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ภาคผนวก

ภาคผนวก ก
โปรแกรมประมวลผลภาพแบบดิจิตอล

```
'-----------------------------------------
'FrmDIPmain
'-----------------------------------------
Private MinIndex(0 To 2) As Integer
Private MaxIndex(0 To 2) As Integer
Private TheKernel() As Single

Private Declare Sub Out Lib "inpout32.dll" Alias "Out32" (ByVal Portaddress As Integer, ByVal Value As Integer)
Private Declare Function Inp Lib "inpout32.dll" Alias "Inp32" (ByVal Portadress As Integer) As Integer

Public pwrite As Integer
Public pread As Integer

Private Sub cmdapply_Click()
        PicORIGINAL.Picture = PicResult.Picture
        Imgoriginal.Picture = PicORIGINAL.Picture
End Sub

Private Sub CmdgetPDF_Click()
Dim pixels() As RGBTriplet
Dim PDFDATA(0 To 255) As Single
Dim bits_per_pixel As Integer
Dim X As Integer
Dim Y As Integer
Dim pix As Integer
Dim i As Integer

    ' Get the pixels from picOriginal.
    GetBitmapPixels PicORIGINAL, pixels, bits_per_pixel
     For i = 0 To 255
        PDFDATA(i) = 0
    Next i
    For Y = 0 To PicORIGINAL.ScaleHeight - 1
        For X = 0 To PicORIGINAL.ScaleWidth - 1
            With pixels(X, Y)
                shade = (CInt(.rgbRed) + .rgbGreen + .rgbBlue) / 3
                .rgbRed = shade
                .rgbGreen = shade
                .rgbBlue = shade
                pix = Int(shade)
                PDFDATA(pix) = PDFDATA(pix) + 1
            End With
```

```
        Next X
    Next Y
    Open txtPDFdata.Text For Output As #1
            For pix = 0 To 255
                    Print #1, PDFDATA(pix)
            Next pix
    Close #1
End Sub

Private Sub cmdGetprofile_Click()
Dim pixels() As RGBTriplet
Dim bits_per_pixel As Integer
Dim X As Integer
Dim Y As Integer

    ' Get the pixels from picOriginal.
    GetBitmapPixels PicORIGINAL, pixels, bits_per_pixel
  Y = Val(Txtyline.Text)
    ' Set the pixel colors.
            Open txtfilenamedata.Text For Output As #1
        For X = 0 To PicORIGINAL.ScaleWidth - 1
            With pixels(X, Y)
                shade = (CInt(.rgbRed) + .rgbGreen + .rgbBlue) / 3
                .rgbRed = shade
                .rgbGreen = shade
                .rgbBlue = shade
            End With
            Print #1, shade
        Next X
        Close #1

End Sub

Private Sub CmdresetOriginal_Click()
            PicORIGINAL.Picture = Picscan.Picture
            Imgoriginal.Picture = PicORIGINAL.Picture
End Sub

Private Sub Cmdstart_Click()
    FraBeltxray.Enabled = True
    lblTime.Enabled = True
    Label3.Enabled = True
    Label4.Enabled = True
            LblBeltMotor.Caption = "RUN"
            LblBeltMotor.BackColor = &HFF00&
            lblXray.Caption = "ON"
```

```
        lblXray.BackColor = &HFFFFF&
        Out pwrite, &H1
        Refresh
        mnuscanimage_Click

        Do
            N = Inp(pread)
        Loop Until N = 0
            Out pwrite, &H0
            LblBeltMotor.Caption = "STOP"
            LblBeltMotor.BackColor = &HFF&
            lblXray.Caption = "OFF"
            lblXray.BackColor = &HFF8080
            FraBeltxray.Enabled = False
            lblTime.Enabled = False
            Label3.Enabled = False
            Label4.Enabled = False
End Sub

Private Sub Imgoriginal_DblClick()
    frmdisplay.Show
    frmdisplay.ImgDisplay.Visible = True
    frmdisplay.Imgdisplay1.Visible = False

End Sub

Private Sub Imgresult_dblClick()
    frmdisplay.Show
    frmdisplay.ImgDisplay.Visible = False
    frmdisplay.Imgdisplay1.Visible = True
End Sub

Private Sub imgresult_MouseDown(Button As Integer, Shift As Integer, X As Single, Y As Single)
        Txtyline.Text = Int((Y * PicResult.Height) / 473)
        PicResult.Cls
        PicResult.Picture = PicORIGINAL.Picture
        PicResult.ForeColor = vbRed
        PicResult.Line (0, Y)-(PicResult.Width, Y), vbRed
        Line1.Y1 = 1680 + Y
        Line1.Y2 = 1680 + Y
End Sub

Private Sub PicResult_MouseDown(Button As Integer, Shift As Integer, X As Single, Y As Single)
        Txtyline.Text = Y
        PicResult.Cls
        PicResult.Picture = PicORIGINAL.Picture
```

```
        PicResult.ForeColor = vbRed
        PicResult.Line (0, Y)-(PicResult.Width, Y), vbRed
End Sub

Private Sub Timer1_Timer()
      N = Time$
      lbltimedisplay.Caption = N
      a = Hour(Time)
      b = Minute(Time)
      c = Second(Time)
End Sub

Private Sub Timer2_Timer()
       LblBeltMotor.Caption = "RUN"
       LblBeltMotor.BackColor = &HFF00&
       Out pwrite, &H1
       TxtbeltMotorTimer.Enabled = True
       Timer2.Enabled = False
       Timer4.Enabled = True
End Sub

Private Sub Timer3_Timer()
    LblBeltMotor.Caption = "STOP"
    LblBeltMotor.BackColor = &HFF&
    Out pwrite, &H0
    Timer3.Enabled = False
    Timer4.Enabled = False
    TxtbeltMotorTimer.Text = 0
    FraBeltxray.Enabled = False
    lblTime.Enabled = False
    Label3.Enabled = False
    Label4.Enabled = False
    Label5.Enabled = False
    Label6.Enabled = False
    Timer2.Enabled = False
    Timer3.Enabled = False
    Timer5.Enabled = False
    Timer6.Enabled = False
    TxtbeltMotorTimer.Text = 60
    TxtXraytimer.Text = 34
    TxtbeltMotorTimer.Enabled = False
    TxtXraytimer.Enabled = False
End Sub

Private Sub Timer4_Timer()
           i = TxtbeltMotorTimer.Text
```

```
        i = i - 1
        TxtbeltMotorTimer.Text = i
End Sub

Private Sub Timer5_Timer()
    lblXray.Caption = "ON"
    lblXray.BackColor = &HFFFFF&
    'Out pwrite, &H2
    TxtXraytimer.Enabled = True
    Timer5.Enabled = False
    Timer7.Enabled = True
End Sub

Private Sub Timer6_Timer()
    lblXray.Caption = "OFF"
    lblXray.BackColor = &HFF8080
    Timer6.Enabled = False
    Timer7.Enabled = False
    TxtXraytimer.Text = "0"
End Sub

Private Sub Timer7_Timer()
    j = TxtXraytimer.Text
    j = j - 1
   TxtXraytimer.Text = j
End Sub

Private Sub Timer8_Timer()
     N = Inp(pread)
     Lbldatain.Caption = N
End Sub

Private Sub Toolbar1_ButtonClick(ByVal Button As MSComctlLib.Button)
    On Error Resume Next
    Select Case Button.Key
        Case "New"
            'ToDo: Add 'New' button code.
            MsgBox "Add 'New' button code."
        Case "Open"
            'ToDo: Add 'Open' button code.
            'MsgBox "Add 'Open' button code."
            mnuopen_Click
        Case "Save"
            'ToDo: Add 'Save' button code.
            'MsgBox "Add 'Save' button code."
            mnusaveas_Click
```

```
        Case "Cut"
            'ToDo: Add 'Cut' button code.
            MsgBox "Add 'Cut' button code."
        Case "Copy"
            'ToDo: Add 'Copy' button code.
            MsgBox "Add 'Copy' button code."
        Case "Paste"
            'ToDo: Add 'Paste' button code.
            MsgBox "Add 'Paste' button code."
        Case "Delete"
            'ToDo: Add 'Delete' button code.
            MsgBox "Add 'Delete' button code."
        Case "Undo"
            'ToDo: Add 'Undo' button code.
            MsgBox "Add 'Undo' button code."
        Case "Redo"
            'ToDo: Add 'Redo' button code.
            MsgBox "Add 'Redo' button code."
        Case "Print"
            'ToDo: Add 'Print' button code.
            'MsgBox "Add 'Print' button code."
            mnuscanimage_Click
        Case "Properties"
            'ToDo: Add 'Properties' button code.
            MsgBox "Add 'Properties' button code."
    End Select
End Sub

' Arrange the controls.
Private Sub ArrangeControls()
    ' Position the result PictureBox.
    PicResult.Move _
        PicORIGINAL.Left + PicORIGINAL.Width + 120, _
        PicORIGINAL.Top, _
        PicORIGINAL.Width, _
        PicORIGINAL.Height
    PicResult.Cls

    PicDummyResult.Move _
        PicORIGINAL.Left + PicORIGINAL.Width + 120, _
        PicORIGINAL.Top, _
        PicORIGINAL.Width, _
        PicORIGINAL.Height

    PicDummyResult.Cls
    ' This makes the image resize itself to
```

```
    ' fit the picture.
    PicResult.Picture = PicResult.Image
    PicDummyResult.Picture = PicDummyResult.Image

    ' Make the form big enough.
    'Width = PicResult.Left + PicResult.Width + _
        Width - ScaleWidth + 120
    'Height = PicResult.Top + PicResult.Height + _
        Height - ScaleHeight + 120
    DoEvents
End Sub

'Arrange the controls.
Private Sub ArrangeControlsRotate(ByVal angle As Single)
Dim new_wid As Single
Dim new_hgt As Single
Dim old_wid As Single
Dim old_hgt As Single

    ' Calculate the result's size.
    old_wid = PicORIGINAL.ScaleWidth
    old_hgt = PicORIGINAL.ScaleHeight
    new_wid = Abs(old_wid * Cos(angle)) + Abs(old_hgt * Sin(angle))
    new_hgt = Abs(old_wid * Sin(angle)) + Abs(old_hgt * Cos(angle))
    new_wid = ScaleX(new_wid, vbPixels, ScaleMode) + PicORIGINAL.Width - ScaleX(PicORIGINAL.ScaleWidth,
vbPixels, ScaleMode)
    new_hgt = ScaleY(new_hgt, vbPixels, ScaleMode) + PicORIGINAL.Height - ScaleY(PicORIGINAL.ScaleHeight,
vbPixels, ScaleMode)

    ' Position the result PictureBox.
    PicResult.Move _
        PicORIGINAL.Left + PicORIGINAL.Width + 120, _
        PicORIGINAL.Top, new_wid, new_hgt
    PicResult.Line (0, 0)-(PicResult.ScaleWidth, PicResult.ScaleHeight), _
        PicResult.BackColor, BF
    PicResult.Picture = PicResult.Image
    PicResult.Visible = True

    ' This makes the image resize itself to
    ' fit the picture.
    PicResult.Picture = PicResult.Image

    DoEvents
End Sub

' Rotate the image.
```

```
Private Sub RotateImage(ByVal pic_from As PictureBox, ByVal pic_to As PictureBox, ByVal angle As Single)
Dim white_pixel As RGBTriplet
Dim input_pixels() As RGBTriplet
Dim result_pixels() As RGBTriplet
Dim bits_per_pixel As Integer
Dim xmax_in As Integer
Dim ymax_in As Integer
Dim CxIn As Single
Dim CyIn As Single
Dim CxOut As Single
Dim CyOut As Single
Dim x_in As Single
Dim y_in As Single
Dim ix_in As Integer
Dim iy_in As Integer
Dim ix_out As Integer
Dim iy_out As Integer
Dim dx As Single
Dim dy As Single
Dim radius As Single
Dim theta As Single
Dim dx1 As Single
Dim dx2 As Single
Dim dy1 As Single
Dim dy2 As Single
Dim v11 As Integer
Dim v12 As Integer
Dim v21 As Integer
Dim v22 As Integer

    ' Set the white pixel's value.
    With white_pixel
        .rgbRed = 255
        .rgbGreen = 255
        .rgbBlue = 255
    End With

    ' Get the pixels from pic_from.
    GetBitmapPixels pic_from, input_pixels, bits_per_pixel

    ' Get the pixels from pic_to.
    GetBitmapPixels pic_to, result_pixels, bits_per_pixel

    ' Get the centers of both images.
    CxIn = pic_from.ScaleWidth / 2
    CyIn = pic_from.ScaleHeight / 2
```

```
CxOut = pic_to.ScaleWidth / 2
CyOut = pic_to.ScaleHeight / 2

' Get the size of the original image.
xmax_in = pic_from.ScaleWidth - 1
ymax_in = pic_from.ScaleHeight - 1

' Calculate the output pixel values.
For iy_out = 0 To pic_to.ScaleHeight - 1
    For ix_out = 0 To pic_to.ScaleWidth - 1
        ' Map the pixel value from
        ' (ix_out, iy_out) to (x_in, y_in).
        dx = ix_out - CxOut
        dy = iy_out - CyOut
        radius = Sqr(dx * dx + dy * dy)
        theta = ATan2(dy, dx)
        x_in = CxIn + radius * Cos(theta + angle)
        y_in = CyIn + radius * Sin(theta + angle)

        ' Find the nearest integral position.
        ix_in = Int(x_in)
        iy_in = Int(y_in)

        ' See if this is in bounds.
        If (ix_in >= 0) And (ix_in < xmax_in) And _
           (iy_in >= 0) And (iy_in < ymax_in) _
        Then
            ' The point lies within the image.
            ' Calculate its value.
            dx1 = x_in - ix_in
            dy1 = y_in - iy_in
            dx2 = 1# - dx1
            dy2 = 1# - dy1

            With result_pixels(ix_out, iy_out)
                ' Calculate the red value.
                v11 = input_pixels(ix_in, iy_in).rgbRed
                v12 = input_pixels(ix_in, iy_in + 1).rgbRed
                v21 = input_pixels(ix_in + 1, iy_in).rgbRed
                v22 = input_pixels(ix_in + 1, iy_in + 1).rgbRed

                .rgbRed = _
                    v11 * dx2 * dy2 + v12 * dx2 * dy1 + _
                    v21 * dx1 * dy2 + v22 * dx1 * dy1

                ' Calculate the green value.
```

```
                v11 = input_pixels(ix_in, iy_in).rgbGreen
                v12 = input_pixels(ix_in, iy_in + 1).rgbGreen
                v21 = input_pixels(ix_in + 1, iy_in).rgbGreen
                v22 = input_pixels(ix_in + 1, iy_in + 1).rgbGreen
                .rgbGreen = _
                    v11 * dx2 * dy2 + v12 * dx2 * dy1 + _
                    v21 * dx1 * dy2 + v22 * dx1 * dy1

                ' Calculate the blue value.
                v11 = input_pixels(ix_in, iy_in).rgbBlue
                v12 = input_pixels(ix_in, iy_in + 1).rgbBlue
                v21 = input_pixels(ix_in + 1, iy_in).rgbBlue
                v22 = input_pixels(ix_in + 1, iy_in + 1).rgbBlue
                .rgbBlue = _
                    v11 * dx2 * dy2 + v12 * dx2 * dy1 + _
                    v21 * dx1 * dy2 + v22 * dx1 * dy1
            End With
        Else
            ' The point is outside the image.
            ' Use white.
            result_pixels(ix_out, iy_out) = white_pixel
        End If
    Next ix_out
Next iy_out

' Set pic_to's pixels.
SetBitmapPixels pic_to, bits_per_pixel, result_pixels
pic_to.Picture = pic_to.Image
End Sub

' Transform the image Negative.
Private Sub TransformImage()
Dim pixels() As RGBTriplet
Dim bits_per_pixel As Integer
Dim X As Integer
Dim Y As Integer

    ' Get the pixels from picOriginal.
    GetBitmapPixels PicORIGINAL, pixels, bits_per_pixel

    ' Set the pixel colors.
    For Y = 0 To PicORIGINAL.ScaleHeight - 1
        For X = 0 To PicORIGINAL.ScaleWidth - 1
            With pixels(X, Y)
                .rgbRed = 255 - .rgbRed
                .rgbGreen = 255 - .rgbGreen
```

```
            .rgbBlue = 255 - .rgbBlue
        End With
    Next X
Next Y

' Set picResult's pixels.
SetBitmapPixels PicResult, bits_per_pixel, pixels
PicResult.Picture = PicResult.Image
Imgresult.Picture = PicResult.Picture
End Sub

Private Sub Form_Load()
    PicORIGINAL.AutoSize = True
    PicORIGINAL.ScaleMode = vbPixels
    PicORIGINAL.AutoRedraw = True
    PicResult.ScaleMode = vbPixels
    PicResult.AutoRedraw = True

    Picscan.AutoSize = True
    Picscan.ScaleMode = vbPixels
    Picscan.AutoRedraw = True

    dlgopenfile.CancelError = True
    dlgopenfile.InitDir = App.Path
    dlgopenfile.Filter = _
        "Bitmaps (*.bmp)|*.bmp|" & _
        "GIFs (*.gif)|*.gif|" & _
        "JPEGs (*.jpg)|*.jpg;*.jpeg|" & _
        "Icons (*.ico)|*.ico|" & _
        "Cursors (*.cur)|*.cur|" & _
        "Run-Length Encoded (*.rle)|*.rle|" & _
        "Metafiles (*.wmf)|*.wmf|" & _
        "Enhanced Metafiles (*.emf)|*.emf|" & _
        "Graphic Files|*.bmp;*.gif;*.jpg;*.jpeg;*.ico;*.cur;*.rle;*.wmf;*.emf|" & _
        "All Files (*.*)|*.*"

    If PicORIGINAL.Picture <> 0 Then
        ArrangeControls
    End If
    Picscan.Picture = PicORIGINAL.Picture
    Imgoriginal.Picture = PicORIGINAL.Picture
    pwrite = &H378
    pread = &H379
    Out pwrite, &H0
End Sub
```

```
Private Sub hbarbrightness_Change()
   Txtbrightness.Text = hbarbrightness.Value

   ' If an image is loaded, transform it.
   If PicORIGINAL.Picture <> 0 Then
      Screen.MousePointer = vbHourglass
      DoEvents
      TransformImageBright
      Screen.MousePointer = vbDefault
   End If
End Sub

Private Sub mnubinarycontrast_Click()
   ShowHistogram PicORIGINAL
   picHistogram.Visible = True
  ' picHistogram.Move _
   '    PicResult.Left, _
    '   PicResult.Top + PicORIGINAL.Height + 50
End Sub

Private Sub mnubrightness_Click()
   ArrangeControls
   hbarbrightness.Enabled = True
   Txtbrightness.Enabled = True
End Sub

Private Sub hbarcontrast_Change()
 If PicResult.Picture <> 0 Then
      Screen.MousePointer = vbHourglass
      DoEvents

      TransformImageContrast

      Screen.MousePointer = vbDefault

      Txtcontrast.Text = hbarcontrast.Value
   End If
End Sub

Private Sub mnucontrast_Click()
         ShowHistograms PicORIGINAL, True
         hbarcontrast.Enabled = True
         Txtcontrast.Enabled = True
End Sub

Private Sub mnuexit_Click()
```

```
    Unload frmmotorxray
    End
End Sub

Private Sub mnuFilterIdentify_Click()
' Create an identity kernel.
    ReDim TheKernel(0 To 0, 0 To 0)
    TheKernel(0, 0) = 1#

    ' Prepare some controls.
    mnuFilterShowFilter.Enabled = True
    lblFilterType.Caption = "Identity"

    ' Apply the filter.
    ApplyTheFilter
End Sub

Private Sub mnuGrayscale_Click()
    ArrangeControls
    TransformImagegray
End Sub

Private Sub mnunegative_Click()
    ArrangeControls
    TransformImage
End Sub

Private Sub mnuopen_Click()
Dim file_name As String

    ' Let the user select a file.
    On Error Resume Next
    dlgopenfile.Flags = cdlOFNFileMustExist + cdlOFNHideReadOnly
    dlgopenfile.ShowOpen
    If Err.Number = cdlCancel Then
        Exit Sub
    ElseIf Err.Number <> 0 Then
        Beep
        MsgBox "Error selecting file.", , vbExclamation
        Exit Sub
    End If
    On Error GoTo 0

    Screen.MousePointer = vbHourglass
    DoEvents
```

```
    file_name = Trim$(dlgopenfile.FileName)
    dlgopenfile.InitDir = Left$(file_name, Len(file_name) _
        - Len(dlgopenfile.FileTitle) - 1)
    Caption = " X-Rays Image Processing [" & dlgopenfile.FileTitle & "]"

    ' Open the original file.
    On Error GoTo LoadError
    PicORIGINAL.Picture = LoadPicture(file_name)
    Imgoriginal.Picture = PicORIGINAL.Picture
    On Error GoTo 0

    ' Make picResult the same size and position it.
    ArrangeControls

    Screen.MousePointer = vbDefault
    Exit Sub

LoadError:
    Screen.MousePointer = vbDefault
    MsgBox "Error " & Format$(Err.Number) & _
        " opening file '" & file_name & "'" & vbCrLf & _
        Err.Description
End Sub

Private Sub mnurotation_Click()
    Const PI = 3.14159265

Dim angle As Single

    ' Do nothing if no picture is loaded.
    If PicORIGINAL.Picture = 0 Then Exit Sub

    ' Get the angle of rotation in radians.
    'On Error GoTo AngleError
    'angle = CSng(txtAngle.Text) * PI / 180
    angle = CSng(-90) * PI / 180
    On Error GoTo 0

    Screen.MousePointer = vbHourglass
    PicResult.Line (0, 0)-(PicResult.ScaleWidth, PicResult.ScaleHeight), _
        PicResult.BackColor, BF
    DoEvents

    ' Arrange picResult.
    ArrangeControlsRotate angle
```

```
    ' Rotate the image.
    RotateImage PicORIGINAL, PicResult, angle

    Screen.MousePointer = vbDefault
    Exit Sub

'AngleError:
    'MsgBox "Invalid angle"
    'txtAngle.SetFocus

End Sub

Private Sub mnusaveas_Click()
    Dim file_name As String

    ' Let the user select a file.
    On Error Resume Next
    dlgopenfile.Flags = cdlOFNOverwritePrompt + cdlOFNHideReadOnly
    dlgopenfile.ShowSave
    If Err.Number = cdlCancel Then
        Exit Sub
    ElseIf Err.Number <> 0 Then
        Beep
        MsgBox "Error selecting file.", , vbExclamation
        Exit Sub
    End If
    On Error GoTo 0

    Screen.MousePointer = vbHourglass
    DoEvents

    file_name = Trim$(dlgopenfile.FileName)
    dlgopenfile.InitDir = Left$(file_name, Len(file_name) _
        - Len(dlgopenfile.FileTitle) - 1)
    Caption = "Complem [" & dlgopenfile.FileTitle & "]"

    ' Save the transformed image into the file.
    On Error GoTo SaveError
    SavePicture PicResult.Picture, file_name
    On Error GoTo 0

    Screen.MousePointer = vbDefault
    Exit Sub

SaveError:
    Screen.MousePointer = vbDefault
```

```
    MsgBox "Error " & Format$(Err.Number) & _
        " saving file '" & file_name & "'" & vbCrLf & _
        Err.Description
End Sub

Private Sub mnuscanimage_Click()
On Error GoTo error:
    r = TWAIN_AcquireToClipboard(Me.hWnd, t%)
    PicORIGINAL.Picture = Clipboard.GetData(vbCFDIB)
    'frmpicDIP.Picresult.Picture = Clipboard.GetData(vbCFDIB)
    'frmpicDIP.ImgDIP.Picture = frmpicDIP.PicDIP.Picture
    Imgoriginal.Picture = PicORIGINAL.Picture
    Picscan.Picture = PicORIGINAL.Picture
    Refresh
error:
End Sub

Private Sub mnuselectsource_Click()
    r = TWAIN_SelectImageSource(Me.hWnd)
End Sub

' Transform the image.
Private Sub TransformImagegray()
Dim pixels() As RGBTriplet
Dim bits_per_pixel As Integer
Dim X As Integer
Dim Y As Integer

    ' Get the pixels from picOriginal.
    GetBitmapPixels PicORIGINAL, pixels, bits_per_pixel

    ' Set the pixel colors.
    For Y = 0 To PicORIGINAL.ScaleHeight - 1
        For X = 0 To PicORIGINAL.ScaleWidth - 1
            With pixels(X, Y)
                shade = (CInt(.rgbRed) + .rgbGreen + .rgbBlue) / 3
                .rgbRed = shade
                .rgbGreen = shade
                .rgbBlue = shade
            End With
        Next X
    Next Y

    ' Set picResult's pixels.
    SetBitmapPixels PicResult, bits_per_pixel, pixels
    PicResult.Picture = PicResult.Image
```

```
    Imgresult.Picture = PicResult.Picture
End Sub

' Transform the image.
Private Sub TransformImageBright()
Dim factor As Single
Dim pixels() As RGBTriplet
Dim bits_per_pixel As Integer
Dim X As Integer
Dim Y As Integer

    ' Get the selected brightness value.
        factor = hbarbrightness.Value / 100#
    ' Get the pixels from picOriginal.
        GetBitmapPixels PicORIGINAL, pixels, bits_per_pixel
    ' Set the pixel colors.
        For Y = 0 To PicORIGINAL.ScaleHeight - 1
          For X = 0 To PicORIGINAL.ScaleWidth - 1
                With pixels(X, Y)
                  If factor < 0 Then
                    ' Make the color darker.
                      .rgbRed = (1 + factor) * .rgbRed
                      .rgbGreen = (1 + factor) * .rgbGreen
                      .rgbBlue = (1 + factor) * .rgbBlue
                  Else
                    ' Make the color brighter.
                        .rgbRed = .rgbRed + factor * (255 - .rgbRed)
                        .rgbGreen = .rgbGreen + factor * (255 - .rgbGreen)
                        .rgbBlue = .rgbBlue + factor * (255 - .rgbBlue)
                End If
            End With
        Next X
    Next Y

    ' Set picResult's pixels.
    SetBitmapPixels PicResult, bits_per_pixel, pixels
    PicResult.Picture = PicResult.Image
    Imgresult.Picture = PicResult.Picture
End Sub

' Transform the image.
Private Sub TransformImageContrast()
Dim pixels() As RGBTriplet
Dim bits_per_pixel As Integer
Dim r_mid As Integer
Dim g_mid As Integer
```

```
Dim b_mid As Integer
Dim r_scale As Single
Dim g_scale As Single
Dim b_scale As Single
Dim r_diff As Integer
Dim g_diff As Integer
Dim b_diff As Integer
Dim r As Integer
Dim g As Integer
Dim b As Integer
Dim X As Integer
Dim Y As Integer

    ' Get the pixels from picOriginal.
    GetBitmapPixels PicORIGINAL, pixels, bits_per_pixel

    ' Get the middle values for the components.
    r_mid = (MaxIndex(0) + MinIndex(0)) / 2
    g_mid = (MaxIndex(1) + MinIndex(1)) / 2
    b_mid = (MaxIndex(2) + MinIndex(2)) / 2

    ' Calculate the scale factors needed to resize
    ' the color values.
    r_scale = hbarcontrast.Value / (MaxIndex(0) - MinIndex(0))
    g_scale = hbarcontrast.Value / (MaxIndex(1) - MinIndex(1))
    b_scale = hbarcontrast.Value / (MaxIndex(2) - MinIndex(2))

    ' Set the colors for each component separately.
    For Y = 0 To PicORIGINAL.ScaleHeight - 1
        For X = 0 To PicORIGINAL.ScaleWidth - 1
            With pixels(X, Y)
                r_diff = .rgbRed - r_mid
                r_diff = r_diff * r_scale
                r = 127 + r_diff
                If r < 0 Then r = 0
                If r > 255 Then r = 255
                .rgbRed = r

                g_diff = .rgbGreen - g_mid
                g_diff = g_diff * g_scale
                g = 127 + g_diff
                If g < 0 Then g = 0
                If g > 255 Then g = 255
                .rgbGreen = g

                b_diff = .rgbBlue - b_mid
```

```
            b_diff = b_diff * b_scale
            b = 127 + b_diff
            If b < 0 Then b = 0
            If b > 255 Then b = 255
            .rgbBlue = b
        End With
    Next X
Next Y

' Set picResult's pixels.
SetBitmapPixels PicResult, bits_per_pixel, pixels
PicResult.Picture = PicResult.Image
Imgresult.Picture = PicResult.Picture

' Show the new brightness histogram.
ShowHistograms PicResult, False
End Sub

' Show the component histograms.
Private Sub ShowHistograms(ByVal picImage As PictureBox, ByVal save_min_max As Boolean)
Dim counts(0 To 2, 0 To 255) As Long
Dim max_count As Long
Dim brightness As Integer
Dim pixels() As RGBTriplet
Dim bits_per_pixel As Integer
Dim X As Integer
Dim Y As Integer
Dim i As Integer
Dim j As Integer

    ' Clear the previous results.
    'For i = 0 To 2
    '   picHistogram(i).Cls
    '   picHistogram(i).Refresh
    'Next i

    ' Get the pixels from picImage.
    GetBitmapPixels picImage, pixels, bits_per_pixel

    ' Count the brightness values.
    For Y = 0 To picImage.ScaleHeight - 1
        For X = 0 To picImage.ScaleWidth - 1
            With pixels(X, Y)
                counts(0, .rgbRed) = counts(0, .rgbRed) + 1
                counts(1, .rgbGreen) = counts(1, .rgbGreen) + 1
                counts(2, .rgbBlue) = counts(2, .rgbBlue) + 1
```

```
        End With
      Next X
    Next Y

    ' Find the largest count value.
    For i = 0 To 2
      ' Skip value 0. There tend to be a lot of
      ' them and they dominate things.
      For j = 1 To 255
        If max_count < counts(i, j) _
          Then max_count = counts(i, j)
      Next j
    Next i

    ' Find the largest and smallest non-zero counts.
    If save_min_max Then
      For i = 0 To 2
        MinIndex(i) = 255
        For brightness = 0 To 255
          If counts(i, brightness) > 0 Then
            MinIndex(i) = brightness
            Exit For
          End If
        Next brightness

        MaxIndex(i) = 0
        For brightness = 255 To 0 Step -1
          If counts(i, brightness) > 0 Then
            MaxIndex(i) = brightness
            Exit For
          End If
        Next brightness
      Next i
    End If
End Sub

'------------------------------
'
'         FILTER
'
'------------------------------
'
'
' Apply an erosion filter.
Private Sub ApplyErosionFilter()
Dim bound As Integer
```

```
Dim input_pixels() As RGBTriplet
Dim result_pixels() As RGBTriplet
Dim black_pixel As RGBTriplet
Dim white_pixel As RGBTriplet
Dim brightness() As Integer
Dim bits_per_pixel As Integer
Dim X As Integer
Dim Y As Integer
Dim i As Integer
Dim j As Integer

    ' Get the kernel's bounds.
    bound = UBound(TheKernel, 1)

    ' Set the white values.
    With white_pixel
        .rgbRed = 255
        .rgbGreen = 255
        .rgbBlue = 255
    End With

    ' Get the pixels from picOriginal.
    GetBitmapPixels PicORIGINAL, input_pixels, bits_per_pixel

    ' Allocate space for the result pixels.
    ReDim result_pixels( _
        LBound(input_pixels, 1) To UBound(input_pixels, 1), _
        LBound(input_pixels, 2) To UBound(input_pixels, 2))

    ' Allocate the brightness values.
    ReDim brightness( _
        LBound(input_pixels, 1) To UBound(input_pixels, 1), _
        LBound(input_pixels, 2) To UBound(input_pixels, 2))

    ' Calculate brightness values.
    For Y = bound To PicORIGINAL.ScaleHeight - 1 - bound
        For X = bound To PicORIGINAL.ScaleWidth - 1 - bound
            With input_pixels(X, Y)
                brightness(X, Y) = CInt(.rgbRed) + .rgbGreen + .rgbBlue
            End With
        Next X
    Next Y

    ' Set the pixel colors. Note that we
    ' must skip the edges because some of
    ' the kernel values would correspond
```

```
    ' to pixels off the image.
    For Y = bound To PicORIGINAL.ScaleHeight - 1 - bound
        For X = bound To PicORIGINAL.ScaleWidth - 1 - bound
            ' Examine the nearby pixels.
            For i = -bound To bound
                For j = -bound To bound
                    ' Get the pixel's brightness
                    If brightness(X + i, Y + j) < TheKernel(i, j) Then Exit For
                Next j
                If j <= bound Then Exit For
            Next i

            ' See if we stopped early.
            If j <= bound Then
                result_pixels(X, Y) = black_pixel
            Else
                result_pixels(X, Y) = white_pixel
            End If
        Next X
    Next Y

    ' Set picResult's pixels.
    SetBitmapPixels PicResult, bits_per_pixel, result_pixels
    PicResult.Picture = PicResult.Image
    Imgresult.Picture = PicResult.Picture
End Sub

' Apply a dilation filter.
Private Sub ApplyDilationFilter()
Dim bound As Integer
Dim input_pixels() As RGBTriplet
Dim result_pixels() As RGBTriplet
Dim black_pixel As RGBTriplet
Dim white_pixel As RGBTriplet
Dim brightness() As Integer
Dim bits_per_pixel As Integer
Dim X As Integer
Dim Y As Integer
Dim i As Integer
Dim j As Integer

    ' Get the kernel's bounds.
    bound = UBound(TheKernel, 1)

    ' Set the white values.
    With white_pixel
```

```
    .rgbRed = 255
    .rgbGreen = 255
    .rgbBlue = 255
End With

' Get the pixels from picOriginal.
GetBitmapPixels PicORIGINAL, input_pixels, bits_per_pixel

' Allocate space for the result pixels.
ReDim result_pixels( _
    LBound(input_pixels, 1) To UBound(input_pixels, 1), _
    LBound(input_pixels, 2) To UBound(input_pixels, 2))

' Allocate the brightness values.
ReDim brightness( _
    LBound(input_pixels, 1) To UBound(input_pixels, 1), _
    LBound(input_pixels, 2) To UBound(input_pixels, 2))

' Calculate brightness values.
For Y = bound To PicORIGINAL.ScaleHeight - 1 - bound
    For X = bound To PicORIGINAL.ScaleWidth - 1 - bound
        With input_pixels(X, Y)
            brightness(X, Y) = CInt(.rgbRed) + .rgbGreen + .rgbBlue
        End With
    Next X
Next Y

' Set the pixel colors. Note that we
' must skip the edges because some of
' the kernel values would correspond
' to pixels off the image.
For Y = bound To PicORIGINAL.ScaleHeight - 1 - bound
    For X = bound To PicORIGINAL.ScaleWidth - 1 - bound
        ' Examine the nearby pixels.
        For i = -bound To bound
            For j = -bound To bound
                ' Get the pixel's brightness
                If brightness(X + i, Y + j) >= TheKernel(i, j) Then Exit For
            Next j
            If j <= bound Then Exit For
        Next i

        ' See if we stopped early.
        If j <= bound Then
            result_pixels(X, Y) = white_pixel
        Else
```

```
            result_pixels(X, Y) = black_pixel
        End If
    Next X
Next Y

' Set picResult's pixels.
SetBitmapPixels PicResult, bits_per_pixel, result_pixels
PicResult.Picture = PicResult.Image
Imgresult.Picture = PicResult.Picture
End Sub

' Manage the mouse and apply the image.
Private Sub ApplyTheFilter(Optional offset As Variant)
    ' Do nothing if no picture is loaded.
    If PicORIGINAL.Picture = 0 Then Exit Sub

    ' Do nothing if no filter is loaded.
    If Len(lblFilterType.Caption) = 0 Then Exit Sub

    Screen.MousePointer = vbHourglass
    PicResult.Line (0, 0)-(PicResult.ScaleWidth, PicResult.ScaleHeight), _
        PicResult.BackColor, BF
    DoEvents

    ' Apply the filter.
    If IsMissing(offset) Then offset = 0
    ApplyFilter TheKernel, offset

    Screen.MousePointer = vbDefault
End Sub


' Apply a filter to an image.
Private Sub ApplyFilter(kernel() As Single, ByVal offset As Integer)
Dim bound As Integer
Dim input_pixels() As RGBTriplet
Dim result_pixels() As RGBTriplet
Dim bits_per_pixel As Integer
Dim X As Integer
Dim Y As Integer
Dim i As Integer
Dim j As Integer
Dim r As Integer
Dim g As Integer
Dim b As Integer
```

```
' Get the kernel's bounds.
bound = UBound(kernel, 1)

' Get the pixels from picOriginal.
GetBitmapPixels PicORIGINAL, input_pixels, bits_per_pixel

' Allocate space for the result pixels.
ReDim result_pixels( _
    LBound(input_pixels, 1) To UBound(input_pixels, 1), _
    LBound(input_pixels, 2) To UBound(input_pixels, 2))

' Set the pixel colors. Note that we
' must skip the edges because some of
' the kernel values would correspond
' to pixels off the image.
For Y = bound To PicORIGINAL.ScaleHeight - 1 - bound
    For X = bound To PicORIGINAL.ScaleWidth - 1 - bound
        ' Start with no color.
        r = offset
        g = offset
        b = offset
        ' Apply the kernel values to
        ' the nearby pixels.
        For i = -bound To bound
            For j = -bound To bound
                With input_pixels(X + i, Y + j)
                    r = r + .rgbRed * kernel(j, i)
                    g = g + .rgbGreen * kernel(j, i)
                    b = b + .rgbBlue * kernel(j, i)
                End With
            Next j
        Next i

        ' Make sure the values are
        ' between 0 and 255.
        If r < 0 Then r = 0
        If r > 255 Then r = 255
        If g < 0 Then g = 0
        If g > 255 Then g = 255
        If b < 0 Then b = 0
        If b > 255 Then b = 255

        ' Set the output pixel value.
        With result_pixels(X, Y)
            .rgbRed = r
            .rgbGreen = g
```

```
            .rgbBlue = b
         End With
      Next X
   Next Y

   ' Set picResult's pixels.
   SetBitmapPixels PicResult, bits_per_pixel, result_pixels
   PicResult.Picture = PicResult.Image
   Imgresult.Picture = PicResult.Picture
End Sub

' Apply a rank filter to an image.
Private Sub ApplyRankFilter(ByVal rank As Integer)
Dim bound As Integer
Dim brightnesses(1 To 9) As Integer
Dim color_values(1 To 9) As RGBTriplet
Dim tmp_brightness As Integer
Dim tmp_color_value As RGBTriplet
Dim input_pixels() As RGBTriplet
Dim result_pixels() As RGBTriplet
Dim bits_per_pixel As Integer
Dim X As Integer
Dim Y As Integer
Dim idx As Integer
Dim i As Integer
Dim j As Integer
Dim sort_done As Boolean

   ' Get the pixels from picOriginal.
   GetBitmapPixels PicORIGINAL, input_pixels, bits_per_pixel

   ' Allocate space for the result pixels.
   ReDim result_pixels( _
      LBound(input_pixels, 1) To UBound(input_pixels, 1), _
      LBound(input_pixels, 2) To UBound(input_pixels, 2))

   ' Set the pixel colors.
   bound = 1
   For Y = bound To PicORIGINAL.ScaleHeight - 1 - bound
      For X = bound To PicORIGINAL.ScaleWidth - 1 - bound
         ' Load the nearby colors.
         idx = 1
         For i = -bound To bound
            For j = -bound To bound
               With input_pixels(X + i, Y + j)
                  brightnesses(idx) = CInt(.rgbRed) + .rgbGreen + .rgbBlue
```

```
                End With
                color_values(idx) = input_pixels(X + i, Y + j)
                idx = idx + 1
            Next j
        Next i

        ' Sort the color values by brightness.
        Do
            sort_done = True
            For i = 1 To 8
                ' See if the i and i+1 entries
                ' are in the right order.
                If brightnesses(i) > brightnesses(i + 1) Then
                    ' Swap them.
                    tmp_brightness = brightnesses(i)
                    brightnesses(i) = brightnesses(i + 1)
                    brightnesses(i + 1) = tmp_brightness
                    tmp_color_value = color_values(i)
                    color_values(i) = color_values(i + 1)
                    color_values(i + 1) = tmp_color_value
                    sort_done = False
                End If
            Next i
            If sort_done Then Exit Do
        Loop

        ' Pick the color with the right rank.
        result_pixels(X, Y) = color_values(rank)
    Next X
Next Y

' Set picResult's pixels.
SetBitmapPixels PicResult, bits_per_pixel, result_pixels
PicResult.Picture = PicResult.Image
Imgresult.Picture = PicResult.Picture
End Sub

' Copy kernel entries from a variant array of
' variant arrays into a normal array.
Private Sub VariantToArray(ByVal var As Variant, ByRef arr() As Single)
Dim bound As Integer
Dim i As Integer
Dim j As Integer

    bound = UBound(var) \ 2
    ReDim arr(-bound To bound, -bound To bound)
```

```
    For i = -bound To bound
        For j = -bound To bound
            arr(i, j) = var(i + bound)(j + bound)
        Next j
    Next i
End Sub

' Apply an offset embossing filter.
Private Sub mnuEmbossing_Click()
    ' Build the kernel.
    VariantToArray Array( _
        Array(1, 0, 0), _
        Array(0, 0, 0), _
        Array(0, 0, -1)), _
        TheKernel

    ' Prepare some controls.
    mnuFilterShowFilter.Enabled = True
    lblFilterType.Caption = "Embossing 3x3"
    ApplyTheFilter 127
End Sub

' Apply an erosion filter.
Private Sub mnuErode_Click()
    ' Build the kernel.
    VariantToArray Array( _
        Array(127, 127, 127), _
        Array(127, 127, 127), _
        Array(127, 127, 127)), _
        TheKernel

    ' Prepare some controls.
    mnuFilterShowFilter.Enabled = True
    lblFilterType.Caption = "Erosion"

    ' Do nothing if no picture is loaded.
    If PicORIGINAL.Picture = 0 Then Exit Sub

    ' Do nothing if no filter is loaded.
    If Len(lblFilterType.Caption) = 0 Then Exit Sub

    Screen.MousePointer = vbHourglass
    PicResult.Line (0, 0)-(PicResult.ScaleWidth, PicResult.ScaleHeight), _
        PicResult.BackColor, BF
    DoEvents
```

```
    ApplyErosionFilter

    Screen.MousePointer = vbDefault
End Sub

' Apply a dilation filter.
Private Sub mnuDilate_Click()
    ' Build the kernel.
    VariantToArray Array( _
        Array(127, 127, 127), _
        Array(127, 127, 127), _
        Array(127, 127, 127)), _
        TheKernel

    ' Prepare some controls.
    mnuFilterShowFilter.Enabled = True
    lblFilterType.Caption = "Dilation"

    ' Do nothing if no picture is loaded.
    If PicORIGINAL.Picture = 0 Then Exit Sub

    ' Do nothing if no filter is loaded.
    If Len(lblFilterType.Caption) = 0 Then Exit Sub

    Screen.MousePointer = vbHourglass
    PicResult.Line (0, 0)-(PicResult.ScaleWidth, PicResult.ScaleHeight), _
        PicResult.BackColor, BF
    DoEvents

    ApplyDilationFilter

    Screen.MousePointer = vbDefault
End Sub

' Let the user define a custom filter.
Private Sub mnuFilterCustom_Click()
Dim bound As Integer
Dim i As Integer
Dim j As Integer
Dim idx As Integer

    frmCustom.Show vbModal

    If Not frmCustom.Canceled Then
        bound = frmCustom.CustomBound
        ReDim TheKernel(-bound To bound, -bound To bound)
```

```
        idx = 0
        For i = -bound To bound
            For j = -bound To bound
                TheKernel(i, j) = CSng(frmCustom.txtCoefficient(idx))
                idx = idx + 1
            Next j
        Next i

        mnuFilterShowFilter.Enabled = True
        lblFilterType.Caption = "Custom " & _
            Format$(bound) & "x" & Format$(bound)
    End If

    Unload frmCustom
End Sub

Private Sub mnuFilterIdentity_Click()
    ' Create an identity kernel.
    ReDim TheKernel(0 To 0, 0 To 0)
    TheKernel(0, 0) = 1#

    ' Prepare some controls.
    mnuFilterShowFilter.Enabled = True
    lblFilterType.Caption = "Identity"

    ' Apply the filter.
    ApplyTheFilter
End Sub

' Display the filter coefficients.
Private Sub mnuFilterShowFilter_Click()
    frmShowFilter.PrepareForm TheKernel
    frmShowFilter.Show vbModal
End Sub

' Apply a strong high pass filter.
Private Sub mnuHighPassStrong_Click()
    ' Build the kernel.
    VariantToArray Array( _
        Array(0, -1, 0), _
        Array(-1, 5, -1), _
        Array(0, -1, 0)), _
        TheKernel

    ' Prepare some controls.
    mnuFilterShowFilter.Enabled = True
```

```
    lblFilterType.Caption = "Strong High Pass 3x3"
    ApplyTheFilter
End Sub
' Apply a very strong high pass filter.
Private Sub mnuHighPassVeryStrong_Click()
    ' Build the kernel.
    VariantToArray Array( _
        Array(-1, -1, -1), _
        Array(-1, 9, -1), _
        Array(-1, -1, -1)), _
        TheKernel

    ' Prepare some controls.
    mnuFilterShowFilter.Enabled = True
    lblFilterType.Caption = "Very Strong High Pass 3x3"
    ApplyTheFilter
End Sub

' Apply a very weak high pass filter.
Private Sub mnuHighPassVeryWeak_Click()
    ' Build the kernel.
    VariantToArray Array( _
        Array(-1 / 12, -1 / 12, -1 / 12), _
        Array(-1 / 12, 20 / 12, -1 / 12), _
        Array(-1 / 12, -1 / 12, -1 / 12)), _
        TheKernel

    ' Prepare some controls.
    mnuFilterShowFilter.Enabled = True
    lblFilterType.Caption = "Weak High Pass 3x3"
    ApplyTheFilter

End Sub

' Apply a weak high pass filter.
Private Sub mnuHighPassWeak_Click()
    ' Build the kernel.
    VariantToArray Array( _
        Array(-1 / 4, -1 / 4, -1 / 4), _
        Array(-1 / 4, 12 / 4, -1 / 4), _
        Array(-1 / 4, -1 / 4, -1 / 4)), _
        TheKernel

    ' Prepare some controls.
    mnuFilterShowFilter.Enabled = True
    lblFilterType.Caption = "Weak High Pass 3x3"
```

```
    ApplyTheFilter
End Sub

' Apply a weak Laplacian edge detection filter.
Private Sub mnuLaplacianWeak_Click()
    ' Build the kernel.
    VariantToArray Array( _
        Array(0, -1, 0), _
        Array(-1, 4, -1), _
        Array(0, -1, 0)), _
        TheKernel

    ' Prepare some controls.
    mnuFilterShowFilter.Enabled = True
    lblFilterType.Caption = "Weak Laplacian 3x3"
    ApplyTheFilter
End Sub

' Apply a strong Laplacian edge detection filter.
Private Sub mnuLaplacianStrong_Click()
    ' Build the kernel.
    VariantToArray Array( _
        Array(-1, -1, -1), _
        Array(-1, 8, -1), _
        Array(-1, -1, -1)), _
        TheKernel

    ' Prepare some controls.
    mnuFilterShowFilter.Enabled = True
    lblFilterType.Caption = "Strong Laplacian 3x3"
    ApplyTheFilter
End Sub

' Apply a very strong Laplacian edge detection filter.
Private Sub mnuLaplacianVeryStrong_Click()
    ' Build the kernel.
    VariantToArray Array( _
        Array(-1, -2, -1), _
        Array(-2, 12, -2), _
        Array(-1, -2, -1)), _
        TheKernel

    ' Prepare some controls.
    mnuFilterShowFilter.Enabled = True
    lblFilterType.Caption = "Very Strong Laplacian 3x3"
    ApplyTheFilter
```

```
End Sub

' Apply a low pass filter.
Private Sub mnuLowPass_Click(Index As Integer)
Dim bound As Integer
Dim i As Integer
Dim j As Integer

    ' Build the kernel.
    bound = (Index - 1) \ 2
    ReDim TheKernel(-bound To bound, -bound To bound)
    For i = -bound To bound
        For j = -bound To bound
            TheKernel(i, j) = 1 / (Index * Index)
        Next j
    Next i

    ' Prepare some controls.
    mnuFilterShowFilter.Enabled = True
    lblFilterType.Caption = "Identity"

    ' Apply the filter.
        lblFilterType.Caption = "Low Pass " & _
        Format$(Index) & "x" & _
        Format$(Index)
    ApplyTheFilter
End Sub

' Apply a peaked low pass filter.
Private Sub mnuFilterLowPassPeaked_Click(Index As Integer)
Dim bound As Integer
Dim i As Integer
Dim j As Integer
Dim total_weight As Integer

    ' Build the kernel.
    bound = (Index - 1) \ 2
    ReDim TheKernel(-bound To bound, -bound To bound)
    For i = -bound To bound
        For j = -bound To bound
            TheKernel(i, j) = 2 * bound + 1 - Abs(i) - Abs(j)
            total_weight = total_weight + TheKernel(i, j)
        Next j
    Next i

    ' Adjust the kernel so the sum of the
```

```
    ' coefficients is 1.
    For i = -bound To bound
        For j = -bound To bound
            TheKernel(i, j) = TheKernel(i, j) / total_weight
        Next j
    Next i

    ' Prepare some controls.
    mnuFilterShowFilter.Enabled = True
    lblFilterType.Caption = "Low Pass Peaked " & _
        Format$(Index) & "x" & _
        Format$(Index)
    ApplyTheFilter
End Sub

' Apply a stongly peaked low pass filter.
Private Sub mnuLowPassStrongPeak_Click()
Dim i As Integer
Dim j As Integer

    ' Build the kernel.
    ReDim TheKernel(-1 To 1, -1 To 1)
    For i = -1 To 1
        For j = -1 To 1
            TheKernel(i, j) = 1 / 20
        Next j
    Next i
    TheKernel(0, 0) = 12 / 20

    ' Prepare some controls.
    mnuFilterShowFilter.Enabled = True
    lblFilterType.Caption = "Strongly Peaked 3x3"
    ApplyTheFilter
End Sub

' Apply a Prewitt edge detector.
Private Sub mnuPrewitt_Click(Index As Integer)
Dim i As Integer
Dim j As Integer

    ' Build the kernel.
    Select Case Index
        Case 0  ' NW to SE
            VariantToArray Array( _
                Array(1, 1, 1), _
                Array(1, -2, -1), _
```

```
            Array(1, -1, -1)), _
            TheKernel
    Case 1  ' N to S
        VariantToArray Array( _
            Array(1, 1, 1), _
            Array(1, -2, 1), _
            Array(-1, -1, -1)), _
            TheKernel
    Case 2  ' NE to SW
        VariantToArray Array( _
            Array(1, 1, 1), _
            Array(-1, -2, 1), _
            Array(-1, -1, 1)), _
            TheKernel
    Case 3  ' E to W
        VariantToArray Array( _
            Array(-1, 1, 1), _
            Array(-1, -2, 1), _
            Array(-1, 1, 1)), _
            TheKernel
    Case 4  ' SE to NW
        VariantToArray Array( _
            Array(-1, -1, 1), _
            Array(-1, -2, 1), _
            Array(1, 1, 1)), _
            TheKernel
    Case 5  ' S to N
        VariantToArray Array( _
            Array(-1, -1, -1), _
            Array(1, -2, 1), _
            Array(1, 1, 1)), _
            TheKernel
    Case 6  ' SW to NE
        VariantToArray Array( _
            Array(1, -1, -1), _
            Array(1, -2, -1), _
            Array(1, 1, 1)), _
            TheKernel
    Case 7  ' W to E
        VariantToArray Array( _
            Array(1, 1, -1), _
            Array(1, -2, -1), _
            Array(1, 1, -1)), _
            TheKernel
End Select
```

```
    ' Prepare some controls.
    mnuFilterShowFilter.Enabled = True
    lblFilterType.Caption = "Prewitt " & _
        mnuPrewitt(Index).Caption
    ApplyTheFilter
End Sub

' Apply a rank filter.
Private Sub mnuRank_Click(Index As Integer)
    ' Prepare some controls.
    mnuFilterShowFilter.Enabled = True
    lblFilterType.Caption = "Rank " & Format$(Index)

    ' Do nothing if no picture is loaded.
    If PicORIGINAL.Picture = 0 Then Exit Sub

    Screen.MousePointer = vbHourglass
    PicResult.Line (0, 0)-(PicResult.ScaleWidth, PicResult.ScaleHeight), _
        PicResult.BackColor, BF
    DoEvents

    ' Apply the filter.
    ApplyRankFilter Index

    Screen.MousePointer = vbDefault
End Sub

' Transform the image.
Private Sub TransformImagebinarycontrast(ByVal cutoff As Single)
Dim pixels() As RGBTriplet
Dim bits_per_pixel As Integer
Dim brightness As Integer
Dim X As Integer
Dim Y As Integer

    ' Get the pixels from picOriginal.
    GetBitmapPixels PicORIGINAL, pixels, bits_per_pixel

    ' Set the pixel color values.
    For Y = 0 To PicORIGINAL.ScaleHeight - 1
        For X = 0 To PicORIGINAL.ScaleWidth - 1
            With pixels(X, Y)
                brightness = (CInt(.rgbRed) + _
                    .rgbGreen + .rgbBlue) / 3
                If brightness >= cutoff Then
                    .rgbRed = 255
```

```
                .rgbGreen = 255
                .rgbBlue = 255
            Else
                .rgbRed = 0
                .rgbGreen = 0
                .rgbBlue = 0
            End If
        End With
    Next X
Next Y

' Set picResult's pixels.
SetBitmapPixels PicResult, bits_per_pixel, pixels
PicResult.Picture = PicResult.Image
Imgresult.Picture = PicResult.Picture
End Sub

' Show the brightness histogram.
Private Sub ShowHistogram(ByVal picImage As PictureBox)
Dim counts(0 To 255) As Long
Dim max_count As Long
Dim brightness As Integer
Dim pixels() As RGBTriplet
Dim bits_per_pixel As Integer
Dim X As Integer
Dim Y As Integer
Dim i As Integer

    ' Clear the previous results.
    picHistogram.Line _
        (picHistogram.ScaleLeft, picHistogram.ScaleTop)- _
        Step(picHistogram.ScaleWidth, picHistogram.ScaleHeight), _
        picHistogram.BackColor, BF
    picHistogram.Refresh

    ' Get the pixels from picImage.
    GetBitmapPixels picImage, pixels, bits_per_pixel

    ' Count the brightness values.
    For Y = 0 To picImage.ScaleHeight - 1
        For X = 0 To picImage.ScaleWidth - 1
            With pixels(X, Y)
                brightness = (CInt(.rgbRed) + _
                    .rgbGreen + .rgbBlue) / 3
                counts(brightness) = counts(brightness) + 1
            End With
```

```
        Next X
    Next Y

    ' Find the largest count value.
    ' Skip value 0. There tend to be a lot of
    ' them and they dominate things.
    For i = 1 To 255
        If max_count < counts(i) _
            Then max_count = counts(i)
    Next i

    ' Display the brightness histogram.
    picHistogram.ScaleTop = 1.1 * max_count
    picHistogram.ScaleHeight = -1.2 * max_count
    picHistogram.ScaleLeft = -1
    picHistogram.ScaleWidth = 258
    For brightness = 0 To 255
        If counts(brightness) > 0 Then _
            picHistogram.Line (brightness, 0)-(brightness + 1, counts(brightness)), , BF
    Next brightness

    ' Make the changes permanent.
    picHistogram.Picture = picHistogram.Image
End Sub

' Set the binary contrast enhancement level.
Private Sub picHistogram_MouseDown(Button As Integer, Shift As Integer, X As Single, Y As Single)
    If PicORIGINAL.Picture <> 0 Then
        picHistogram.Cls
        picHistogram.Line _
            (X, picHistogram.ScaleTop)- _
            Step(0, picHistogram.ScaleHeight), vbRed
        Screen.MousePointer = vbHourglass
        DoEvents

        TransformImagebinarycontrast X

        Screen.MousePointer = vbDefault
    End If
End Sub
```

```
'----------------------------
'FrmDisplay
'----------------------------
Private Sub Form_Load()
    ImgDisplay.Picture = FrmDIPmain.PicORIGINAL.Picture
    Imgdisplay1.Picture = FrmDIPmain.PicResult.Picture
End Sub

Private Sub ImgDisplay_dblclick()
    Unload frmdisplay
End Sub

Private Sub Imgdisplay1_dblClick()
    Unload frmdisplay
End Sub

'----------------------------------
'FrmCustom
'----------------------------------
Option Explicit
Public Canceled As Boolean
Public CustomBound As Integer

Private Sub CmdClose_Click()
    Me.Hide
End Sub

Private Sub CmdOK_Click()
    Canceled = False
    Me.Hide
End Sub

Private Sub Form_Load()
 ' Assume we will cancel.
    Canceled = True
    TxtBound.Text = "1"
End Sub

' Set a new filter size.
Private Sub txtBound_Change()
Dim new_bound As Integer
Dim i As Integer
Dim j As Integer
Dim idx As Integer
Dim X As Single
Dim Y As Single
```

```
Dim wid As Single

    ' Get the new bound.
    On Error Resume Next
    new_bound = CInt(TxtBound.Text)
    If Err.Number > 0 Then Exit Sub
    If new_bound < 0 Then Exit Sub

    CustomBound = new_bound

    ' Position the controls.
    idx = 0
    Y = txtCoefficient(0).Top
    For i = -CustomBound To CustomBound
        X = txtCoefficient(0).Left
        For j = -CustomBound To CustomBound
            ' See if we need a new TextBox.
            If idx > txtCoefficient.UBound Then
                Load txtCoefficient(idx)
            End If

            ' Position the control.
            txtCoefficient(idx).Move X, Y
            txtCoefficient(idx).Visible = True
            X = X + txtCoefficient(0).Width + 120
            idx = idx + 1
        Next j
        Y = Y + txtCoefficient(0).Height + 120
    Next i

    ' Size the form and position the buttons.
    Height = txtCoefficient(idx - 1).Top + _
        txtCoefficient(idx - 1).Height + _
        CmdOK.Height + 2 * 120 + _
        Height - ScaleHeight
    wid = txtCoefficient(idx - 1).Left + _
        txtCoefficient(idx - 1).Width + 120 + _
        Width - ScaleWidth
    If wid < 2 * CmdOK.Width + 3 * 120 _
        Then wid = 2 * CmdOK.Width + 3 * 120
    Width = wid

    ' Position the buttons.
    CmdOK.Move ScaleWidth / 2 - CmdOK.Width - 60, _
        ScaleHeight - CmdOK.Height - 120
    CmdCancel.Move ScaleWidth / 2 + 60, CmdOK.Top
```

```
    ' Hide unneeded controls.
    For idx = idx To txtCoefficient.UBound
        txtCoefficient(idx).Visible = False
    Next idx
End Sub

'-----------------------------------------------------------------
'EZTWAIN32
'-----------------------------------------------------------------
' 32-bit EZTWAIN functions for Visual Basic 5.0
Declare Function TWAIN_AcquireToClipboard Lib "EZTW32.DLL" (ByVal hwndApp&, ByVal wPixTypes&) As Long
Declare Function TWAIN_SelectImageSource Lib "EZTW32.DLL" (ByVal hwndApp&) As Long


'-----------------------------------------------------------------
'Parallel Interface
'-----------------------------------------------------------------
Private Declare Sub Out Lib "inpout32.dll" Alias "Out32" (ByVal Portaddress As Integer, ByVal Value As Integer)
Public pwrite As Integer
```

สามารถดู Source Code ของแฟ้ม DDB Helper ได้จาก CD-ROM ประกอบวิทยานิพนธ์

ภาคผนวก ข

ข้อมูลอุปกรณ์อิเล็กทรอนิกส์และอุปกรณ์ในการสร้างหม้อแปลงไฟฟ้า

INTEGRATED CIRCUITS
UNITRODE

UC1842/3/4/5
UC2842/3/4/5
UC3842/3/4/5

Current Mode PWM Controller

FEATURES

- Optimized For Off-line And DC To DC Converters
- Low Start Up Current (<1mA)
- Automatic Feed Forward Compensation
- Pulse-by-pulse Current Limiting
- Enhanced Load Response Characteristics
- Under-voltage Lockout With Hysteresis
- Double Pulse Suppression
- High Current Totem Pole Output
- Internally Trimmed Bandgap Reference
- 500khz Operation
- Low Ro Error Amp

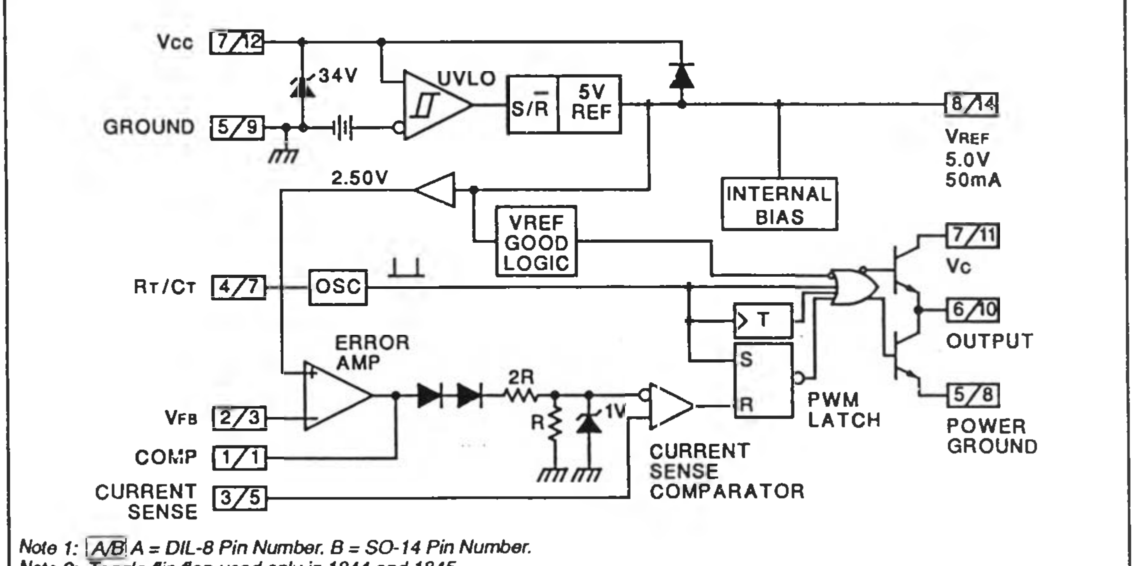
DESCRIPTION

The UC1842/3/4/5 family of control ICs provides the necessary features to implement off-line or DC to DC fixed frequency current mode control schemes with a minimal external parts count. Internally implemented circuits include under-voltage lockout featuring start up current less than 1mA, a precision reference trimmed for accuracy at the error amp input, logic to insure latched operation, a PWM comparator which also provides current limit control, and a totem pole output stage designed to source or sink high peak current. The output stage, suitable for driving N Channel MOSFETs, is low in the off state.

Differences between members of this family are the under-voltage lockout thresholds and maximum duty cycle ranges. The UC1842 and UC1844 have UVLO thresholds of 16V (on) and 10V (off), ideally suited to off-line applications. The corresponding thresholds for the UC1843 and UC1845 are 8.4V and 7.6V. The UC1842 and UC1843 can operate to duty cycles approaching 100%. A range of zero to 50% is obtained by the UC1844 and UC1845 by the addition of an internal toggle flip flop which blanks the output off every other clock cycle.

5

BLOCK DIAGRAM



Note 1: A/B A = DIL-8 Pin Number. B = SO-14 Pin Number.
Note 2: Toggle flip flop used only in 1844 and 1845.

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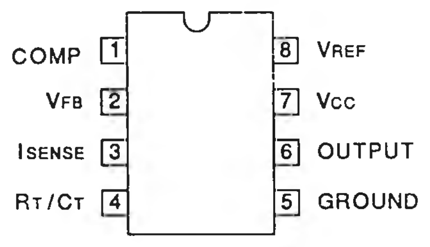
ABSOLUTE MAXIMUM RATINGS (Note 1)

Supply Voltage (Low Impedance Source) 30V
Supply Voltage (I_{CC} <30mA) . . . . . Self Limiting
Output Current . . . . . ±1A
Output Energy (Capacitive Load) 5µJ
Analog Inputs (Pins 2, 3) . . . . . -0.3V to +6.3V
Error Amp Output Sink Current 10mA
Power Dissipation at $T_A \leq 25°C$ (DIL-8) 1W
Power Dissipation at $T_A \leq 25°C$ (SOIC-14) 725mW
Storage Temperature Range . . . . . -65°C to +150°C
Lead Temperature (Soldering, 10 Seconds) . . . . . 300°C

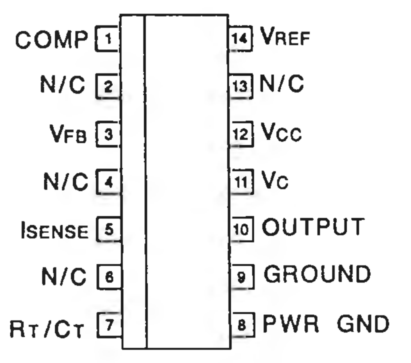
Note 1: All voltages are with respect to Pin 5.
All currents are positive into the specified terminal.
Consult Packaging Section of Databook for thermal limitations and considerations of packages.

CONNECTION DIAGRAMS

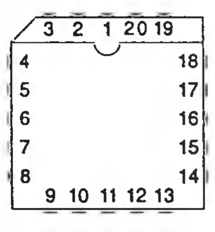
DIL-8, SOIC-8 (TOP VIEW)
N or J Package, D8 Package



SOIC-14 (TOP VIEW)
D Package



PLCC-20 (TOP VIEW)
Q Package



PACKAGE PIN FUNCTION	
FUNCTION	PIN
N/C	1
COMP	2
N/C	3
N/C	4
VFB	5
N/C	6
ISENSE	7
N/C	8
N/C	9
RT/CT	10
N/C	11
PWR GND	12
GROUND	13
N/C	14
OUTPUT	15
N/C	16
VC	17
VCC	18
N/C	19
VREF	20

ELECTRICAL CHARACTERISTICS: Unless otherwise stated, these specifications apply for -55°C ≤ T_A ≤ 125°C for the UC184X; -40°C ≤ T_A ≤ 85°C for the UC284X; 0°C ≤ T_A ≤ 70°C for the 384X; V_{CC} = 15V (Note 5); R_T = 10k; C_T =3.3nF, T_A=T_J.

PARAMETER	TEST CONDITIONS	UC1842/3/4/5 UC2842/3/4/5			UC3842/3/4/5			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Reference Section								
Output Voltage	T_J = 25°C, I_O = 1mA	4.95	5.00	5.05	4.90	5.00	5.10	V
Line Regulation	12 ≤ V_{IN} ≤ 25V		6	20		6	20	mV
Load Regulation	1 ≤ I_O ≤ 20mA		6	25		6	25	mV
Temp. Stability	(Note 2) (Note 7)		0.2	0.4		0.2	0.4	mV/°C
Total Output Variation	Line, Load, Temp. (Note 2)	4.9		5.1	4.82		5.18	V
Output Noise Voltage	10Hz ≤ f ≤ 10kHz, T_J = 25°C (Note2)		50			50		µV
Long Term Stability	T_A = 125°C, 1000Hrs. (Note 2)		5	25		5	25	mV
Output Short Circuit		-30	-100	-180	-30	-100	-180	mA
Oscillator Section								
Initial Accuracy	T_J = 25°C (Note 6)	47	52	57	47	52	57	kHz
Voltage Stability	12 ≤ V_{CC} ≤ 25V		0.2	1		0.2	1	%
Temp. Stability	T_{MIN} ≤ T_A ≤ T_{MAX} (Note 2)		5			5		%
Amplitude	$V_{PIN\,4}$ peak to peak (Note 2)		1.7			1.7		V
Error Amp Section								
Input Voltage	$V_{PIN\,1}$ = 2.5V	2.45	2.50	2.55	2.42	2.50	2.58	V
Input Bias Current			-0.3	-1		-0.3	-2	µA
A_{VOL}	2 ≤ V_O ≤ 4V	65	90		65	90		dB
Unity Gain Bandwidth	(Note 2) T_J = 25°C	0.7	1		0.7	1		MHz
PSRR	12 ≤ V_{CC} ≤ 25V	60	70		60	70		dB
Output Sink Current	$V_{PIN\,2}$ = 2.7V, $V_{PIN\,1}$ = 1.1V	2	6		2	6		mA
Output Source Current	$V_{PIN\,2}$ = 2.3V, $V_{PIN\,1}$ = 5V	-0.5	-0.8		-0.5	-0.8		mA
V_{OUT} High	$V_{PIN\,2}$ = 2.3V, R_L = 15k to ground	5	6		5	6		V
V_{OUT} Low	$V_{PIN\,2}$ = 2.7V, R_L = 15k to Pin 8		0.7	1.1		0.7	1.1	V
Current Sense Section								
Gain	(Notes 3 and 4)	2.85	3	3.15	2.85	3	3.15	V/V
Maximum Input Signal	$V_{PIN\,1}$ = 5V (Note 3)	0.9	1	1.1	0.9	1	1.1	V
PSRR	12 ≤ V_{CC} ≤ 25V (Note 3) (Note 2)		70			70		dB
Input Bias Current			-2	-10		-2	-10	µA
Delay to Output	$V_{PIN\,3}$ = 0 to 2V (Note 2)		150	300		150	300	ns

Note 2: These parameters, although guaranteed, are not 100% tested in production.
Note 3: Parameter measured at trip point of latch with $V_{PIN\,2}$ = 0.
Note 4: Gain defined as

$$A = \frac{\Delta\,V_{PIN1}}{\Delta\,V_{PIN3}},\ 0 \le V_{PIN3} \le 0.8V$$

Note 5: Adjust Vcc above the start threshold before setting at 15V.
Note 6: Output frequency equals oscillator frequency for the UC1842 and UC1843.
Output frequency is one half oscillator frequency for the UC1844 and UC1845.
Note 7: Temperature stability, sometimes referred to as average temperature coefficient, is described by the equation:

$$Temp\ Stability = \frac{V_{REF}(max) - V_{REF}(min)}{T_J(max) - T_J(min)}$$

V_{REF} (max) and V_{REF} (min) are the maximum and minimum reference voltages measured over the appropriate temperature range. Note that the extremes in voltage do not necessarily occur at the extremes in temperature.

ELECTRICAL CHARACTERISTICS: Unless otherwise stated, these specifications apply for $-55°C \le T_A \le 125°C$ for the UC184X; $-40°C \le T_A \le 85°C$ for the UC284X; $0°C \le T_A \le 70°C$ for the 384X; V_{CC} = 15V (Note 5); R_T = 10k; C_T =3.3nF, T_A=T_J.

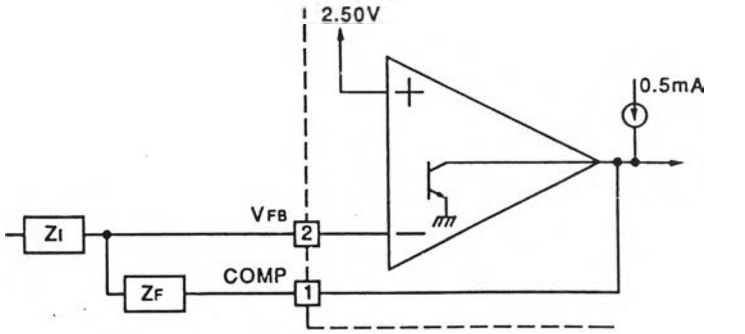
PARAMETER	TEST CONDITION	UC1842/3/4/5 UC2842/3/4/5			UC3842/3/4/5			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Output Section								
Output Low Level	I_{SINK} = 20mA		0.1	0.4		0.1	0.4	V
	I_{SINK} = 200mA		1.5	2.2		1.5	2.2	V
Output High Level	I_{SOURCE} = 20mA	13	13.5		13	13.5		V
	I_{SOURCE} = 200mA	12	13.5		12	13.5		V
Rise Time	T_J = 25°C, C_L = 1nF (Note 2)		50	150		50	150	ns
Fall Time	T_J = 25°C, C_L = 1nF (Note 2)		50	150		50	150	ns
Under-voltage Lockout Section								
Start Threshold	X842/4	15	16	17	14.5	16	17.5	V
	X843/5	7.8	8.4	9.0	7.8	8.4	9.0	V
Min. Operating Voltage After Turn On	X842/4	9	10	11	8.5	10	11.5	V
	X843/5	7.0	7.6	8.2	7.0	7.6	8.2	V
PWM Section								
Maximum Duty Cycle	X842/3	95	97	100	95	97	100	%
	X844/5	46	48	50	47	48	50	%
Minimum Duty Cycle				0			0	%
Total Standby Current								
Start-Up Current			0.5	1		0.5	1	mA
Operating Supply Current	$V_{PIN\,2}$ = $V_{PIN\,3}$ = 0V		11	17		11	17	mA
Vcc Zener Voltage	I_{CC} = 25mA	30	34		30	34		V

Note 2: These parameters, although guaranteed, are not 100% tested in production.
Note 3: Parameter measured at trip point of latch with $V_{PIN\,2}$ = 0.
Note 4: Gain defined as:

$$A = \frac{\Delta\, V_{PIN\,1}}{\Delta\, V_{PIN\,3}};\ 0 \le V_{PIN\,3} \le 0.8V.$$

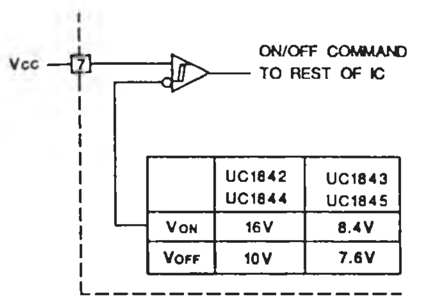
Note 5: Adjust Vcc above the start threshold before setting at 15V.
Note 6: Output frequency equals oscillator frequency for the UC1842 and UC1843. Output frequency is one half oscillator frequency for the UC1844 and UC1845.

ERROR AMP CONFIGURATION

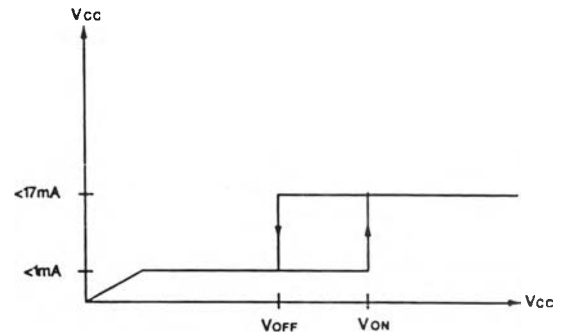


Error Amp can Source or Sink up to 0.5mA

UNDER-VOLTAGE LOCKOUT

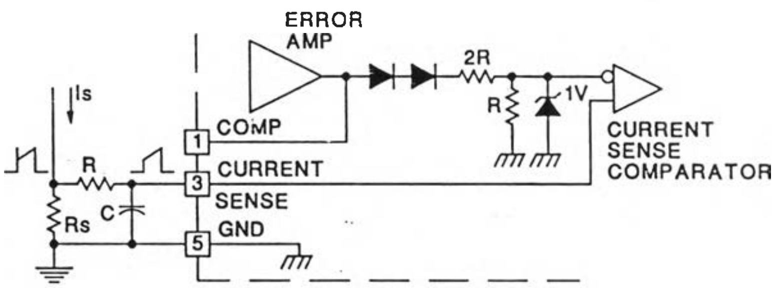


	UC1842 UC1844	UC1843 UC1845
V_{ON}	16V	8.4V
V_{OFF}	10V	7.6V



During under-voltage lock-out, the output driver is biased to sink minor amounts of current. Pin 6 should be shunted to ground with a bleeder resistor to prevent activating the power switch with extraneous leakage currents.

CURRENT SENSE CIRCUIT

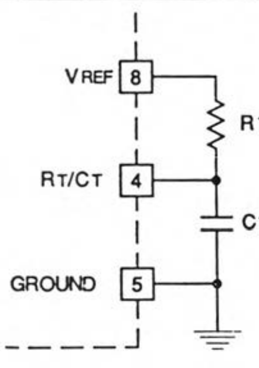


Peak Current (Is) is Determined By The Formula

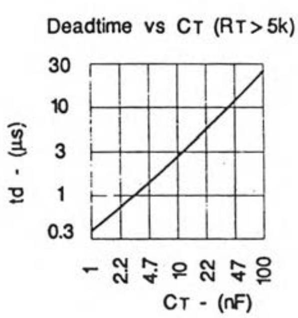
$$I_{SMAX} \approx \frac{1.0V}{R_S}$$

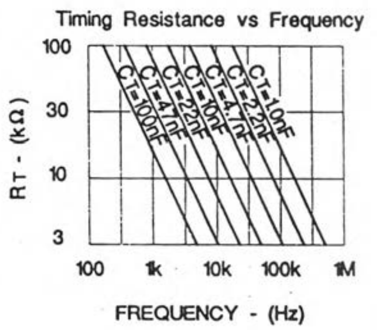
A small RC filter may be required to suppress switch transients.

OSCILLATOR SECTION

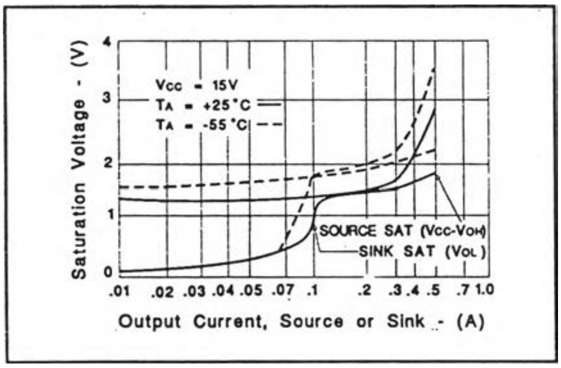


For $R_T > 5k$ $f \approx \frac{1.72}{R_T C_T}$

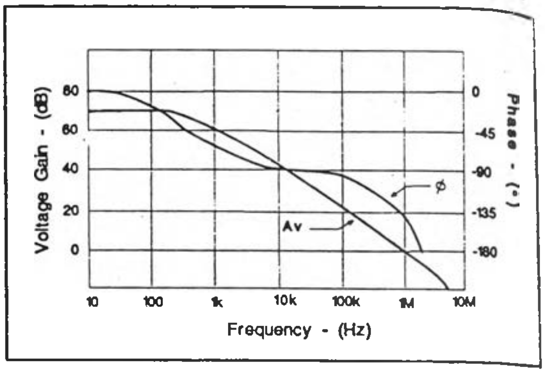




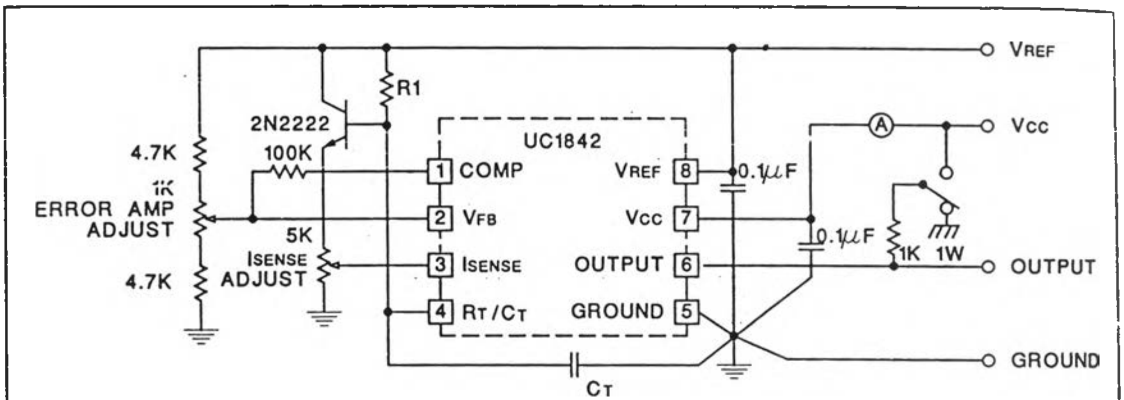
OUTPUT SATURATION CHARACTERISTICS



ERROR AMPLIFIER OPEN-LOOP FREQUENCY RESPONSE

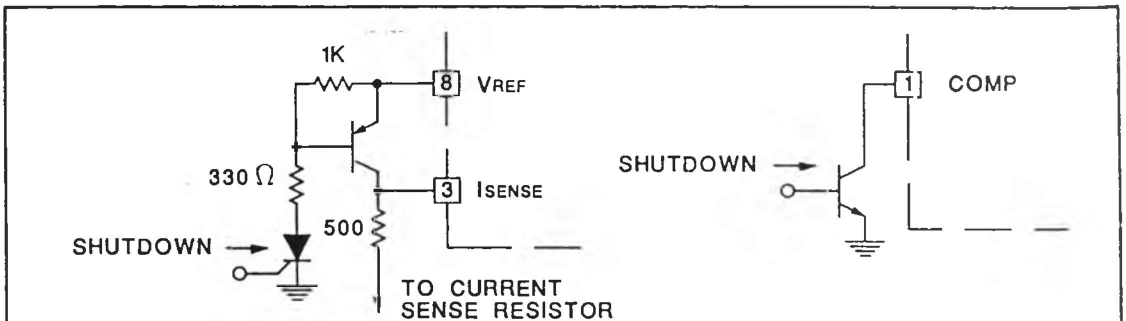


OPEN-LOOP LABORATORY FIXTURE



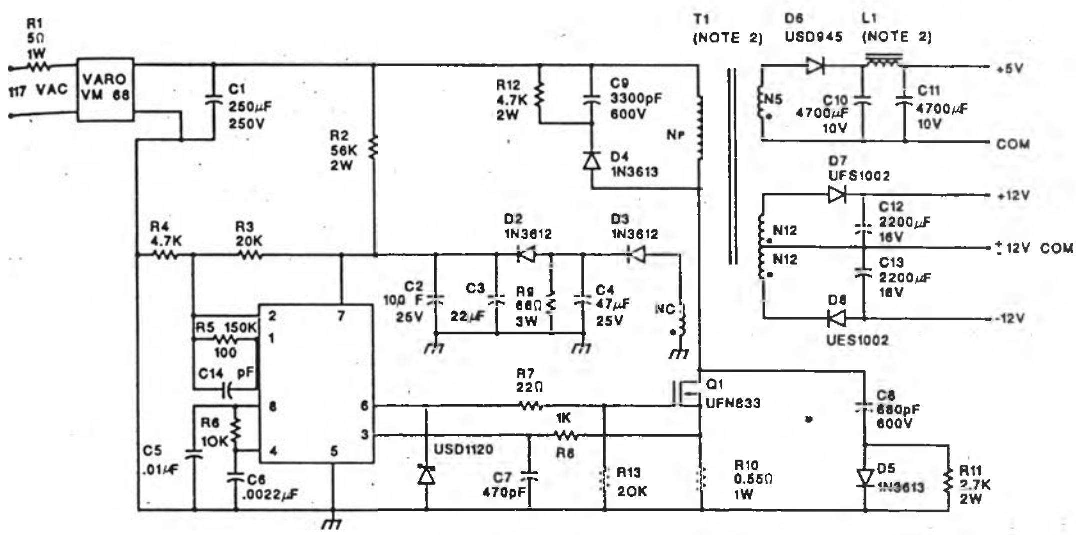
High peak currents associated with capacitive loads necessitate careful grounding techniques. Timing and bypass capacitors should be connected close to pin 5 in a single point ground. The transistor and 5k potentiometer are used to sample the oscillator waveform and apply an adjustable ramp to pin 3.

SHUT DOWN TECHNIQUES



Shutdown of the UC1842 can be accomplished by two methods; either raise pin 3 above 1V or pull pin 1 below a voltage two diode drops above ground. Either method causes the output of the PWM comparator to be high (refer to block diagram). The PWM latch is reset dominant so that the output will remain low until the next clock cycle after the shutdown condition at pin 1 and/or 3 is removed. In one example, an externally latched shutdown may be accomplished by adding an SCR which will be reset by cycling Vcc below the lower UVLO threshold. At this point the reference turns off, allowing the SCR to reset.

OFFLINE FLYBACK REGULATOR

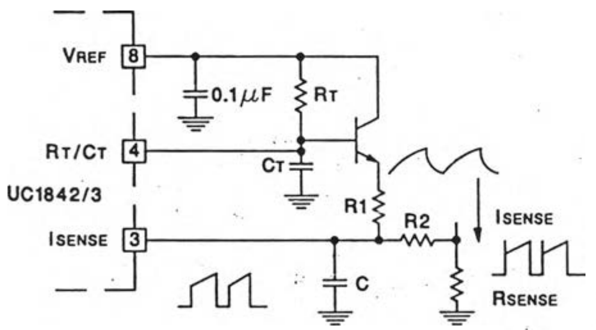


Power Supply Specifications

1. Input Voltage	95VAC to 130VA (50 Hz/60Hz)
2. Line Isolation	3750V
3. Switching Frequency	40kHz
4. Efficiency @ Full Load	70%

5. Output Voltage:
   - A. +5V, ±5%; 1A to 4A load
     Ripple voltage: 50mV P-P Max
   - B. +12V, ±3%; 0.1A to 0.3A load
     Ripple voltage: 100mV P-P Max
   - C. -12V ,±3%; 0.1A to 0.3A load
     Ripple voltage: 100mV P-P Max

SLOPE COMPENSATION



A fraction of the oscillator ramp can be resistively summed with the current sense signal to provide slope compensation for converters requiring duty cycles over 50%.

Note that capacitor, CT forms a filter with R2 to suppress the leading edge switch spikes.

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INTEGRATED CIRCUITS
UNITRODE

UC1842A/3A/4A/5A
UC2842A/3A/4A/5A
UC3842A/3A/4A/5A

Current Mode PWM Controller

FEATURES

- Optimized for Off-line and DC to DC Converters
- Low Start Up Current (<0.5mA)
- Trimmed Oscillator Discharge Current
- Automatic Feed Forward Compensation
- Pulse-by-Pulse Current Limiting
- Enhanced Load Response Characteristics
- Under-Voltage Lockout With Hysteresis
- Double Pulse Suppression
- High Current Totem Pole Output
- Internally Trimmed Bandgap Reference
- 500kHz Operation
- Low Ro Error Amp

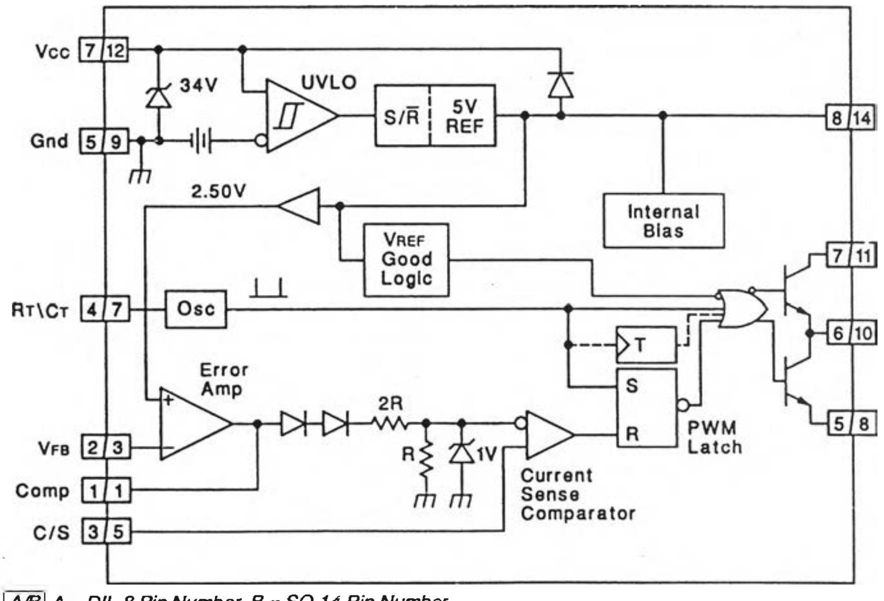
DESCRIPTION

The UC1842A/3A/4A/5A family of control ICs is a pin for pin compatible improved version of the UC3842/3/4/5 family. Providing the necessary features to control current mode switched mode power supplies, this family has the following improved features. Start up current is guaranteed to be less than 0.5mA. Oscillator discharge is trimmed to 8.3mA. During under voltage lockout, the output stage can sink at least 10mA at less than 1.2V for Vcc over 5V.

The difference between members of this family are shown in the table below.

Part #	UVLO On	UVLO Off	Maximum Duty Cycle
UC1842A	16.0V	10.0V	<100%
UC1843A	8.5V	7.9V	<100%
UC1844A	16.0V	10.0V	<50%
UC1845A	8.5V	7.9V	<50%

BLOCK DIAGRAM



Note 1: A/B A = DIL-8 Pin Number. B = SO-14 Pin Number.
Note 2: Toggle flip flop used only in 1844A and 1845A.

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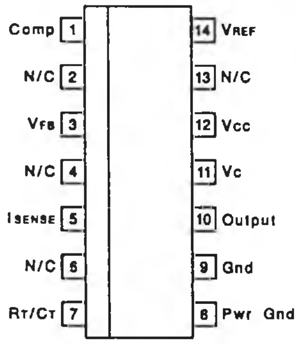
ABSOLUTE MAXIMUM RATINGS (Note 1)

Supply Voltage (Low Impedance Source) 30V
Supply Voltage (Icc mA)..................... Self Limiting
Output Current .... ±1A
Output Energy (Capacitive Load)..................... 5μJ
Analog Inputs (Pins 2, 3) .... -0.3V to +6.3V
Error Amp Output Sink Current 10mA
Power Dissipation at $T_A \leq 25°C$ (DIL-8)................ 1W
Storage Temperature Range .... -65°C to +150°C
Lead Temperature (Soldering, 10 Seconds) .... 300°C

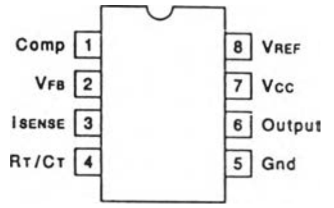
Note 1. All voltages are with respect to Ground, Pin 5. Currents are positive into, negative out of the specified terminal. Consult Packaging Section of Databook for thermal limitations and considerations of packages. Pin numbers refer to DIL package only.

SOIC-14 (TOP VIEW)
D Package

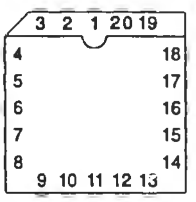


CONNECTION DIAGRAMS

DIL-8, SOIC-8 (TOP VIEW)
J or N, D8 Package



PLCC-20, LCC-20
(TOP VIEW)
Q, L Packages



PACKAGE PIN FUNCTION	
FUNCTION	PIN
N/C	1
Comp	2
N/C	3-4
VFB	5
N/C	6
ISENSE	7
N/C	8-9
RT/CT	10
N/C	11
Pwr Gnd	12
Gnd	13
N/C	14
Output	15
N/C	16
Vc	17
Vcc	18
N/C	19
VREF	20

ELECTRICAL CHARACTERISTICS

Unless otherwise stated, these specifications apply for $-55°C \leq T_A \leq 125°C$ for the UC184xA; $-40°C \leq T_A \leq 85°C$ for the UC284xA; $0 \leq T_A \leq 70°C$ for the UC384xA; V_{CC} = 15V (Note 5); R_T = 10k; C_T = 3.3nF; $T_A = T_J$; Pin numbers refer to DIL-8.

PARAMETER	TEST CONDITIONS	UC184xA\UC284xA			UC384xA			UNITS
		MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	
Reference Section								
Output Voltage	T_J = 25°C, Io = 1mA	4.95	5.00	5.05	4.90	5.00	5.10	V
Line Regulation	$12 \leq V_{IN} \leq 25V$		6	20		6	20	mV
Load Regulation	$1 \leq I_O \leq 20mA$		6	25		6	25	mV
Temp. Stability	(Note 2, Note 7)		0.2	0.4		0.2	0.4	mV/°C
Total Output Variation	Line, Load, Temp.	4.9		5.1	4.82		5.18	V
Output Noise Voltage	$10Hz \leq f \leq 10kHz$ T_J = 25°C (Note 2)		50			50		μV
Long Term Stability	T_A = 125°C, 1000Hrs. (Note 2)		5	25		5	25	mV
Output Short Circuit		-30	-100	-180	-30	-100	-180	mA
Oscillator Section								
Initial Accuracy	T_J = 25°C (Note 6)	47	52	57	47	52	57	kHz
Voltage Stability	$12 \leq V_{CC} \leq 25V$		0.2	1		0.2	1	%
Temp. Stability	$T_{MIN} \leq T_A \leq T_{MAX}$ (Note 2)		5			5		%
Amplitude	$V_{PIN 4}$ peak to peak (Note 2)		1.7			1.7		V
Discharge Current	T_J = 25°C, $V_{PIN 4}$ = 2V	7.8	8.3	8.8	7.8	8.3	8.8	mA

ELECTRICAL CHARACTERISTICS (cont.)

Unless otherwise stated, these specifications apply for -55°C ≤ T_A ≤ 125°C for the UC184xA; -40°C ≤ T_A ≤ 85°C for the UC284xA; 0 ≤ T_A ≤ 70°C for the UC384xA; V_{CC} = 15V (Note 5); R_T = 10k; C_T = 3.3nF; T_A = T_J; Pin numbers refer to DIL-8.

PARAMETER	TEST CONDITIONS	UC184xA\UC284xA			UC384xA			UNITS
		MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	
	$V_{PIN\,4}$ = 2V	7.5		8.8	7.6		8.8	mA
Error Amp Section								
Input Voltage	$V_{PIN\,1}$ = 2.5V	2.45	2.50	2.55	2.42	2.50	2.58	V
Input Bias Current			-0.3	-1		-0.3	-2	µA
A_{VOL}	2 ≤ V_O ≤ 4V	65	90		65	90		dB
Unity Gain Bandwidth	T_J = 25°C (Note 2)	0.7	1		0.7	1		MHz
PSRR	12 ≤ V_{CC} ≤ 25V	60	70		60	70		dB
Output Sink Current	$V_{PIN\,2}$ = 2.7V, $V_{PIN\,1}$ = 1.1V	2	6		2	6		mA
Output Source Current	$V_{PIN\,2}$ = 2.3V, $V_{PIN\,1}$ = 5V	-0.5	-0.8		-0.5	-0.8		mA
V_{OUT} High	$V_{PIN\,2}$ = 2.3V, R_L = 15k to ground	5	6		5	6		V
V_{OUT} Low	$V_{PIN\,2}$ = 2.7V, R_L = 15k to Pin 8		0.7	1.1		0.7	1.1	V
Current Sense Section								
Gain	(Note 3, Note 4)	2.85	3	3.15	2.85	3	3.15	V/V
Maximum Input Signal	$V_{PIN\,1}$ = 5V (Note 3)	0.9	1	1.1	0.9	1	1.1	V
PSRR	12 ≤ V_{CC} ≤ 25V (Note 3)		70			70		dB
Input Bias Current			-2	-10		-2	-10	µA
Delay to Output	$V_{PIN\,3}$ = 0 to 2V (Note 2)		150	300		150	300	ns
Output Section								
Output Low Level	I_{SINK} = 20mA		0.1	0.4		0.1	0.4	V
	I_{SINK} = 200mA		15	2.2		15	2.2	V
Output High Level	I_{SOURCE} = 20mA	13	13.5		13	13.5		V
	I_{SOURCE} = 200mA	12	13.5		12	13.5		V
Rise Time	T_J = 25°C, C_L = 1nF (Note 2)		50	150		50	150	ns
Fall Time	T_J = 25°C, C_L = 1nF (Note 2)		50	150		50	150	ns
UVLO Saturation	V_{CC} = 5V, I_{SINK} = 10mA		0.7	1.2		0.7	1.2	V
Under-Voltage Lockout Section								
Start Threshold	x842A/4A	15	16	17	14.5	16	17.5	V
	x843A/5A	7.8	8.4	9.0	7.8	8.4	9.0	V
Min. Operation Voltage After	x842A/4A	9	10	11	8.5	10	11.5	V
TurnOn	x843A/5A	7.0	7.6	8.2	7.0	7.6	8.2	V
PWM Section								
Maximum Duty Cycle	x842A/3A	94	96	100	94	96	100	%
	x844A/5A	47	48	50	47	48	50	%
Minimum Duty Cycle				0			0	%
Total Standby Current								
Start-Up Current			0.3	0.5		0.3	0.5	mA
Operating Supply Current	$V_{PIN\,2}$ = $V_{PIN\,3}$ = 0V		11	17		11	17	mA

Note 2: These parameters, although guaranteed, are not 100% tested in production.

Note 3: Parameter measured at trip point of latch with V_{PIN2} = 0.

Note 4: Gain defined as: $A = \frac{\Delta V_{PIN\,1}}{\Delta V_{PIN\,3}}$; $0 \le V_{PIN\,3} \le 0.8V$.

Note 5: Adjust Vcc above the start threshold before setting at 15V.

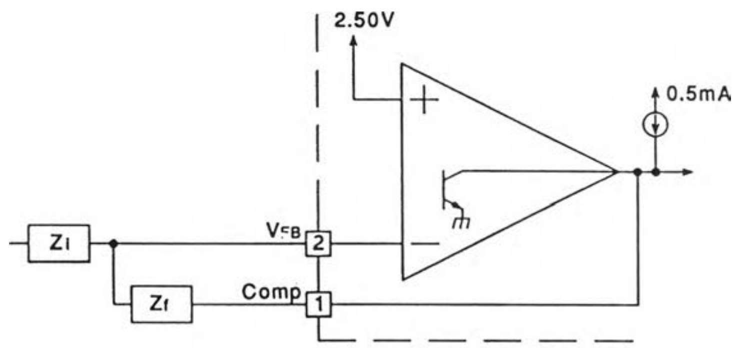
Note 6: Output frequency equals oscillator frequency for the UC1842A and UC1843A. Output frequency is one half oscillator frequency for the UC1844A and UC1845A.

Note 7: "Temperature stability, sometimes referred to as average temperature coefficient, is described by the equation:

$$Temp\ Stability = \frac{V_{REF}(max) - V_{REF}(min)}{T_J(max) - T_J(min)}.$$

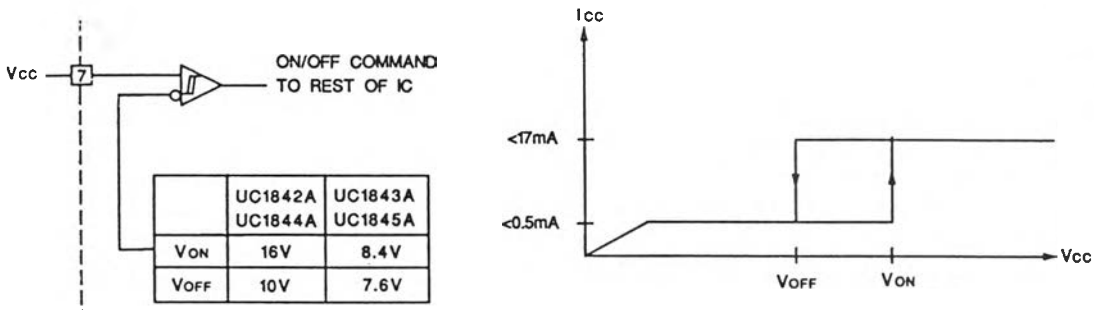
V_{REF} (max) and V_{REF} (min) are the maximum & minimum reference voltage measured over the appropriate temperature range. Note that the extremes in voltage

Error Amp Configuration



Error Amp can Source and Sink up to 0.5mA, and Sink up to 2mA.

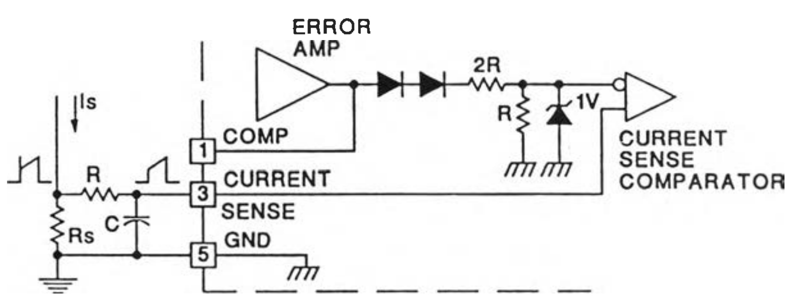
Under-Voltage Lockout



	UC1842A UC1844A	UC1843A UC1845A
V_{ON}	16V	8.4V
V_{OFF}	10V	7.6V

During UVLO, the Output is low.

Current Sense Circuit



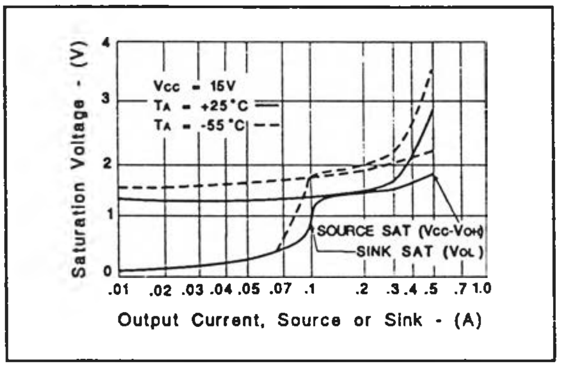
Peak Current (Is) is Determined By The Formula

$$I_{SMAX} = \frac{1.0V}{R_S}$$

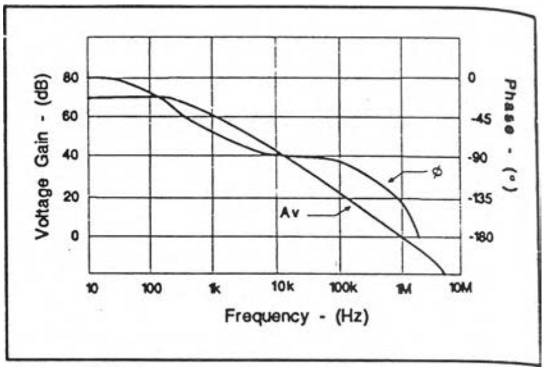
A small RC filter may be required to suppress switch transients.

APPLICATIONS DATA (cont.)

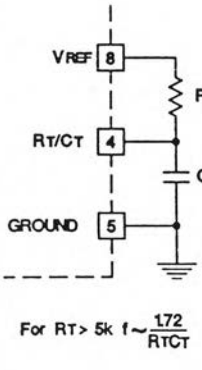
Output Saturation Characteristics



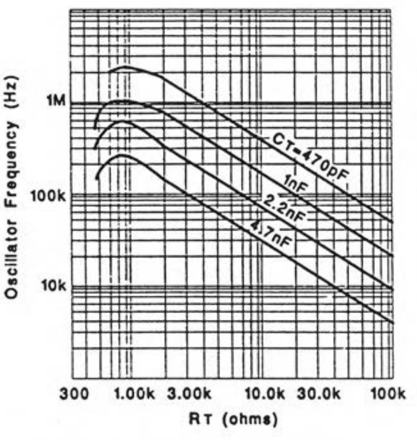
Error Amplifier Open-Loop Frequency Response



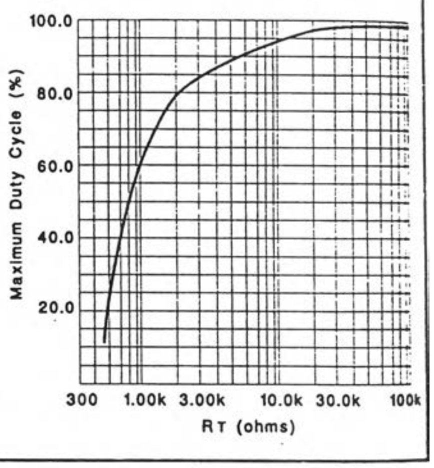
Oscillator Section



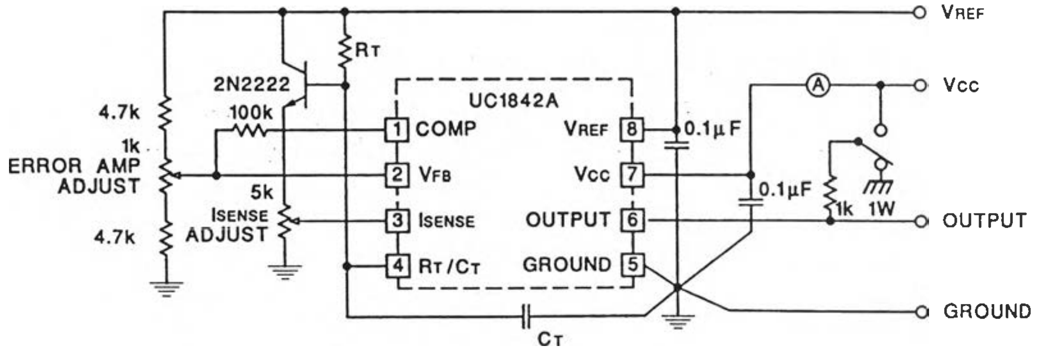
Oscillator Frequency vs Timing Resistance



Maximum Duty Cycle vs Timing Resistor



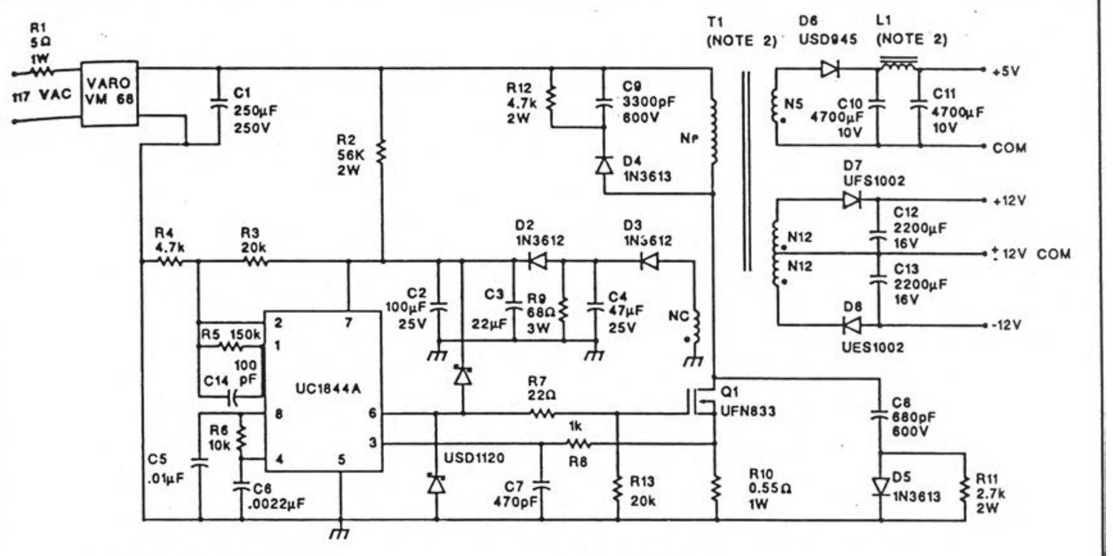
Open-Loop Laboratory Test Fixture



High peak currents associated with capacitive loads necessitate careful grounding techniques. Timing and bypass capacitors should be connected close to pin 5 in a single point ground. The transistor and 5k potentiometer are used to sample the oscillator waveform and apply an adjustable ramp to pin 3.

APPLICATIONS DATA (cont.)

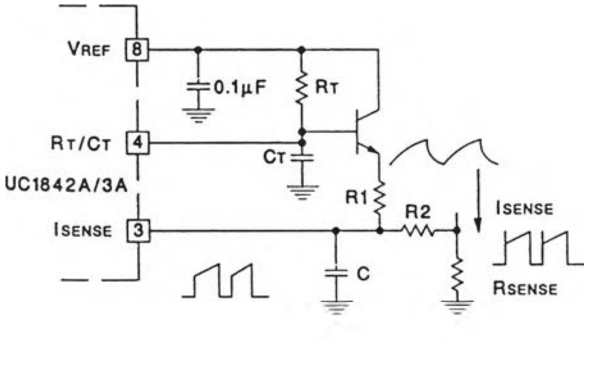
Off-line Flyback Regulator



Power Supply Specifications

1. Input Voltage — 95VAC to 130VA (50 Hz/60Hz)
2. Line Isolation — 3750V
3. Switching Frequency — 40kHz
4. Efficiency @ Full Load — 70%
5. Output Voltage:
   A. +5V, ±5%; 1A to 4A load
      Ripple voltage: 50mV P-P Max
   B. +12V, ±3%; 0.1A to 0.3A load
      Ripple voltage: 100mV P-P Max
   C. -12V ,±3%; 0.1A to 0.3A load
      Ripple voltage: 100mV P-P Max

Slope Compensation



A fraction of the oscillator ramp can be resistively summed with the current sense signal to provide slope compensation for converters requiring duty cycles over 50%.
Note that capacitor, C, forms a filter with R2 to suppress the leading edge switch spikes.

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International
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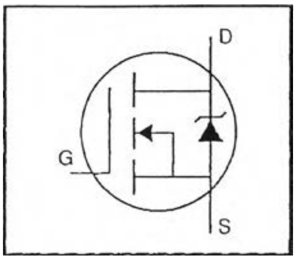
IRFPG50

HEXFET® Power MOSFET

- Dynamic dv/dt Rating
- Repetitive Avalanche Rated
- Isolated Central Mounting Hole
- Fast Switching
- Ease of Paralleling
- Simple Drive Requirements



$V_{DSS} = 1000V$

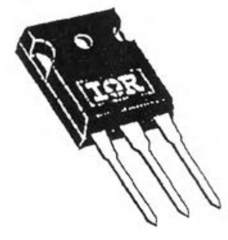
$R_{DS(on)} = 2.0\Omega$

$I_D = 6.1A$

Description

Third Generation HEXFETs from International Rectifier provide the designer with the best combination of fast switching, ruggedized device design, low on-resistance and cost-effectiveness.

The TO-247 package is preferred for commercial–industrial applications where higher power levels preclude the use of TO-220 devices. The TO-247 is similar but superior to the earlier TO-218 package because of its isolated mounting hole. It also provides greater creepage distance between pins to meet the requirements of most safety specifications.



TO-247AC

Absolute Maximum Ratings

	Parameter	Max.	Units
I_D @ T_C = 25°C	Continuous Drain Current, V_{GS} @ 10 V	6.1	A
I_D @ T_C = 100°C	Continuous Drain Current, V_{GS} @ 10 V	3.9	
I_{DM}	Pulsed Drain Current ①	24	
P_D @ T_C = 25°C	Power Dissipation	190	W
	Linear Derating Factor	1.5	W/°C
V_{GS}	Gate-to-Source Voltage	±20	V
E_{AS}	Single Pulse Avalanche Energy ②	800	mJ
I_{AR}	Avalanche Current ①	6.0	A
E_{AR}	Repetitive Avalanche Energy ①	19	mJ
dv/dt	Peak Diode Recovery dv/dt ③	1.0	V/ns
T_J T_{STG}	Operating Junction and Storage Temperature Range	-55 to +150	°C
	Soldering Temperature, for 10 seconds	300 (1.6mm from case)	
	Mounting Torque, 6-32 or M3 screw	10 lbf•in (1.1 N•m)	

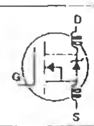
Thermal Resistance

	Parameter	Min.	Typ.	Max.	Units
$R_{\theta JC}$	Junction-to-Case	—	—	0.65	°C/W
$R_{\theta CS}$	Case-to-Sink, Flat, Greased Surface	—	0.24	—	
$R_{\theta JA}$	Junction-to-Ambient	—	—	40	

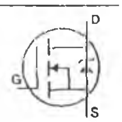
IRFPG50

International
IOR Rectifier

Electrical Characteristics @ T_J = 25°C (unless otherwise specified)

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$V_{(BR)DSS}$	Drain-to-Source Breakdown Voltage	1000	—	—	V	V_{GS}=0V, I_D= 250μA
$\Delta V_{(BR)DSS}/\Delta T_J$	Breakdown Voltage Temp. Coefficient	—	1.2	—	V/°C	Reference to 25°C, I_D= 1mA
$R_{DS(on)}$	Static Drain-to-Source On-Resistance	—	—	2.0	Ω	V_{GS}=10V, I_D=3.6A ④
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	V_{DS}=V_{GS}, I_D= 250μA
g_{fs}	Forward Transconductance	5.4	—	—	S	V_{DS}=100V, I_D=3.6A ④
I_{DSS}	Drain-to-Source Leakage Current	—	—	100	μA	V_{DS}=1000V, V_{GS}=0V
		—	—	500		V_{DS}=800V, V_{GS}=0V, T_J=125°C
I_{GSS}	Gate-to-Source Forward Leakage	—	—	100	nA	V_{GS}=20V
	Gate-to-Source Reverse Leakage	—	—	-100		V_{GS}=-20V
Q_g	Total Gate Charge	—	—	190	nC	I_D=6.1A
Q_{gs}	Gate-to-Source Charge	—	—	23		V_{DS}=400V
Q_{gd}	Gate-to-Drain ("Miller") Charge	—	—	110		V_{GS}=10V See Fig. 6 and 13 ④
$t_{d(on)}$	Turn-On Delay Time	—	19	—	ns	V_{DD}=500V
t_r	Rise Time	—	35	—		I_D=6.1A
$t_{d(off)}$	Turn-Off Delay Time	—	130	—		R_G=6.2Ω
t_f	Fall Time	—	36	—		R_D=81Ω See Figure 10 ④
L_D	Internal Drain Inductance	—	5.0	—	nH	Between lead, 6 mm (0.25in.) from package and center of die contact 
L_S	Internal Source Inductance	—	13	—		
C_{iss}	Input Capacitance	—	2800	—	pF	V_{GS}=0V
C_{oss}	Output Capacitance	—	250	—		V_{DS}=25V
C_{rss}	Reverse Transfer Capacitance	—	84	—		f=1.0MHz See Figure 5

Source-Drain Ratings and Characteristics

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
I_S	Continuous Source Current (Body Diode)	—	—	6.1	A	MOSFET symbol showing the integral reverse p-n junction diode. 
I_{SM}	Pulsed Source Current (Body Diode) ①	—	—	24		
V_{SD}	Diode Forward Voltage	—	—	1.8	V	T_J=25°C, I_S=6.1A, V_{GS}=0V ④
t_{rr}	Reverse Recovery Time	—	630	950	ns	T_J=25°C, I_F=6.1A
Q_{rr}	Reverse Recovery Charge	—	3.5	5.3	μC	di/dt=100A/μs ④
t_{on}	Forward Turn-On Time	Intrinsic turn-on time is neglegible (turn-on is dominated by L_S+L_D)				

Notes:

① Repetitive rating; pulse width limited by max. junction temperature (See Figure 11)

② V_{DD}=50V, starting T_J=25°C, L=40mH R_G=25Ω, I_{AS}=6.1A (See Figure 12)

③ I_{SD}≤6.1A, di/dt≤120A/μs, V_{DD}≤600 , T_J≤150°C

④ Pulse width ≤ 300 μs; duty cycle ≤2%.

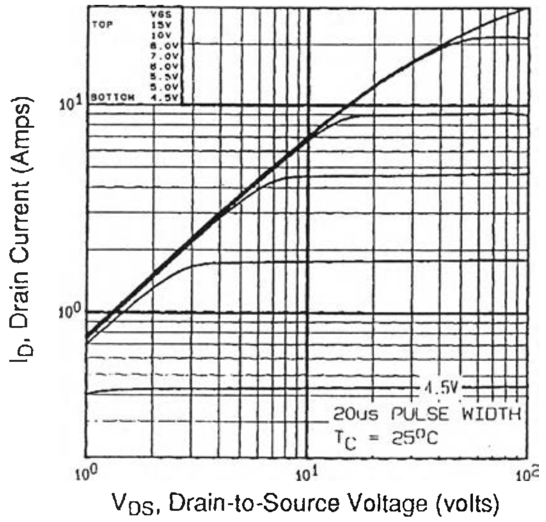


Fig 1. Typical Output Characteristics

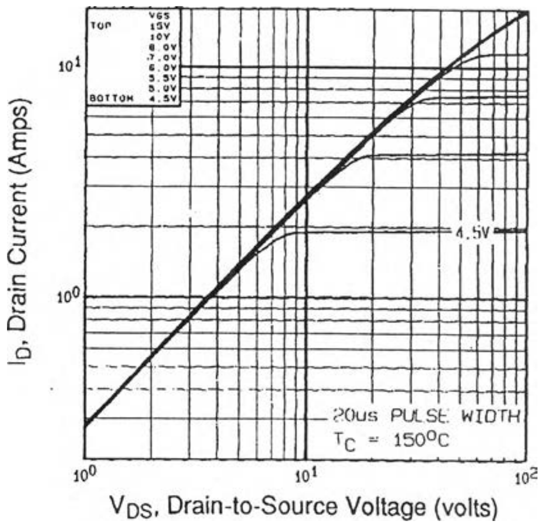


Fig 2. Typical Output Characteristics

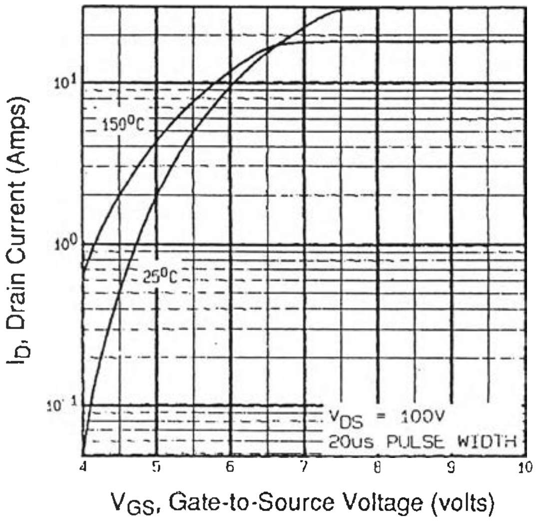


Fig 3. Typical Transfer Characteristics

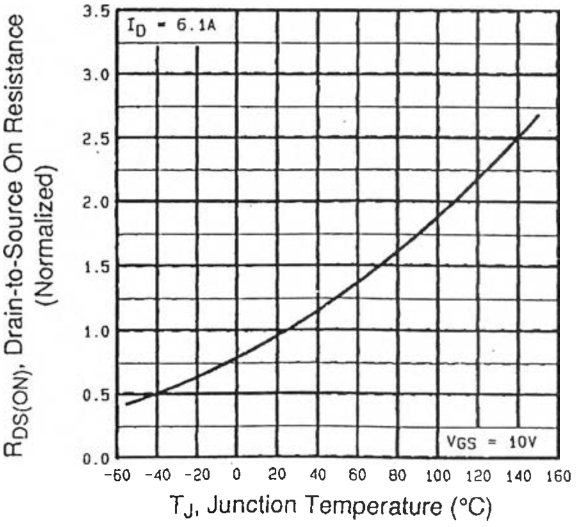


Fig 4. Normalized On-Resistance Vs. Temperature

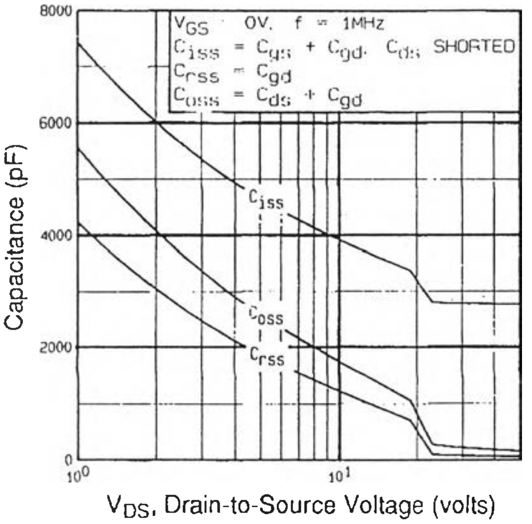


Fig 5. Typical Capacitance Vs. Drain-to-Source Voltage

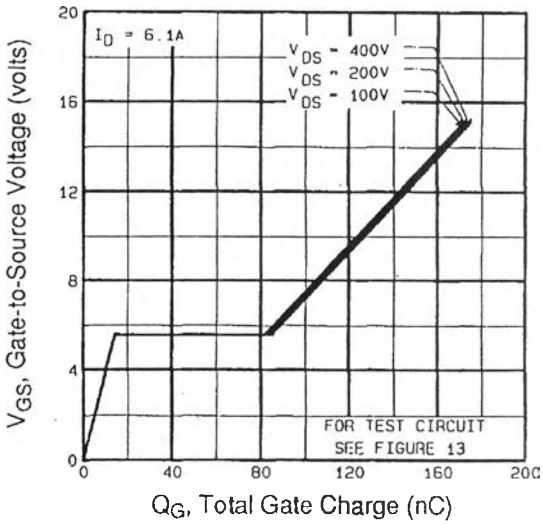


Fig 6. Typical Gate Charge Vs. Gate-to-Source Voltage

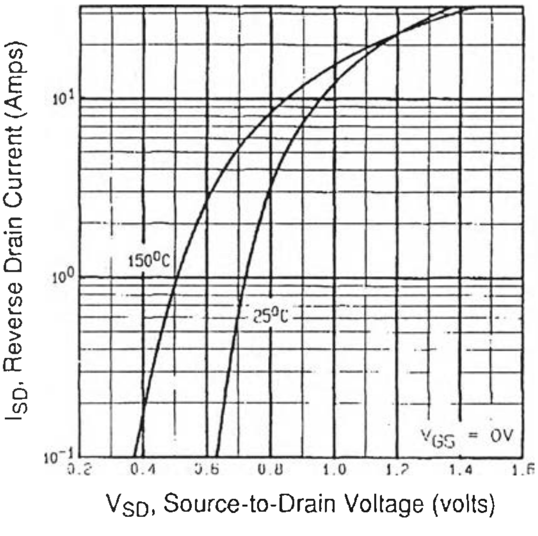


Fig 7. Typical Source-Drain Diode Forward Voltage

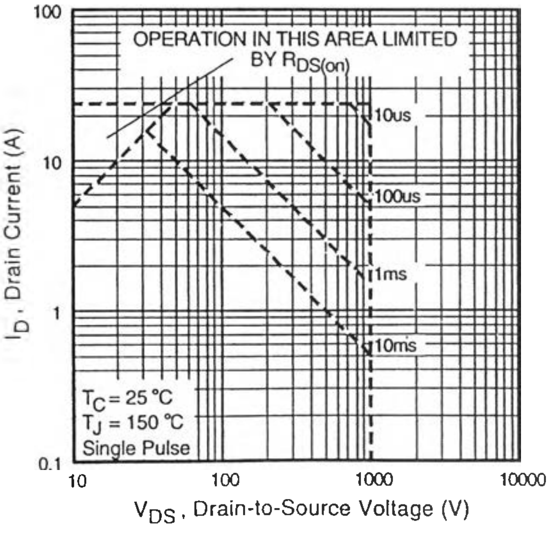


Fig 8. Maximum Safe Operating Area

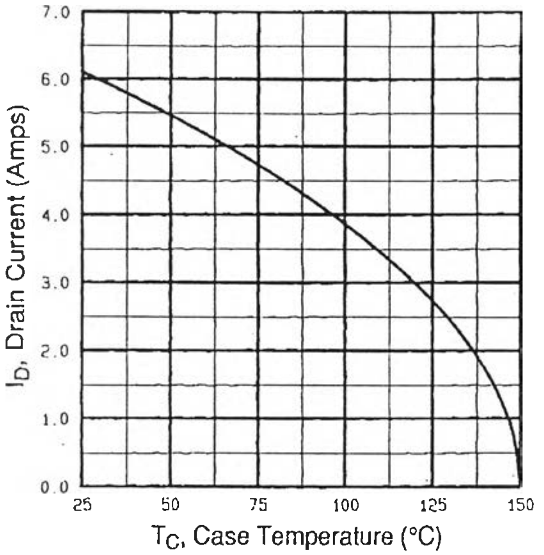


Fig 9. Maximum Drain Current Vs. Case Temperature

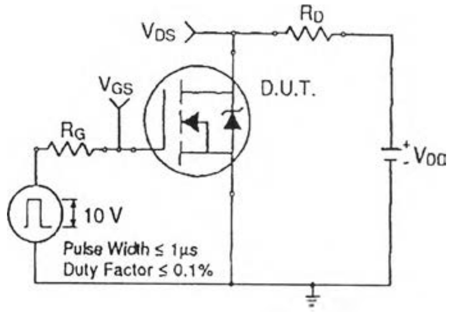


Fig 10a. Switching Time Test Circuit

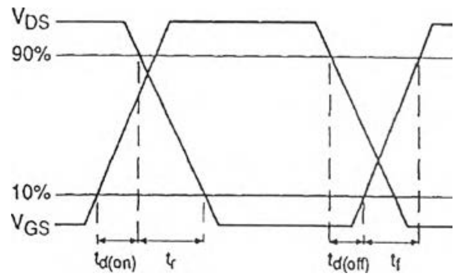


Fig 10b. Switching Time Waveforms

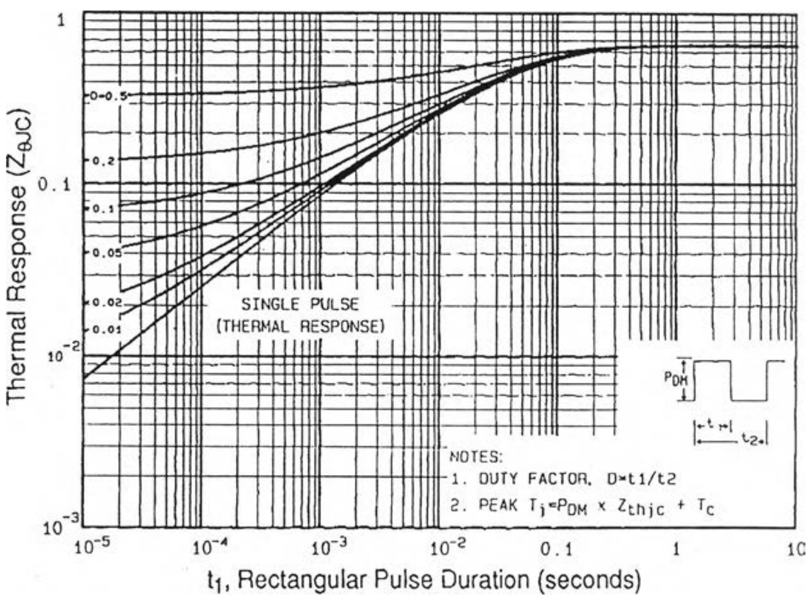


Fig 11. Maximum Effective Transient Thermal Impedance, Junction-to-Case

IRFPG50

International
IOR Rectifier

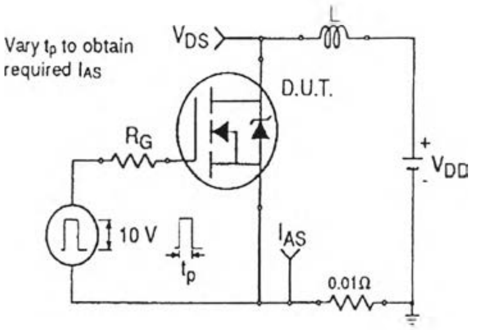


Fig 12a. Unclamped Inductive Test Circuit

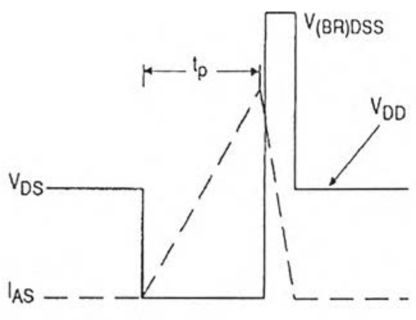


Fig 12b. Unclamped Inductive Waveforms

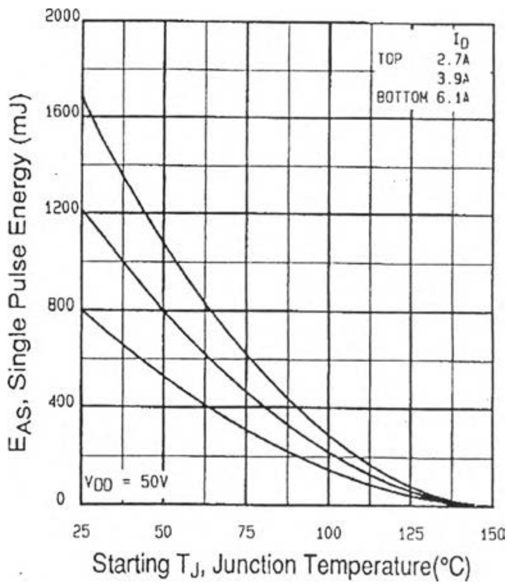


Fig 12c. Maximum Avalanche Energy Vs. Drain Current

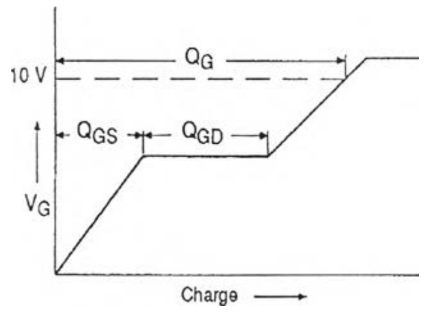


Fig 13a. Basic Gate Charge Waveform

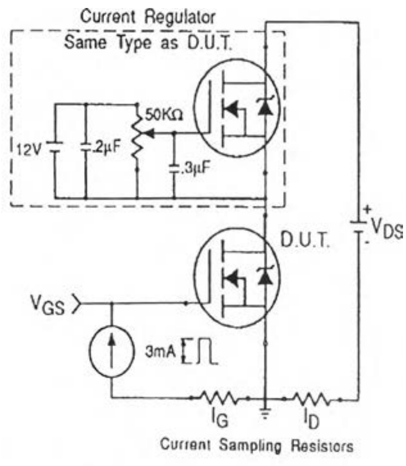


Fig 13b. Gate Charge Test Circuit

Peak Diode Recovery dv/dt Test Circuit

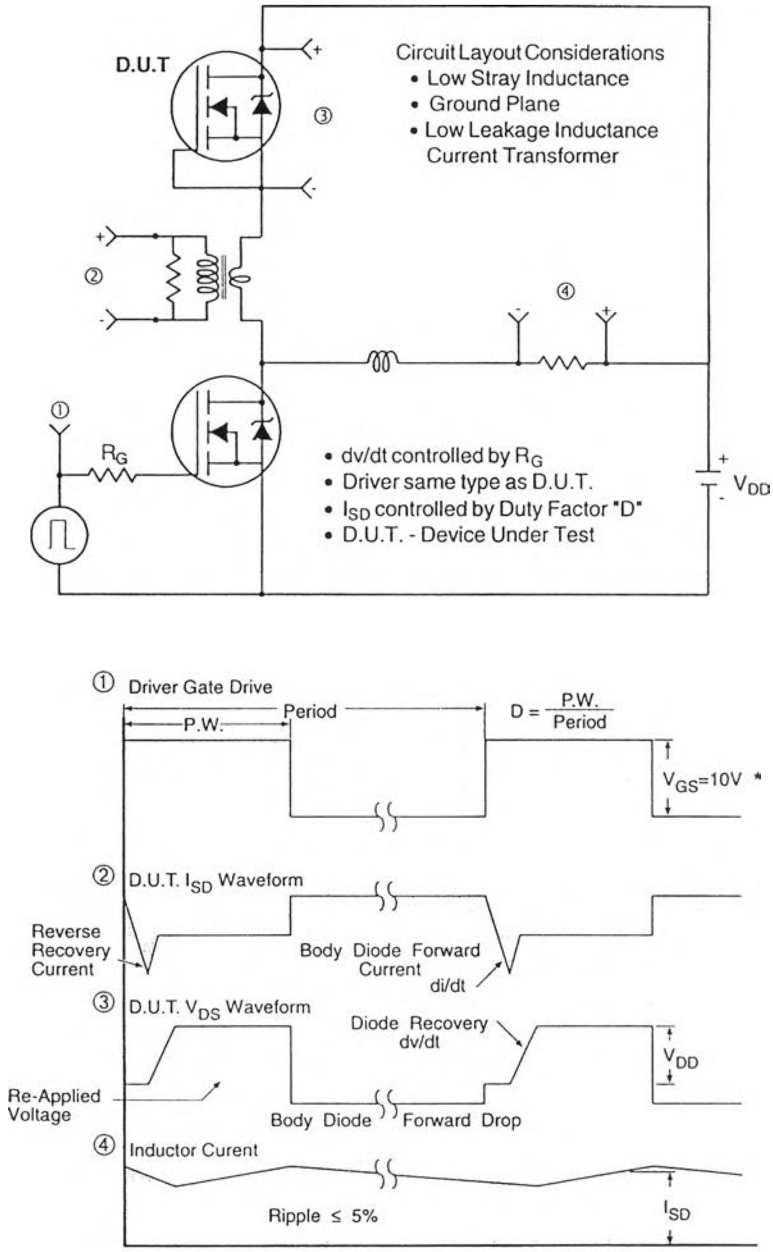
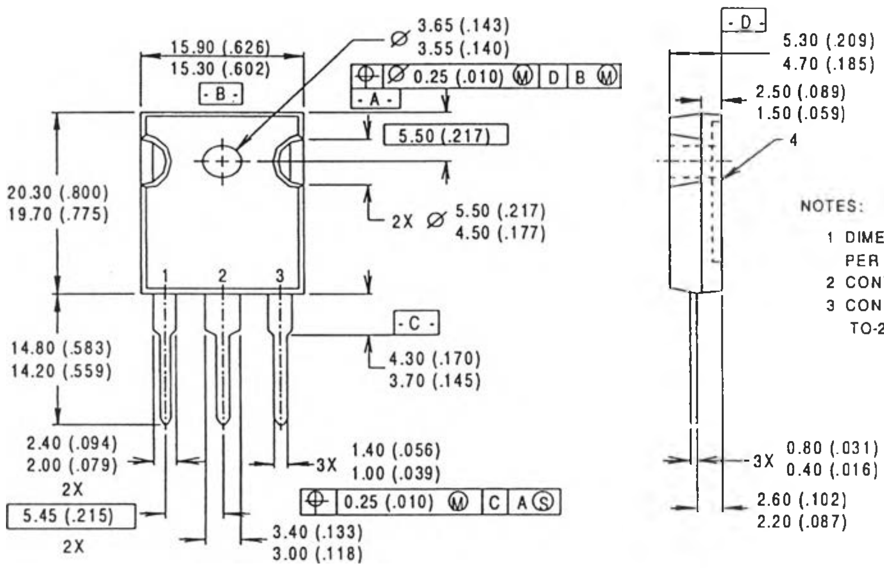


Fig 14. For N-Channel HEXFETS

TO-247AC Package Details



NOTES:

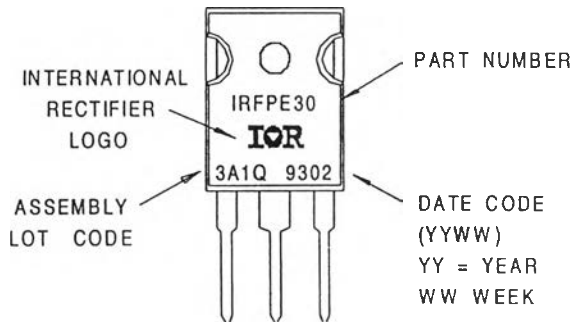
1 DIMENSIONING & TOLERANCING PER ANSI Y14.5M, 1982.
2 CONTROLLING DIMENSION : INCH.
3 CONFORMS TO JEDEC OUTLINE TO-247-AC.

LEAD ASSIGNMENTS

1 - GATE
2 - DRAIN
3 - SOURCE
4 - DRAIN

Part Marking

EXAMPLE : THIS IS AN IRFPE30 WITH ASSEMBLY LOT CODE 3A1Q



International
IOR Rectifier

WORLD HEADQUARTERS: 233 Kansas St., El Segundo, California 90245, Tel: (310) 322 3331
EUROPEAN HEADQUARTERS: Hurst Green, Oxted, Surrey RH8 9BB, UK Tel: ++ 44 1883 732020
IR CANADA: 15 Lincoln Court, Brampton, Ontario L6T 3Z2, Tel: (905) 453 2200
IR GERMANY: Saalburgstrasse 157, 61350 Bad Homburg Tel: ++ 49 6172 96590
IR ITALY: Via Liguria 49, 10071 Borgaro, Torino Tel: ++ 39 11 451 0111
IR FAR EAST: 171 (K&H Bldg.) 30-4 Nishi-ikebukuro 3-chome, Toshima-ku, Tokyo Japan Tel: 81 33 983 0086
IR SOUTHEAST ASIA: 315 Outram Road, #10-02 Tan Boon Liat Building, Singapore 16907 Tel: 65 221 8371

Data and specifications subject to change without notice.

Material characteristics

Material	Symbol	Unit	H 56 Z	H 55 Z	H 54 Z	H 53 Z	H 52 A	H 52 B	H 52 Z	H 51 A	H 51 Z
Initial permeability	μ iac		11 ±20%	17 ±20%	50 ±20%	130 ±20%	250 ±20%	800 ±20%	1200 ±20%	1200 ±20%	1200 ±15%
Relative loss facter	tan δ / μ	X 10⁻⁶	<200 40MHz <250 100MHz	<160 40MHz <220 100MHz	< 60 5 MHz ≤ 80 10MHz	< 30 1 MHz <120 10MHz	< 25 1 MHz < 60 5 MHz	< 20 0.5MHz < 40 1 MHz	< 5 0.1MHz < 12 0.5MHz	< 3 0.1MHz < 8 0.5MHz	<1.5 0.1MHz < 4 0.5MHz
Temperature factor −30~20 °C 20~55 °C 20~70 °C	α μ r	X 10⁻⁶			 4~20	 3~10 3~10	 0~5	 0~2 	 1.5~7 1.5~7	 0.2~2	 0.3~2 0.2~1
Saturation flux density	Bs	Gauss	2000	2100	2500	2900	3300	3900	3800	4650	4650
		mT	200	210	250	290	330	390	380	465	465
Residual flux density	Br	Gauss	1100	1200	1300	1600	2200	1700	1600	1500	1500
		mT	110	120	130	160	220	170	160	150	150
Coercive force	Hc	Oe	12	10	8.0	3.0	2.0	0.7	0.5	0.5	0.5
		A/m	960	800	640	240	160	56	40	40	40
Hysteresis material constant	η B	X 10⁻⁶ / mT						<1.8 10kHz	<0.5 10kHz	<0.6 100kHz	<0.4 100kHz
Disaccomodation factor	DF	X 10⁻⁶	< 50	<−50	< 30	< 20	< 10	< 20	< 10	< 6	< 4
Curie temperature	Tc	°C	>450	>450	>400	>350	>300	>250	>230	>200	>200
Resistivity	ρ	Ω-cm	10^5	10^5	10^5	10^5	10^4	500	500	500	500
Density	d	g/cm³	4.3	4.3	4.5	4.5	4.4	4.6	4.7	4.7	4.7

Note : 1) The values were obtained with toroidal cores (FR 25 φ/15 φ/5).

2) The values were obtained at 23±2 °C unless otherwise specified.

3) Initial permeability were measured at 10 kHz, 0.8 A/m.

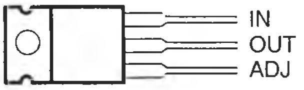
H 21 B	H 22 Z	H 23 B	H 24 B	H 24 A	H 24 Z	H 25 Z	H 28 B	H 49 N	H 49 B	H 45	H 63	H 63 B	H 45 A	H 63 A
2000 ±20%	2000 ±20%	3500 ±20%	4000 ±20%	5000 ±20%	7000 ±25%	12000 ±30%	3500 ±20%	1600 ±20%	1700 ±20%	2500 ±20%	2500 ±20%	2000 ±20%	2400 ±20%	1250 ±20%
<3.5 100kHz	<2.5 100kHz	<3.0 10kHz	< 15 100kHz	< 40 100kHz	< 7 10kHz	< 8 10kHz	< 50 100kHz	< 5 100kHz	< 8 100kHz	< 4 100kHz	< 4 100kHz	< 5 100kHz	< 5 100kHz	< 3 100kHz
0.5~2 0.5~2	0.4~1.2 0.4~1.2	0~2.0 0~2.0	0~1.5 0~1.5	-0.5~2 -0.5~2	0~2.0 0~2.0	0~1.5	-3~3							
4100	4200	4000	4400	4500	4000	4000	4700	5000	5300	4700	5200	5000	4800	4700
410	420	400	440	450	400	400	470	500	530	470	520	500	480	470
1100	800	900	1500	1500	900	950	1000	1500	1800	1000	1200	1500	1200	3100
110	80	90	150	150	90	95	100	150	180	100	120	150	120	310
0.30	0.15	0.30	0.13	0.13	0.13	0.05	0.20	0.16	0.20	0.16			0.16	0.25
24.0	12.0	24.0	10.4	10.4	10.4	4.0	16.0	12.8			12.8	12.8	12.8	20.0
<0.4 10kHz	<0.4 10kHz	<1.0 10kHz	<1.0 10kHz	<1.0 10kHz	<1.0 10kHz	<1.0 10kHz	<0.8 100kHz							
<3.0	<2.0	<3.0	<3.0	<3.0	<3.0	<2.0	<3.0							
>160	>170	>125	>145	>145	>125	>125	>200	>230	>230	>200	>230	>200	>200	>270
400	500	20	20	10	3	3	100	100	1000	100	100	100	100	1000
4.8	4.8	4.8	4.8	4.8	4.9	4.9	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.7

TL783
HIGH-VOLTAGE ADJUSTABLE REGULATOR

SLVS036E – SEPTEMBER 1981 – REVISED FEBRUARY 2000

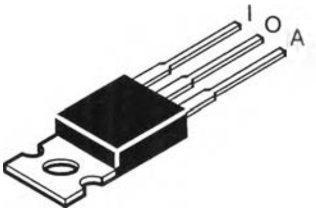
- **Output Adjustable From 1.25 V to 125 V When Used With an External Resistor Divider**
- **700-mA Output Current**
- **Full Short-Circuit, Safe-Operating-Area, and Thermal-Shutdown Protection**
- **0.001%/V Typical Input Voltage Regulation**
- **0.15% Typical Output Voltage Regulation**
- **76-dB Typical Ripple Rejection**
- **Standard TO-220AB Package**

KC PACKAGE
(TOP VIEW)



The OUT terminal is in electrical contact with the mounting base.

TO-220AB



description

The TL783 is an adjustable three-terminal high-voltage regulator with an output range of 1.25 V to 125 V and a DMOS output transistor capable of sourcing more than 700 mA. It is designed for use in high-voltage applications where standard bipolar regulators cannot be used. Excellent performance specifications, superior to those of most bipolar regulators, are achieved through circuit design and advanced layout techniques.

As a state-of-the-art regulator, the TL783 combines standard bipolar circuitry with high-voltage double-diffused MOS transistors on one chip to yield a device capable of withstanding voltages far higher than standard bipolar integrated circuits. Because of its lack of secondary-breakdown and thermal-runaway characteristics usually associated with bipolar outputs, the TL783 maintains full overload protection while operating at up to 125 V from input to output. Other features of the device include current limiting, safe-operating-area (SOA) protection, and thermal shutdown. Even if ADJ is inadvertently disconnected, the protection circuitry remains functional.

Only two external resistors are required to program the output voltage. An input bypass capacitor is necessary only when the regulator is situated far from the input filter. An output capacitor, although not required, improves transient response and protection from instantaneous output short circuits. Excellent ripple rejection can be achieved without a bypass capacitor at the adjustment terminal.

The TL783C is characterized for operation over the virtual junction temperature range of 0°C to 125°C.

AVAILABLE OPTIONS

T_J	PACKAGED DEVICE HEAT-SINK MOUNTED (KC)	CHIP FORM (Y)
0°C to 125°C	TL783CKC	TL783Y

Chip forms are tested at 25°C.

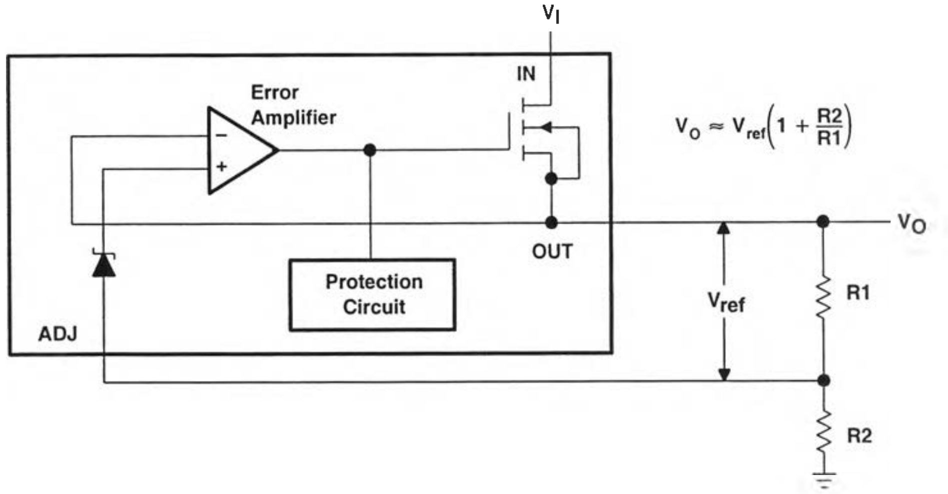
Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

TEXAS INSTRUMENTS
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

TL783
HIGH-VOLTAGE ADJUSTABLE REGULATOR

SLVS036E – SEPTEMBER 1981 – REVISED FEBRUARY 2000

functional block diagram



absolute maximum ratings over operating temperature range (unless otherwise noted)†

Input-to-output differential voltage, $V_I - V_O$ .... 125 V
Operating free-air, T_A; case, T_C; or virtual junction, T_J, temperature .... 150°C
Package thermal impedance, θ_{JA} (see Notes 1 and 2) .... 22°C/W
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds .... 260°C
Storage temperature range, T_{stg} .... –65°C to 150°C

† Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

NOTES: 1. Maximum power dissipation is a function of T_J(max), θ_{JA}, and T_A. The maximum allowable power dissipation at any allowable ambient temperature is $P_D = (T_J(max) - T_A)/\theta_{JA}$. Operating at the absolute maximum T_J of 150°C can impact reliability. Due to variations in individual device electrical characteristics and thermal resistance, the built-in thermal overload protection may be activated at power levels slightly above or below the rated dissipation.
2. The package thermal impedance is calculated in accordance with JESD 51.

recommended operating conditions

		MIN	MAX	UNIT
Input-to-output voltage differential, $V_I - V_O$			125	V
Output current, I_O		15	700	mA
Operating virtual junction temperature, T_J	TL783C	0	125	°C

electrical characteristics at $V_I - V_O = 25$ V, $I_O = 0.5$ A, $T_J = 0°C$ to 125°C (unless otherwise noted)

PARAMETER	TEST CONDITIONS†			TL783C MIN	TL783C TYP	TL783C MAX	UNIT
Input voltage regulation‡	$V_I - V_O = 20$ V to 125 V,	P ≤ rated dissipation	$T_J = 25°C$		0.001	0.01	%/V
			$T_J = 0°C$ to 125°C		0.004	0.02	
Ripple rejection	$\Delta V_{I(PP)} = 10$ V,	$V_O = 10$ V,	f = 120 Hz	66	76		dB
Output voltage regulation	$I_O = 15$ mA to 700 mA,	$T_J = 25°C$	$V_O \le 5$ V		7.5	25	mV
			$V_O \ge 5$ V		0.15%	0.5%	
	$I_O = 15$ mA to 700 mA,	P ≤ rated dissipation	$V_O \le 5$ V		20	70	mV
			$V_O \ge 5$ V		0.3%	1.5%	
Output voltage change with temperature					0.4%		
Output voltage long-term drift	1000 hours at $T_J = 125°C$,	$V_I - V_O = 125$ V			0.2%		
Output noise voltage	f = 10 Hz to 10 kHz,	$T_J = 25°C$			0.003%		
Minimum output current to maintain regulation	$V_I - V_O = 125$ V					15	mA
Peak output current	$V_I - V_O = 25$ V,	t = 1 ms			1100		mA
	$V_I - V_O = 15$ V,	t = 30 ms			715		
	$V_I - V_O = 25$ V,	t = 30 ms		700	900		
	$V_I - V_O = 125$ V,	t = 30 ms		100	250		
ADJ input current					83	110	μA
Change in ADJ input current	$V_I - V_O = 15$ V to 125 V,	$I_O = 15$ mA to 700 mA,	P ≤ rated dissipation		0.5	5	μA
Reference voltage (OUT to ADJ)	$V_I - V_O = 10$ V to 125 V, See Note 3	$I_O = 15$ mA to 700 mA,	P ≤ rated dissipation,	1.2	1.27	1.3	V

† Pulse-testing techniques maintain the junction temperature as close to the ambient temperature as possible. Thermal effects must be taken into account separately.

‡ Input voltage regulation is expressed here as the percentage change in output voltage per 1-V change at the input.

NOTE 3: Due to the dropout voltage and output current-limiting characteristics of this device, output current is limited to less than 700 mA at input-to-output voltage differentials of less than 25 V.

electrical characteristics at $V_I - V_O = 25$ V, $I_O = 0.5$ A, $T_J = 25°C$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS†			TL783Y MIN	TL783Y TYP	TL783Y MAX	UNIT
Input voltage regulation‡	$V_I - V_O = 20$ V to 125 V,	P ≤ rated dissipation			0.001		%/V
Ripple rejection	$\Delta V_{I(PP)} = 10$ V,	$V_O = 10$ V,	f = 120 Hz		76		dB
Output voltage regulation	$I_O = 15$ mA to 700 mA		$V_O \le 5$ V		7.5		mV
			$V_O \ge 5$ V		0.15%		
	$I_O = 15$ mA to 700 mA,	P ≤ rated dissipation	$V_O \le 5$ V		20		mV
			$V_O \ge 5$ V		0.3%		
Output voltage change with temperature					0.4%		
Output noise voltage	f = 10 Hz to 10 kHz				0.003%		
Peak output current	$V_I - V_O = 25$ V,	t = 1 ms			1100		mA
	$V_I - V_O = 15$ V,	t = 30 ms			715		
	$V_I - V_O = 25$ V,	t = 30 ms			900		
	$V_I - V_O = 125$ V,	t = 30 ms			250		
ADJ input current					83		μA
Change in ADJ input current	$V_I - V_O = 15$ V to 125 V,	$I_O = 15$ mA to 700 mA,	P ≤ rated dissipation		0.5		μA
Reference voltage (OUT to ADJ)	$V_I - V_O = 10$ V to 125 V, See Note 3	$I_O = 15$ mA to 700 mA,	P ≤ rated dissipation,		1.27		V

† Pulse-testing techniques maintain the junction temperature as close to the ambient temperature as possible. Thermal effects must be taken into account separately.
‡ Input voltage regulation is expressed here as the percentage change in output voltage per 1-V change at the input.
NOTE 3: Due to the dropout voltage and output current-limiting characteristics of this device, output current is limited to less than 700 mA at input-to-output voltage differentials of less than 25 V.

TYPICAL CHARACTERISTICS

OUTPUT CURRENT LIMIT
vs
INPUT-TO-OUTPUT VOLTAGE DIFFERENTIAL

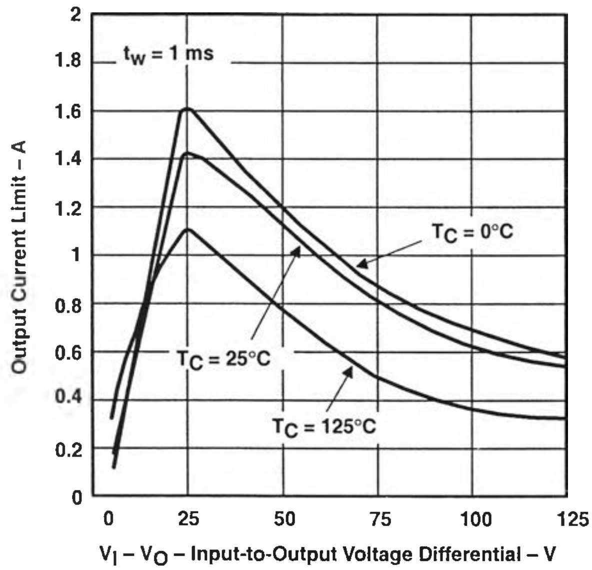


Figure 1

OUTPUT CURRENT LIMIT
vs
INPUT-TO-OUTPUT VOLTAGE DIFFERENTIAL

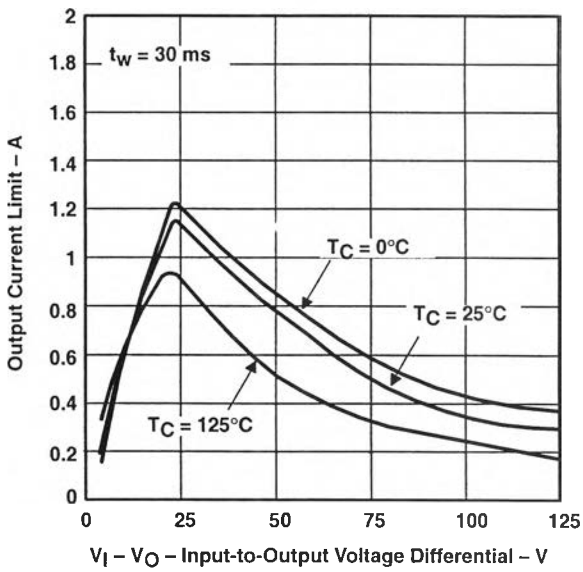


Figure 2

OUTPUT CURRENT LIMIT
vs
TIME

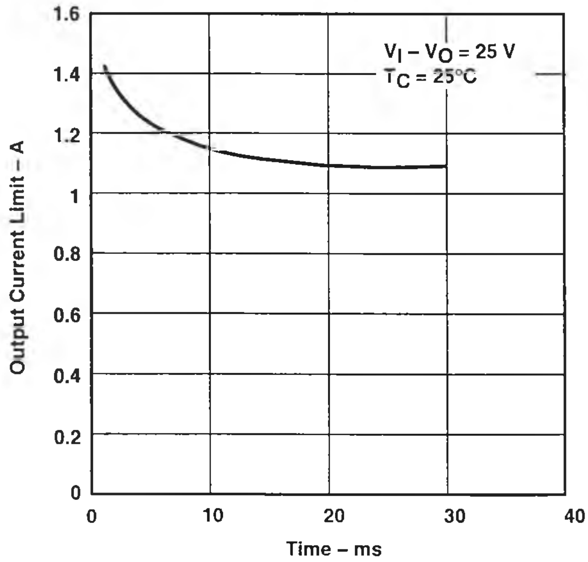


Figure 3

RIPPLE REJECTION
vs
OUTPUT VOLTAGE

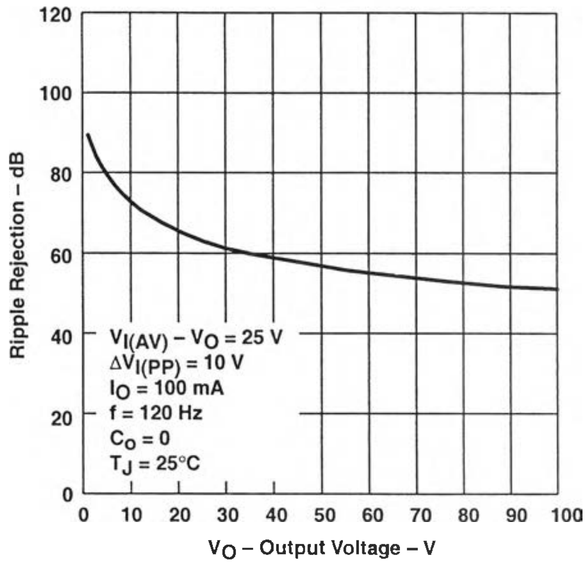


Figure 4

TYPICAL CHARACTERISTICS†

RIPPLE REJECTION
vs
OUTPUT CURRENT

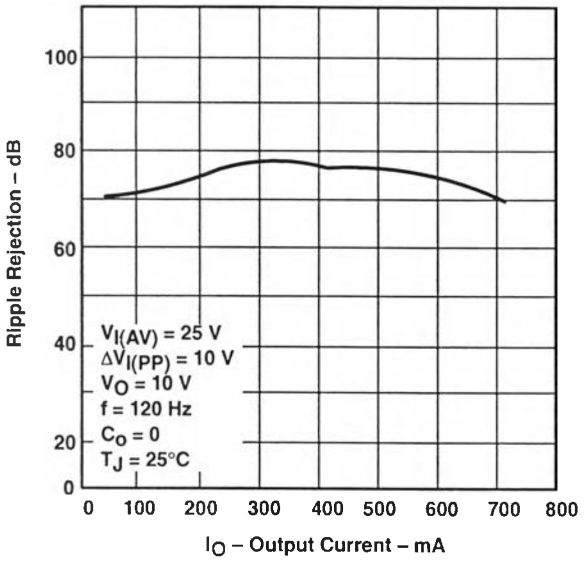


Figure 5

RIPPLE REJECTION
vs
FREQUENCY

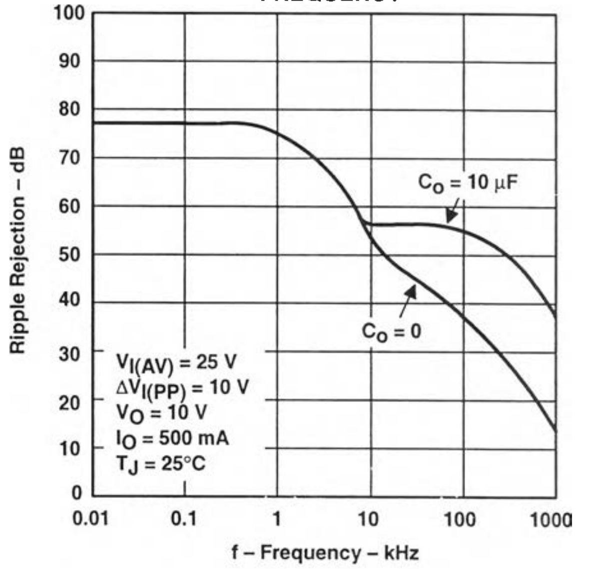


Figure 6

OUTPUT IMPEDANCE
vs
FREQUENCY

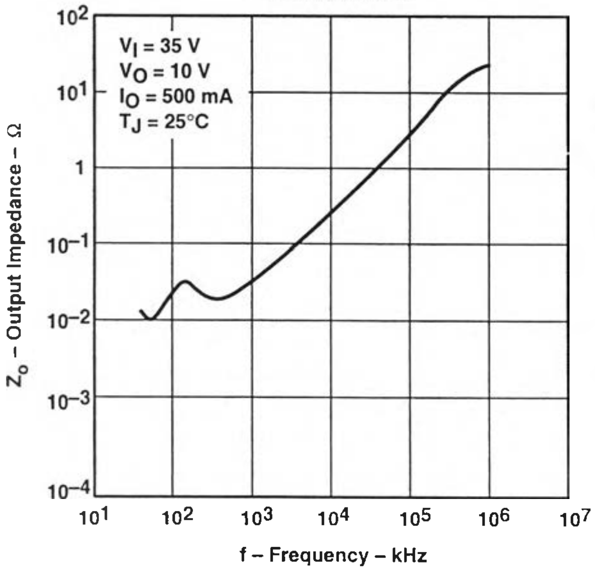


Figure 7

REFERENCE VOLTAGE
vs
VIRTUAL JUNCTION TEMPERATURE

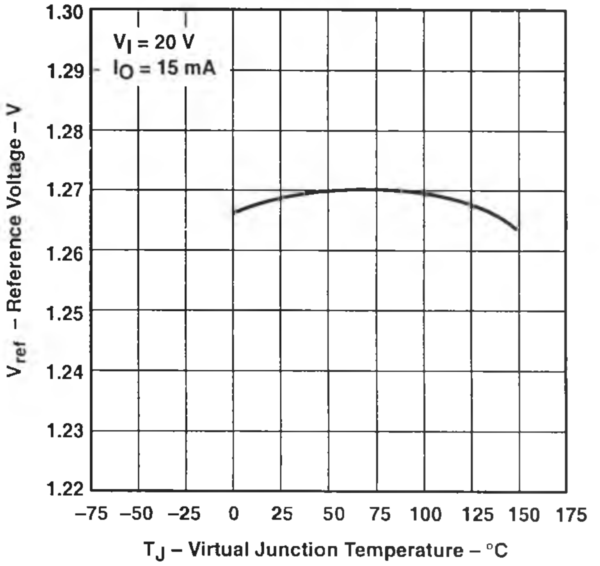


Figure 8

† Data at high and low temperatures are applicable only within the recommended operating free-air temperature ranges of the various devices.

TYPICAL CHARACTERISTICS

INPUT CURRENT AT ADJ
vs
VIRTUAL JUNCTION TEMPERATURE

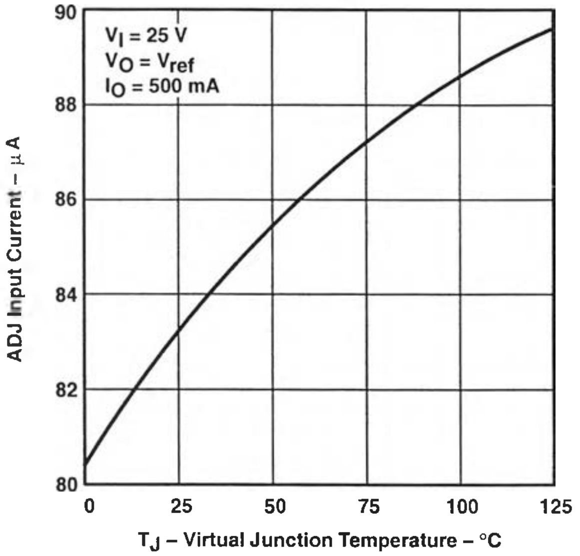


Figure 9

DROPOUT VOLTAGE
vs
VIRTUAL JUNCTION TEMPERATURE

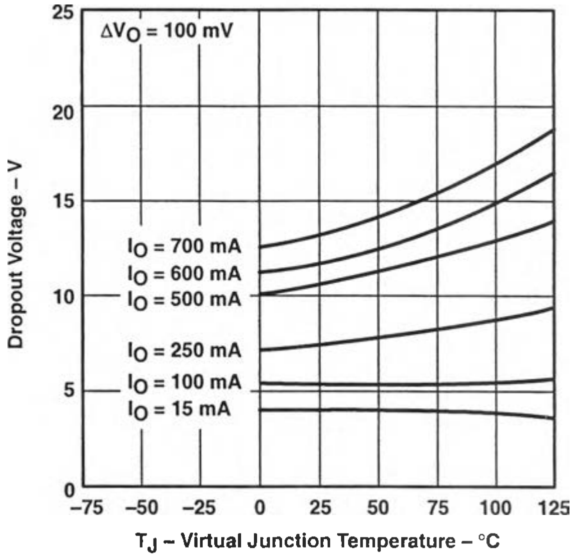


Figure 10

OUTPUT VOLTAGE DEVIATION
vs
VIRTUAL JUNCTION TEMPERATURE

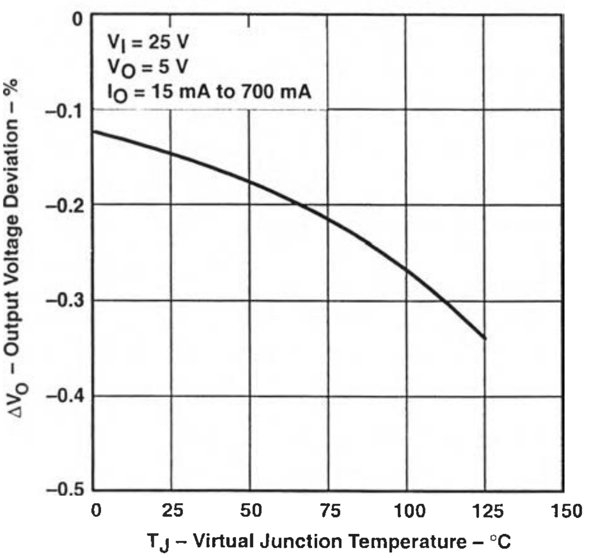
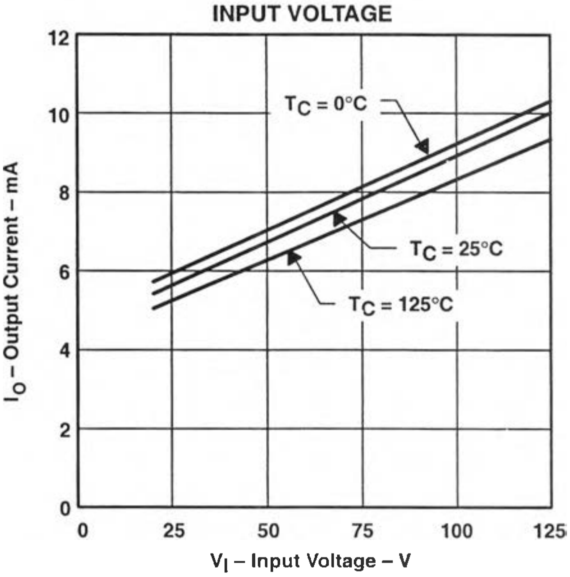


Figure 11

OUTPUT CURRENT†
vs
INPUT VOLTAGE



† This is the minimum current required to maintain voltage regulation.

Figure 12

TYPICAL CHARACTERISTICS

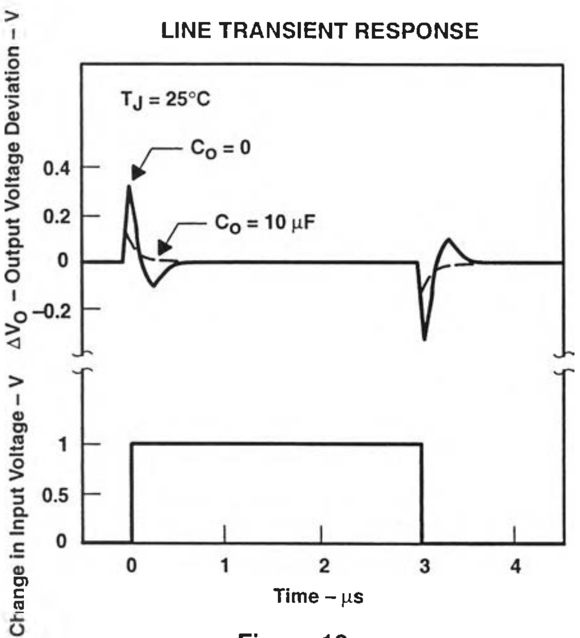


Figure 13

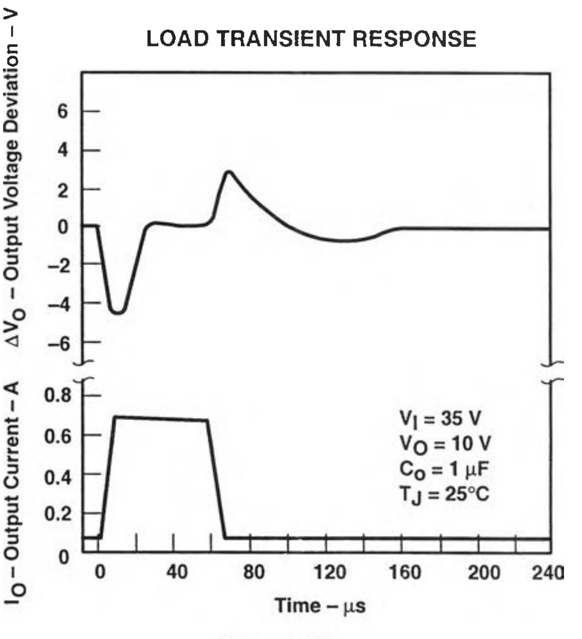


Figure 14

DESIGN CONSIDERATIONS

The internal reference (see functional block diagram) generates 1.25 V nominal (V_{ref}) between OUT and ADJ. This voltage is developed across R1 and causes a constant current to flow through R1 and the programming resistor R2, giving an output voltage of:

$$V_O = V_{ref}(1 + R2/R1) + I_{I(ADJ)}(R2)$$

or

$$V_O \approx V_{ref}(1 + R2/R1)$$

The TL783 was designed to minimize the input current at ADJ and maintain consistency over line and load variations, thereby minimizing the associated (R2) error term.

To maintain $I_{I(ADJ)}$ at a low level, all quiescent operating current is returned to the output terminal. This quiescent current must be sunk by the external load and is the minimum load current necessary to prevent the output from rising. The recommended R1 value of 82 Ω provides a minimum load current of 15 mA. Larger values can be used when the input-to-output differential voltage is less than 125 V (see the output-current curve in Figure 14) or when the load sinks some portion of the minimum current.

DESIGN CONSIDERATIONS

bypass capacitors

The TL783 regulator is stable without bypass capacitors; however, any regulator becomes unstable with certain values of output capacitance if an input capacitor is not used. Therefore, the use of input bypassing is recommended whenever the regulator is located more than four inches from the power-supply filter capacitor. A 1-µF tantalum or aluminum electrolytic capacitor usually is sufficient.

Adjustment-terminal capacitors are not recommended for use on the TL783 because they can seriously degrade load transient response as well as create a need for extra protection circuitry. Excellent ripple rejection presently is achieved without this added capacitor.

Due to the relatively low gain of the MOS output stage, output voltage dropout may occur under large load transient conditions. The addition of an output bypass capacitor greatly enhances load transient response and prevents dropout. For most applications, it is recommended that an output bypass capacitor be used, with a minimum value of:

$$C_O\ (\mu F) = 15/V_O$$

Larger values provide proportionally better transient-response characteristics.

protection circuitry

The TL783 regulator includes built-in protection circuits capable of guarding the device against most overload conditions encountered in normal operation. These protective features are current limiting, safe-operating-area protection, and thermal shutdown. These circuits protect the device under occasional fault conditions only. Continuous operation in the current limit or thermal shutdown mode is not recommended.

The internal protection circuits of the TL783 protect the device up to maximum-rated V_I as long as certain precautions are taken. If V_I is instantaneously switched on, transients exceeding maximum input ratings may occur, which can destroy the regulator. These are usually caused by lead inductance and bypass capacitors causing a ringing voltage on the input. In addition, when rise times in excess of 10 V/ns are applied to the input, a parasitic npn transistor in parallel with the DMOS output can be turned on, causing the device to fail. If the device is operated over 50 V and the input is switched on rather than ramped on, a low-Q capacitor, such as tantalum or aluminum electrolytic should be used rather than ceramic, paper, or plastic bypass capacitors. A Q factor of 0.015 or greater usually provides adequate damping to suppress ringing. Normally, no problems occur if the input voltage is allowed to ramp upward through the action of an ac line rectifier and filter network.

Similarly, when an instantaneous short circuit is applied to the output, both ringing and excessive fall times can result. A tantalum or aluminum electrolytic bypass capacitor is recommended to eliminate this problem. However, if a large output capacitor is used and the input is shorted, addition of a protection diode may be necessary to prevent capacitor discharge through the regulator. The amount of discharge current delivered is dependent on output voltage, size of capacitor, and fall time of V_I. A protective diode (see Figure 17) is required only for capacitance values greater than:

$$C_O\ (\mu F) = 3 \times 10^4/(V_O)^2$$

Care always should be taken to prevent insertion of regulators into a socket with power on. Power should be turned off before removing or inserting regulators.

DESIGN CONSIDERATIONS

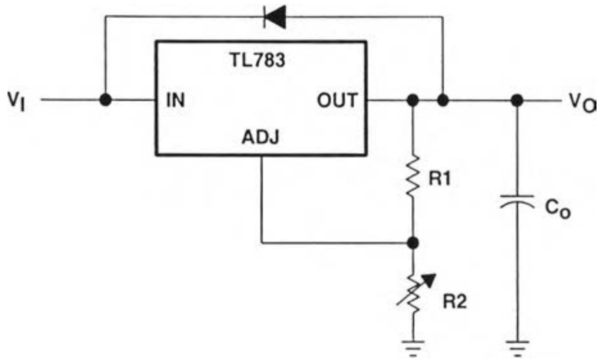


Figure 15. Regulator With Protective Diode

load regulation

The current-set resistor (R1) should be located close to the regulator output terminal rather than near the load. This eliminates long line drops from being amplified, through the action of R1 and R2, to degrade load regulation. To provide remote ground sensing, R2 should be near the load ground.

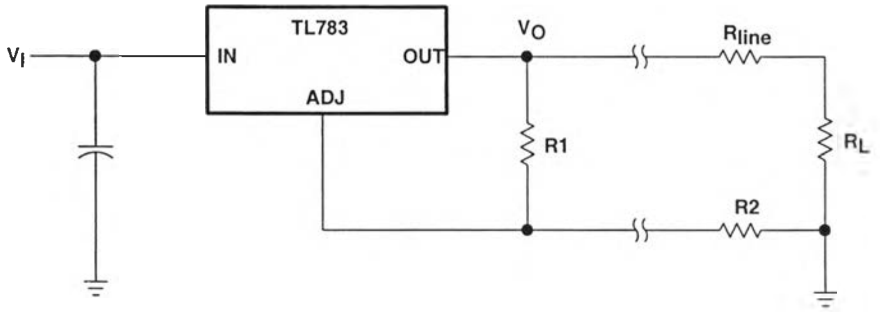
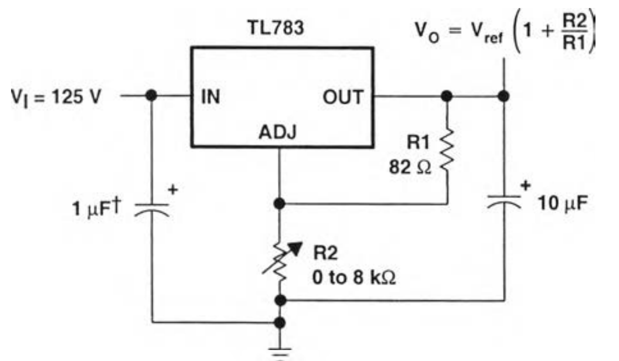


Figure 16. Regulator With Current-Set Resistor

APPLICATION INFORMATION



† Needed if device is more than 4 inches from filter capacitor

Figure 17. 1.25-V to 115-V Adjustable Regulator

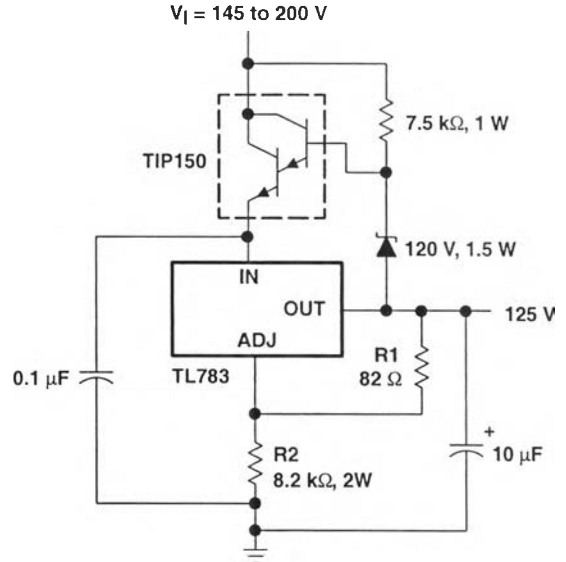


Figure 18. 125-V Short-Circuit-Protected Off-Line Regulator

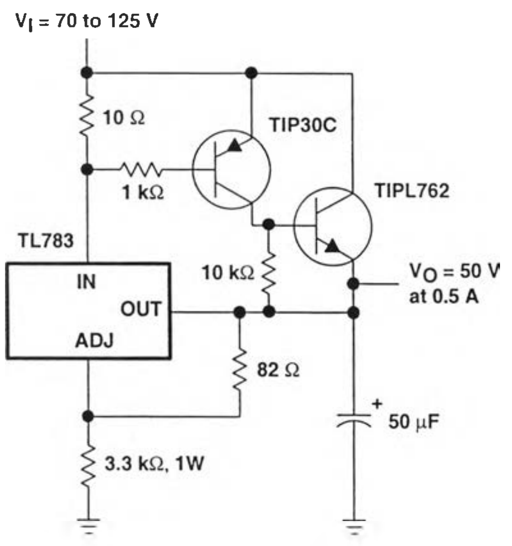


Figure 19. 50-V Regulator With Current Boost

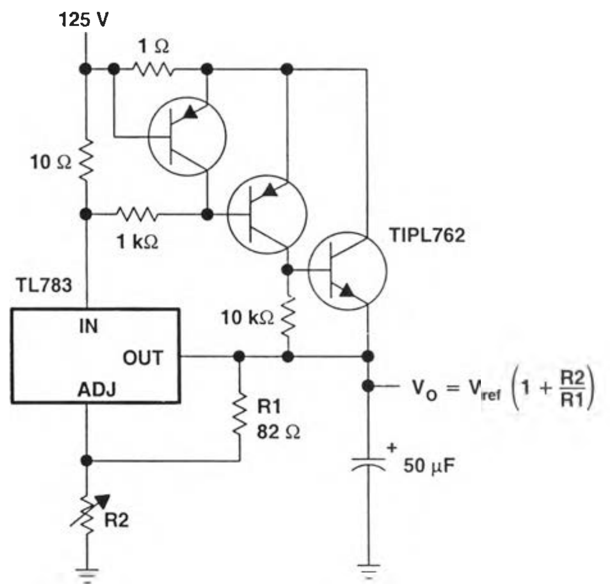


Figure 20. Adjustable Regulator With Current Boost and Current Limit

APPLICATION INFORMATION

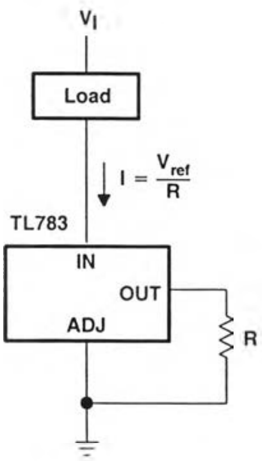


Figure 21. Current-Sinking Regulator

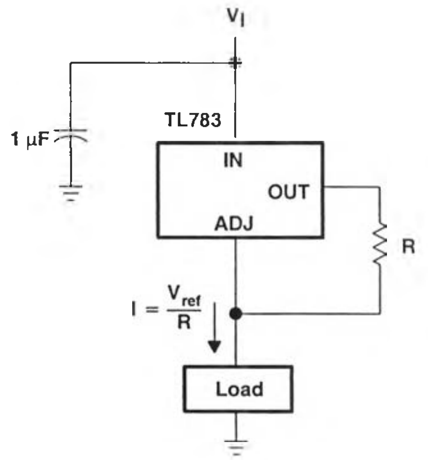


Figure 22. Current-Sourcing Regulator

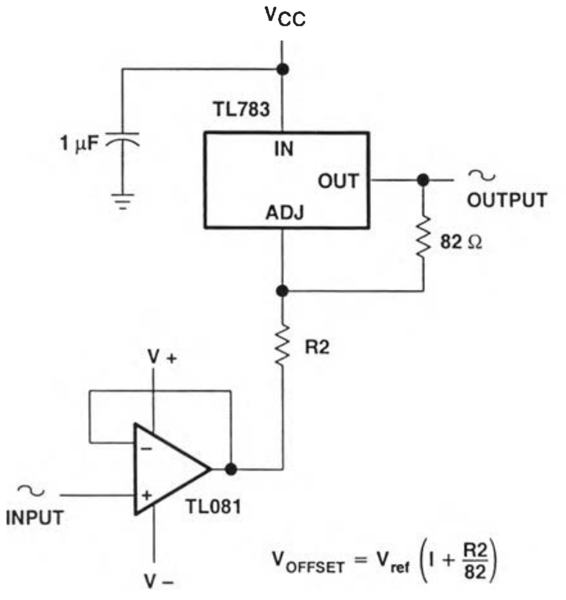


Figure 23. High-Voltage Unity-Gain Offset Amplifier

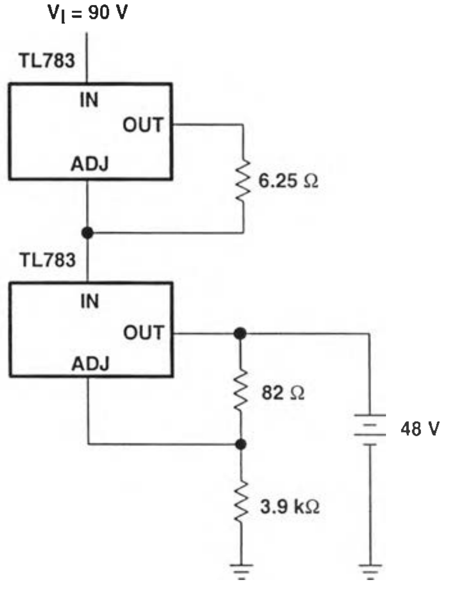


Figure 24. 48-V, 200-mA Float Charger

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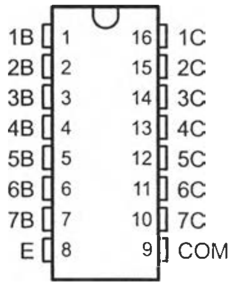
ULN2001A, ULN2002A, ULN2003A, ULN2004A, ULQ2003A, ULQ2004A HIGH-VOLTAGE HIGH-CURRENT DARLINGTON TRANSISTOR ARRAY

The ULN2001A is obsolete and is no longer supplied.

SLRS027F – DECEMBER 1976 – REVISED FEBRUARY 2003

- **500-mA-Rated Collector Current (Single Output)**
- **High-Voltage Outputs . . . 50 V**
- **Output Clamp Diodes**
- **Inputs Compatible With Various Types of Logic**
- **Relay-Driver Applications**
- **Designed to Be Interchangeable With Sprague ULN2001A Series**

ULN2001A . . . D OR N PACKAGE
ULN2002A . . . N PACKAGE
ULN2003A, ULN2004A . . . D, N, OR NS PACKAGE
ULQ2003A, ULQ2004A . . . D OR N PACKAGE
(TOP VIEW)



description/ordering information

The ULN2001A, ULN2002A, ULN2003A, ULN2004A, ULQ2003A, and ULQ2004A are high-voltage, high-current Darlington transistor arrays. Each consists of seven npn Darlington pairs that feature high-voltage outputs with common-cathode clamp diodes for switching inductive loads. The collector-current rating of a single Darlington pair is 500 mA. The Darlington pairs can be paralleled for higher current capability. Applications include relay drivers, hammer drivers, lamp drivers, display drivers (LED and gas discharge), line drivers, and logic buffers. For 100-V (otherwise interchangeable) versions of the ULN2003A and ULN2004A, see the SN75468 and SN75469, respectively.

ORDERING INFORMATION

T_A	PACKAGE†		ORDERABLE PART NUMBER	TOP-SIDE MARKING
–20°C to 70°C	PDIP (N)	Tube of 25	ULN2002AN	ULN2002AN
			ULN2003AN	ULN2003AN
			ULN2004AN	ULN2004AN
	SOIC (D)	Tube of 40	ULN2003AD	ULN2003A
		Reel of 2500	ULN2003ADR	
		Tube of 40	ULN2004AD	ULN2004A
		Reel of 2500	ULN2004ADR	
	SOP (NS)	Reel of 2000	ULN2003ANSR	ULN2003A
			ULN2004ANSR	ULN2004A
–40°C to 85°C	PDIP (N)	Tube of 25	ULQ2003AN	ULQ2003A
			ULQ2004AN	ULQ2004AN
	SOIC (D)	Tube of 40	ULQ2003AD	ULQ2003A
		Reel of 2500	ULQ2003ADR	ULQ2003A
		Tube of 40	ULQ2004AD	ULQ2004A
		Reel of 2500	ULQ2004ADR	ULQ2004A

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

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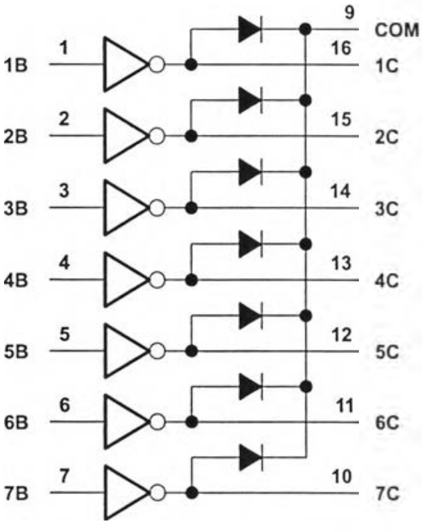
The ULN2001A is obsolete and is no longer supplied.

description/ordering information (continued)

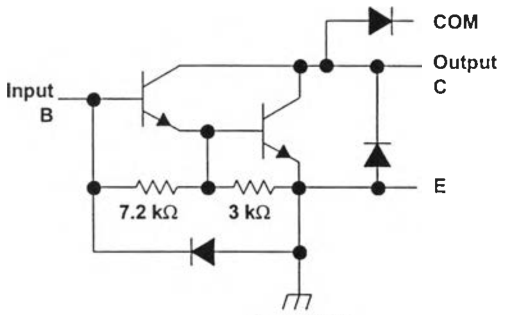
The ULN2001A is a general-purpose array and can be used with TTL and CMOS technologies. The ULN2002A is designed specifically for use with 14-V to 25-V PMOS devices. Each input of this device has a Zener diode and resistor in series to control the input current to a safe limit. The ULN2003A and ULQ2003A have a 2.7-kΩ series base resistor for each Darlington pair for operation directly with TTL or 5-V CMOS devices. The ULN2004A and ULQ2004A have a 10.5-kΩ series base resistor to allow operation directly from CMOS devices that use supply voltages of 6 V to 15 V. The required input current of the ULN/ULQ2004A is below that of the ULN/ULQ2003A, and the required voltage is less than that required by the ULN2002A.

logic diagram

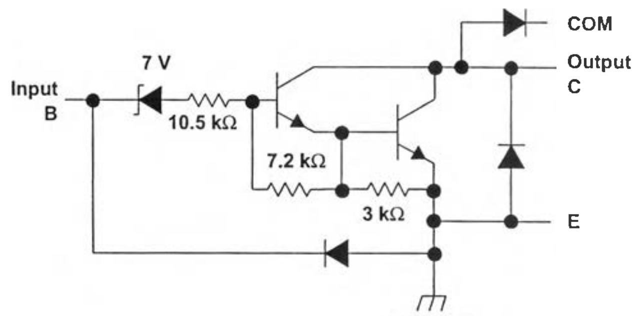


The ULN2001A is obsolete and is no longer supplied.

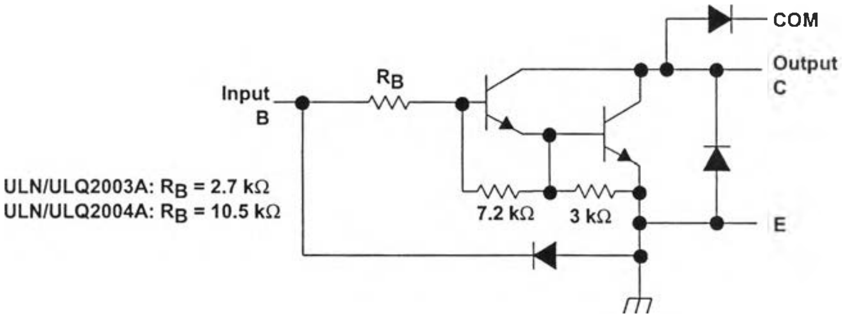
schematics (each Darlington pair)



ULN2001A



ULN2002A



ULN2003A, ULN2004A, ULQ2003A, ULQ2004A

All resistor values shown are nominal.

The ULN2001A is obsolete and is no longer supplied.

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)†

Collector-emitter voltage	50 V
Clamp diode reverse voltage (see Note 1)	50 V
Input voltage, V_I (see Note 1)	30 V
Peak collector current (see Figures 14 and 15)	500 mA
Output clamp current, I_{OK}	500 mA
Total emitter-terminal current	–2.5 A
Operating free-air temperature range, T_A, ULN200xA	–20°C to 70°C
ULQ200xA	–40°C to 85°C
ULQ200xAT	–40°C to 105°C
Package thermal impedance, θ_{JA} (see Notes 2 and 3): D package	73°C/W
N package	67°C/W
NS package	64°C/W
Package thermal impedance, θ_{JC} (see Notes 4 and 5): D package	36°C/W
N package	54°C/W
Operating virtual junction temperature, T_J	150°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds	260°C
Storage temperature range, T_{stg}	–65°C to 150°C

† Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

NOTES:
1. All voltage values are with respect to the emitter/substrate terminal E, unless otherwise noted.
2. Maximum power dissipation is a function of T_J(max), θ_{JA}, and T_A. The maximum allowable power dissipation at any allowable ambient temperature is $P_D = (T_J(max) – T_A)/\theta_{JA}$. Operating at the absolute maximum T_J of 150°C can affect reliability.
3. The package thermal impedance is calculated in accordance with JESD 51-7.
4. Maximum power dissipation is a function of T_J(max), θ_{JC}, and T_C. The maximum allowable power dissipation at any allowable case temperature is $P_D = (T_J(max) – T_C)/\theta_{JC}$. Operating at the absolute maximum T_J of 150°C can affect reliability.
5. The package thermal impedance is calculated in accordance with MIL-STD-883.

electrical characteristics, T_A = 25°C (unless otherwise noted)

PARAMETER		TEST FIGURE	TEST CONDITIONS	ULN2001A			ULN2002A			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	
$V_{I(on)}$	On-state input voltage	6	V_{CE} = 2 V, I_C = 300 mA						13	V
$V_{CE(sat)}$	Collector-emitter saturation voltage	5	I_I = 250 µA, I_C = 100 mA		0.9	1.1		0.9	1.1	V
			I_I = 350 µA, I_C = 200 mA		1	1.3		1	1.3	
			I_I = 500 µA, I_C = 350 mA		1.2	1.6		1.2	1.6	
V_F	Clamp forward voltage	8	I_F = 350 mA		1.7	2		1.7	2	V
I_{CEX}	Collector cutoff current	1	V_{CE} = 50 V, I_I = 0			50			50	µA
		2	V_{CE} = 50 V, T_A = 70°C, I_I = 0			100			100	
			V_{CE} = 50 V, T_A = 70°C, V_I = 6 V						500	
$I_{I(off)}$	Off-state input current	3	V_{CE} = 50 V, I_C = 500 µA, T_A = 70°C	50	65		50	65		µA
I_I	Input current	4	V_I = 17 V					0.82	1.25	mA
I_R	Clamp reverse current	7	V_R = 50 V, T_A = 70°C			100			100	µA
			V_R = 50 V			50			50	
h_{FE}	Static forward-current transfer ratio	5	V_{CE} = 2 V, I_C = 350 mA	1000						
C_i	Input capacitance		V_I = 0, f = 1 MHz		15	25		15	25	pF

electrical characteristics, T_A = 25°C (unless otherwise noted) (continued)

PARAMETER		TEST FIGURE	TEST CONDITIONS		ULN2003A			ULN2004A			UNIT
					MIN	TYP	MAX	MIN	TYP	MAX	
$V_{I(on)}$	On-state input voltage	6	V_{CE} = 2 V	I_C = 125 mA						5	V
				I_C = 200 mA			2.4			6	
				I_C = 250 mA			2.7				
				I_C = 275 mA						7	
				I_C = 300 mA			3				
				I_C = 350 mA						8	
$V_{CE(sat)}$	Collector-emitter saturation voltage	5	I_I = 250 μA,	I_C = 100 mA		0.9	1.1		0.9	1.1	V
			I_I = 350 μA,	I_C = 200 mA		1	1.3		1	1.3	
			I_I = 500 μA,	I_C = 350 mA		1.2	1.6		1.2	1.6	
I_{CEX}	Collector cutoff current	1	V_{CE} = 50 V,	I_I = 0			50			50	μA
		2	V_{CE} = 50 V, T_A = 70°C	I_I = 0			100			100	
				V_I = 1 V						500	
V_F	Clamp forward voltage	8	I_F = 350 mA			1.7	2		1.7	2	V
$I_{I(off)}$	Off-state input current	3	V_{CE} = 50 V, T_A = 70°C	I_C = 500 μA,	50	65		50	65		μA
I_I	Input current	4	V_I = 3.85 V			0.93	1.35				mA
			V_I = 5 V						0.35	0.5	
			V_I = 12 V						1	1.45	
I_R	Clamp reverse current	7	V_R = 50 V				50			50	μA
			V_R = 50 V,	T_A = 70°C			100			100	
C_i	Input capacitance		V_I = 0,	f = 1 MHz		15	25		15	25	pF

The ULN2001A is obsolete and is no longer supplied.

electrical characteristics over recommended operating conditions (unless otherwise noted)

PARAMETER		TEST FIGURE	TEST CONDITIONS		ULQ2003A			ULQ2004A			UNIT
					MIN	TYP	MAX	MIN	TYP	MAX	
$V_{I(on)}$	On-state input voltage	6	V_{CE} = 2 V	I_C = 125 mA						5	V
				I_C = 200 mA			2.7			6	
				I_C = 250 mA			2.9				
				I_C = 275 mA						7	
				I_C = 300 mA			3				
				I_C = 350 mA						8	
$V_{CE(sat)}$	Collector-emitter saturation voltage	5	I_I = 250 µA,	I_C = 100 mA		0.9	1.2		0.9	1.1	V
			I_I = 350 µA,	I_C = 200 mA		1	1.4		1	1.3	
			I_I = 500 µA,	I_C = 350 mA		1.2	1.7		1.2	1.6	
I_{CEX}	Collector cutoff current	1	V_{CE} = 50 V,	I_I = 0			100			50	µA
		2	V_{CE} = 50 V	I_I = 0						100	
				V_I = 1 V						500	
V_F	Clamp forward voltage	8	I_F = 350 mA			1.7	2.3		1.7	2	V
$I_{I(off)}$	Off-state input current	3	V_{CE} = 50 V,	I_C = 500 µA		65		50	65		µA
I_I	Input current	4	V_I = 3.85 V			0.93	1.35				mA
			V_I = 5 V						0.35	0.5	
			V_I = 12 V						1	1.45	
I_R	Clamp reverse current	7	V_R = 50 V,	T_A = 25°C			100			50	µA
			V_R = 50 V				100			100	
C_i	Input capacitance		V_I = 0,	f = 1 MHz		15	25		15	25	pF

switching characteristics, T_A = 25°C

PARAMETER		TEST CONDITIONS	ULN2001A, ULN2002A, ULN2003A, ULN2004A			UNIT
			MIN	TYP	MAX	
t_{PLH}	Propagation delay time, low- to high-level output	See Figure 9		0.25	1	µs
t_{PHL}	Propagation delay time, high- to low-level output	See Figure 9		0.25	1	µs
V_{OH}	High-level output voltage after switching	V_S = 50 V, I_O ≈ 300 mA, See Figure 10	V_S–20			mV

switching characteristics over recommended operating conditions (unless otherwise noted)

PARAMETER		TEST CONDITIONS	ULQ2003A, ULQ2004A			UNIT
			MIN	TYP	MAX	
t_{PLH}	Propagation delay time, low- to high-level output	See Figure 9		1	10	µs
t_{PHL}	Propagation delay time, high- to low-level output	See Figure 9		1	10	µs
V_{OH}	High-level output voltage after switching	V_S = 50 V, I_O ≈ 300 mA, See Figure 10	V_S–500			mV

The ULN2001A is obsolete
and is no longer supplied.

SLRS027F – DECEMBER 1976 – REVISED FEBRUARY 2003

PARAMETER MEASUREMENT INFORMATION

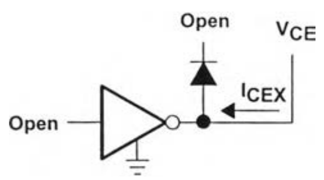


Figure 1. I_{CEX} Test Circuit

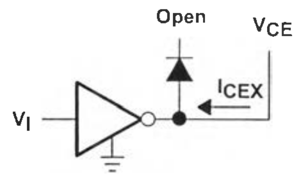


Figure 2. I_{CEX} Test Circuit

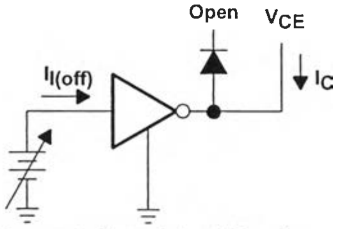


Figure 3. $I_{I(off)}$ Test Circuit

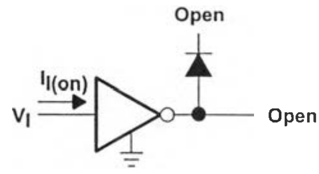
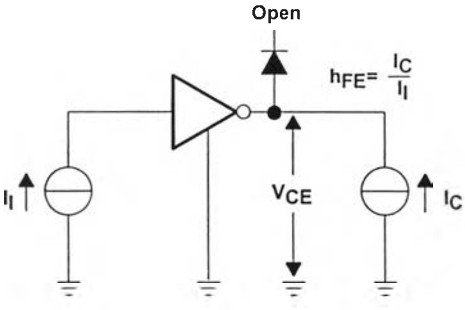


Figure 4. I_I Test Circuit



NOTE: I_I is fixed for measuring $V_{CE(sat)}$, variable for measuring h_{FE}.

Figure 5. h_{FE}, $V_{CE(sat)}$ Test Circuit

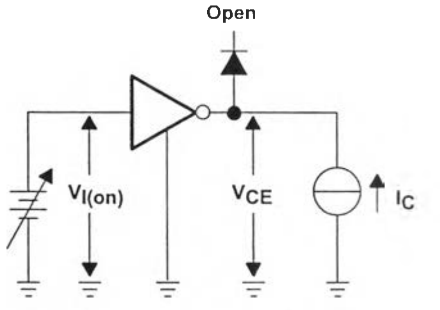


Figure 6. $V_{I(on)}$ Test Circuit

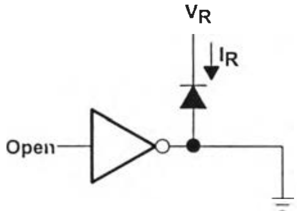


Figure 7. I_R Test Circuit

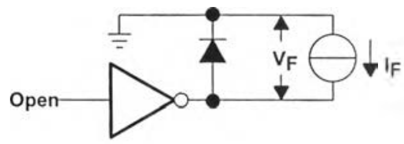
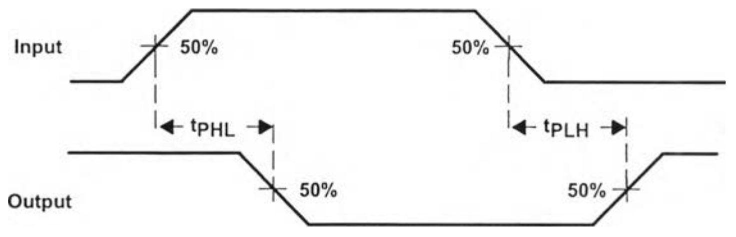


Figure 8. V_F Test Circuit

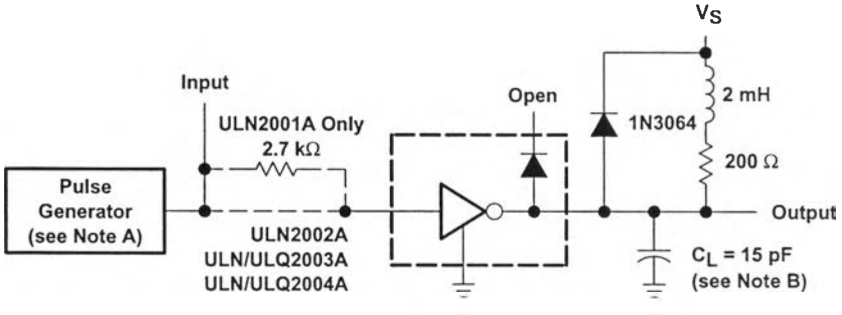
The ULN2001A is obsolete and is no longer supplied.

PARAMETER MEASUREMENT INFORMATION

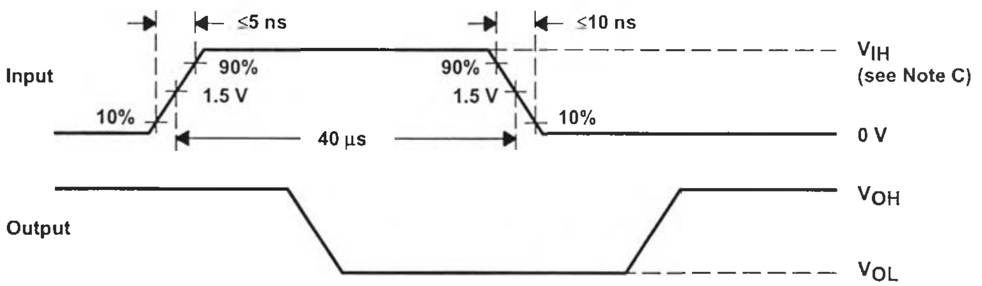


VOLTAGE WAVEFORMS

Figure 9. Propagation Delay-Time Waveforms



TEST CIRCUIT



VOLTAGE WAVEFORMS

NOTES: A. The pulse generator has the following characteristics: PRR = 12.5 kHz, Z_O = 50 Ω.
B. C_L includes probe and jig capacitance.
C. For testing the ULN2001A, the ULN2003A, and the ULQ2003A, V_{IH} = 3 V; for the ULN2002A, V_{IH} = 13 V; for the ULN2004A and the ULQ2004A, V_{IH} = 8 V.

Figure 10. Latch-Up Test Circuit and Voltage Waveforms

The ULN2001A is obsolete and is no longer supplied.

TYPICAL CHARACTERISTICS

COLLECTOR-EMITTER SATURATION VOLTAGE vs COLLECTOR CURRENT (ONE DARLINGTON)

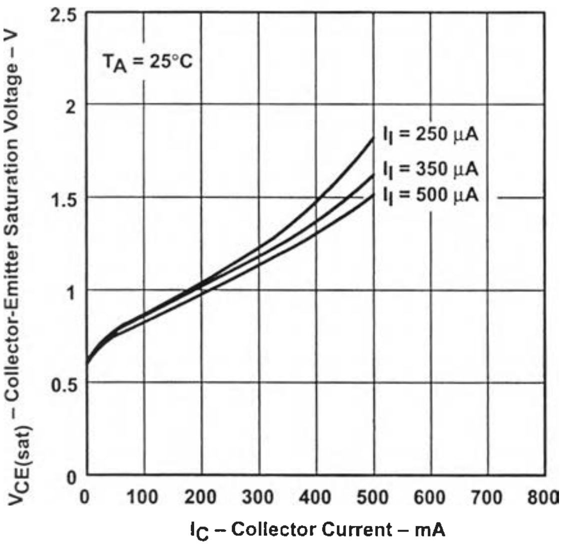


Figure 11

COLLECTOR-EMITTER SATURATION VOLTAGE vs TOTAL COLLECTOR CURRENT (TWO DARLINGTONS IN PARALLEL)

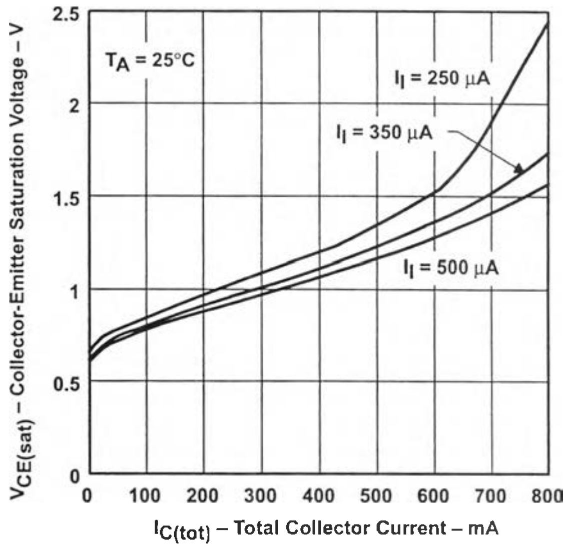


Figure 12

COLLECTOR CURRENT vs INPUT CURRENT

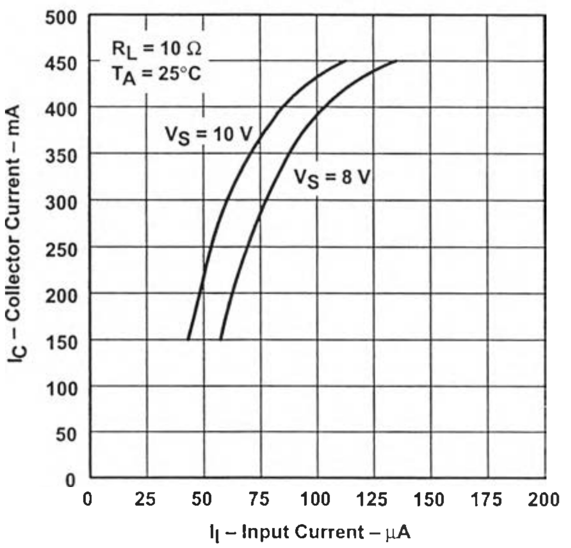


Figure 13

The ULN2001A is obsolete
and is no longer supplied.

THERMAL INFORMATION

D PACKAGE
MAXIMUM COLLECTOR CURRENT
vs
DUTY CYCLE

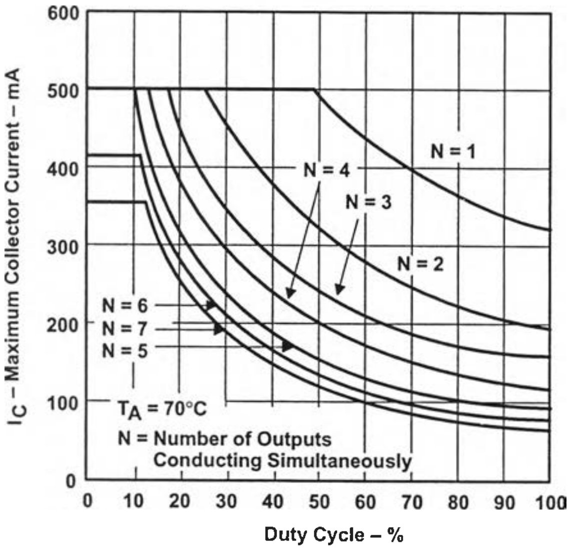


Figure 14

N PACKAGE
MAXIMUM COLLECTOR CURRENT
vs
DUTY CYCLE

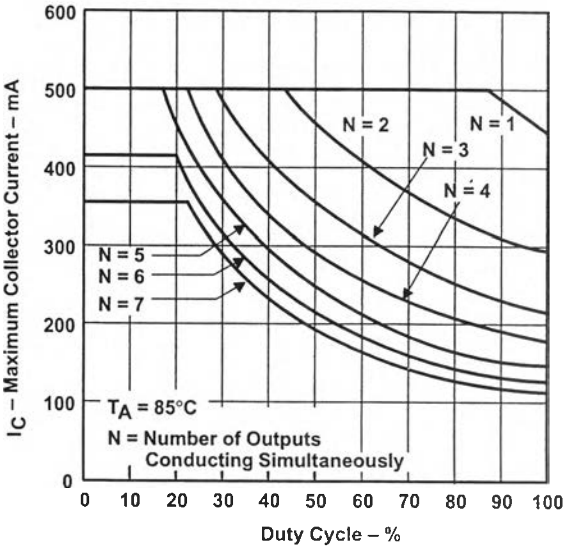


Figure 15

The ULN2001A is obsolete
and is no longer supplied.

APPLICATION INFORMATION

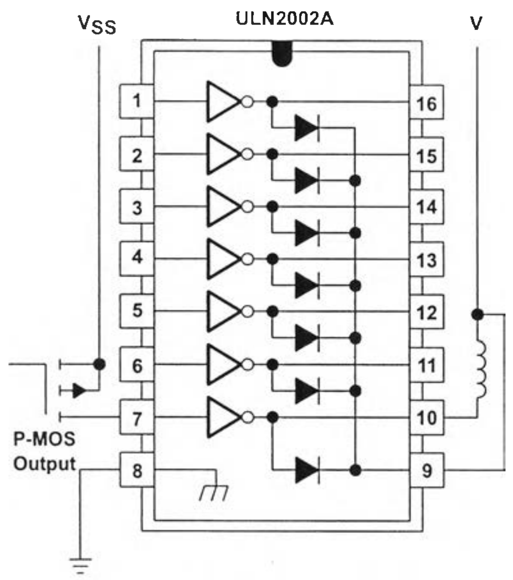


Figure 16. P-MOS to Load

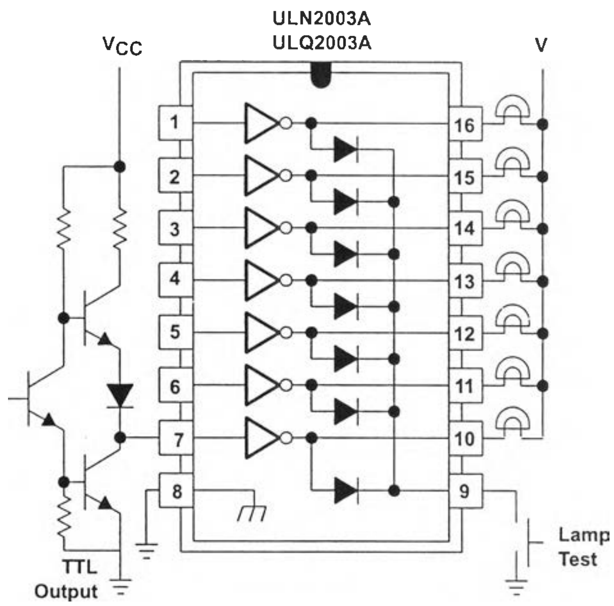


Figure 17. TTL to Load

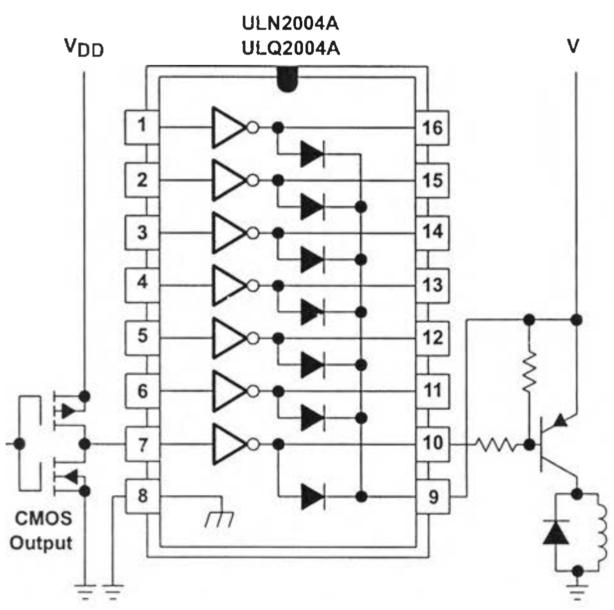


Figure 18. Buffer for Higher Current Loads

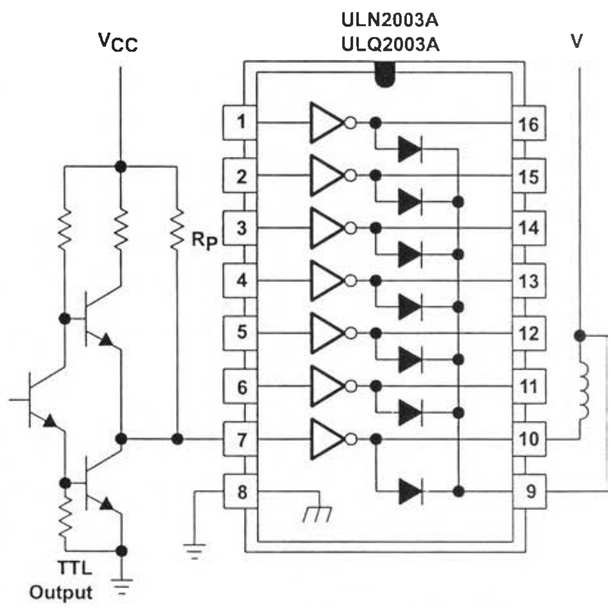


Figure 19. Use of Pullup Resistors to Increase Drive Current

ภาคผนวก ค
การออกแบบหม้อแปลงไฟฟ้าแบบสวิตชิง

การออกแบบหม้อแปลงไฟฟ้าแบบสวิตชิง มีขั้นตอนการออกแบบดังต่อไปนี้

(ในวิทยานิพนธ์ฉบับนี้ได้ทำการใช้และดัดแปลงหม้อแปลงไฟฟ้าของ นาย ฉัตรชัย อัสดาธร [5] ประกอบการทำวิทยานิพนธ์)

ก. พิกัดของหม้อแปลงไฟฟ้า (Transformer Rating)

ในงานวิจัยนี้ ทำการออกแบบหม้อแปลงไฟฟ้าที่มีพิกัดดังต่อไปนี้

1. ศักดาไฟฟ้าด้านทางเข้า	=	50	V
2. ศักดาไฟฟ้าด้านทางออก	=	12,000	V
3. กระแสไฟฟ้าด้านทางเข้า	=	2	A
4. กระแสไฟฟ้าด้านทางออก	=	1	mA
5. กำลังไฟฟ้า	=	60	W
6. ความถี่ในการใช้งาน	=	12.6	kHz

7. รูปแบบในการทำงานเป็นแบบฟลายแบคคอนเวอร์เตอร์

ในทางปฏิบัตินั้น วงจรไฟฟ้าแบบสวิตชิงจะมีประสิทธิภาพระหว่าง 68 %ถึง 90% สำหรับงานวิจัยนี้ประเมินประสิทธิภาพที่ 80% ดังนั้น สามารถหาค่าพารามิเตอร์ต่างๆที่ใช้งานจริงได้ดังนี้

จากสมการประสิทธิภาพ

$$\eta = \frac{P_{out}}{P_{in}} \times 100\ \% \qquad (1)$$

จาก η = 80% และ P_{out} = 60 W สามารถหากำลังไฟฟ้าทางด้านทางเข้าใหม่ได้ ดังสมการ

กำลังไฟฟ้าทางด้านทางเข้า

$$P_{in} = \frac{P_{out}}{\eta} \times 100\ \% \qquad (2)$$

ดังนั้น สามารถหากำลังไฟฟ้าด้านทางเข้า

$$P_{in} = \frac{60 \times 100\ \%}{80} = 75\ W$$

และสามารถหากระแสไฟฟ้าทางด้านทางเข้าได้ดังสมการ

จากสมการกำลังไฟฟ้า $P_{in} = P_{out}$ (3)

หรือ $V_I I_I = V_o I_o$ (4)

จากสมการข้างต้นสามารถหากระแสไฟฟ้าทางด้านทางเข้า

$$I_I = \frac{P_o}{V_I} \quad (5)$$

จาก V_I = 50 Vและ P_{out} = 60 W สามารถหากระแสทางด้านทางเข้าได้ดังสมการ

กระแสทางด้านทางเข้า $I_I = \frac{60\ W}{50} \approx 1.2$ A

ข. การเลือกขนาดและชนิดของแกนหม้อแปลงไฟฟ้า (Core Selection)

ขนาดของแกนหม้อแปลงไฟฟ้าแบบสวิตชิงหาได้ดังสมการ

$$A_p = A_e A_w = \frac{0.68 \times P \times D \times 10^8}{f \times B_{max}} \quad (6)$$

แทนค่า P_{out} = 60 W , D = 400 circular mil per amp , f = 40 kHz และB_{max} = 2400 G ลงในสมการที่ 6 จะได้

$$\text{ขนาดของหม้อแปลง} = \frac{0.068 \times 60 \times 400 \times 10^8}{40 \times 10^3 \times 2400} = 1{,}700\ cm^4$$

เลือกแกนเฟอร์ไรต์แบบ EE80/76 มีค่า $A_e = 3.77\ cm^2$ และ $A_w = 14.80\ cm^2$ สามารถหา $A_e A_w = 3.77 \times 14.80 = 55.796\ cm^4$ จากทฤษฎีต้องเผื่อพื้นที่ของแกนหม้อแปลงไฟฟ้า คือ $A_e A_w = 2 \times 55.796 = 111.592\ cm^4$ ดังนั้น ไม่สามารถใช้แกนเฟอร์ไรต์แบบ EE80/769 ตามปกติได้จึงต้องต่อแกนเพิ่ม (ในวิทยานิพนธ์ฉบับนี้ได้ทำการใช้แกนหม้อแปลงไฟฟ้าของ นาย ฉัตรชัย อัสดาธร [5] ประกอบการทำวิทยานิพนธ์)

ค. หาจำนวนรอบของขดลวดตัวนำทางด้านปฐมภูมิ

สามารถหาจำนวนรอบของขดลวดตัวนำทางด้านปฐมภูมิได้ดังสมการ

$$N_p = \frac{(V_p \times \tau_m \times 10^3)}{A_e \times B_{max}} \quad (7)$$

แทนค่า V_p = 50 V , τ_m = 50 μs, A_e = 377 mm^2 , ΔB_m = 2400 G ลงในสมการที่ 7 สามารถหาจำนวนรอบของขดลวดตัวนำทางด้านปฐมภูมิได้ดังสมการ

$$N_p = \frac{(50 \times 50 \times 10^3)}{377 \times 240} = 27.63 \text{ รอบ}$$ โดยทั้งนี้ใช้ N_p = 22 รอบ

ในวิทยานิพนธ์นี้ใช้จำนวนรอบของขดลวดตัวนำทางด้านปฐมภูมิ 22 รอบ 2เส้นคู่

ง. หาจำนวนรอบของขดลวดตัวนำทางดานทุติยภูมิ

หาจำนวนรอบของขดลวดตัวนำทางด้านทุติยภูมิได้ดังสมการ

$$N_s = \frac{N_p \times V_s}{V_p} \quad (8)$$

แทนค่า N_p = 22 รอบ , V_s = 12,000V และ V_p = 50V ลงในสมการที่ 8 สามารถหาจำนวนรอบของขดลวดตัวนำทางด้านทุติยภูมิได้ ดังสมการ

$$N_s = \frac{22 \times 12{,}000}{50} = 5{,}280 \text{ รอบ}$$ ดังนั้น N_s = 5,280 รอบ

จำนวนขดที่พันจริง = 5000 รอบ

จ.ขนาดของขดลวดตัวนำ

สามารถหาขนาดของขดลวดตัวนำได้จากสมการดังนี้

$$d_{wire} = I \times D \text{ circular mil} \quad (9)$$

ขนาดขดลวดตัวนำทางด้านปฐมภูมิ

จาก I_p = 1.2 A แทนค่าลงในสมการจะได้

$$d_{wire} = 1.2 \times 400 = 480 \text{ circular mil}$$

เปิดตารางเทียบเบอร์ขนาดของขดลวดตัวนำพบว่า d_{wire} AWG25 เท่ากับ 320.4 circular mil 2 สองเส้นคู่ ดังนั้น d_{wire} เท่ากับ 640.8 circular mil

ขนาดขดลวดตัวนำทางด้านทุติยภูมิ

จาก I_s = 1 mA แทนค่าลงในสมการจะได้

$$d_{wire} = 1\text{mA} \times 400 = 10 \text{ circular mil}$$

ในวิทยานิพนธ์นี้ได้ใช้ขวดลวดทุติยภูมิเดิมโดยมีลายละเอียดดังนี้

จากตารางเทียบเบอร์ขนาดของขดลวดตัวนำพบว่าd_{wire} จากการคำนวณมีค่าอยู่ระหว่าง ขดลวดตัวนำเบอร์ AWG 40 มีค่า d_{wire}= 9.9 circular mil และ AWG 39 มีค่า d_{wire}= 12.5

circular mil เลือกใช้ AWG 39 เพราะมีค่า d_{wire} มากกว่าค่า d_{wire} ที่ได้จากการคำนวณ ดังนั้น ขดลวดตัวนำทางด้านทุติยภูมิมีขนาดเท่ากับ AWG 39

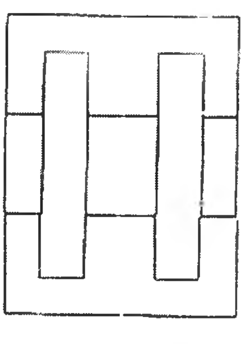
แต่จากการทดลองไม่สามารถใช้ขดลวดตัวนำทางด้านทุติยภูมิขนาด AWG 39 ได้เนื่องจากขณะทดสอบหม้อแปลงไฟฟ้าขดลวดตัวนำทางด้านทุติยภูมิจะมีอุณหภูมิสูงมากจนทำให้เกิดการอาร์คระหว่างขดลวดตัวนำ เนื่องจากความร้อนที่เกิดจากขดลวดตัวนำทำให้ความเป็นฉนวนสูญเสียไป ดังนั้นจึงเปลี่ยนไปใช้ขดลวดตัวนำขนาด AWG 30 ซึ่งทำให้มีขนาดของขดลวดตัวนำเพิ่มขึ้นประมาณ 30 % อุณหภูมิของขดลวดตัวนำขณะที่หม้อแปลงไฟฟ้าทำงานอยู่ในระดับปกติ

การพันขดลวดตัวนำและการฉนวน

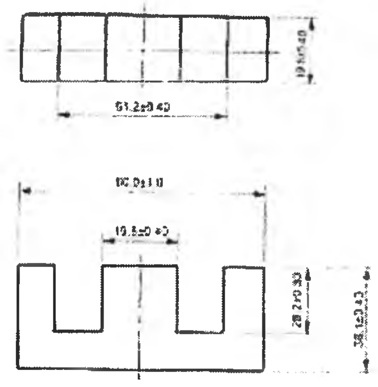
การออกแบบวิธีการพันขดลวดตัวนำและการฉนวนของหม้อแปลงไฟฟ้าแบบสวิตชิงจะต้องพิจารณาถึงการนำไปใช้งานและความปลอดภัยในการใช้งานหลักและเนื่องจากแกนหม้อแปลงไฟฟ้าแบบ EE80/76 ที่มีจำหน่ายไม่มีบอบบินมาให้ จึงต้องทำการสร้างบอบบินขึ้น

การออกแบบและสร้างบอบบิน

การออกแบบบอบบินสำหรับหม้อแปลงไฟฟ้าศักดาสูงให้เหมาะสมกับการพันขดลวดตัวนำจะต้องคำนึงถึงขนาดของศักดาไฟฟ้าเป็นหลัก ในขณะเดียวกันขนาดของแกนตัวนำของหม้อแปลงไฟฟ้าก็มีความจำเป็นในการออกแบบและสร้างบอบบิน เพื่อให้ได้ขนาดของบอบบินที่พอเหมาะกับแกนตัวนำของหม้อแปลงไฟฟ้า ในงานวิจัยนี้เลือกแกนเฟอร์ไรต์ที่มีขนาด พื้นที่ในการพันลวดมากที่สุดและมีจำหน่ายในประเทศ คือ แกนเฟอร์ไรต์แบบ EE80/76 ซึ่งขนาดของแกนตัวนำของหม้อแปลงไฟฟ้าแบบเฟอร์ไรต์แบบ EE80/76 มีขนาดดังนี้



รูปที่ 1 ขนาดของแกนเฟอร์ไรต์แบบ EE80/76



รูปที่ 2 การเพิ่มเนื้อที่การพันลวดด้วยการต่อความยาวของแกนตัวนำ

เนื่องจากไม่สามารถพันขดลวดตัวนำได้ทั้งหมดจากตามที่คำนวณลงในขนาดของแกนตัวนำปกติ จึงจำเป็นต้องทำการต่อแกนตัวนำเพิ่มอีกหนึ่งส่วน เพื่อทำให้มีเนื้อที่ในการพันขดลวดตัวนำเพิ่มขึ้น แต่ในทางปฏิบัติก็ไม่สามารถพันขดลวดตัวนำทางด้านทุติยภูมิได้ทั้งหมด เนื่องจากความหนาของฉนวนที่หาได้ ซึ่งสามารถพันขดลวดตัวนำทางด้านทุติยภูมิได้เพียง 5,000 รอบเท่านั้น แสดงดังรูปที่ 1

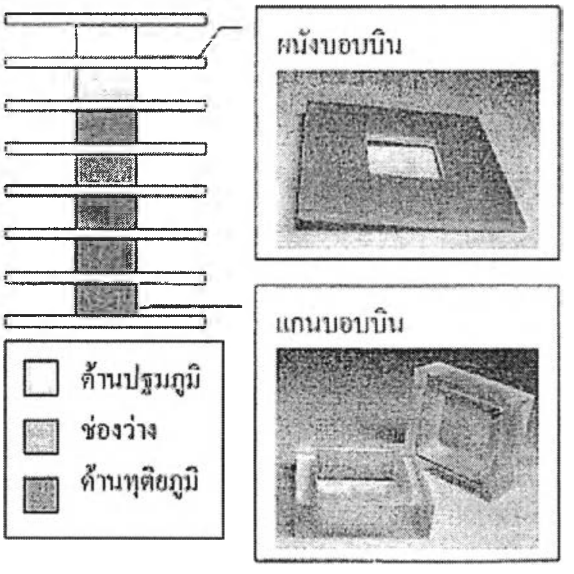
ส่วนของขดลวดตัวนำทางด้านปฐมภูมิจะต้องแยกห่างจากขดลวดตัวนำทางด้านทุติยภูมิ เพื่อป้องกันการอาร์คระหว่างขดลวดทั้งสอง ผนังของบอบบินจะใช้แผ่นไฟเบอร์ซึ่งมีค่าความเป็นฉนวนสูง มาเจาะช่องและตัดทำเป็นผนัง ส่วนตัวแกนบอบบินจะใช้พลาสติกใสหนามาตัดและเจาะช่อง ซึ่งมีรายละเอียดดังนี้

ผนังของบอบบิน ทำมาจากแผ่นไฟเบอร์หนา 2 มิลลิเมตร ตัดเป็นรูปสี่เหลี่ยมจัตุรัสมีความกว้าง 6 เซนติเมตร และ มีความยาว 6 เซนติเมตร ส่วนช่องด้านในตัดเป็นรูปสี่เหลี่ยมจัตุรัสมีความกว้าง 2 เซนติเมตร และ มีความยาว 2 เซนติเมตร

แกนของบอบบิน ทำมาจากพลาสติกประเภท Acrylic ใสหนา 1 เซนติเมตร โดยตัดเป็นรูปสี่เหลี่ยมจัตุรัสมีความกว้าง 3 เซนติเมตร และ มีความยาว 3 เซนติเมตร ส่วนช่องด้านในตัดเป็นรูปสี่เหลี่ยมจัตุรัสมีความกว้าง 2 เซนติเมตร และ มีความยาว 2 เซนติเมตร

การทำบอบบินหนึ่งชุดจะต้องการแกนบอบบินไว้จำนวน 7 แกนและผนังของบอบบินไว้จำนวน 8 แผ่น และ ประกอบกันตามดังรูปที่ 3 ซึ่งเมื่อนำแกนมาประกอบส่วนของบอบ

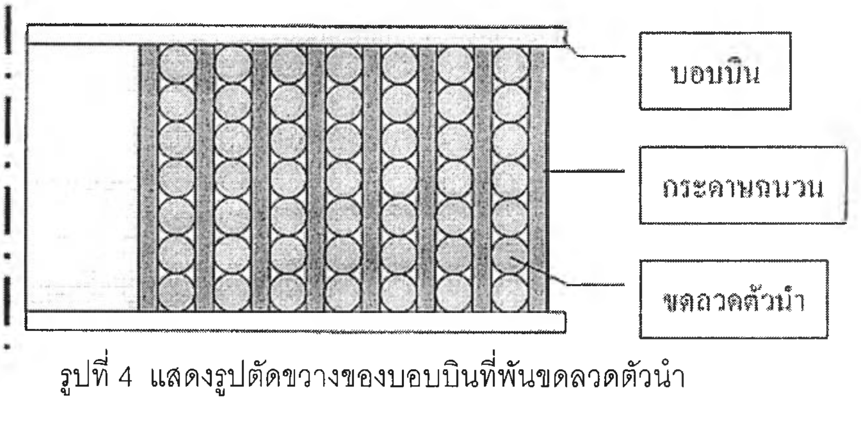
บินที่มีขดลวดตัวนำพันอยู่ก็จะถูกจัดเรียงโดยรูปแบบของแกน ทำให้สามารถถอดออกมาตรวจสอบหรือซ่อมแซมได้เป็นส่วนๆ



รูปที่ 3 แสดงแบบของบอบบิน

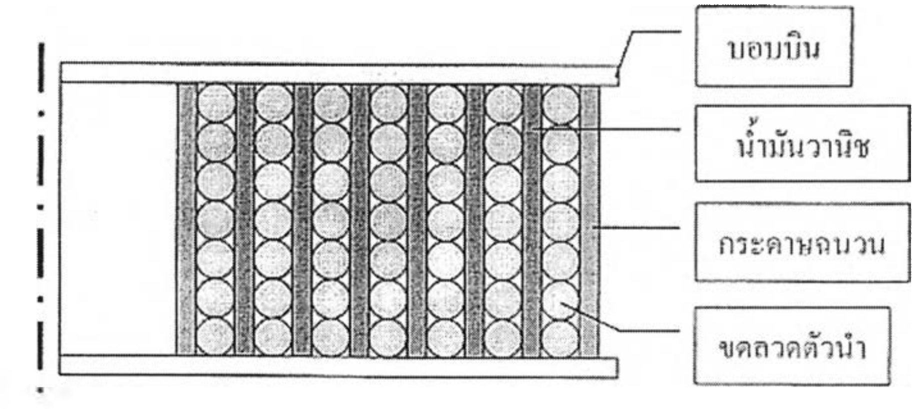
การพันขดลวดตัวนำทางด้านปฐมภูมิ

จากจำนวนรอบของขดลวดตัวนำทางด้านปฐมภูมิเท่ากับ 22 รอบเส้นคู่ใช้ขดลวดตัวนำเบอร์ AWG 25 มีขนาดเส้นผ่านศูนย์กลาง 0.018 นิ้ว (0.036 นิ้ว เส้นคู่) หรือ ประมาณ 0.0457 เซนติเมตร (0.0914 ซม.เส้นคู่) บอบบินมีขนาดกว้าง 1 เซนติเมตร ดังนั้นสามารถพันขดลวดตัวนำได้เท่ากับ 1/0.0914 $\approx$ 11 รอบต่อชั้นและสามารถพันขดลวดตัวนำทั้งหมดเท่ากับกับ 22/11 = 2 ชั้น แต่ละชั้นที่พันขดลวดตัวนำจะพันทับ สำหรับการพันขดลวดตัวนำทางด้านปฐมภูมิและฉนวนทั้งหมด ดังแสดงในรูปที่ 4



รูปที่ 4 แสดงรูปตัดขวางของบอบบินที่พันขดลวดตัวนำ

ในทางปฏิบัตินั้นการพันขดลวดตัวนำแล้วเคลือบด้วยน้ำมันวานิช ดังแสดงในรูปที่ 5



รูปที่ 5 แสดงภาพตัดขวางของบอบบินที่พันขดลวดตัวนำในทางปฏิบัติ

การพันขดลวดตัวนำทางด้านทุติยภูมิ

จากจำนวนรอบของขดลวดตัวนำทางด้านทุติยภูมิเท่ากับ 5,000 รอบ บอบบินที่ออกแบบมาให้สามารถพันขดลวดตัวนำออกเป็น 5 ชุด โดยแต่ละชุดจะพันขดลวดตัวนำจำนวน 1,000 รอบ ใช้ขดลวดตัวนำเบอร์ AWG 30 มีขนาดเส้นผ่านศูนย์กลาง 0.0113 นิ้ว หรือ ประมาณ 0.029 เซนติเมตร บอบบินมีขนาดกว้าง 1 เซนติเมตร ดังนั้นสามารถพันขดลวดตัวนำได้เท่ากับ 1/0.029 $\approx$ 34 รอบต่อชั้นและ สามารถพันขดลวดตัวนำทั้งหมดเท่ากับ 100/34 = 29 ชั้น แต่ละ ชั้นที่พันขดลวดตัวนำจะพันทับด้วยกระดาษฉนวนซึ่งมีความหนาเท่ากับ 0.1 มิลลิเมตร หรือเท่ากับ 0.01 เซนติเมตร จำนวน 31 ชั้น ช่องว่างในการพันขดลวดตัวนำมีประมาณ 1.7 เซนติเมตร ,สามารถรวมความสูงของขดลวดตัวนำและเทปฉนวนเท่ากับ (29 x 0.029) + (29 x 0.01) = 1.131 เซนติเมตร ซึ่งพอสำหรับการพันขดลวดตัวนำทางด้านทุติยภูมิและฉนวนทั้งหมด

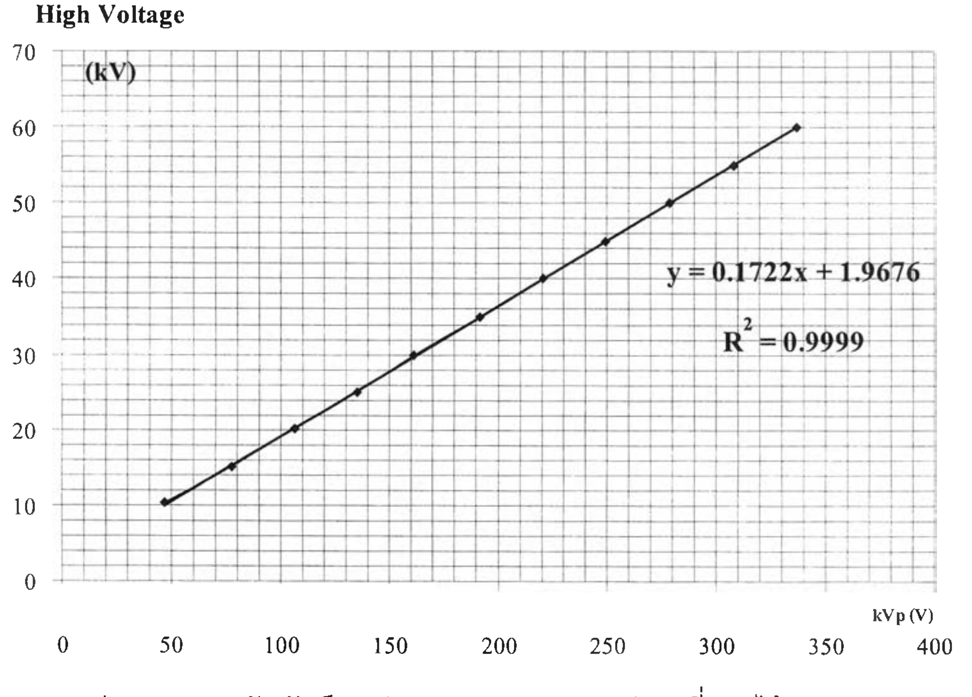
ภาคผนวก ง

การทดสอบระบบจ่ายไฟฟ้าศักดาสูงแบบสวิตชิงและไฟฟ้าศักดาต่ำ สำหรับหลอดรังสีเอกซ์

ทำการปรับค่าความต้านทานแบบปรับค่าได้แล้วอ่านความสัมพันธ์ระหว่างไฟฟ้าศักดาสูงจาก Electrostatic Meter และค่าที่อ่านได้จาก kVp Meter ที่ได้ติดตั้งบันทึกข้อมูลดังแสดงในตาราง และกราฟด้านล่าง

ตาราง ผลการทดลองหาความสัมพันธ์ระหว่าง kV Output (kV) กับค่าที่อ่านได้จาก kVp Meter

ลำดับที่	KVp Meter (V)	KV Output (kV)	ลำดับที่	KVp Meter (V)	KV Output (kV)
1	47	10.3	7	221	40.0
2	78	15.1	8	250	45.0
3	106	20.1	9	279	50.0
4	135	25.1	10	308	55.0
5	161	29.9	11	337	60.0
6	192	35.0	12	400	71.0



กราฟแสดงความสัมพันธ์ระหว่าง kV Output (kV) กับค่าที่อ่านได้จาก kVp Meter

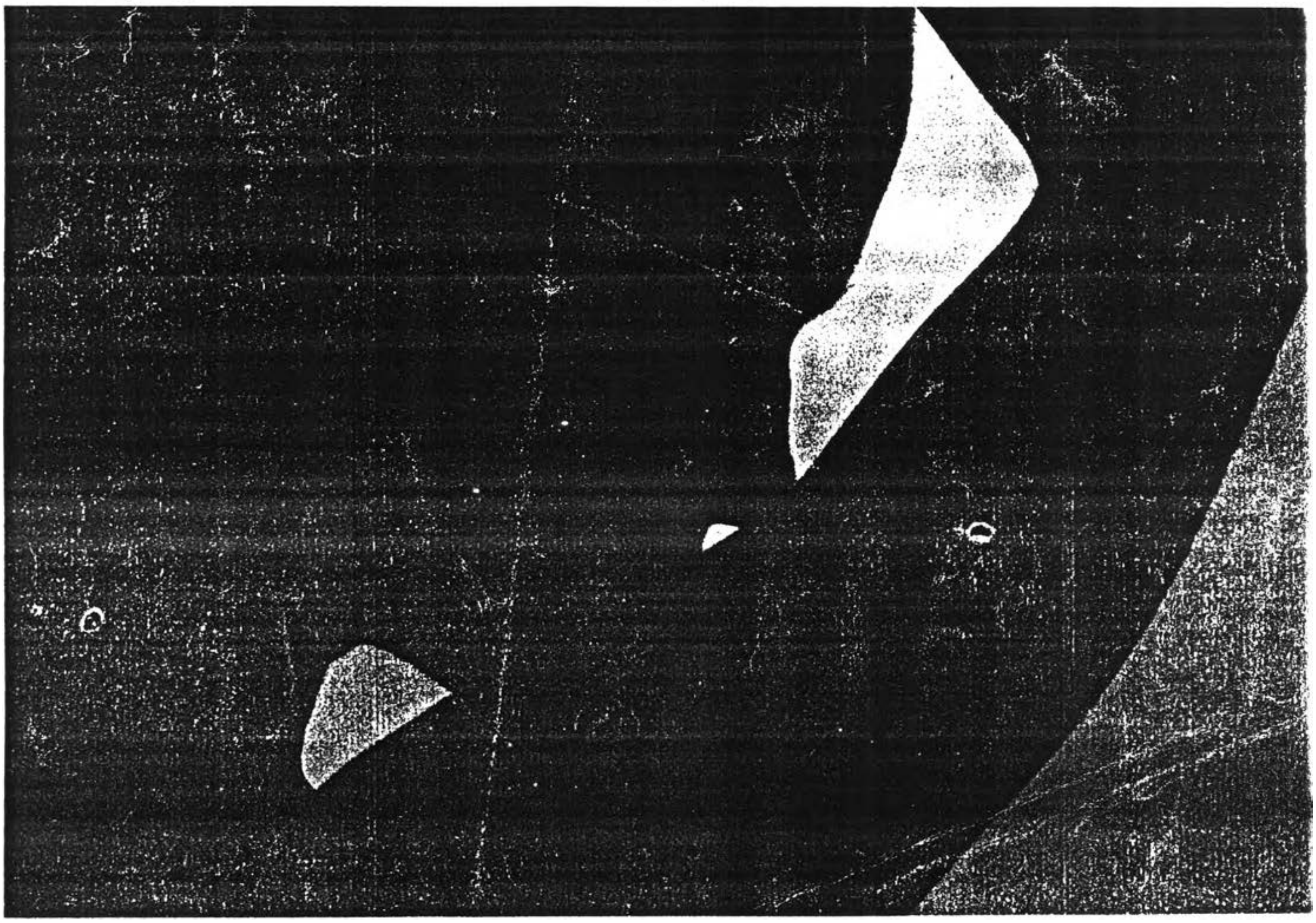
ภาคผนวก จ
หมายเลขและขนาดของ IQI แบบเส้นลวดของ DIN54 109
และแบบแสดงคุณสมบัติของแผ่นเรืองรังสีเชิงพาณิชย์

ตารางหมายเลขและขนาดของ IQI แบบเส้นลวดของ DIN54 109

หมายเลข	1	2	3	4	5	6	7	8
เส้นผ่าศูนย์กลาง (มม.)	3.20	2.50	2.00	1.60	1.25	1.00	0.80	0.63
หมายเลข	9	10	11	12	13	14	15	16
เส้นผ่าศูนย์กลาง (มม.)	0.50	0.40	0.32	0.25	0.20	0.16	0.125	0.100

Intensifying Screen

Intensifying screens for medical radiography



OKAMOTO X-Ray cassettes and Intensifying Screens
are being used in all over the World!!

Excellent combination of OKAMOTO Intensifying Screen and OKAMOTO X-Ray Cassette

Merits on Adoption of Rare Earth Intensifying Screen

1. Reduction of radiation exposure
Radiation exposure to patients is reduced greatly compared to conventional $CaWO_4$ intensifying screen system.

2. Elimination of motion blur
Since exposure time is greatly shortened, motion blur with motion subjects such as the heart, digestive organs etc. have been reduced and image quality has been improved.

3. Reduction of X-ray unit capacity
A small capacity unit can have the same efficiency as a large one, which can reduce unit cost. Especially portable units can be adopted effectively.

4. Adoption of small focal spot X-ray tube
A small focal spot-X-ray tube can be adopted generally and image quality will be improved. Also magnification radiography can be put into general use.

Type of Rare Earth Intensifying Screen

LDS High definition
Best used in the extremities, bones, skull and chest. Speed and image quality are equal to Kodak Lanex Fine.
Extremities, bones, skull and chest

LMS Satisfactory speed and definition
Speed is about twice of LDS. It can be universally used for normal voltage radiography. Especially, good results can be obtained in stomach and intestines.
Stomach and intestines

LUS, L-660 High speed and Super high speed
Best results can be obtained in angiography, magnification radiography small capacity unit radiography and examinations in the motion subjects and gonadal region.
Speed and image quality of LUS Screen are equal to KODAK LANEX Regular screen.
Urinary organs, pregancy, lumbar vertebra

LC Gradual Speed
Speed is gradually varied from 1 to 2 and 1 to 3.

OKAMOTO Rare Earth Intensifying Screens Characteristics Table

Screen	Relative Speed*	Relative Sharpness*
LDS	45	115
LMS	100	100
LUS	200	68
L-660	260	53

(*LMS values assigned 100)

Type of Blue Emitting Screens

DD High definition
Definition is very excellent and most suitable for large capacity X-ray radiography. This is also suitable for high-voltage radiography.
Chest, bones and skull

DMS Satisfactory speed and definition
Speed and definition are centered between DS and DD. Good results can be obtained in every part of the body.
Stomach and intestines

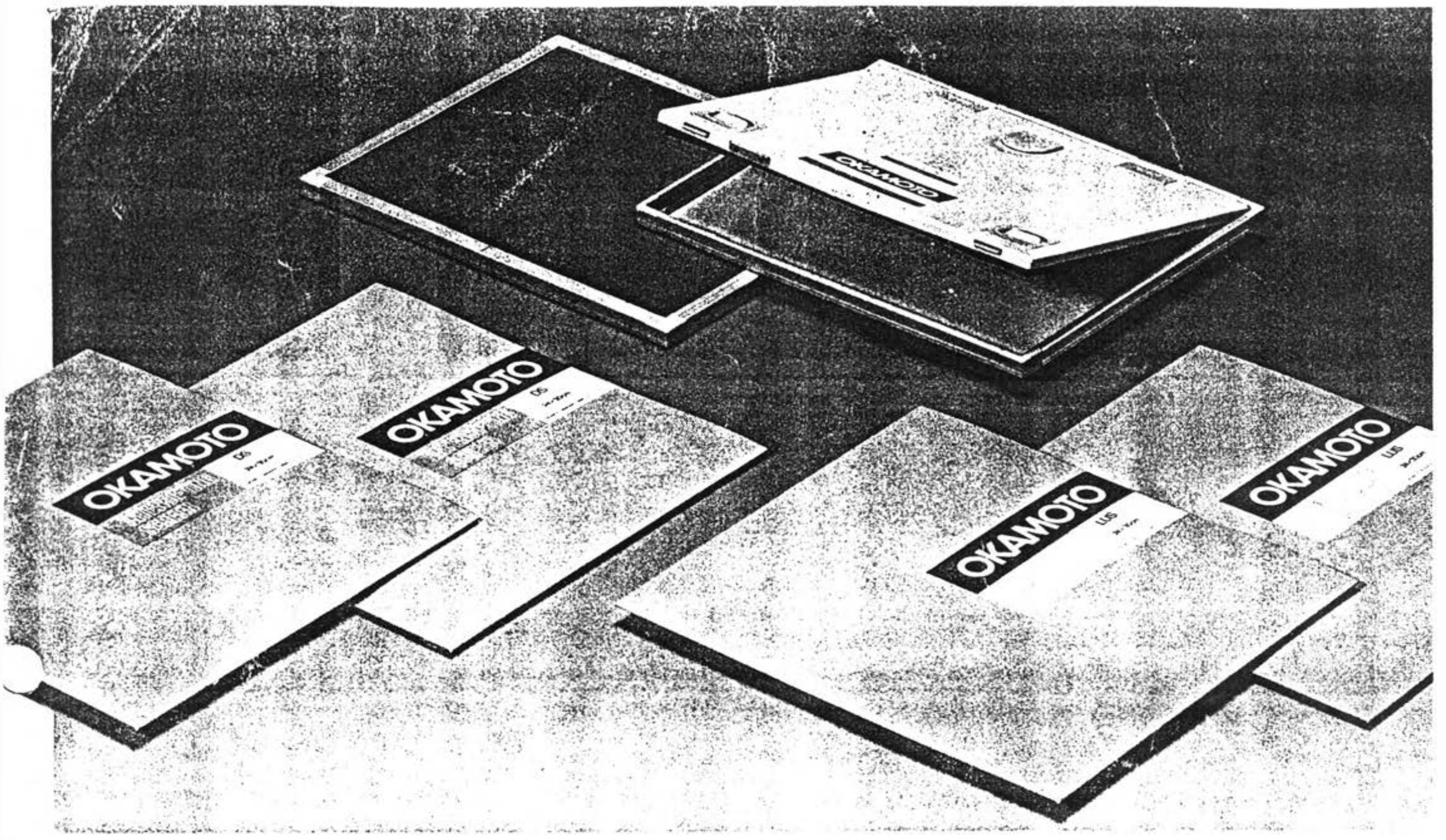
DS High speed
For larger dosage radiography. Good results can be obtained with minimum exposure.
This screen has the same speed as DUPONT HI-PLUS
Stomach and lumbar vertebra

KS Super high speed
This is specially designed as very fast screen, and has more than two times the speed of DMS. It is recommended to be used in the case where speed is the primary requirement.
Small capacity units, pregnancy and Urinary organs.

EC Gradual Speed
Speed is gradually varied from 1 to 2 and 1 to 3.

Rare Earth Blue Emitting Screens

Q-65, Q-120 High Speed and Super high Speed
These are Blue emitting every fast Screens. Can be used same as Green emitting LUS and L-660 Screens.
Urinary organs, Pregancy, Lumbar vertebra



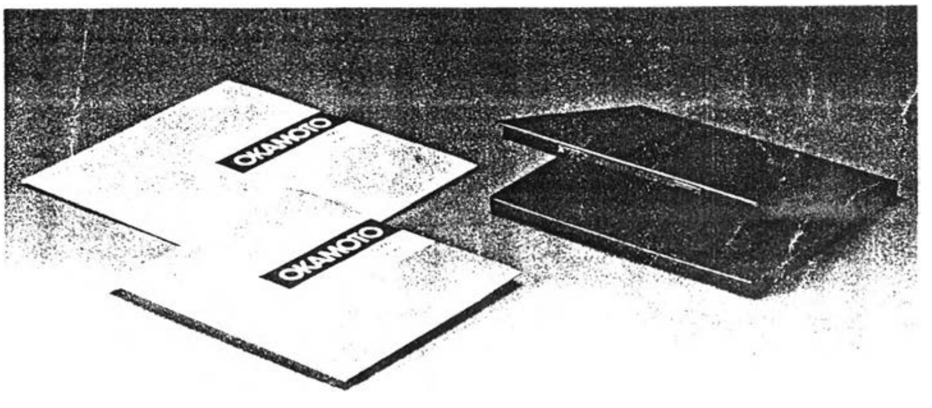
OKAMOTO Intensifying Screens Characteristics Table

Screen	Relative Speed*	Relative Sharpness*
DD	50	118
DMS	100	100
DS	185	70
KS	225	50
Q-65	300	75
Q-120	600	58

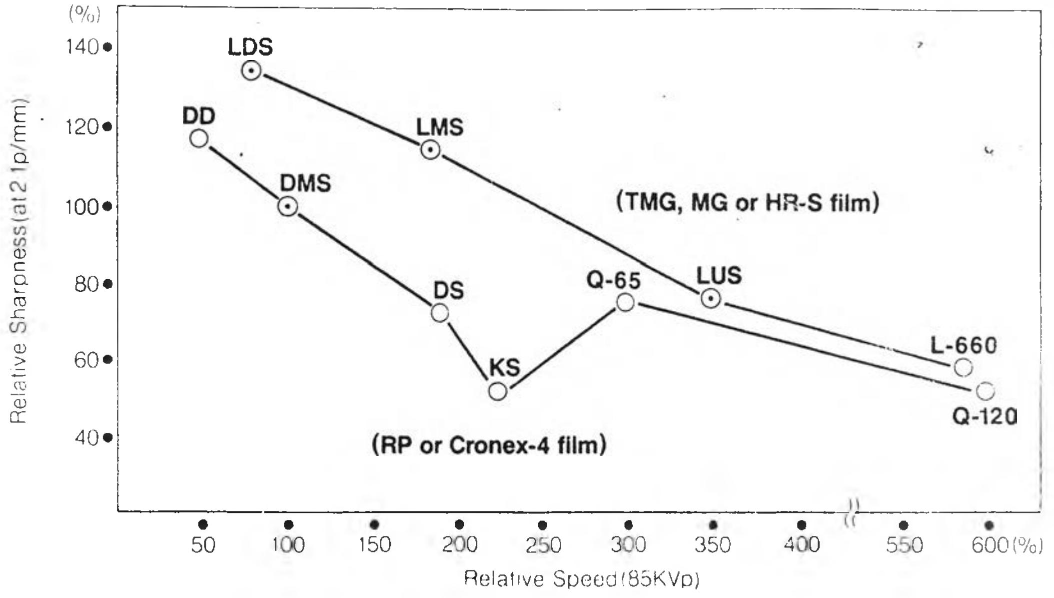
(*DMS values assigned 100)

OKAMOTO Mammography Screens

S-100 **Mammography Use**
Single screen designed for mammography. Equal to KODAK Min-R screen.



OKAMOTO Intensifying Screens Characteristics Chart



Most suitable objects radiographed for OKAMOTO Intensifying Screen

Objects / Type of Screen	Upper & lower limbs	Chest	Head Tomogran	Stomach	Urinary organs	Pregnancy Children's Hip-Joint	Head & leg	Lumber vertebra
DD	⊙	○						
DMS		⊙	○	⊙				
DS				○	⊙	○		⊙
KS					⊙	⊙		○
Q-65					○	⊙		○
Q-120								
EC	Complete Vertebrae Column							
LDS	⊙	⊙	⊙	○			⊙	
LMS	○	○	⊙	⊙			○	
LUS				○	⊙	⊙		⊙
L-660								
LC	Complete Vertebrae Column							
S-100	Mammography							

▭ Standard Type ▭ Orth Type ⊙ = Most suitable object ○ = Suitable objects

Specifications are subject to change without prior notice

Distributed by

OKAMOTO MANUFACTURING CO., LTD.

Exporter:

Royal Trading Co., Ltd.

NO. 30-6, 3-chome, Nishi Waseda, Shinjuku-ku, Tokyo 169, Japan
Phone (03) 3207-0417 Fax: (03) 3207-1452

PRINTED IN JAPAN '96.10-H02

ประวัติผู้เขียนวิทยานิพนธ์

นายคมกฤส มะวิญธร เกิดเมื่อวันที่ 15 เดือนสิงหาคม พุทธศักราช 2520 ที่จังหวัดลำปาง สำเร็จการศึกษาปริญญาวิศวกรรมศาสตรบัณฑิตจากภาควิชาวิศวกรรมโยธาคณะวิศวกรรมศาสตร์ มหาวิทยาลัยเชียงใหม่ เมื่อปีการศึกษา 2541 เข้าศึกษาต่อในหลักสูตรวิศวกรรมศาสตรมหาบัณฑิต ภาควิชานิวเคลียร์เทคโนโลยี คณะวิศวกรรมศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย เมื่อปีการศึกษา 2544