2],b[2],h[2]);
  fill(negro);
  textSize(18);
  text(" &apos;TÍTULO DEL MENÚ&apos; ", x[2]+25, y[2]+45);
}

void pintar_3()  {
  if (sobreBoton == 3){
    if(mousePressed){
      fill(negro);
      cerrar();
    }
    else {fill(rojo);}
  }
  else {fill(rojoO);}
  rect(x[3],y[3],b[3],h[3]);
  fill(negro);
  textSize(18);
  text(" Cerrar ", x[3]+5, y[3]+45);
}

void pintar_4() {
  noFill();
  rect(x[4],y[4],b[4],h[4]);

  //Gráfica de medida continua
  if (modo_medidaC == true && modo_medidaU == false
  && modo_nombrar == false)  {
    tomar_medida();
    fill(blanco);
    text(peso+" kg", 35, 560);
  }
}

void pintar_5() {
  if (sobreBoton == 5){
    if(mousePressed){
      fill(negro);
      if (medidaU_lista == false && modo_medidaC == false
      && modo_nombrar == false && modo_frecuencia == false) {
        modo_medidaU = true;
        medida_unica();
        medidaU_lista = true;
      }
    }
    else {fill(cyan);}
  }
  else {fill(cyanO);}
  rect(x[5],y[5],b[5],h[5]);
  fill(negro);
```

```
  textSize(18);
  text("Medida", x[5]+5, y[5]+35);
  text("Única", x[5]+5, y[5]+55);
}

void pintar_6()  {
  fill(blanco);
  rect(x[6],y[6],b[6],h[6]);
  fill(negro);
  textSize(15);
  text("Medida", x[6]+5, y[6]+40);
  text("Continua", x[6]+5,y[6]+65);
}

void pintar_7() {
  if (sobreBoton == 7){
    if(mousePressed){
      fill(negro);
      if (modo_medidaU == false && modo_frecuencia == false)  {
        if (modo_guardar == true)  {
          modo_nombrar = true;
          fill(negro);
          rect(x[9],y[9],b[9],h[9]);
          fill(blanco);
          text("Escribe el nombre del archivo y pulsa INTRO",35,
540);
        }
        else if (modo_guardar == false)  {modo_medidaC = true;}
      }
    }
    else {fill(verde);}
  }
  else {fill(verdeO);}
  rect(x[7],y[7],b[7],h[7]);
}

void pintar_8() {
  if (sobreBoton == 8){
    if(mousePressed){
      if (modo_medidaC == true)  {
        fill(negro);
        modo_medidaC = false;
        xPos = x[4];
        if (modo_guardar == true)  {folio.close();}
        puesta_cero();
      }
    }
    else {fill(rojo);}
  }
  else {fill(rojoO);}
  rect(x[8],y[8],b[8],h[8]);
}

void pintar_9()  {
  fill(negro);
  if (modo_nombrar == true || modo_frecuencia == true)  {noFill();}
  rect(x[9],y[9],b[9],h[9]);

  //Texto de la medida única
  if (modo_medidaC == false)  {
    if (texto_imprimir != null)  {
      fill(blanco);
      text(texto_imprimir, 35, 540);
```

```
      }
      if (modo_medidaU == true)  {
        //dibuja el rectangulo del boton "RESET"
        stroke(blanco);
        noFill();
        rect(x[11],y[11],b[11],h[11]);
        stroke(negro);
        fill(blanco);
        //Puesta a cero de medidaU
        if (sobreBoton == 11)  {
          fill(rojo);
          if(mousePressed)  {
            puesta_cero();
          }
        }
      textSize(18);
      text(" RESET ", x[11]+5,y[11]+20);
      }
    }

    //Texto de medida continua
    if (modo_medidaC == true && modo_medidaU == false
    && modo_nombrar == false)  {
      tomar_medida();
      fill(negro);
      rect(x[9],y[9],b[9],h[9]);
      fill(blanco);
      text(peso+" kg", 35, 560);
    }

    //Texto de selección de frecuencia de muestreo
    if (modo_medidaC == false && modo_medidaU == false
    && modo_nombrar == false && modo_frecuencia == true)  {
      fill(negro);
      rect(x[9],y[9],b[9],h[9]);
      fill(blanco);
      text(numero_string, 35, 560);
      text("Escribe la frec. de muestreo y pulsa INTRO",35, 540);
    }
  }

  void pintar_10() {
    if (sobreBoton == 10){
      if(mousePressed){
        fill(negro);
        if (medidaU_lista == false && modo_medidaC == false
        && modo_nombrar == false && modo_medidaU == false
        && modo_frecuencia == false) {
          modo_frecuencia = true;
          fill(negro);
          rect(x[9],y[9],b[9],h[9]);
          fill(blanco);
          text("Escribe el nombre del archivo y pulsa INTRO",35, 540);
        }
      }
      else {fill(amarillo);}
    }
    else {fill(amarilloO);}
    rect(x[10],y[10],b[10],h[10]);
    fill(negro);
    textSize(14);
    text("Frec.", x[10]+5, y[10]+25);
    text("Muestreo", x[10]+5, y[10]+45);
```

```
  text(frecuencia, x[10]+5,y[10]+65);
}


void puesta_cero()  {
  modo_medidaU = false;
  medidaU_lista = false;
  variable = 0;
  variable0 = 0;
  texto_imprimir = null;
  miPuerto.clear();
  nombre_archivo = "";
  nombre = "";
  modo_medidaC = false;
  modo_nombrar = false;
  numero = 0;
  numero_string = "";
  contador_frecuencia = 0;
  for (int i=0; i < 16; i++)  {datosC[i] = 0;}
  cont_media = 0;
  puntero_media = 0;
}

void medida_unica()  {
  float peso_final = 0;
  for (int j = 0; j < 50; j++)  {
    tomar_medida();
    peso_final = peso_final + peso;
  }
  peso_final = peso_final / 50;
  texto_imprimir="El peso es: "+Float.toString(peso)+" kg";
}

void tomar_medida()  {
  int inicio = 0;
  if (miPuerto.available()>3 )  {
    while (inicio<2)  {
      if(miPuerto.read()==255)  {
        inicio++;
      }
      else  {
        inicio=0;
      }
    }
    if (miPuerto.available()>0 && inicio==2)  {
      variable=miPuerto.read();
      inicio++;
    }
    if (miPuerto.available()>0 && inicio==3)  {
      variable0=miPuerto.read();
      medida=variable+variable0*256;
      if (modo_medidaC == true)  {media_aritmetica();}
      peso = map(medida,0,622,0,20);
      calibracion();
      peso = round(peso*10000.0f)/10000.0f;
      inicio=0;

      if (modo_medidaC == true)  {
        if (modo_guardar == true)  {
          folio.println(peso);
        }
        if (medida > 622)  {medida = 622;}
        float altura = map(medida,0,622, 0, h[4]-3);
```

```
          stroke(rojo);
          line(xPos, y[4]+h[4]-altura-3, xPos, y[4]+h[4]-altura);
          if (xPos >= x[4]+b[4])  {
            xPos = x[4];
            fill(gris);
            rect(x[4],y[4],b[4],h[4]);
          }
          else  {
            xPos++;
          }
          stroke(negro);
        }
      }
    }
}


void media_aritmetica()  {
  datosC[15] = datosC[15] * cont_media -
datosC[puntero_media] + medida;
  datosC[15] = datosC[15] / cont_media;
  datosC[puntero_media] = medida;
  if (puntero_media < 15) {puntero_media++;}
  else  {puntero_media = 0;}
  if (cont_media < 15)  {cont_media++;}
}


void enviar_byte(int dato)  {
  byte lowB = byte(dato % 256);
  byte highB = byte(dato / 256);
  miPuerto.write(255);
  miPuerto.write(255);
  miPuerto.write(lowB);
  miPuerto.write(highB);
}


void sobre_boton()  {
  /*comprueba si el ratón esta sobre algún botón y
  actualiza el valor de sobreBoton */
  if (mouseX > x[1] && mouseX < (x[1]+b[1]) &&
  mouseY > y[1] && mouseY < (y[1]+h[1]))  {sobreBoton = 1;}

  else if (mouseX > x[3] && mouseX < (x[3]+b[3]) &&
  mouseY > y[3] && mouseY < (y[3]+h[3]))  {sobreBoton = 3;}

  else if (mouseX > x[5] && mouseX < (x[5]+b[5]) &&
  mouseY > y[5] && mouseY < (y[5]+h[5]))  {sobreBoton = 5;}

  else if (mouseX > x[6] && mouseX < (x[6]+b[6]) &&
  mouseY > y[6] && mouseY < (y[6]+h[6]))  {sobreBoton = 6;}

  else if (mouseX > x[7] && mouseX < (x[7]+b[7]) &&
  mouseY > y[7] && mouseY < (y[7]+h[7]))  {sobreBoton = 7;}

  else if (mouseX > x[8] && mouseX < (x[8]+b[8]) &&
  mouseY > y[8] && mouseY < (y[8]+h[8]))  {sobreBoton = 8;}

  else if (mouseX > x[9] && mouseX < (x[9]+b[9]) &&
  mouseY > y[9] && mouseY < (y[9]+h[9])
  && modo_medidaU == false)  {sobreBoton = 9;}
```

```
  else if (mouseX > x[10] && mouseX < (x[10]+b[10]) &&
  mouseY > y[10] && mouseY < (y[10]+h[10]))  {sobreBoton = 10;}

  else if (mouseX > x[11] && mouseX < (x[11]+b[11]) &&
  mouseY > y[11] && mouseY < (y[11]+h[11]))  {sobreBoton = 11;}

  else {sobreBoton = 0;}

}

void cerrar() {
  if (modo_medidaC == true && modo_guardar == true)  {
    folio.close();
  }
  exit();
}

void keyPressed(){
  if(key==ESC){
    cerrar();
  }
  // Introducción del nombre del nombre del fichero
  if (modo_nombrar == true && modo_frecuencia == false)  {
    if (key == ENTER)  {
      nombre_archivo = nombre+".txt";
      modo_nombrar = false;
      modo_medidaC = true;
      folio = createWriter(nombre_archivo);
      folio.print("Frecuencia = ");
      folio.print(frecuencia);
      folio.println(" Hz");
      fill(negro);
      rect(x[9],y[9],b[9],h[9]);
      delay(25*15);
      miPuerto.clear();
      background(gris);
    }
    else if (modo_frecuencia == false)  {
      nombre = nombre + key;
      fill(negro);
      rect(x[9],y[9],b[9],h[9]);
      fill(blanco);
      text(nombre, 35, 560);
      text("Escribe el nombre del archivo y pulsa INTRO",35, 540);
    }
  }
  // Introdución de la frecuencia de muestreo
  else if (modo_frecuencia == true && modo_nombrar == false)  {
    if (key == ENTER || contador_frecuencia > 3)  {
      int frec_deseada = int(numero);
      if (frec_deseada > 100)  {frecuencia = 100;}
      else   {frecuencia = int(numero);}
      modo_frecuencia = false;
      fill(negro);
      rect(x[9],y[9],b[9],h[9]);
      puesta_cero();
      enviar_byte(frecuencia);
    }
    else if (modo_nombrar == false)  {
      if (key >= &apos;0&apos; && key <= &apos;9&apos; )  {
        numero_string = numero_string + key;
        int digito = int(key-&apos;0&apos;);
        //println(digito);//TRAZA
```

```
         numero = numero*10 + digito;
         //println(numero); //TRAZA
         fill(negro);
         rect(x[9],y[9],b[9],h[9]);
         fill(blanco);
         text(numero_string, 35, 560);
         text("Escribe la frec. de muestreo y pulsa INTRO",35, 540);
         contador_frecuencia++; //limita el numero max de digitos de
freq.
       }
     }

   }
 }

 void calibracion()  {
   peso = 0.82209799 * peso + 0.20997731;
   if (peso < 0)  {peso = 0;}
 }
```

ANEXO 5: Datos de calibración y Resultados finales

Resultados del ensayo de medida. Medidas en kg.

Peso	Medida1	Medida2	Medida3	Medida4	Media
0,000	0,0322	0,0322	0,0322	0,0322	0,032
0,926	1,1576	1,0932	1,0932	1,0932	1,109
1,930	1,9614	1,9293	1,9614	1,9614	1,953
3,987	4,3087	4,2765	4,2444	4,2765	4,277
5,984	7,0096	7,0096	7,0096	7,0096	7,010
7,989	9,3569	9,3248	9,3248	9,3248	9,333
10,003	11,9293	11,8971	11,8971	11,8971	11,905
11,994	14,3408	14,3408	14,2765	14,3087	14,317
14,021	16,8489	16,7846	16,7846	16,7846	16,801
16,000	19,1961	19,1318	19,0675	19,0675	19,116
17,997	21,5434	21,5434	21,5113	21,5434	21,535
19,987	24,3408	24,3730	24,3730	24,3730	24,365

Resultados del ensayo de medida. Medidas en kg.

Peso	Medida1	Medida2	Medida3	Medida4	Media	Error relativo
1,004	0,9646	0,9006	0,9646	0,9325	0,941	6,32%
2,910	2,8939	2,8617	2,8617	2,8617	2,870	1,38%
4,914	5,0161	5,0161	5,0161	5,0161	5,016	2,08%
6,869	7,0418	7,0740	7,0740	7,0418	7,058	2,75%
8,884	8,8746	8,9068	9,0032	9,0354	8,955	0,80%
10,887	10,5466	10,5788	10,5466	10,5466	10,555	3,05%
12,923	13,0225	13,0225	13,0225	13,0225	13,023	0,77%
14,904	15,0649	15,0913	15,0649	14,9856	15,052	0,99%
16,912	17,3392	17,1806	17,1013	17,1806	17,200	1,71%
18,479	18,4566	18,4566	18,4566	18,4566	18,457	0,12%
19,987	19,7954	19,6909	19,6909	19,7702	19,737	1,25%
					Error relativo promedio	1,93%

ANEXO 6: Datasheet

6.1 Galgas: Catálogo HBM serie LY11
6.2 Amplificador de instrumentación: AD623
6.3 Regulador de tensión: LM7805

Strain Gauges

Absolute precision from HBM

Specifications – Series Y

SG construction		Foil SG with embedded measuring grid
Measuring grid		
Material		Constantan foil
Thickness	µm *(microinch)*	approx. 3.8 or 5 *(150 or 197)*, depending on SG type
Carrier		
Material	µm *(microinch)*	Polyimide
Thickness		45 ± 10 *(1.772 ± 394)*
Covering agent		
Material	µm *(microinch)*	Polyimide
Thickness		25 ± 12 *(984 ± 472)*
Connections		Nickel plated Cu leads, approx. 30 mm long
length without connection leads		Integrated solder tabs, approx. 1.5 mm long, approx. 1.6 ... 2.2 mm *(0.063 ± 0.087 inch)* wide Solder tabs with strain relief made of copper-beryllium
Nominal resistance	Ω	120, 350, 700 or 1,000, depending on SG type
Resistance tolerance[2]	%	± 0.3 without; ± 0.35 with connection leads
Gage factor		approx. 2
Nominal value of gauge factor		Specified on each package
Gage factor tolerance with ≤ 1.5 mm *(0.059 inch)* measuring grid length	%	± 1.5
with ≥ 3 mm *(0.118 inch)* measuring grid length	%	± 1
Temperature coefficient of the gauge factor	1/K *(1/°F)*	approx. (115 ± 10) · 10^{-6} *((64 ± 5.5) · 10^{-6})*
Nominal value of gauge factor temperature coefficient		Specified on each package
Reference temperature	°C *(°F)*	23 *(73.4)*
Operating temperature range		
for static, i.e. zero point-related measurements	°C *(°F)*	-70 ... +200 *(-94 ... +392)*
for dynamic, i.e. non-zero point-related measurements	°C *(°F)*	-200 ... +200 *(-328 ... +392)*
Transverse sensitivity		Specified on each package
at reference temperature when using Z70 adhesive	%	- 0.1
on SG type LY11-6/120		
Temperature response		Specified on each package
Temperature response as required, adapted to coefficients of thermal expansion		
α for ferritic steel	1/K *(1/°F)*	10.8 · 10^{-6} *(6.0 · 10^{-6})*
α for aluminum	1/K *(1/°F)*	23 · 10^{-6} *(12.8 · 10^{-6})*
α for plastic material	1/K *(1/°F)*	65 · 10^{-6} *(36.1 · 10^{-6})*
α for austenitic steel	1/K *(1/°F)*	16 · 10^{-6} *(8.9 · 10^{-6})*
α for titanium	1/K *(1/°F)*	9 · 10^{-6} *(5.0 · 10^{-6})*
α for molybdenum	1/K *(1/°F)*	5.4 · 10^{-6} *(3.0 · 10^{-6})*
α for quartz glass / composite	1/K *(1/°F)*	0.5 · 10^{-6} *(0.3 · 10^{-6})*
Tolerance of temperature response	1/K *(1/°F)*	± 0.3 · 10^{-6} *(± 0.17 · 10^{-6})*
Temperature response with matching in the range of [3]	°C *(°F)*	-10 ... +20 *(14 ... 248)*
Mechanical hysteresis[1]		
at reference temperature and strain ε = ± 1,000 µm/m (microstrain)		
on SG type LY11-6/120		
at 1st load cycle and adhesive Z 70	µm/m (microstrain)	1
at 3rd load cycle and adhesive Z 70	µm/m (microstrain)	0.5
at 1st load cycle and adhesive X 60	µm/m (microstrain)	2.5
at 3rd load cycle and adhesive X 60	µm/m (microstrain)	1
Maximum elongation[1]		
at reference temperature using adhesive Z 70		
on SG type LY11-6/120		
Absolute strain value ε for positive direction	µm/m (microstrain)	50,000 (Δ5 %)
Absolute strain value ε for negative direction	µm/m (microstrain)	50,000 (Δ5 %)
Fatigue life[1]		
at reference temperature using adhesive X 60		
on SG type LY61-6/120		
Achievable number of load cycles Lw at		
alternating strain ε_w = ± 1,000 µm/m and zero point drift ε_m Δ ≤ 300	µm/m (microstrain)	>> 10^7 (test was interrupted at 10^7)
ε_m Δ ≤ 30	µm/m (microstrain)	> 10^7 (test was interrupted at 10^7)
Minimum radius of curvature, longitudinal and transverse,		
at reference temperature for strain gauges with leads	mm *(inch)*	0.3 *(0.012)*
for SG with integrated solder tabs		
within measuring grid area	mm *(inch)*	0.3 *(0.012)*
within solder tabs area	mm *(inch)*	2 *(0.079)*
Bonding material than can be used		
Cold-curing adhesives		Z 70; X 60; X 280
Hot-curing adhesives		EP 150; EP 310S

[1] The data depend on the various parameters of the specific application and are therefore stated for representative examples only.
[2] With measuring grid lengths of 0.3 mm *(0.012 inch)* and 0.6 mm *(0.024 inch)*, the nominal resistance may deviate by ± 1%. For the types LY 51/ LY5x the deviation is ± 0.75%. For XY9x, RY9x and the KY types (per chain) it is ± 0.5%.
[3] Matching to plastic (code number 8) is only possible in the temperature range of -10°C ... +50°C *(14°F ... +122°F)*.

Series Y

with 1 measuring grid / linear SG

LY11

Linear SG
Temperature response matched to steel
with α = 10,8 · 10⁻⁶/K *(6.0 · 10⁻⁶/°F)*

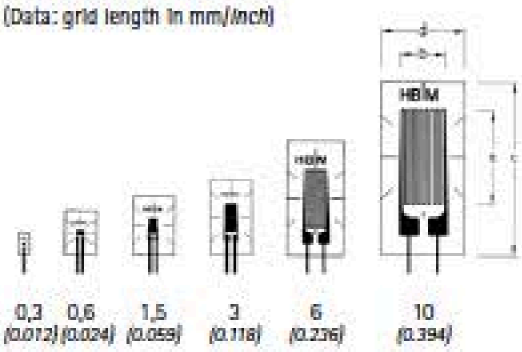
LY13

Temperature response matched to aluminum
with α = 23 · 10⁻⁶/K *(12.8 · 10⁻⁶/°F)*

LY1x

Temperature response matched to customer's choice
see page 16

Illustrations show actual size
(Data: grid length in mm/*inch*)



Contents per package: 10 pcs.

Types available ex stock		Variants	Nominal resistance	Dimensions (mm/*inch*)				Max. perm. effective bridge ex. voltage	Solder terminals
				Measuring grid		Measuring grid carrier			
Steel	Aluminum	Other	Ω	a	b	c	d	V	
1-LY11-0.3/120		1-LY1x-0.3/120[#]	120	0.3 *0.012*	0.9 *0.035*	2 *0.079*	1.2 *0.047*	0.6	LS 7
1-LY11-0.6/120	1-LY13-0.6/120	1-LY1x-0.6/120[#]	120	0.6 *0.024*	1 *0.039*	5 *0.197*	3.2 *0.126*	1.5	LS 7
1-LY11-1.5/120	1-LY13-1.5/120	1-LY1x-1.5/120	120	1.5 *0.059*	1.2 *0.047*	6.5 *0.256*	4.7 *0.185*	2.5	LS 7
1-LY11-3/120	1-LY13-3/120	1-LY1x-3/120	120	3 *0.118*	1.6 *0.063*	8.5 *0.335*	4.5 *0.177*	4	LS 7
1-LY11-3/120A		1-LY1x-3/120A	120	3 *0.118*	1.6 *0.063*	8.5 *0.335*	4.5 *0.177*	4	LS 7
1-LY11-6/120	1-LY13-6/120	1-LY1x-6/120	120	6 *0.236*	2.7 *0.106*	13 *0.512*	6 *0.236*	8	LS 5
1-LY11-6/120A		1-LY1x-6/120A	120	6 *0.236*	2.7 *0.106*	13 *0.512*	6 *0.236*	8	LS 5
1-LY11-10/120	1-LY13-10/120	1-LY1x-10/120	120	10 *0.394*	4.6 *0.181*	18.5 *0.728*	9.5 *0.374*	13	LS 5
1-LY11-10/120A		1-LY1x-10/120A	120	10 *0.394*	4.6 *0.181*	18.5 *0.728*	9.5 *0.374*	13	LS 5
1-LY11-1.5/350	1-LY13-1.5/350	1-LY1x-1.5/350[#]	350	1.5 *0.059*	1.2 *0.047*	5.7 *0.224*	4.7 *0.185*	4.5	LS 7
1-LY11-3/350	1-LY13-3/350	1-LY1x-3/350	350	3 *0.118*	1.6 *0.063*	8.5 *0.335*	4.5 *0.177*	7	LS 7
		1-LY1x-3/350A	350	3 *0.118*	1.6 *0.063*	8.5 *0.335*	4.5 *0.177*	7	LS 7
1-LY11-6/350	1-LY13-6/350	1-LY1x-6/350	350	6 *0.236*	2.8 *0.11*	13 *0.512*	6 *0.236*	13	LS 5
		1-LY1x-6/350A	350	6 *0.236*	2.8 *0.11*	13 *0.512*	6 *0.236*	13	LS 5
1-LY11-10/350		1-LY1x-10/350	350	10 *0.394*	5.0 *0.197*	18.5 *0.728*	9.5 *0.374*	23	LS 5
		1-LY1x-10/350A	350	10 *0.394*	5.0 *0.197*	18.5 *0.728*	9.5 *0.374*	23	LS 5

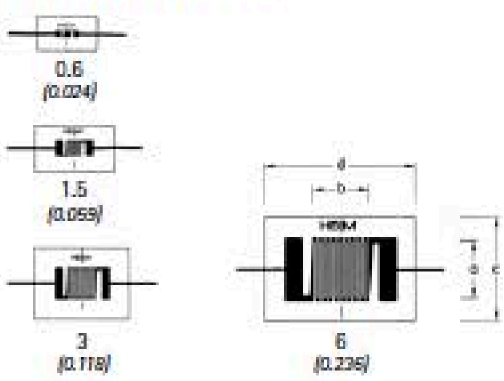
LY21

Linear SG
Temperature response matched to steel
with a = 10,8 · 10⁻⁶/K *(6.0 · 10⁻⁶/°F)*

LY2x

Temperature response matched to customer's choice
see page 16

Illustrations show actual size
(Data: grid length in mm/*inch*)



Contents per package: 10 pcs.

Types available ex stock		Variants	Nominal resistance	Dimensions (mm/*inch*)				Max. perm. effective bridge ex. voltage	Solder terminals
				Measuring grid		Measuring grid carrier			
Steel	Aluminum	Other	Ω	a	b	c	d	V	
1-LY21-0.6/120		1-LY2x-0.6/120[#]	120	0.6 *0.024*	0.6 *0.024*	3.5 *0.138*	6.4 *0.252*	1	LS 7
		1-LY2x-1.5/120	120	1.5 *0.059*	1.5 *0.059*	4.7 *0.185*	8.3 *0.327*	2	LS 5
1-LY21-3/120		1-LY2x-3/120	120	3 *0.118*	2.8 *0.11*	7.5 *0.295*	10 *0.394*	6	LS 5
		1-LY2x-6/120	120	6 *0.236*	6 *0.236*	11 *0.433*	16 *0.63*	12	LS 4

[#] Types are only available with matching to aluminum, ferritic or austenitic steel

Single Supply, Rail-to-Rail, Low Cost Instrumentation Amplifier

AD623

FEATURES
Easy to Use
Higher Performance than Discrete Design
Single and Dual Supply Operation
Rail-to-Rail Output Swing
Input Voltage Range Extends 150 mV Below Ground (Single Supply)
Low Power, 575 μA Max Supply Current
Gain Set with One External Resistor
Gain Range 1 (No Resistor) to 1,000

HIGH ACCURACY DC PERFORMANCE
0.1% Gain Accuracy (G = 1)
0.35% Gain Accuracy (G > 1)
25 ppm Gain Drift (G = 1)
200 μV Max Input Offset Voltage (AD623A)
2 μV/°C Max Input Offset Drift (AD623A)
100 μV Max Input Offset Voltage (AD623B)
1 μV/°C Max Input Offset Drift (AD623B)
25 nA Max Input Bias Current

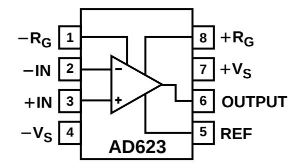
NOISE
35 nV/√Hz RTI Noise @ 1 kHz (G = 1)

EXCELLENT AC SPECIFICATIONS
90 dB Min CMRR (G = 10); 84 dB Min CMRR (G = 5) (@ 60 Hz, 1K Source Imbalance)
800 kHz Bandwidth (G = 1)
20 μs Settling Time to 0.01% (G = 10)

APPLICATIONS
Low Power Medical Instrumentation
Transducer Interface
Thermocouple Amplifier
Industrial Process Controls
Difference Amplifier
Low Power Data Acquisition

CONNECTION DIAGRAM

8-Lead Plastic DIP (N), SOIC (R) and μSOIC (RM) Packages



PRODUCT DESCRIPTION

The AD623 is an integrated single supply instrumentation amplifier that delivers rail-to-rail output swing on a single supply (+3 V to +12 V supplies). The AD623 offers superior user flexibility by allowing single gain set resistor programming, and conforming to the 8-lead industry standard pinout configuration. With no external resistor, the AD623 is configured for unity gain (G = 1) and with an external resistor, the AD623 can be programmed for gains up to 1,000.

The AD623 holds errors to a minimum by providing superior AC CMRR that increases with increasing gain. Line noise, as well as line harmonics, will be rejected since the CMRR remains constant up to 200 Hz. The AD623 has a wide input common-mode range and can amplify signals that have a common-mode voltage 150 mV below ground. Although the design of the AD623 has been optimized to operate from a single supply, the AD623 still provides superior performance when operated from a dual voltage supply (±2.5 V to ±6.0 V).

Low power consumption (1.5 mW at 3 V), wide supply voltage range, and rail-to-rail output swing make the AD623 ideal for battery powered applications. The rail-to-rail output stage maximizes the dynamic range when operating from low supply voltages. The AD623 replaces discrete instrumentation amplifier designs and offers superior linearity, temperature stability and reliability in a minimum of space. Until the AD623, this level of instrumentation amplifier performance has not been achieved.

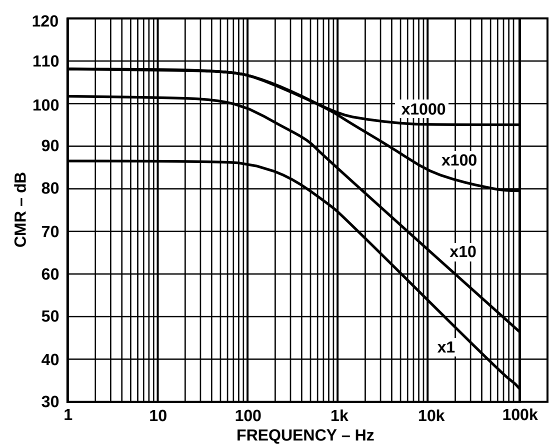


Figure 1. CMR vs. Frequency, +5 V_S, 0 V_S

REV. C

One Technology Way, P.O. Box 9106, Norwood, MA 02062-9106, U.S.A.
Tel: 781/329-4700 World Wide Web Site: http://www.analog.com
Fax: 781/326-8703

AD623–SPECIFICATIONS

SINGLE SUPPLY (typical @ +25°C Single Supply, V_S = +5 V, and R_L = 10 kΩ, unless otherwise noted)

Model Specification	Conditions	AD623A Min	AD623A Typ	AD623A Max	AD623ARM Min	AD623ARM Typ	AD623ARM Max	AD623B Min	AD623B Typ	AD623B Max	Units
GAIN	G = 1 + (100 k/R_G)										
Gain Range		1		1000	1		1000	1		1000	
Gain Error[1]	G1 V_{OUT} = 0.05 V to 3.5 V G > 1 V_{OUT} = 0.05 V to 4.5 V										
G = 1			0.03	0.10		0.03	0.10		0.03	0.05	%
G = 10			0.10	0.35		0.10	0.35		0.10	0.35	%
G = 100			0.10	0.35		0.10	0.35		0.10	0.35	%
G = 1000			0.10	0.35		0.10	0.35		0.10	0.35	%
Nonlinearity,	G1 V_{OUT} = 0.05 V to 3.5 V G > 1 V_{OUT} = 0.05 V to 4.5 V										
G = 1–1000			50			50			50		ppm
Gain vs. Temperature											
G = 1			5	10		5	10		5	10	ppm/°C
G > 1[1]			50			50			50		ppm/°C
VOLTAGE OFFSET	Total RTI Error = V_{OSI} + V_{OSO}/G										
Input Offset, V_{OSI}			25	200		200	500		25	100	µV
Over Temperature				350			650			160	µV
Average TC			0.1	2		0.1	2		0.1	1	µV/°C
Output Offset, V_{OSO}			200	1000		500	2000		200	500	µV
Over Temperature				1500			2600			1100	µV
Average TC			2.5	10		2.5	10		2.5	10	µV/°C
Offset Referred to the Input vs. Supply (PSR)											
G = 1		80	100		80	100		80	100		dB
G = 10		100	120		100	120		100	120		dB
G = 100		120	140		120	140		120	140		dB
G = 1000		120	140		120	140		120	140		dB
INPUT CURRENT											
Input Bias Current			17	25		17	25		17	25	nA
Over Temperature				27.5			27.5			27.5	nA
Average TC			25			25			25		pA/°C
Input Offset Current			0.25	2		0.25	2		0.25	2	nA
Over Temperature				2.5			2.5			2.5	nA
Average TC			5			5			5		pA/°C
INPUT											
Input Impedance											
Differential			2‖2			2‖2			2‖2		GΩ‖pF
Common-Mode			2‖2			2‖2			2‖2		GΩ‖pF
Input Voltage Range[2]	V_S = +3 V to +12 V	$(–V_S) – 0.15$		$(+V_S) – 1.5$	$(–V_S) – 0.15$		$(+V_S) – 1.5$	$(–V_S) – 0.15$		$(+V_S) – 1.5$	V
Common-Mode Rejection at 60 Hz with 1 kΩ Source Imbalance											
G = 1	V_{CM} = 0 V to 3 V	70	80		70	80		77	86		dB
G = 10	V_{CM} = 0 V to 3 V	90	100		90	100		94	100		dB
G = 100	V_{CM} = 0 V to 3 V	105	110		105	110		105	110		dB
G = 1000	V_{CM} = 0 V to 3 V	105	110		105	110		105	110		dB
OUTPUT											
Output Swing	R_L = 10 kΩ	+0.01		$(+V_S) – 0.5$	+0.01		$(+V_S) – 0.5$	+0.01		$(+V_S) – 0.5$	V
	R_L = 100 kΩ	+0.01		$(+V_S) – 0.15$	+0.01		$(+V_S) – 0.15$	+0.01		$(+V_S) – 0.15$	V
DYNAMIC RESPONSE											
Small Signal –3 dB Bandwidth											
G = 1			800			800			800		kHz
G = 10			100			100			100		kHz
G = 100			10			10			10		kHz
G = 1000			2			2			2		kHz
Slew Rate			0.3			0.3			0.3		V/µs
Settling Time to 0.01%	V_S = +5 V										
G = 1	Step Size: 3.5 V		30			30			30		µs
G = 10	Step Size: 4 V, V_{CM} = 1.8 V		20			20			20		µs

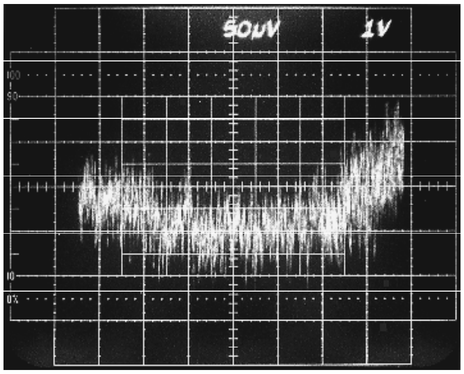


Figure 38. Gain Nonlinearity (G = –100, 15 ppm/Div)

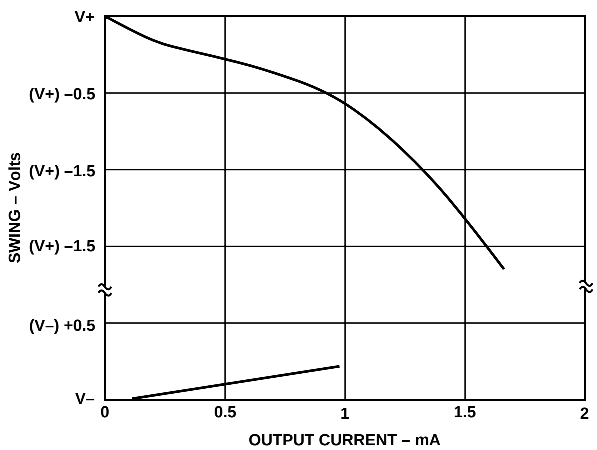


Figure 39. Output Voltage Swing vs. Output Current

THEORY OF OPERATION

The AD623 is an instrumentation amplifier based on a modified classic three op amp approach, to assure single or dual supply operation even at common-mode voltages at the negative supply rail. Low voltage offsets, input and output, as well as absolute gain accuracy, and one external resistor to set the gain, make the AD623 one of the most versatile instrumentation amplifiers in its class.

The input signal is applied to PNP transistors acting as voltage buffers and providing a common-mode signal to the input amplifiers (Figure 40). An absolute value 50 kΩ resistor in each of the amplifiers' feedback assures gain programmability.

The differential output is

$$V_O = \left(1 + \frac{100\ k\Omega}{R_G}\right) V_C$$

The differential voltage is then converted to a single-ended voltage using the output amplifier, which also rejects any common-mode signal at the output of the input amplifiers.

Since all the amplifiers can swing to either supply rails, as well as have their common-mode range extended to below the negative supply rail, the range over which the AD623 can operate is further enhanced (Figures 19 and 20).

The output voltage at Pin 6 is measured with respect to the potential at Pin 5. The impedance of the reference pin is 100 kΩ, so in applications requiring V/I conversion, a small resistor between Pins 5 and 6 is all that is needed.

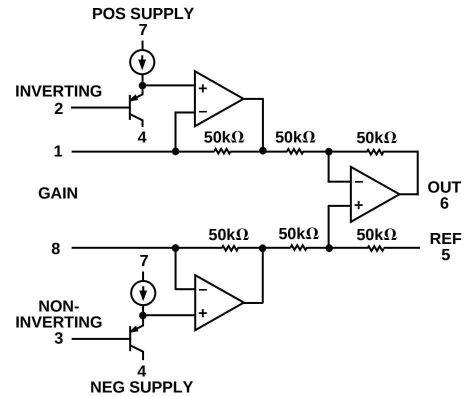


Figure 40. Simplified Schematic

The bandwidth of the AD623 is reduced as the gain is increased, since all the amplifiers are of voltage feedback type. At unity gain, it is the output amplifier that limits the bandwidth. Therefore even at higher gains the AD623 bandwidth does not roll off as quickly.

APPLICATIONS

Basic Connection

Figure 41 shows the basic connection circuit for the AD623. The $+V_S$ and $–V_S$ terminals are connected to the power supply. The supply can be either bipolar ($V_S = \pm 2.5$ V to ± 6 V) or single supply ($–V_S = 0$ V, $+V_S = 3.0$ V to 12 V). Power supplies should be capacitively decoupled close to the devices power pins. For best results, use surface mount 0.1 µF ceramic chip capacitors and 10 µF electrolytic tantalum capacitors.

The input voltage, which can be either single-ended (tie either –IN or +IN to ground) or differential is amplified by the programmed gain. The output signal appears as the voltage difference between the Output pin and the externally applied voltage on the REF input. For a ground referenced output, REF should be grounded.

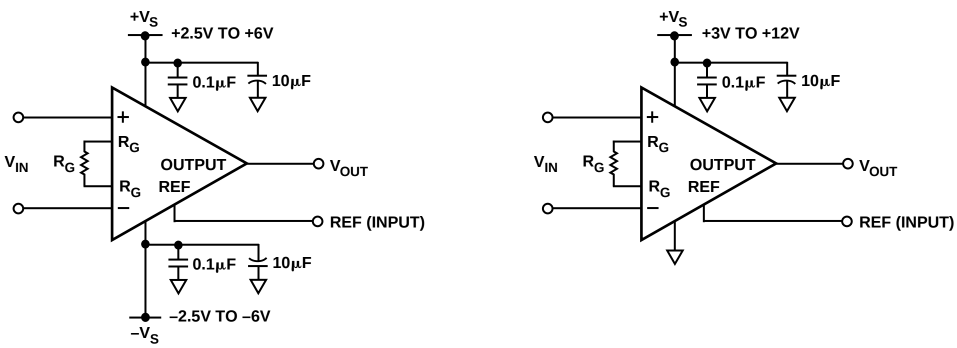
GAIN SELECTION

The AD623's gain is resistor programmed by R_G, or more precisely, by whatever impedance appears between Pins 1 and 8. The AD623 is designed to offer accurate gains using 0.1%–1% tolerance resistors. Table I shows required values of R_G for various gains. Note that for G = 1, the R_G terminals are unconnected ($R_G = \infty$). For any arbitrary gain, R_G can be calculated by using the formula

$$R_G = 100\ k\Omega/(G – 1)$$

REFERENCE TERMINAL

The reference terminal potential defines the zero output voltage and is especially useful when the load does not share a precise ground with the rest of the system. It provides a direct means of injecting a precise offset to the output. The reference terminal is also useful when bipolar signals are being amplified as it can be used to provide a virtual ground voltage. The voltage on the reference terminal can be varied from $–V_S$ to $+V_S$.



a. Dual Supply *b. Single Supply*

Figure 41. Basic Connections

Table I. Required Values of Gain Resistors

Desired Gain	1% Std Table Value of R_G, Ω	Calculated Gain Using 1% Resistors
2	100 k	2
5	24.9 k	5.02
10	11 k	10.09
20	5.23 k	20.12
33	3.09 k	33.36
40	2.55 k	40.21
50	2.05 k	49.78
65	1.58 k	64.29
100	1.02 k	99.04
200	499	201.4
500	200	501
1000	100	1001

INPUT AND OUTPUT OFFSET VOLTAGE

The low errors of the AD623 are attributed to two sources, input and output errors. The output error is divided by the programmed gain when referred to the input. In practice, the input errors dominate at high gains and the output errors dominate at low gains. The total V_{OS} for a given gain is calculated as:

Total Error RTI = Input Error + (Output Error/G)

Total Error RTO = (Input Error × G) + Output Error

RTI offset errors and noise voltages for different gains are shown below in Table II.

Table II. RTI Error Sources

Gain	Max Total Input Offset Error µV	µV	Max Total Input Offset Drift µV/°C	µV/°C	Total Input Referred Noise (nV/√Hz)
	AD623A	AD623B	AD623A	AD623B	AD623A & AD623B
1	1200	600	12	11	62
2	700	350	7	6	45
5	400	200	4	3	38
10	300	150	3	2	35
20	250	125	2.5	1.5	35
50	220	110	2.2	1.2	35
100	210	105	2.1	1.1	35
1000	200	100	2	1	35

INPUT PROTECTION

Internal supply referenced clamping diodes allow the input, reference, output and gain terminals of the AD623 to safely withstand overvoltages of 0.3 V above or below the supplies. This is true for all gains, and for power on and off. This last case is particularly important since the signal source and amplifier may be powered separately.

If the overvoltage is expected to exceed this value, the current through these diodes should be limited to about 10 mA using external current limiting resistors. This is shown in Figure 42. The size of this resistor is defined by the supply voltage and the required overvoltage protection.

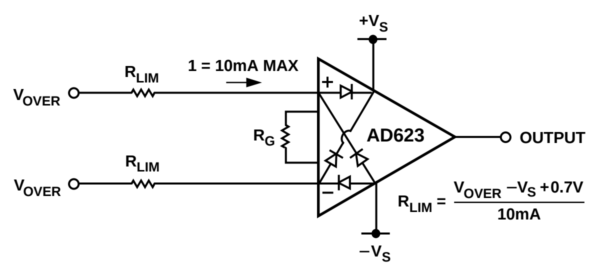


Figure 42. Input Protection

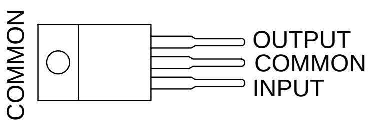
RF INTERFERENCE

All instrumentation amplifiers can rectify high frequency out-of-band signals. Once rectified, these signals appear as dc offset errors at the output. The circuit of Figure 43 provides good RFI suppression without reducing performance within the in amps pass band. Resistor R1 and capacitor C1 (and likewise, R2 and C2) form a low-pass RC filter that has a –3 dB BW equal to: $F = 1/(2\pi R1C1)$. Using the component values shown, this filter has a –3 dB bandwidth of approximately 40 kHz. Resistors R1 and R2 were selected to be large enough to isolate the circuit's input from the capacitors, but not large enough to significantly increase the circuit's noise. To preserve common-mode rejection in the amplifier's pass band, capacitors C1 and C2 need to be 5% or better units, or low cost 20% units can be tested and "binned" to provide closely matched devices.

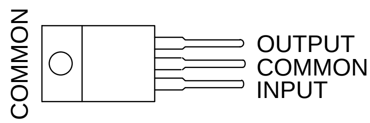
Capacitor C3 is needed to maintain common-mode rejection at the low frequencies. R1/R2 and C1/C2 form a bridge circuit whose output appears across the in amp's input pins. Any mismatch between C1 and C2 will unbalance the bridge and reduce common-mode rejection. C3 ensures that any RF signals

- **3-Terminal Regulators**
- **Output Current up to 1.5 A**
- **Internal Thermal-Overload Protection**
- **High Power-Dissipation Capability**
- **Internal Short-Circuit Current Limiting**
- **Output Transistor Safe-Area Compensation**

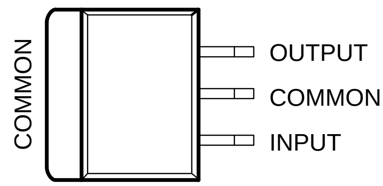
**KC (TO-220) PACKAGE
(TOP VIEW)**



**KCS (TO-220) PACKAGE
(TOP VIEW)**



**KTE PACKAGE
(TOP VIEW)**



description/ordering information

This series of fixed-voltage integrated-circuit voltage regulators is designed for a wide range of applications. These applications include on-card regulation for elimination of noise and distribution problems associated with single-point regulation. Each of these regulators can deliver up to 1.5 A of output current. The internal current-limiting and thermal-shutdown features of these regulators essentially make them immune to overload. In addition to use as fixed-voltage regulators, these devices can be used with external components to obtain adjustable output voltages and currents, and also can be used as the power-pass element in precision regulators.

ORDERING INFORMATION

T_J	$V_{O(NOM)}$ (V)	PACKAGE†		ORDERABLE PART NUMBER	TOP-SIDE MARKING
0°C to 125°C	5	POWER-FLEX (KTE)	Reel of 2000	µA7805CKTER	µA7805C
		TO-220 (KC)	Tube of 50	µA7805CKC	µA7805C
		TO-220, short shoulder (KCS)	Tube of 20	µA7805CKCS	
	8	POWER-FLEX (KTE)	Reel of 2000	µA7808CKTER	µA7808C
		TO-220 (KC)	Tube of 50	µA7808CKC	µA7808C
		TO-220, short shoulder (KCS)	Tube of 20	µA7808CKCS	
	10	POWER-FLEX (KTE)	Reel of 2000	µA7810CKTER	µA7810C
		TO-220 (KC)	Tube of 50	µA7810CKC	µA7810C
	12	POWER-FLEX (KTE)	Reel of 2000	µA7812CKTER	µA7812C
		TO-220 (KC)	Tube of 50	µA7812CKC	µA7812C
		TO-220, short shoulder (KCS)	Tube of 20	µA7812CKCS	
	15	POWER-FLEX (KTE)	Reel of 2000	µA7815CKTER	µA7815C
		TO-220 (KC)	Tube of 50	µA7815CKC	µA7815C
		TO-220, short shoulder (KCS)	Tube of 20	µA7815CKCS	
	24	POWER-FLEX (KTE)	Reel of 2000	µA7824CKTER	µA7824C
		TO-220 (KC)	Tube of 50	µA7824CKC	µA7824C

† Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at www.ti.com/sc/package.

APPLICATION INFORMATION

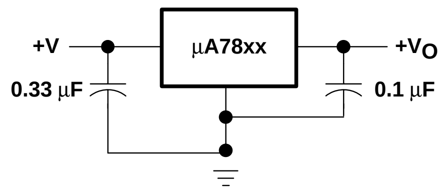


Figure 1. Fixed-Output Regulator

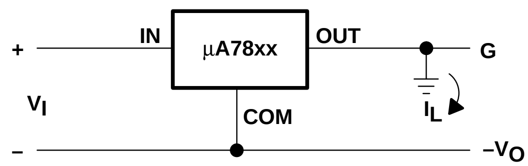
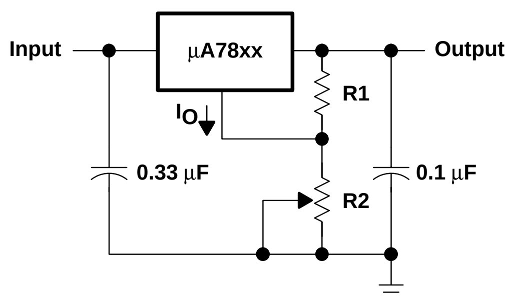


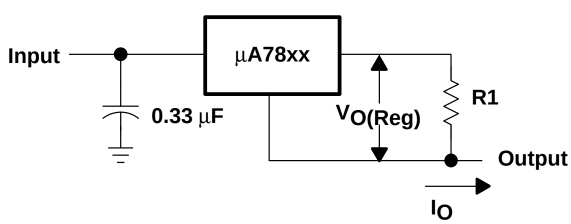
Figure 2. Positive Regulator in Negative Configuration (V_I Must Float)



NOTE A: The following formula is used when V_{XX} is the nominal output voltage (output to common) of the fixed regulator:

$$V_O = V_{xx} + \left(\frac{V_{xx}}{R1} + I_Q\right)R2$$

Figure 3. Adjustable-Output Regulator



$I_O = (V_O/R1) + I_O$ Bias Current

Figure 4. Current Regulator