Apéndice A

Intensidad dispersada por un sistema LDA de una dimensión

A.1. Desarrollo de la ecuación (8.10)

Se ha presentado en el apartado 8.4 la expresión de la intensidad dispersada por una partícula, debido a la incidencia de dos haces de luz, formando entre ellos un ángulo α en un sistema LDA de una dimensión, con un determinado campo eléctrico E_{in1} y E_{in2} o intensidad I_{in1} y I_{in2} en el punto de medida.

El campo incidente del haz 1 y del haz 2 plano paralelos, los podemos expresar en notación compleja calculados en un punto del espacio ρ, con vectores de propagación y polarización $\hat{s}_1$, $\hat{p}_1$ y $\hat{s}_2$, $\hat{p}_2$ respectivamente, de la forma

$$E_{in1}(\rho) = \sqrt{\frac{2I_{in1}(\rho)}{n_m}\sqrt{\frac{\mu_o}{\epsilon_o}}}\; e^{j(w_o t - k\hat{s}_1\rho)}\hat{p}_1 \tag{A.1}$$

$$E_{in2}(\rho) = \sqrt{\frac{2I_{in2}(\rho)}{n_m}\sqrt{\frac{\mu_o}{\epsilon_o}}}\; e^{j(w_o t - k\hat{s}_2\rho)}\hat{p}_2 \tag{A.2}$$

con n_m el índice de refracción del medio de propagación de los haces, ϵ_o la permitividad dieléctrica en el vacío y μ_o la permeabilidad magnética en el vacío.

Aplicando las consideraciones y aproximaciones del apartado 8.2, el campo dispersado en campo lejano en cada punto de la apertura receptora (r, θ, ϕ) por una partícula, moviéndose con una cierta velocidad en el espacio $V_p = (V_{px}, V_{py}, V_{pz})$, de coeficientes de dispersión $\sigma_1(\theta, \phi)$ y $\sigma_2(\theta, \phi)$ para cada uno de los haces incidentes 1 y 2, son

$$E_{d1}(r,\theta,\phi) = \sqrt{\frac{2I_{in1}}{n_m}\sqrt{\frac{\mu_o}{\epsilon_o}}}\ \frac{e^{j((w_o+\Delta w_1)t-kr)}}{kr}\ \sigma_1(\theta,\phi) \tag{A.3}$$

$$E_{d2}(r,\theta,\phi) = \sqrt{\frac{2I_{in2}}{n_m}\sqrt{\frac{\mu_o}{\epsilon_o}}}\ \frac{e^{j((w_o+\Delta w_2)t-kr)}}{kr}\ \sigma_2(\theta,\phi) \tag{A.4}$$

donde w_o es la pulsación de la señal incidente, Δw_1 y Δw_2 son los desplazamientos frecuenciales de las señales dispersadas debido al efecto Doppler.

La relación entre la frecuencia o pulsación Doppler de cada uno de los haces y los parámetros de la fuente y geometría , para cada haz en particular, es

$$\Delta w_1 = k(\hat{r} - \hat{s}_1)V_p \tag{A.5}$$

$$\Delta w_2 = k(\hat{r} - \hat{s}_2)V_p \tag{A.6}$$

El campo total dispersado en un punto de la apertura receptora (r, θ, ϕ) en campo lejano, será la suma vectorial de los campos eléctricos $E_d = E_{d1} + E_{d2}$. Sumando las ecuaciones (A.3) y (A.4), tenemos

$$E_{d1}(r,\theta,\phi) = \sqrt{\frac{2I_{in1}}{n_m}\sqrt{\frac{\mu_o}{\epsilon_o}}}\frac{\sigma_1(\theta,\phi)}{kr}e^{j((w_o+\Delta w_1)t-kr)} + \sqrt{\frac{2I_{in2}}{n_m}\sqrt{\frac{\mu_o}{\epsilon_o}}}\frac{\sigma_2(\theta,\phi)}{kr}e^{j((w_o+\Delta w_2)t-kr)} \tag{A.7}$$

y agrupando la expresión de forma más conveniente

$$E_d(r,\theta,\phi) = \sqrt{\frac{2}{n_m}\sqrt{\frac{\mu_o}{\epsilon_o}}}\ \frac{e^{-jkr}}{kr}\left[\sigma_1\sqrt{I_{in1}}\ e^{j(w_o+\Delta w_1)t} + \sigma_2\sqrt{I_{in2}}\ e^{j(w_o+\Delta w_2)t}\right] \tag{A.8}$$

Ahora que ya tenemos el campo total dispersado, aplicando la ecuación (8.2), que nos relaciona el campo eléctrico con la intensidad, que es proporcional al modulo al cuadrado del campo $\mid E_d \mid^2$, y sabiendo que

$$\mid E_d \mid^2 = E_d E_d^* \tag{A.9}$$

la intensidad dispersada será

$$I_d = \frac{n_m}{2} \sqrt{\frac{\epsilon_o}{\mu_o}}\ E_d E_d^* \tag{A.10}$$

Así pues, a partir de la ecuación (A.8) calculamos el módulo del campo al cuadrado,

$$\begin{aligned} \mid E_d \mid^2 &= \sqrt{\frac{2}{n_m}\sqrt{\frac{\mu_o}{\epsilon_o}}}\ \frac{e^{-jkr}}{kr}\left[\sigma_1\sqrt{I_{in1}}\ e^{j(w_o+\Delta w_1)t} + \sigma_2\sqrt{I_{in2}}\ e^{j(w_o+\Delta w_2)t}\right]\cdot \\ \cdot\ &\sqrt{\frac{2}{n_m}\sqrt{\frac{\mu_o}{\epsilon_o}}}\ \frac{e^{jkr}}{kr}\left[\sigma_1^*\sqrt{I_{in1}}\ e^{-j(w_o+\Delta w_1)t} + \sigma_2^*\sqrt{I_{in2}}\ e^{-j(w_o+\Delta w_2)t}\right] \end{aligned} \tag{A.11}$$

Si desarrollamos el producto de la ecuación (A.11) y aplicando las relaciones trigonométricas de una función cosenoidal con la función exponencial compleja, conocida como funciones de Euler

$$\cos(A) = \frac{e^{j(A)} + e^{-j(A)}}{2} \tag{A.12}$$

$$\Re\{e^{j(A)}\} = \cos(A) \tag{A.13}$$

obtenemos

$$\begin{aligned} \mid E_d \mid^2 &= \frac{2}{n_m}\sqrt{\frac{\mu_o}{\epsilon_o}}\ \frac{1}{k^2r^2}\Big[I_{in1}\mid \sigma_1(\theta,\phi)\mid^2 + I_{in2}\mid \sigma_2(\theta,\phi)\mid^2 + \\ &+\ \sqrt{I_{in1}I_{in2}}\cdot 2\Re\left\{\sigma_1(\theta,\phi)\cdot\sigma_2^*(\theta,\phi)\cdot e^{(j2\pi f_{dop}t)}\right\}\Big] \end{aligned} \tag{A.14}$$

o expresada en función de un coseno

$$\begin{aligned} \mid E_d \mid^2 &= \frac{2}{n_m}\sqrt{\frac{\mu_o}{\epsilon_o}}\ \frac{1}{k^2r^2}\Big[I_{in1}\mid \sigma_1(\theta,\phi)\mid^2 + I_{in2}\mid \sigma_2(\theta,\phi)\mid^2 + \\ &+\ \sqrt{I_{in1}I_{in2}}\cdot D(\theta,\phi)\cdot\cos(2\pi f_{dop}t - \psi(\theta,\phi))\Big] \end{aligned} \tag{A.15}$$

$$f_{dop} = \frac{k(\hat{s}_2 - \hat{s}_1)V_p}{2\pi} = \frac{\Delta w_1 - \Delta w_2}{2\pi} \tag{A.16}$$

donde f_{dop} es la frecuencia Doppler, diferencia de las frecuencias Doppler de cada uno de los haces dispersados, $D(\theta, \phi)$ es la amplitud de la componente alterna de la mezcla o interferencia de los dos haces dispersados, y $\psi(\theta, \phi)$ la fase de la componente Doppler.

Una vez obtenida la expresión del módulo del campo eléctrico dispersado por una partícula en movimiento, producido por la incidencia de los haces de luz, la intensidad dispersada en un punto del espacio, aplicando la relación presentada en la ecuación (A.10), es

$$\begin{aligned} I_d(r,\theta,\phi) &= \frac{1}{k^2r^2}\Big(I_{in1}|\ \sigma_1(\theta,\phi)\ |^2 + I_{in2}|\ \sigma_2(\theta,\phi)\ |^2 + \\ &+ \sqrt{I_{in1}I_{in2}}\cdot D(\theta,\phi)\cdot\cos(2\pi f_{dop}t - \psi(\theta,\phi))\Big) \end{aligned} \tag{A.17}$$

Apéndice B

Intensidad dispersada por un sistema 2D-LDA

B.1. Desarrollo de la ecuación (9.21)

Se ha presentado en el apartado 9.3 la expresión de la intensidad dispersada por una partícula, debido a la incidencia de tres haces de luz, de subíndice A, B y C, formando entre ellos un ángulo α en un sistema LDA de una dimensión, con un determinado campo eléctrico E_{inA} E_{inB} y E_{inC} o intensidad I_{inA} I_{inB} y I_{inC} en el punto de medida.

El campo incidente del haz A, haz B y haz C plano paralelos, los podemos expresar en notación compleja calculados en un punto del espacio ρ, con vectores de propagación y polarización $\hat{s}_A$, $\hat{p}_A$, $\hat{s}_B$, $\hat{p}_B$ y $\hat{s}_C$, $\hat{p}_C$ respectivamente, de la forma

$$E_{inA1}(\rho) = \sqrt{\frac{2I_{inA}(\rho)}{n_m}\sqrt{\frac{\mu_o}{\epsilon_o}}}\; e^{j(w_o t - k\hat{s}_A\rho)}\hat{p}_A \tag{B.1}$$

$$E_{inB}(\rho) = \sqrt{\frac{2I_{inB}(\rho)}{n_m}\sqrt{\frac{\mu_o}{\epsilon_o}}}\; e^{j(w_o t - k\hat{s}_B\rho)}\hat{p}_B \tag{B.2}$$

$$E_{inC}(\rho) = \sqrt{\frac{2I_{inC}(\rho)}{n_m}\sqrt{\frac{\mu_o}{\epsilon_o}}}\; e^{j(w_o t - k\hat{s}_C\rho)}\hat{p}_C \tag{B.3}$$

con n_m el índice de refracción del medio de propagación de los haces, ϵ_o la permitividad dieléctrica en el vacío y μ_o la permeabilidad magnética en el vacío.

Aplicando las consideraciones y aproximaciones del apartado 8.2, el campo dispersado en campo lejano en cada punto de la apertura receptora (r, θ, ϕ) por una partícula, moviéndose con una cierta velocidad en el espacio $V_p = (V_{px}, V_{py}, V_{pz})$, de coeficientes de dispersión $\sigma_A(\theta,\phi)$, $\sigma_B(\theta,\phi)$ y $\sigma_C(\theta,\phi)$ para cada uno de los haces incidentes A, B y C, son

$$E_{dA}(r,\theta,\phi) = \sqrt{\frac{2I_{inA}}{n_m}\sqrt{\frac{\mu_o}{\epsilon_o}}}\,\frac{e^{j((w_o+\Delta w_A)t-kr)}}{kr}\,\sigma_A(\theta,\phi) \tag{B.4}$$

$$E_{dB}(r,\theta,\phi) = \sqrt{\frac{2I_{inB}}{n_m}\sqrt{\frac{\mu_o}{\epsilon_o}}}\,\frac{e^{j((w_o+\Delta w_B)t-kr)}}{kr}\,\sigma_B(\theta,\phi) \tag{B.5}$$

$$E_{dC}(r,\theta,\phi) = \sqrt{\frac{2I_{inC}}{n_m}\sqrt{\frac{\mu_o}{\epsilon_o}}}\,\frac{e^{j((w_o+\Delta w_C)t-kr)}}{kr}\,\sigma_C(\theta,\phi) \tag{B.6}$$

donde w_o es la pulsación de la señal incidente, Δw_A, Δw_B y Δw_C son los desplazamientos frecuenciales de las señales dispersadas debido al efecto Doppler.

La relación entre la frecuencia o pulsación Doppler de cada uno de los haces y los parámetros de la fuente y geometría , para cada haz en particular, es

$$\Delta w_A = k(\hat{r} - \hat{s}_A)V_p \tag{B.7}$$

$$\Delta w_B = k(\hat{r} - \hat{s}_B)V_p \tag{B.8}$$

$$\Delta w_C = k(\hat{r} - \hat{s}_C)V_p \tag{B.9}$$

El campo total dispersado en un punto de la apertura receptora (r,θ,ϕ) en campo lejano, será la suma vectorial de los campos eléctricos $E_{d2D} = E_{dA}+E_{dB}+E_{dC}$. Sumando las ecuaciones (B.4), (B.5) y (B.6), tenemos

$$\begin{aligned} E_{d2D}(r,\theta,\phi) &= \sqrt{\frac{2I_{inA}}{n_m}\sqrt{\frac{\mu_o}{\epsilon_o}}}\frac{\sigma_A(\theta,\phi)}{kr}e^{j((w_o+\Delta w_A)t-kr)} + \\ &+ \sqrt{\frac{2I_{inB}}{n_m}\sqrt{\frac{\mu_o}{\epsilon_o}}}\frac{\sigma_B(\theta,\phi)}{kr}e^{j((w_o+\Delta w_B)t-kr)} + \\ &+ \sqrt{\frac{2I_{inC}}{n_m}\sqrt{\frac{\mu_o}{\epsilon_o}}}\frac{\sigma_C(\theta,\phi)}{kr}e^{j((w_o+\Delta w_C)t-kr)} \end{aligned} \tag{B.10}$$

y agrupando la expresión de forma más conveniente

$$\begin{aligned} E_{d2D}(r,\theta,\phi) &= \sqrt{\frac{2}{n_m}\sqrt{\frac{\mu_o}{\epsilon_o}}}\,\frac{e^{-jkr}}{kr}\Bigg[\sigma_1\sqrt{I_{inA}}\;e^{j(w_o+\Delta w_A)t}+\sigma_B\sqrt{I_{inB}}\;e^{j(w_o+\Delta w_B)t}+ \\ &+\;\; \sigma_C\sqrt{I_{inC}}\;e^{j(w_o+\Delta w_C)t}\Bigg] \end{aligned} \tag{B.11}$$

Ahora que ya tenemos el campo total dispersado, aplicando la ecuación (8.2), que nos relaciona el campo eléctrico con la intensidad, que es proporcional al modulo al cuadrado del campo $\mid E_{d2D} \mid^2$, y sabiendo que

$$\mid E_{d2D} \mid^2 = E_{d2D}E^*_{d2D} \tag{B.12}$$

la intensidad dispersada será

$$I_{d2D} = \frac{n_m}{2}\sqrt{\frac{\epsilon_o}{\mu_o}}\;E_{d2D}E^*_{d2D} \tag{B.13}$$

Así pues, a partir de la ecuación (B.11) calculamos el módulo del campo al cuadrado,

$$\begin{aligned} \mid E_{d2D} \mid^2 &= \sqrt{\frac{2}{n_m}\sqrt{\frac{\mu_o}{\epsilon_o}}}\,\frac{e^{-jkr}}{kr}\Bigg[\sigma_A\sqrt{I_{inA}}\;e^{j(w_o+\Delta w_A)t}+\sigma_B\sqrt{I_{inB}}\;e^{j(w_o+\Delta w_B)t}+ \\ &+\;\; \sigma_C\sqrt{I_{inC}}\;e^{j(w_o+\Delta w_C)t}\Bigg]\cdot\sqrt{\frac{2}{n_m}\sqrt{\frac{\mu_o}{\epsilon_o}}}\,\frac{e^{jkr}}{kr}\Bigg[\sigma^*_A\sqrt{I_{inA}}\;e^{-j(w_o+\Delta w_A)t}+ \\ &+\;\; \sigma^*_B\sqrt{I_{inB}}\;e^{-j(w_o+\Delta w_B)t}+\sigma^*_C\sqrt{I_{inC}}\;e^{-j(w_o+\Delta w_C)t}\Bigg] \end{aligned} \tag{B.14}$$

Si desarrollamos el producto de la ecuación (B.14) y aplicando las relaciones trigonométricas de una función cosenoidal con la función exponencial compleja, conocida como funciones de Euler

$$\cos(A) = \frac{e^{j(A)}+e^{-j(A)}}{2} \tag{B.15}$$

$$\Re\{e^{j(A)}\} = \cos(A) \tag{B.16}$$

obtenemos

$$\begin{aligned}
\mid E_{d2D} \mid^2 &= \frac{2}{n_m}\sqrt{\frac{\mu_o}{\epsilon_o}}\,\frac{1}{k^2r^2}\Big[I_{inA}\mid \sigma_A(\theta,\phi)\mid^2 + I_{inB}\mid \sigma_B(\theta,\phi)\mid^2 + I_{inC}\mid \sigma_C(\theta,\phi)\mid^2 \\
&+ \sqrt{I_{inA}I_{inB}}\cdot 2\Re\left\{\sigma_A(\theta,\phi)\cdot\sigma_B^*(\theta,\phi)\cdot e^{(j2\pi f_{dop_{A-B}}t)}\right\} \\
&+ \sqrt{I_{inA}I_{inC}}\cdot 2\Re\left\{\sigma_A(\theta,\phi)\cdot\sigma_C^*(\theta,\phi)\cdot e^{(j2\pi f_{dop_{A-C}}t)}\right\} \\
&+ \sqrt{I_{inB}I_{inC}}\cdot 2\Re\left\{\sigma_B(\theta,\phi)\cdot\sigma_C^*(\theta,\phi)\cdot e^{(j2\pi f_{dop_{B-C}}t)}\right\}\Big]
\end{aligned} \tag{B.17}$$

o expresada en función de un coseno

$$\begin{aligned}
\mid E_{d2D} \mid^2 &= \frac{2}{n_m}\sqrt{\frac{\mu_o}{\epsilon_o}}\,\frac{1}{k^2r^2}\Big[I_{inA}\mid \sigma_A(\theta,\phi)\mid^2 + I_{inB}\mid \sigma_B(\theta,\phi)\mid^2 + I_{inC}\mid \sigma_C(\theta,\phi)\mid^2 + \\
&+ \sqrt{I_{inA}I_{inB}}\cdot D_{2D_{A-B}}(\theta,\phi)\cdot\cos(2\pi f_{dop_{A-B}}t - \psi_{2D_{A-B}}(\theta,\phi)) \\
&+ \sqrt{I_{inA}I_{inC}}\cdot D_{2D_{A-C}}(\theta,\phi)\cdot\cos(2\pi f_{dop_{A-C}}t - \psi_{2D_{A-C}}(\theta,\phi)) \\
&+ \sqrt{I_{inB}I_{inC}}\cdot D_{2D_{B-C}}(\theta,\phi)\cdot\cos(2\pi f_{dop_{B-C}}t - \psi_{2D_{B-C}}(\theta,\phi))\Big]
\end{aligned} \tag{B.18}$$

$$f_{dop_{A-B}} = \frac{k(\hat{s}_B - \hat{s}_A)V_p}{2\pi} = \frac{\Delta w_A - \Delta w_B}{2\pi} \tag{B.19}$$

$$f_{dop_{A-C}} = \frac{k(\hat{s}_C - \hat{s}_A)V_p}{2\pi} = \frac{\Delta w_A - \Delta w_C}{2\pi} \tag{B.20}$$

$$f_{dop_{B-C}} = \frac{k(\hat{s}_C - \hat{s}_B)V_p}{2\pi} = \frac{\Delta w_B - \Delta w_C}{2\pi} \tag{B.21}$$

donde $f_{dop_{A-B}}$, $f_{dop_{A-C}}$ y $f_{dop_{B-C}}$ son las frecuencia Doppler o de batido, diferencia de las frecuencias Doppler de los haces dispersados dos a dos, $D_{2D_{A-B}}(\theta,\phi)$, $D_{2D_{A-C}}(\theta,\phi)$ y $D_{2D_{B-C}}(\theta,\phi)$ son las amplitudes de la componentes alternas de las mezclas o interferencias de los tres batidos, y $\psi_{2D_{A-B}}(\theta,\phi)$, $\psi_{2D_{A-C}}(\theta,\phi)$ y $\psi_{2D_{B-C}}(\theta,\phi)$ las fases de la componentes Doppler.

Una vez obtenida la expresión del módulo del campo eléctrico dispersado por una partícula en movimiento, producido por la incidencia de los haces de luz, la intensidad dispersada en un punto del espacio, aplicando la relación presentada en la ecuación (B.13), es

$$\begin{aligned} I_{d_{2D}}(r,\theta,\phi) &= \frac{1}{k^2r^2}\Big[I_{inA}\mid \sigma_A(\theta,\phi)\mid^2 + I_{inB}\mid \sigma_B(\theta,\phi)\mid^2 + I_{inC}\mid \sigma_C(\theta,\phi)\mid^2 + \\ &+ \sqrt{I_{inA}I_{inB}}\cdot D_{2D_{A-B}}(\theta,\phi)\cos(2\pi f_{dop_{A-B}}t - \psi_{2D_{A-B}}(\theta,\phi)) + \\ &+ \sqrt{I_{inA}I_{inC}}\cdot D_{2D_{A-C}}(\theta,\phi)\cos(2\pi f_{dop_{A-C}}t - \psi_{2D_{A-C}}(\theta,\phi)) + \\ &+ \sqrt{I_{inB}I_{inC}}\cdot D_{2D_{B-C}}(\theta,\phi)\cos(2\pi f_{dop_{B-C}}t - \psi_{2D_{B-C}}(\theta,\phi))\Big] \end{aligned} \quad \text{(B.22)}$$

Apéndice C

Vectores del sistema LDA con haces en el eje X

De una manera análoga, en este segundo caso, dos haces de luz localizados en el eje X y $-X$, se focalizan mediante una lente transmisora localizada en el plano XY, formando un ángulo β_3 y β_4 respecto a la bisectriz (eje Z), con vectores de propagación $\hat{s}_3$ y $\hat{s}_4$ y vectores de polarización $\hat{p}_3$ y $\hat{p}_4$, definidos en la figura C.1

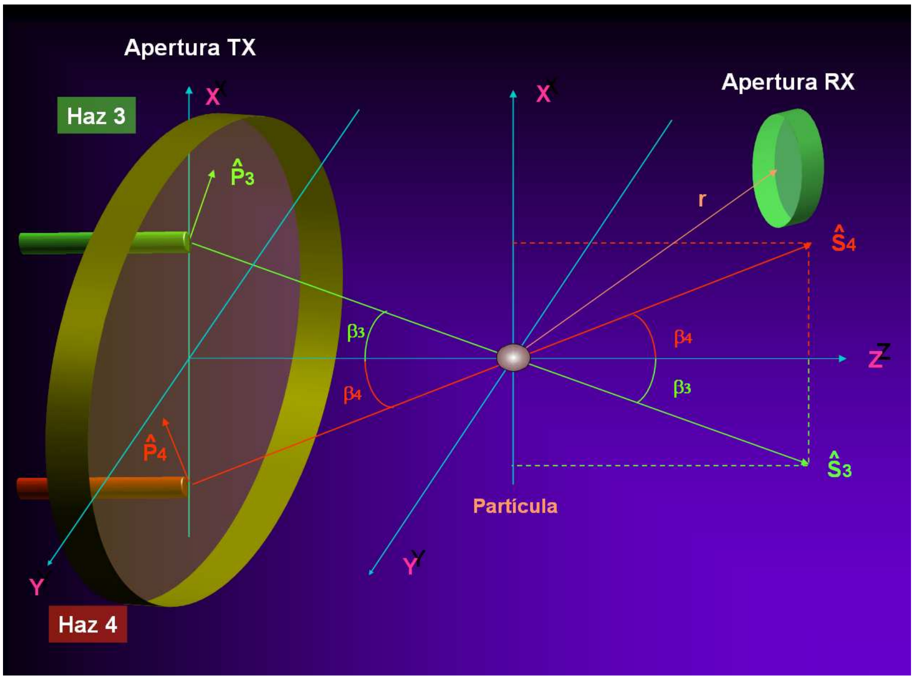


Figura C.1 Geometría Sistema LDA con haces en el eje X

Los vectores de propagación y polarización unitario, en función de las coordenadas cartesianas (x,y,z) y del ángulo β_3 y β_4 del haz 3 y 4 respectivamente, son

$$\hat{s}_3 = [-\sin(\beta_3),\ 0,\ \cos(\beta_3)\ ] \tag{C.1}$$

$$\hat{s}_4 = [\ \sin(\beta_4),\ 0,\ \cos(\beta_4)\ ] \tag{C.2}$$

$$\hat{p}_3 = [\ \cos(\beta_3),\ 0,\ \sin(\beta_3)\ ] \tag{C.3}$$

$$\hat{p}_4 = [\ \cos(\beta_4),\ 0,\ -\sin(\beta_4)\ ] \tag{C.4}$$

A partir de los datos anteriores, podemos calcular los ángulos θ_3, ϕ_3 y θ_4, ϕ_4, y los vectores unitarios $\hat{e}_{\theta_3}$, $\hat{e}_{\phi_3}$ y $\hat{e}_{\theta_4}$, $\hat{e}_{\phi_4}$ substituyendo las ecuaciones (8.54), (8.55), (8.56) y (8.57) en (8.58) (8.44), (8.43) y (8.41).

✠ Relación ángulos haz 3 (θ_3, ϕ_3):

$$\cos(\theta_3) = \frac{-x\sin(\beta_3) + z\cos(\beta_3)}{\sqrt{x^2+y^2+z^2}} \tag{C.5}$$

$$\sin(\theta_3) = \frac{\left[[y\cos(\beta_3)]^2 + [x\cos(\beta_3) + z\sin(\beta_3)]^2 + [y\sin(\beta_3)]^2\right]^{1/2}}{\sqrt{x^2+y^2+z^2}} \tag{C.6}$$

$$\cos(\phi_3) = \frac{x\cos(\beta_3) + z\sin(\beta_3)}{\sin(\theta_3)\sqrt{x^2+y^2+z^2}} \tag{C.7}$$

✠ Relación ángulos haz 4 (θ_4, ϕ_4):

$$\cos(\theta_4) = \frac{x\sin(\beta_4) + z\cos(\beta_4)}{\sqrt{x^2+y^2+z^2}} \tag{C.8}$$

$$\sin(\theta_4) = \frac{\left[[y\cos(\beta_4)]^2 + [x\cos(\beta_4) - z\sin(\beta_4)]^2 + [y\sin(\beta_4)]^2\right]^{1/2}}{\sqrt{x^2+y^2+z^2}} \tag{C.9}$$

$$\cos(\phi_4) = \frac{x\cos(\beta_4) - z\sin(\beta_4)}{\sin(\theta_4)\sqrt{x^2+y^2+z^2}} \tag{C.10}$$

✠ Relación vectores unitarios haz 3 ($\hat{e}_{\theta_3}$, $\hat{e}_{\phi_3}$):

$$\hat{e}_{\theta_3} = [\hat{e}_{\theta_{3x}}, \hat{e}_{\theta_{3z}}, \hat{e}_{\theta_{3z}}] \tag{C.11}$$

$$\hat{e}_{\theta_{3x}} = \frac{zx\cos(\beta_3) + z^2\sin(\beta_3) + y^2\sin(\beta_3)}{\sin(\theta_3)\sqrt{x^2+y^2+z^2}} \tag{C.12}$$

$$\hat{e}_{\theta_{3y}} = \frac{-yx\sin(\beta_3) + zy\cos(\beta_3)}{\sin(\theta_3)\sqrt{x^2+y^2+z^2}} \tag{C.13}$$

$$\hat{e}_{\theta_{3z}} = \frac{-y^2\cos(\beta_3) - x^2\cos(\beta_3) - xz\sin(\beta_3)}{\sin(\theta_3)\sqrt{x^2+y^2+z^2}} \tag{C.14}$$

$$\hat{e}_{\phi_3} = [\hat{e}_{\phi_{3x}}, \hat{e}_{\phi_{3z}}, \hat{e}_{\phi_{3z}}] \tag{C.15}$$

$$\hat{e}_{\phi_{3y}} = \frac{-x\cos(\beta_3)}{\sin(\theta_3)\sqrt{x^2+y^2+z^2}} \tag{C.16}$$

$$\hat{e}_{\phi_{3y}} = \frac{z\sin(\beta_3) + x\cos(\beta_3)}{\sin(\theta_3)\sqrt{x^2+y^2+z^2}} \tag{C.17}$$

$$\hat{e}_{\phi_{3z}} = \frac{-y\sin(\beta_3)}{\sin(\theta_3)\sqrt{x^2+y^2+z^2}} \tag{C.18}$$

✠ Relación vectores unitarios haz 4 ($\hat{e}_{\theta_4}$, $\hat{e}_{\phi_4}$):

$$\hat{e}_{\theta_4} = [\hat{e}_{\theta_{4x}}, \hat{e}_{\theta_{4z}}, \hat{e}_{\theta_{4z}}] \tag{C.19}$$

$$\hat{e}_{\theta_{4x}} = \frac{zx\cos(\beta_4) - z^2\sin(\beta_4) - y^2\sin(\beta_4)}{\sin(\theta_4)\sqrt{x^2+y^2+z^2}} \tag{C.20}$$

$$\hat{e}_{\theta_{4y}} = \frac{yx\sin(\beta_4) + yx\cos(\beta_4)}{\sin(\theta_4)\sqrt{x^2+y^2+z^2}} \tag{C.21}$$

$$\hat{e}_{\theta_{4z}} = \frac{-y^2\cos(\beta_4) - x^2\cos(\beta_4) + zx\sin(\beta_4)}{\sin(\theta_4)\sqrt{x^2+y^2+z^2}} \tag{C.22}$$

$$\hat{e}_{\phi_4} = [\hat{e}_{\phi_{4x}}, \hat{e}_{\phi_{4z}}, \hat{e}_{\phi_{4z}}] \tag{C.23}$$

$$\hat{e}_{\phi_{4x}} = \frac{-y\cos(\beta_4)}{\sin(\theta_4)\sqrt{x^2+y^2+z^2}} \tag{C.24}$$

$$\hat{e}_{\phi_{4y}} = \frac{x\cos(\beta_4) - z\sin(\beta_4)}{\sin(\theta_4)\sqrt{x^2+y^2+z^2}} \tag{C.25}$$

$$\hat{e}_{\phi_{4z}} = \frac{y\sin(\beta_4)}{\sin(\theta_4)\sqrt{x^2+y^2+z^2}} \tag{C.26}$$

Apéndice D

Especificaciones láser y equipos de medida

D.1. Especificaciones láser Monocrom 532RH80

MONOCROM

Fx.- (34-3) 814 3767 Tl.-814 3736
E.mail: monocrom@mundivia.es
MONOCROM S.L.
Pol.Ind.Roquetas
E-08800-Vilanova i La Geltrú- Spain
V.A.T.: ESB60355948

532RH80 Data sheet / September 2001

DIODE PUMPED SOLID STATE CW GREEN LASER **532RH80**

GENERAL SPECS.

Output wavelength	532 nm
Min/Max .Po @ 532nm	60/80 mW
Laser class product (EN-60825)	3b
Divergence (typ)	10 mrd
Beam diameter (1/e²)	1mm
M²	<3
Polarization	Lineal
Operation temperature range	15 to 45°C
Power stability [%]	short term : <5 long term: 10
Pointing stability [rd]	(angular drift) (lateral drift)
Noise (30 Hz to 2 Mhz) [% rms]	<0,5%
Cooling	TEC
Expected lifetime @ Po max.	> 5.000 hr
Warm up time	< 5 min. (to get Po and Pointing stability)
Estate and warnign output signals (by SUB-D9 connector)	Power & Laser ON. Over temp. & Over current
Power requirements	5 Vdc / 4 A
Dimensions	Laser unit 160x75x50mm Power supply 120x30mm

Other optical specs. to be considered with different lens systems.

D.2. Especificaciones medidor de potencia óptica Anritsu ML9002A

OPTICAL MEASURING INSTRUMENTS

Anritsu

OPTICAL HANDY POWER METER

ML9002A

The ML9002A is a compact handy power meter with a measurement level as wide as other more expensive instruments. Seven optical sensors are available for different wavelengths, measurement levels, and optical input types. Each can be calibrated for three common wavelengths so absolute optical power can be read directly. Each optical sensor can either be incorporated directly in the main frame or connected using a connecting cord. The ML9002A can be used to check optical disks, optical printers and optical communications systems and can back-up on-side operations as a powerful multifunctional measuring instrument for maintenance.

Features

- Accurate optical power measurement

The power of a narrow beam can be accurately measured even when an adaptor is changed because anti-reflection optical sensor is used.

- Long-distance measurement with wide measurement level range

An unprecedented wide measurement level has been achieved in this handy optical power meter. Optical power of −70 to +3 dBm (MA9621A Optical Power Sensor) in the 1.3 µm band and −70 to +10 dBm (MA9423A Optical Power Sensor) in the 0.85 µm band can be measured.

- Direct absolute power readings for three wavelengths

Each optical sensor is calibrated at three wavelengths (0.633/0.78/0.85 µm or 0.66/0.78/0.85 µm for short wavelengths, and 0.85/1.3/1.55 µm for long wavelengths). The absolute power is indicated automatically just by switching to the measured wavelength.

- Flexible measurements

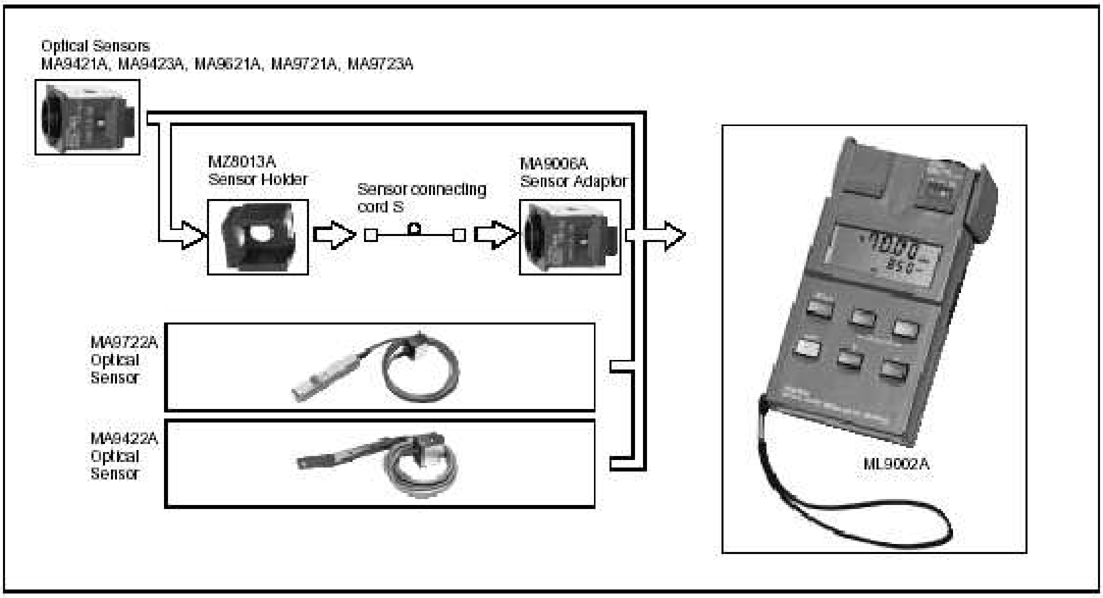
Two types of connections, a plug-in system (sensor incorporated into main frame), or a cord system (sensor connected using connecting cord), are possible so that measurement capabilities are flexible.

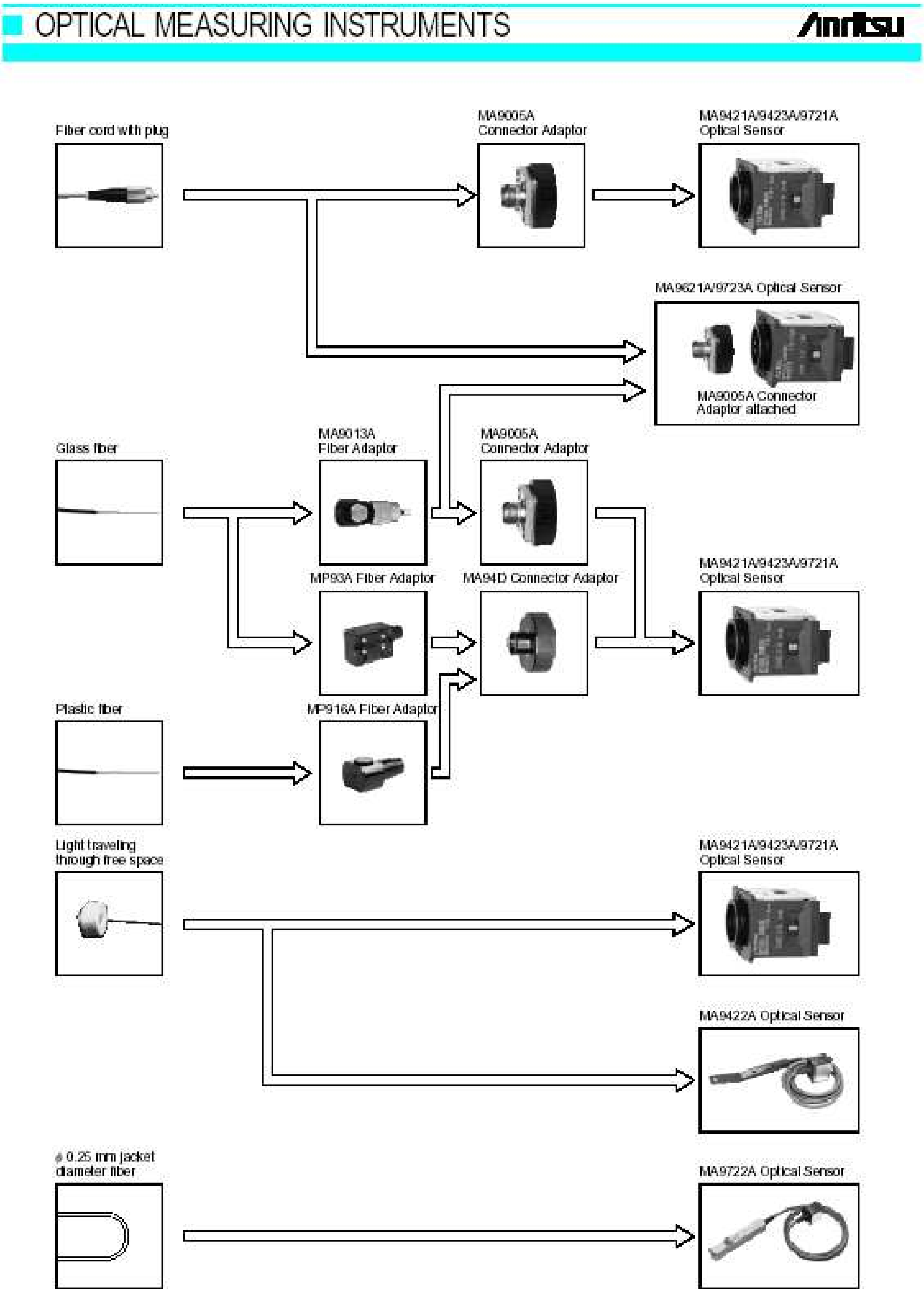
- Monitoring without cutting optical fiber

The optical power in an optical fiber cable (ø0.25 mm, UV-coated fiber) can be measured by using the MA9722A Optical Power Sensor.

- Compatible with various connectors

The ML9002A can be quickly connected to FC, D4. RUNGE, ST, DIN, DIAMOND, and SC connectors just by replacing the connector adaptor.




OPTICAL MEASURING INSTRUMENTS
Anritsu
Fiber cord with plug
MA9005A
Connector Adaptor
MA9421A/9423A/9721A
Optical Sensor
MA9621A/9723A Optical Sensor
MA9005A Connector
Adaptor attached
Glass fiber
MA9013A
Fiber Adaptor
MA9005A
Connector Adaptor
MP93A Fiber Adaptor
MA94D Connector Adaptor
MA9421A/9423A/9721A
Optical Sensor
Plastic fiber
MP916A Fiber Adaptor
Light traveling
through free space
MA9421A/9423A/9721A
Optical Sensor
MA9422A Optical Sensor
ϕ 0.25 mm jacket
diameter fiber
MA9722A Optical Sensor

OPTICAL MEASURING INSTRUMENTS

Anritsu

Specifications

Main frame	Unit display	W, W(REL), dBm, and dB(REL), selectable, 4 digits						
	Recorder output	1 V/full-scale, 0.316 V/–5 dB						
	Averaging	ON/OFF settings						
	Range hold	Range settings						
	Buzzer	1 dB sound threshold level setting						
	Auto power off	After 5 minutes non-use (with internal Ni-Cd battery)						
	Dimensions and mass	90 (W) x 196 (H) x 38 (D) mm, ≤700 g						
Sensors	Model	MA9421A	MA9422A	MA9423A	MA9621A	MA9721A	MA9723A	MA9722A
	Wavelength (μm)	0.38 to 1.15			0.75 to 1.7	0.75 to 1.8		
	Element	Si photodiode			InGaAs photodiode	Ge photodiode		
	Active area diameter	9.5 mm	9 mm	9.5 mm	1 mm	5 mm	1 mm	3 mm
	Input	Direct			FC connector adaptor	Direct	FC connector adaptor	Direct*1
	Measurement range (dBm)	–60 to +20 (at 0.85 μm)	–50 to +20 (at 0.85 μm)	–70 to +10 (at 0.85 μm)	–70 to +3 (at 1.3 μm)	–40 to +10 (at 1.3 μm)	–60 to +3(at 1.3 μm, 0° to 40°C)	–50 to 0 (at 1.3 μm, 0° to 40°C)
	Dimensions and mass	30 (W) x 30 (H) x 37 (D) mm, ≤100 g	15 (W) x 18 (H) x 140 (D) mm, ≤200 g	30 (W) x 30 (H) x 37 (D) mm, ≤100 g				20 (W) x 20 (H) x 128 (D) mm, ≤300 g
Overall	Measurement accuracy	±5% (–10 dBm, CW mode)				±5% (–10 dBm, CW mode)*2		Not specified
	Calibration wavelength	0.633/0.78/0.85 μm		0.66/0.78/0.85 μm	0.85/1.3/1.55 μm			Not specified
	Measurement resolution	W/W(REL): 0.1 to 1%, dBm/dB(REL): 0.01 dB						
	Operating hours	20 hr or more, floating operation possible (on internal Ni-Cd battery)						
	Temperature range	Operating: 0° to 50°C, Storage: –30° to 50°C, Recharging: 10° to 45°C						
	EMC*3	EN55011: 1991, Group 1, Class A EN50082-1: 1992						
	Safety	EN61010-1: 1993 (Installation Category II, Pollution Degree II)						

*1: Used for 0.25 μm jacket diameter fiber
*2: For wavelength 1.55 μm, it is specified at 23° ±5°C
*3: Electromagnetic Compatibility

Ordering information

Please specify model/order number, name and quantity when ordering.

Model/Order No.	Name	
	Main frame	
ML9002A	Optical Handy Power Meter	
	Optical sensors	
MA9421A	Optical Sensor	
MA9422A	Optical Sensor (Thin sensor)	
MA9423A	Optical Sensor	
MA9621A	Optical Sensor (MA9005A Connector Adaptor attached)	
MA9721A	Optical Sensor	
MA9722A	Optical Sensor (fiber identification sensor)	
MA9723A	Optical Sensor (MA9005A Connector Adaptor attached)	
	Standard accessories	
Z0178	AC adaptor:	1 pc
J0017	Power cord, 2.5 m:	1 pc
B0232	Blank panel:	1 pc
W0400CE	ML9002A instruction manual:	1 copy
J0477	Auto-power-off override plug:	1 pc
	Optional accessories	
MA9005A*	Connector Adaptor (for optical sensor)	
MA9006A	Sensor Adaptor (for sensor connecting cord S/T)	
MP93A	Fiber Adaptor (≤150 μm clad dia., 0.8 to 1.0 mm jacket dia.)	
MP94D	Connector Adaptor (for MP93A and MP916A)	
MA9013A	Fiber Adaptor	
MZ8013A	Sensor Holder	
J0056B	FC-FC-2M-SM (FC optical fiber cord, 2 m, SM)	
J0200B	FC-FC-2M-GI (FC optical fiber cord, 2 m, GI)	
J0436	Sensor connecting cord S (for ML9002A sensors)	
J0438	Recorder output cord	
Z0179	Carrying case (with shoulder strap)	
Z0182	Soft case	
B0234	Battery box	

*: Choose from the options listed in the following table when ordering non-FC optical connector.

Optical connector options table

Option No.	Optical connector
21	D4
22	RUNGE
23	Amphenol Type 906
24	OF-2
34	DIAMOND*1
35	HP-SMA, Amphenol Type 905
38	ST
39	DIN
40	SC
41	TOCP172*2

*1: 3.5 mm diameter ferule, M9 screw
*2: For MA9421A, MA9423A only

D.3. Especificaciones analizador de espectros Anritsu MS2661B


Anritsu
MS2651B/2661B
Spectrum Analyzer
9 kHz to 3 GHz

Specifications

Except where noted otherwise, specified values are obtained after warming up the equipment for 30 minutes at a constant ambient temperature and then performing calibration. The typical values are given for reference, and are not guaranteed.

<table>
<tr><th colspan="2">Model</th><th>MS2651B</th><th>MS2661B</th></tr>
<tr><td rowspan="10">Frequency</td><td>Frequency range</td><td colspan="2">9 kHz to 3 GHz</td></tr>
<tr><td>Display frequency accuracy</td><td colspan="2">± (display frequency × reference frequency accuracy + span × span accuracy + 100 Hz)
•Span: ≥10 kHz, after calibration</td></tr>
<tr><td>Marker frequency display accuracy</td><td colspan="2">Normal: Same as display frequency accuracy, Delta: Same as frequency span accuracy</td></tr>
<tr><td>Frequency counter</td><td colspan="2">Resolution: 1 Hz, 10 Hz, 100 Hz, 1 kHz
Accuracy: Display frequency × reference frequency accuracy ±1 LSD (at S/N: ≥20 dB)</td></tr>
<tr><td>Frequency span</td><td>Setting range: 0 Hz, 1 kHz to 3.1 GHz
Accuracy: ±2.5% (span: ≥10 kHz)</td><td>Setting range: 0 Hz, 1 kHz to 3.1 GHz
Accuracy: ±2.5% (span: ≥10 kHz)
±5% (span: <10 kHz with option 02)</td></tr>
<tr><td>Resolution bandwidth (RBW) (3 dB bandwidth)</td><td colspan="2">Setting range:
1 kHz, 3 kHz, 10 kHz, 30 kHz, 100 kHz, 300 kHz, 1 MHz, 5 MHz (manually settable, or automatically settable according to frequency span) •Option 02 (MS2661B only): 30 Hz, 100 Hz, and 300 Hz are added.
Measurements of noise, C/N, adjacent channel power and channel power by measure function are executed with the calculated equivalent noise bandwidth of the RBW.
Selectivity (60 dB : 3 dB): ≤10:1 (RBW: 1 to 300 kHz), ≤15:1 (RBW: 1, 5 MHz)</td></tr>
<tr><td>Video bandwidth (VBW)</td><td colspan="2">1 Hz to 3 MHz (1-3 sequence), OFF (manually settable, or automatically settable according to RBW)</td></tr>
<tr><td rowspan="2">Noise sideband, stability</td><td>Noise sideband: ≤-90 dBc/Hz (1 GHz, 10 kHz offset)</td><td>Noise sideband: ≤-100 dBc/Hz (1 GHz, 10 kHz offset)</td></tr>
<tr><td colspan="2">Residual FM: ≤20 Hzp-p/0.1 s (1 GHz, span: 0 Hz)
Frequency drift: ≤200 Hz/min (span: ≤10 kHzxn, sweep time: ≤100 s)
•After 1-hour warm-up at constant ambient temperature</td></tr>
<tr><td>Reference oscillator</td><td colspan="2">Frequency: 10 MHz
Aging rate: 2 × 10^{-6}/year (typical); Option 01: 1 × 10^{-7}/year, 2 × 10^{-8}/day
Temperature characteristics: 1 × 10^{-6} (typical, 0° to 50°C); Option 01: ±5 × 10^{-8} (0° to 50°C, referenced to 25°C)</td></tr>
<tr><td rowspan="7">Amplitude</td><td rowspan="2">Level measurement</td><td colspan="2">Measurement range: Average noise level to +30 dBm
Maximum input level: +30 dBm (CW average power, RF ATT: ≥10 dB), ± 50 Vdc</td></tr>
<tr><td>Average noise level:
≤-110 dBm (1 MHz to 1 GHz),
≤-110 dBm + f [GHz] dB (>1 GHz)
•RBW: 1 kHz, VBW: 1 Hz, RF ATT: 0 dB
Residual response:
≤-95 dBm (RF ATT: 0 dB, input: 50 Ω termination, 1 MHz to 3 GHz)</td><td>Average noise level:
≤-115 dBm (1 MHz to 1 GHz),
≤-115 dBm + f [GHz] dB (>1 GHz),
≤-114 dBm (1 MHz to 1 GHz, at Option 08 pre-amplifier installed),
≤-114 dBm + 1.5f [GHz] dB (>1 MHz, at Option 08 pre-amplifier installed)
•RBW: 1 kHz, VBW: 1 Hz, RF ATT: 0 dB
Residual response:
≤-100 dBm (RF ATT: 0 dB, input: 50 Ω termination, 1 MHz to 3 GHz)</td></tr>
<tr><td>Total level accuracy</td><td colspan="2">±1.3 dB (100 kHz to 3 GHz) •Level measurement accuracy after calibration using internal calibration signal
Total level accuracy: Reference level accuracy (0 to −49.9 dBm) + frequency response + log linearity (0 to −20 dB) + calibration signal source accuracy</td></tr>
<tr><td>Reference level</td><td colspan="2">Setting range
Log scale: −100 to +30 dBm, Linear scale: 224 µV to 7.07 V
Unit
Log scale: dBm, dBµV, dBmV, V, dBµVemf, W, dBµV/m
Linear scale: V
Reference level accuracy:
±0.4 dB (−49.9 to 0 dBm), ±0.75 dB (−69.9 to −50 dBm, 0.1 to +30 dBm), ±1.5 dB (−80 to −70 dBm)
•After calibration, at 100 MHz, 1 MHz span (when RF ATT, RBW, VBW, and sweep time set to AUTO)
RBW switching uncertainty: ±0.3 dB (1 kHz to 1 MHz), ±0.4 dB (5 MHz) •After calibration, referenced to RBW 3 kHz
Input attenuator (RF ATT)
Setting range: 0 to 70 dB (10 dB steps) •Manually settable, or automatically settable according to reference level
Switching uncertainty: ±0.3 dB (0 to 50 dB), ±1.0 dB (0 to 70 dB)
•After calibration, frequency: 100 MHz, referenced to RF ATT: 10 dB</td></tr>
<tr><td>Frequency response</td><td colspan="2">±0.5 dB (100 kHz to 3 GHz, referenced to 100 MHz, RF ATT: 10 dB, 18° to 28°C)
±1.5 dB (9 to 100 kHz, referenced to 100 MHz, RF ATT: 10 dB, 18° to 28°C)
±1.0 dB (100 kHz to 3 GHz, referenced to 100 MHz, RF ATT: 10 to 50 dB)</td></tr>
<tr><td>Waveform display</td><td colspan="2">Scale (10 div)
Log scale: 10, 5, 2, 1 dB/div
Linear scale: 10, 5, 2, 1%/div
Linearity (after calibration)
Log scale: ±0.4 dB (0 to −20 dB, RBW: ≤1 MHz), ±1.0 dB (0 to −70 dB, RBW: ≤100 kHz),
±1.5 dB (0 to −85 dB, RBW: ≤3 kHz), ±2.5 dB (0 to −90 dB, RBW: ≤3 kHz)
Linear scale: ±4% (compared to reference level)
Marker level resolution
Log scale: 0.01 dB, Linear scale: 0.02% of reference level</td></tr>
<tr><td>Spurious response</td><td>2nd harmonic distortion:
≤-55 dBc (10 to 100 MHz), ≤-60 dBc (0.1 to 1.5 GHz)
•Mixer input: −30 dBm
Two signals 3rd order intermodulation distortion:
≤-70 dBc (10 MHz to 3 GHz)
•Frequency difference of two signals: ≥50 kHz, mixer input: −30 dBm)</td><td>2nd harmonic distortion:
≤-60 dBc (10 to 200 MHz), ≤-75 dBc (0.2 to 1.5 GHz),
≤-80 dBc (0.8 to 1 GHz) •Mixer input: −30 dBm
Two signals 3rd order intermodulation distortion:
≤-70 dBc (10 to 100 MHz), ≤-80 dBc (0.1 to 3 GHz)
•Frequency difference of two signals: ≥50 kHz, mixer input: −30 dBm</td></tr>
</table>

Model		MS2651B	MS2661B
Amplitude	1 dB gain compression	≥–5 dBm (≥100 MHz, at mixer input)	
	Maximum dynamic range	1 dB gain compression level to average noise level: >105 dB (0.1 to 1 GHz), >105 dB – f [GHz] dB (>1 GHz) Distortion characteristics (RBW: 1 kHz) 2nd harmonic: >67.5 dB (10 to 100 MHz), >70 dB (100 to 500 MHz), >70 – f [GHz] dB (0.5 to 1 GHz) 3rd order intermodulation: >76.6 dB (10 MHz to 1 GHz), >76.6 – (2/3)f [GHz] dB (1 to 3 GHz)	1 dB gain compression level to average noise level: >110 dB (0.1 to 1 GHz), >110 dB – f [GHz] dB (>1 GHz), >109 dB (0.1 to 1 GHz, at Option 08 pre-amplifier installed), >109 dB – 1.5f [GHz] (>1 GHz, at Option 08 pre-amplifier installed) Distortion characteristics (RBW: 1 kHz) 2nd harmonic: >72.5 dB (10 to 200 MHz), >80 dB (200 to 500 MHz), >80 – f [GHz] dB (0.5 to 1.5 GHz), >82.5 – f [GHz] dB (0.8 to 1 GHz) 3rd order intermodulation: >80 dB (10 to 100 MHz), >83.3 dB (0.1 to 1 GHz), >83.3 – (2/3)f [GHz] dB (1 to 3 GHz)
Sweep	Sweep time	Setting range: 20 ms to 1000 s (Manually settable, or automatically settable according to span, RBW, and VBW) Accuracy: ±15% (20 ms to 100 s), ±45% (110 to 1000 s), ±1% (time domain sweep: digital zero span mode)	
	Sweep mode	Continuous, single	
	Time domain sweep mode	Analog zero span, digital zero span	
	Zone sweep	Sweeps only in frequency range indicated by zone marker	
	Tracking sweep	Sweeps while tracing peak points within zone marker (zone sweep also possible)	
Functions	Number of data points	501	
	Detection mode	NORMAL: Simultaneously displays max. and min. points between sample points POS PEAK: Displays max. point between sample points NEG PEAK: Displays min. point between sample points SAMPLE: Displays momentary value at sample points Detection mode switching uncertainty: ±0.5 dB (at reference level)	
	Display	Color TFT-LCD, Size: 5.5", Number of colors: 17 (RGB, each 64-scale settable), intensity adjustment: 5 steps settable	
	Display functions	Trace A: Displays frequency spectrum Trace B: Displays frequency spectrum Trace Time: Displays time domain waveform at center frequency Trace A/B: Displays Trace A and Trace B simultaneously. Simultaneous sweep of same frequency, alternate sweep of independent frequencies Trace A/BG: Displays frequency region to be observed (background) and object band (foreground) selected from background with zone marker simultaneously at alternate sweep Trace A/Time: Displays frequency spectrum, and time domain waveform at center frequency simultaneously at alternate sweep Trace move/calculation: A→B, B→A, A↔B, A+B→A, A–B→A, A–B+DL→A	
	Storage functions	NORMAL, VIEW, MAX HOLD, MIN HOLD, AVERAGE, CUMULATIVE, OVER WRITE	
	FM demodulation waveform display function	Demodulation range: 2, 5, 10, 20, 50, 100, 200 kHz/div Marker display accuracy: ±5% of full scale (referenced to center frequency, DC-coupled, RBW: 5 MHz, VBW: 1 Hz, CW) Demodulation frequency response: DC (50 Hz at AC-coupled) to 100 kHz *Range: ≤20 kHz/div, VBW: OFF, at 3 dB bandwidth DC (50 Hz at AC-coupled) to 500 kHz *Range: ≥50 kHz/div, VBW: OFF, at 3 dB bandwidth *RBW: ≥100 kHz usable	
	Input connector	N-J, 50 Ω	
	Auxiliary signal input and output	IF OUTPUT: 455 kHz (RBW: ≤30 kHz), 10.695 MHz (RBW: ≥100 kHz), BNC connector VIDEO OUTPUT (Y): 0 to 0.5 V ±0.1 V (100 MHz, from lower edge to upper edge at 10 dB/div or 10%/div, 75 Ω terminated, BNC connector) COMPOSITE OUTPUT: For NTSC, 1 Vp-p (75 Ω terminated), BNC connector EXT REF INPUT: 10 MHz ±10 Hz, ≥0 dBm (50 Ω terminated), BNC connector	
	Signal search	AUTO TUNE, PEAK→CF, PEAK→REF, SCROLL	
	Zone marker	NORMAL, DELTA	
	Marker →	MARKER→CF, MARKER→REF, MARKER→CF STEP SIZE, ΔMARKER→SPAN, ZONE→SPAN	
	Peak search	PEAK, NEXT PEAK, NEXT RIGHT PEAK, NEXT LEFT PEAK, MIN DIP, NEXT DIP	
	Multimarker	Number of markers: 10 max. (HIGHEST 10, HARMONICS, MANUAL SET)	
	Measure	Noise power (dBm/Hz, dBm/ch), C/N (dBc/Hz, dBc/ch), occupied bandwidth (power N% method, X-dB down method), adjacent channel power (REF: total power/reference level/in-band level method, channel designate display: 2 channels × 2 graphic display), average power of burst signal (average power in designated time range of time domain waveform), channel power (dBm, dBm/Hz), template comparison (upper/lower limits × each 2, time domain), MASK (upper/lower × each 2, frequency domain)	
	Save/recall	Saves and recalls setting conditions and waveform data to internal memory (max. 12) or memory card	
	Hard copy	Printer (HP dotmatrix, EPSON dotmatrix or compatible models): Display data can be hard-copied via RS-232C, GPIB and Centronics (Option 10) interface Plotter (HP-GL, GP-GL compatible models): Display can be output via RS-232C and GPIB interface	

Model		MS2651B	MS2661B
Functions	PTA	Language: PTL (interpreter based on BASIC) Programming: Using editor of external computer Program memory: Memory card, upload/download to/from external computer Programming capacity: 192 KB Data processing: Directly accesses measurement data according to system variables, system subroutines, and system functions	
	RS-232C	Outputs data to printer and plotter. Control from external computer (excluding power switch)	
	GPIB	Meets IEEE488.2. Controlled by external computer (excluding power switch). Or controls external equipment with PTA Interface function: SH1, AH1, T6, L4, SR1, RL1, PP0, DC1, DT1, C1, C2, C3, C4, C28	
	Correction	Automatic correction of insertion loss of MA1621A Impedance Transformer Correction accuracy (RF ATT: ≥10 dB): ±2.5 dB (9 to 100 kHz), ±1.5 dB (100 kHz to 2 GHz), ±2.0 dB (2 to 3 GHz) •Typical value Antenna correction coefficients: Correct display and measurement of field strengths (dBµV/m) for specified antennas, Internal antenna correction coefficients (MP534A/651A Dipole Antenna, MP635A/666A Log-Periodic Antenna, MP414B Loop Antenna, and four antennas user-defined; writes via GPIB or RS-232C interface, saves/loads to/from memory card)	
	Memory card interface	Functions: Saving/recalling measurement parameters/waveform data, uploading/downloading PTA programs; Applicable cards: SRAM, EPROM, Flash EPROM •Only SRAM writable; Card capacity: 2 MB max. Connector: PCMCIA Rel. 2.0, 2 slots	
Others	Conducted emission	Meets the EN55011 (Group 1, Class A)	
	Radiated emission	Meets the EN55011 (Group 1, Class A)	
	Static discharge	Meets the EN50082-1	
	Radiation field	Meets the EN50082-1	
	Conducted susceptibility	Meets the IEC801-4 (Level II)	
	Vibration	Meets the MIL-STD-810D	
	Power (operating range)	85 to 132/170 to 250 Vac (automatic voltage switching), 47.5 to 63 Hz, 380 to 420 Hz (85 to 132 Vac only), ≤320 VA	
	Dimensions and mass	320 (W) × 177 (H) × 351 (D) mm, ≤10.8 kg (without option)	
	Ambient temperature	0° to +50°C (operate), −40° to +75°C (storage)	

●Option 01: Reference crystal oscillator

Frequency	10 MHz
Aging rate	≤1 × 10^{-7}/year, ≤2 × 10^{-8}/day (after power on, with reference to frequency after 24 h)
Temperature characteristics	±5 × 10^{-8} (0° to 50°C, with reference to 25°C)
Buffer output	BNC connector, 10 MHz, >2 Vp-p (200 Ω terminated)

●Option 02: Narrow resolution bandwidth (MS2661B only)

Resolution bandwidth (3 dB)	30 Hz, 100 Hz, 300 Hz
Resolution bandwidth switching uncertainty	±0.4 dB (RBW 3 kHz referenced)
Selectivity (60 dB:3 dB)	≤15:1 (RBW: 100, 300 Hz), ≤20:1 (RBW: 30 Hz)

●Option 04: High-speed time domain sweep

Sweep time	12.5 µs, 25 µs, 50 µs, 100 to 900 µs (one most significant digit settable) 1.0 to 19 ms (two upper significant digits settable)
Accuracy	±1%
Marker level resolution	0.1 dB (log scale), 0.2% (linear scale, relative to reference level)

●Option 06: Trigger/gate circuit

Trigger switch		FREERUN, TRIGGERED
Trigger source	EXT	Trigger level: ±10 V (resolution: 0.1 V), TTL level Trigger slope: Rise/Fall Connector: BNC
	VIDEO	Trigger level (at log scale): −100 to 0 dB (resolution: 1 dB) Trigger slope: Rise/Fall
	WIDE IF VIDEO	Trigger level: High, middle, or low selectable Bandwidth: ≥20 MHz Trigger slope: Rise/Fall
	LINE	Frequency: 47.5 to 63 Hz (line lock)
	TV	Method: M-NTSC, B/G/H PAL Sync: V-SYNC, H-SYNC Sync line (NTSC) H-SYNC (ODD): 7 to 262 line, H-SYNC (EVEN): 1 to 263 line Sync line (PAL) H-SYNC (ODD): 1 to 312 line, H-SYNC (EVEN): 317 to 625 line •Option 16 required

Trigger delay	Pre-trigger (displays waveform from previous max. 1 screen at trigger occurrence point) Range: –time span to 0 s Resolution: time span/500 Post trigger (displays waveform from after max. 65.5 ms at trigger occurrence point) Range: 0 to 65.5 ms Resolution: 1 µs
Gate sweep	In frequency domain, displays spectrum of input signal in specified gate interval Gate delay: 0 to 65.5 ms (from trigger point, resolution: 1 µs) Gate width: 2 µs to 65.5 ms (from gate delay, resolution: 1 µs)

●Option 07: AM/FM demodulator

Voice output	With internal loudspeaker and earphone connector (ø3.5 jack), adjustable volume

●Option 08: Pre-amplifier*1

Frequency range		100 kHz to 3 GHz, 100 kHz to 2.5 GHz (with Option 22)
Noise figure		≤7 dB (typical, <2 GHz), ≤12 dB (typical, ≥2 GHz), ≤9 dB (typical, <2 GHz, with Option 22), ≤14 dB (typical, ≥2 GHz, with Option 22)
Amplitude	**Measurement range**	Average noise level to +10 dBm
	Max. input level	CW average power: +10 dBm, ±50 Vdc
	Average noise level	MS2651B: ≤–130 dBm (1 MHz to 1 GHz), ≤–130 dBm + 1.5f [GHz] dB (>1 GHz) MS2661B: ≤–134 dBm (1 MHz to 1 GHz), ≤–134 dBm + 2f [GHz] dB (>1 GHz), ≤–132 dBm (1 MHz to 1 GHz, with Option 22), ≤–132 dBm + 2f [GHz] dB (≥1 GHz, with Option 22) •RBW: 1 kHz, VBW: 1 Hz, RF ATT: 0 dB
	Reference level	Setting range Log scale: –120 to +10 dBm, or equivalent level Linear scale: 22.4 µV to 707 mV, 27.4 µV to 487 mV with Option 22 Reference level accuracy: ±0.5 dB (–69.9 to –20 dBm), ±0.75 dB (–89.9 to –70 dBm, –19.9 to +10 dBm) •After calibration, referenced to 100 MHz, 1 MHz span (RF ATT, RBW, VBW, and sweep time set to AUTO) RBW switching uncertainty: ±0.5 dB (after calibration, referenced to 3 kHz RBW) RF ATT switching uncertainty: ±0.5 dB (0 to 50 dB), ±1.0 dB (0 to 70 dB) •After calibration, referenced to 100 MHz, RF ATT: 10 dB
	Frequency response	±2.0 dB (100 kHz to 3 GHz, referenced to 100 MHz, RF ATT: 10 to 50 dB) ±2.0 dB (with Option 22, 100 kHz to 2.5 GHz, referenced to 100 MHz, RF ATT: 10 dB, 18° to 28°C)
	Linearity of waveform display	Log scale (after calibration): ±0.5 dB (0 to –20 dB), ±1.0 dB (0 to –60 dB), ±1.5 dB (0 to –75 dB) Linear scale (after calibration): ±5% (according to reference level)
	Spurious response	Two signals 3rd order intermodulation distortion: ≤–70 dBc (10 MHz to 3 GHz, 10 MHz to 2.5 GHz with Opton 22) •Frequency difference of two signals: ≥50 kHz, Pre-amplifier input*2: –55 dBm
	1 dB gain compression	≥–35 dBm (≥100 MHz, at pre-amplifier input*2)

*1 Overall specification with pre-amplifier on (Noise figure is the simple performance.)
*2 Pre-amplifier input level = RF input level – RF ATT setting level

●Option 10: Centronics interface

Function	Outputs data to printer (Centronics standard). GPIB interface can not be installed simultaneously
Connector	D-sub 25-pin (jack)

●Option 12: QP detector (MS2661B only)

Functions	QP detection •Requires Option 02. When Option 12 installed, Option 02 RBW 100 Hz 3 dB bandwidth changed to 150 Hz (typical)
6 dB bandwidth	200 Hz, 9 kHz, 120 kHz Accuracy: ±30% (18° to 28°C)
Display	LOG scale, 5 dB/div (10 divisions) Linearity: ≤±2.0 dB (0 to –40 dB, CW signal, reference level: 60 dBµV, RF ATT: 0 dB, 18° to 28°C)

Apéndice E

Especificaciones componentes ópticos

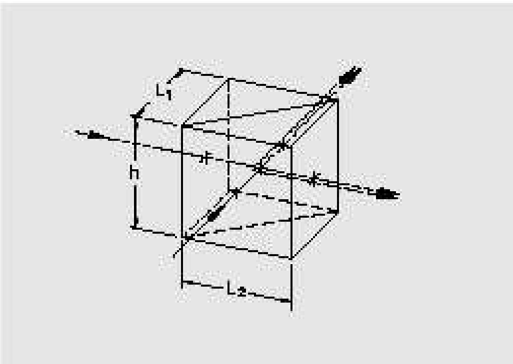
E.1. Especificaciones divisor de haz Linos 335563 y 335510

LINOS

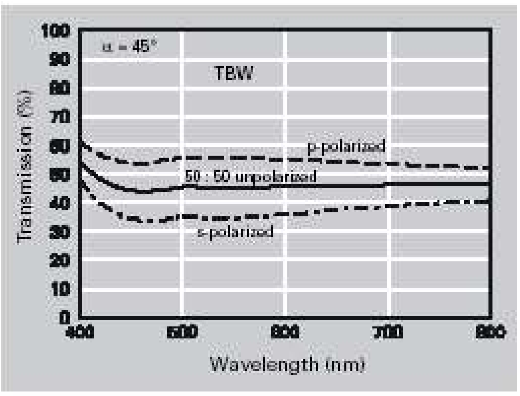
Beamsplitter Cubes

- for splitting or combining light beams
- no angular or lateral deflection of transmitted beams
- reflected and transmitted beams transit identical optical paths
- compact, rugged units
- designed for use with low-power lasers (0.1 J/cm² for 10 ns pulses at 1064 nm)
- optionally available with other beamsplitting ratios

➤ see pp. E 12-13 of this catalog regarding custom coatings for beamsplitter cubes
➤ custom beamsplitter cubes fabricated from other materials and/or having other dimensions available for higher quantities by special order; see Specification Sheet "Optical Components" at the end of this chapter



h height
L_1 width
L_2 length



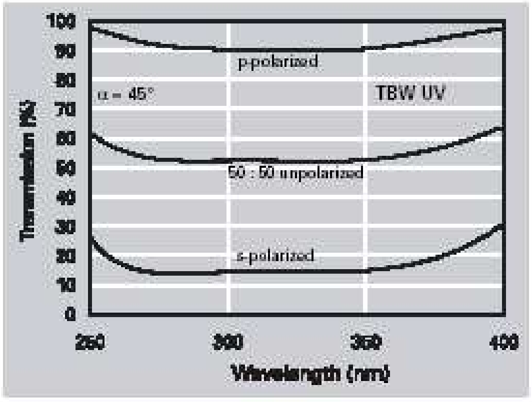
Beamsplitter cubes

- fabricated from N-BK7 glass
- reflectance ≈ transmittance ± 5% for unpolarized light
- absorbance < 5%
- broadband AR-coated
- 8' angular beam deflection tolerance

Dimensions $h = L_1 = L_2$ (mm)	Part No.	Tolerance h (mm)	Tolerance L_1 (mm)	Tolerance L_2 (mm)
5	33 5505	-0.075	0.3	0.3
10	33 5510	-0.09	0.3	0.3
20	33 5520	-0.13	0.4	0.4
25	33 5525	-0.13	0.4	0.4
30	33 5530	-0.16	0.4	0.4
40	33 5540	-0.16	0.4	0.4
50	33 5550	-0.19	0.4	0.4
80	33 5580	-0.22	0.4	0.4

Plano Optics

LINOS



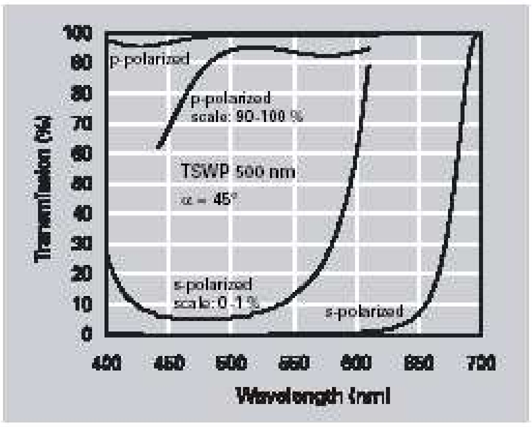
Beamsplitter cube for the UV

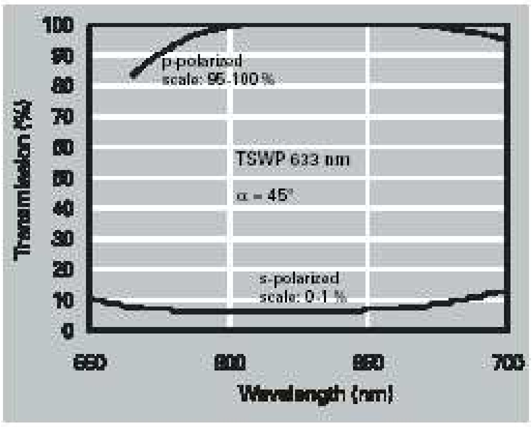
- fabricated from fused silica
- reflectance ≈ transmittance ± 5% for unpolarized light
- broadband AR-coated
- 8' angular beam deflection tolerance

Dimensions $h = L_1 = L_2$ (mm)	Part No.	Tolerances h (mm)	L_1 (mm)	L_2 (mm)
20	33 5521	-0.13	±0.4	±0.4

Polarizing beamsplitter cubes

- fabricated from F2 or SF2 glass
- p-polarized light: R ≤ 0.5% T ≥ 99%
- s-polarized light: R ≥ 99% T ≤ 0.5%
- extinction ratio > 200:1 (1000:1 at center wavelength)
- broadband ARB2 AR-coatings
- 8' angular beam deflection tolerance





Dimensions $h = L_1 = L_2$ (mm)	450-550 nm λ_0 = 500 nm Part No.	550-700 nm λ_0 = 633 nm Part No.	700-900 nm λ_0 = 800 nm Part No.	Tolerances h (mm)	L_1 (mm)	L_2 (mm)
5		33 5561	33 5507	-0.075	±0.3	±0.3
10	33 5564	33 5563	33 5513	-0.09	±0.3	±0.3
20		33 5565	33 5523	-0.13	±0.4	±0.4

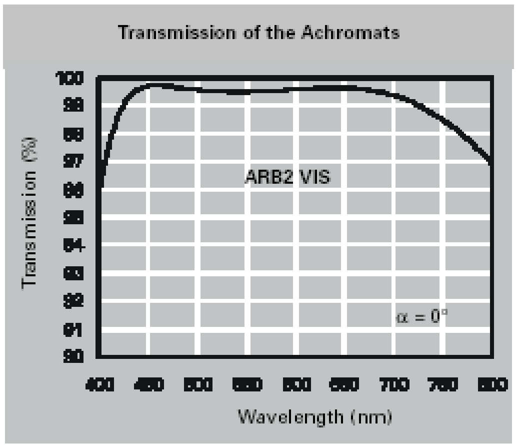
E.2. Especificaciones acromato Linos 32572 y 63201

LINOS

Achromats

WinLens

- cemented doublets
- minimal longitudinal chromatic aberration
- minimal spherical aberration/ wavefront distortion
- tight focal length tolerance
- broadband anti-reflection coating ARB2 VIS
- mounted or unmounted
- achromats in CA/CL mounts mating to Microbench



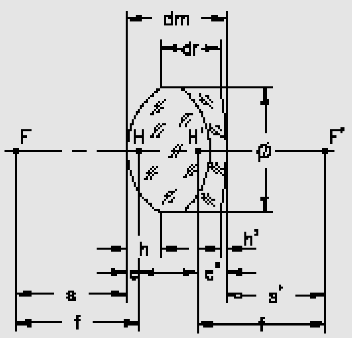
ARB2 broadband antireflection coating for the VIS
Transmission 450-700 nm > 99 %

Positive Achromats

		unmounted	mounted *)								
f (mm)	Ø (mm)	Part No.	Mount	Clear Ø (mm)	Part No.	Centering Accuracy	Surface Quality	dm (mm)	dm Tolerance (mm)	dr (mm)	Ø Tolerance (mm)
6	3	32 2250	CA	2.5	■ 06 3119	5'	3x0.16	2.7	± 0.1	2.2	-0.08
10	6	32 2206	CA	5	■ 06 3120	4'	3x0.16	3.0	± 0.2	2.1	-0.08
16	8	32 2207	CA	7	■ 06 3121	4'	3x0.16	3.5	± 0.2	2.4	-0.09
20	10	32 2201	CA	9	■ 06 3122	10'	5x0.16	4.2	± 0.2	2.9	-0.09
25	12.5	32 2284	CA	11.5	■ 06 3123	10'	5x0.16	5.5	± 0.2	4.0	-0.11
30	12.5	32 2285	CA	11.5	■ 06 3130	10'	5x0.16	5.0	± 0.2	3.7	-0.11
35	12.5	32 2286	CA	11.5	■ 06 3131	10'	5x0.16	5.0	± 0.2	3.9	-0.11
40	12.5	32 2337	CA	11.5	■ 06 3132	3'	3x0.16	6.3	± 0.1	5.1	-0.11
45	12.5	32 2338	CA	11.5	■ 06 3133	3'	3x0.16	5.5	± 0.1	4.4	-0.11
50	12.5	32 2339	CA	11.5	■ 06 3134	3'	3x0.16	5.0	± 0.1	4.1	-0.11
60	12.5	32 2341	CA	11.5	■ 06 3135	3'	3x0.16	5.3	± 0.1	4.5	-0.11
80	12.5	32 2343	CA	11.5	■ 06 3136	3'	3x0.16	5.5	± 0.1	5.1	-0.11
100	12.5	32 2345	CA	11.5	■ 06 3137	3'	3x0.16	5.3	± 0.1	4.8	-0.11
300	12.5	32 2348	CA	11.5	■ 06 3139	3'	3x0.16	4.0	± 0.1	3.8	-0.11
40	18	32 2209	CA	17	■ 06 3127	3'	5x0.16	7.0	± 0.2	4.5	-0.11
50	18	32 2265	CA	17	■ 06 3125	3'	5x0.16	6.5	± 0.2	4.6	-0.11
60	18	32 2266	CA	17	■ 06 3126	3'	5x0.16	6.0	± 0.2	4.4	-0.11
80	18	32 2210	CA	17	■ 06 3128	3'	5x0.16	5.8	± 0.2	4.6	-0.11
100	18	32 2236	CA	17	■ 06 3129	3'	5x0.16	5.8	± 0.2	4.8	-0.11
50	22.4	32 2321	CL	21.4	■ 06 3141	3'	3x0.16	7.5	± 0.2	5.2	-0.13
60	22.4	32 2322	CL	21.4	■ 06 3142	3'	3x0.16	7.0	± 0.2	5.1	-0.13
80	22.4	32 2323	CL	21.4	■ 06 3143	3'	3x0.16	7.0	± 0.2	5.1	-0.13
100	22.4	32 2324	CL	21.4	■ 06 3144	3'	3x0.16	9.0	± 0.1	7.5	-0.13
140	22.4	32 2326	CL	21.4	■ 06 3146	3'	3x0.16	8.0	± 0.1	6.9	-0.13
200	22.4	32 2328	CL	21.4	■ 06 3148	3'	3x0.16	6.0	± 0.1	5.2	-0.13
500	22.4	32 2329	CL	21.4	■ 06 3149	3'	3x0.16	6.0	± 0.1	5.7	-0.13
60	25.4	32 2306	CL 25.4	24	■ 06 3212	3'	5x0.25	9.5	± 0.2	6.2	-0.13
80	25.4	32 2307	CL 25.4	24	■ 06 3213	3'	5x0.25	8.2	± 0.2	5.8	-0.13
100	25.4	32 2308	CL 25.4	24	■ 06 3214	3'	5x0.25	7.2	± 0.2	5.3	-0.13
120	25.4	32 2309	CL 25.4	24	■ 06 3215	3'	5x0.25	7.2	± 0.2	5.6	-0.13

*) see chapter optic mounts for mount dimensions
■ in mount mating directly to microbench

continued overleaf



f	focal length
s	object distance
s'	image distance
e	distance, primary principal point-primary vertex
e'	distance, secondary principal point-secondary vertex
Ø	lens diameter
dm	center thickness
dr	edge thickness
h	primary vertex
h'	sagittal height secondary vertex
F, F'	focal points
H, H'	principal points

Tolerances: focal length f : ± 1 %
image distance s' : ± 1 %

custom achromats (other focal lengths, diameters) are available for higher quantities by special order;
see Specifcation Sheet "Optical Components" at the end of this chapter

h (mm)	h' (mm)	e (mm)	e' (mm)	$s_{588\,nm}$ (mm)	$s'_{588\,nm}$ (mm)	$f_{488\,nm}$ (mm)	$f_{546\,nm}$ (mm)	$f_{588\,nm}$ (mm)	$f_{633\,nm}$ (mm)	$f_{852\,nm}$ (mm)	$f_{1064\,nm}$ (mm)
0.3	0.1	0.45	1.41	5.56	4.60	6.01	6.01	6.02	6.02	6.04	6.07
0.7	0.2	0.39	1.50	10.00	8.89	10.36	10.38	10.39	10.40	10.45	10.49
0.8	0.3	0.33	1.81	16.01	14.54	16.36	16.35	16.35	16.35	16.39	16.43
1.0	0.3	0.38	2.24	20.32	18.46	20.72	20.70	20.70	20.71	20.75	20.81
1.2	0.3	0.48	2.96	24.86	22.38	25.35	25.33	25.33	25.43	25.40	25.46
1.0	0.3	0.45	2.65	29.80	27.59	30.27	30.24	30.24	30.25	30.31	30.39
0.9	0.2	0.43	2.66	34.60	32.38	34.94	35.04	35.04	35.04	34.98	35.19
0.8	0.4	2.28	2.85	37.82	37.24	40.09	40.09	40.11	40.13	40.28	40.38
0.7	0.3	2.07	2.51	42.96	42.52	45.02	45.02	45.04	45.06	45.21	45.39
0.6	0.3	0.90	2.36	49.11	47.65	50.02	50.01	50.02	50.04	50.20	50.40
0.5	0.3	1.11	2.30	58.88	57.69	60.00	59.99	60.00	60.03	60.22	60.46
0.4	0.2	1.14	2.37	78.80	77.57	79.96	79.94	79.95	79.96	80.23	80.54
0.3	0.2	1.17	2.18	98.82	97.81	100.03	99.99	100.01	100.05	100.35	100.74
0.1	0.1	0.27	2.27	299.59	297.58	299.98	299.85	299.89	299.98	300.87	302.03
1.9	0.6	0.51	4.11	39.67	36.06	40.16	40.16	40.18	40.20	40.34	40.50
1.6	0.3	0.17	4.08	49.90	45.98	50.01	50.04	50.07	50.10	50.30	50.51
1.4	0.2	0.13	3.78	60.00	56.36	60.10	60.11	60.14	60.17	60.38	60.63
1.0	0.2	0.26	3.51	79.91	76.66	80.10	80.13	80.17	80.22	80.52	80.85
0.8	0.1	0.09	3.66	100.04	96.47	100.12	100.11	100.14	100.18	100.51	100.91
2.0	0.4	0.15	4.28	49.9	45.8	50.05	50.04	50.06	50.08	50.23	50.37
1.5	0.4	0.42	3.72	60.0	56.7	60.48	60.47	60.48	60.51	60.68	60.85
1.3	0.6	1.26	3.29	79.1	77.1	80.35	80.34	80.36	80.40	80.66	80.98
1.0	0.5	1.57	4.27	98.6	95.9	100.18	100.16	100.19	100.23	100.55	100.94
0.7	0.4	3.33	3.86	136.7	136.2	140.10	140.07	140.09	140.15	140.58	141.13
0.5	0.2	4.96	2.89	195.3	197.4	200.31	200.26	200.30	200.38	201.00	201.79
0.2	0.1	4.39	3.44	495.0	496.0	499.58	499.43	499.52	499.71	501.25	503.20
3.0	0.3	0.42	6.58	61.18	54.19	60.72	60.74	60.76	60.80	61.02	61.27
2.0	0.4	0.35	5.01	80.51	75.85	80.77	80.81	80.86	80.92	81.23	81.57
1.6	0.3	0.35	4.33	100.47	96.50	100.74	100.77	100.82	100.89	101.26	101.68
1.5	0.1	0.24	4.90	120.27	115.13	120.06	120.02	120.03	120.08	120.43	120.89

LINOS

Positive Achromats; continued from preceding page

WinLens

		unmounted	mounted *)								
f (mm)	Ø (mm)	Part No.	Mount	Clear Ø (mm)	Part No.	Centering Accuracy	Surface Quality	dm (mm)	dm Tolerance (mm)	dr (mm)	Ø Tolerance (mm)
80	31.5	32 2287	CL 31.5	30	06 3200	3'	5x0.25	11.5	± 0.2	7.8	-0.16
100	31.5	32 2288	CL 31.5	30	06 3201	3'	5x0.25	9.5	± 0.2	6.6	-0.16
120	31.5	32 2269	CL 31.5	30	06 3202	3'	5x0.25	9.4	± 0.2	6.9	-0.16
140	31.5	32 2239	CL 31.5	30	06 3203	3'	5x0.25	9.0	± 0.2	6.9	-0.16
150	31.5	32 2227	CL 31.5	30	06 3232	3'	5x0.25	8.6	± 0.1	6.9	-0.20
160	31.5	32 2270	CL 31.5	30	06 3204	3'	5x0.25	8.6	± 0.2	6.8	-0.16
200	31.5	32 2271	CL 31.5	30	06 3205	6'	5x0.25	8.1	± 0.2	6.6	-0.16
250	31.5	32 2272	CL 31.5	30	06 3206	6'	5x0.25	8.0	± 0.2	6.8	-0.16
300	31.5	32 2273	CL 31.5	30	06 3207	6'	5x0.25	9.0	± 0.2	8.0	-0.16
400	31.5	32 2275	CL 31.5	30	06 3208	6'	5x0.25	7.0	± 0.2	6.3	-0.16
600	31.5	32 2277	CL 31.5	30	06 3209	6'	5x0.25	7.0	± 0.2	6.5	-0.16
1330	31.5	32 2276	CL 31.5	30	06 3210	6'	5x0.25	6.6	± 0.2	6.4	-0.16
90	40	32 2389	40	38	03 2567	6'	5x0.4	14.5	± 0.2	10.4	-0.16
120	40	32 2388	40	38	03 2568	6'	5x0.4	13.0	± 0.2	9.9	-0.16
140	40	32 2385	40	38	03 2569	6'	5x0.4	12.7	± 0.2	10.1	-0.16
160	40	32 2384	40	38	03 2570	6'	5x0.4	11.0	± 0.2	8.7	-0.16
180	40	32 2246	40	38	03 2587	6'	5x0.4	10.8	± 0.2	8.2	-0.16
200	40	32 2293	40	38	03 2571	6'	5x0.4	10.0	± 0.2	7.7	-0.16
250	40	32 2294	40	38	03 2572	6'	5x0.4	9.5	± 0.2	7.6	-0.16
300	40	32 2295	40	38	03 2573	3'	5x0.4	11.0	± 0.2	9.4	-0.16
400	40	32 2296	40	38	03 2574	3'	5x0.4	9.0	± 0.2	7.8	-0.16
450	40	32 2297	40	38	03 2575	3'	5x0.4	9.0	± 0.2	8.1	-0.16
80	50	32 2301	50	48	03 2576	3'	5x0.4	20.0	± 0.2	11.9	-0.16
100	50	32 2302	50	48	03 2577	3'	5x0.4	17.5	± 0.2	11.2	-0.16
120	50	32 2303	50	48	03 2578	3'	5x0.4	15.5	± 0.2	10.3	-0.16
200	50	32 2304	50	48	03 2579	3'	5x0.4	12.5	± 0.2	8.9	-0.16
300	50	32 2305	50	48	03 2580	3'	5x0.4	12.0	± 0.2	9.6	-0.16
160	50.8	32 2310	50.8	48	03 2557	6'	5x0.4	13.5	± 0.2	8.6	-0.19
250	50.8	32 2311	50.8	48	03 2558	6'	5x0.4	11.5	± 0.2	8.4	-0.19
400	50.8	32 2312	50.8	48	03 2559	6'	5x0.4	10.5	± 0.2	8.6	-0.19
150	63	32 2383	63	60	03 2501	4'	5x0.4	21.5	± 0.2	15.3	-0.19
400	63	32 2229	63	60	03 2581	4'	5x0.4	14.0	± 0.2	11.0	-0.19
500	63	32 2230	63	60	03 2582	4'	5x0.4	13.0	± 0.2	10.7	-0.19
600	63	32 2231	63	60	03 2583	4'	5x0.4	12.5	± 0.2	10.5	-0.19
800	63	32 2232	63	60	03 2584	4'	5x0.4	13.0	± 0.2	11.5	-0.19
160	80	32 2267	80	78	03 2502	4'	5x0.4	29.0	± 0.2	18.8	-0.19
310	80	32 2278	80	78	03 2592	4'	5x0.4	18.5	± 0.2	12.3	-0.19
500	80	32 2279	80	78	03 2593	4'	5x0.4	16.0	± 0.2	12.2	-0.19
1000	80	32 2241	80	78	03 2585	2'	5x0.4	17.0	± 0.2	15.1	-0.19
1185	80	32 2242	80	78	03 2586	2'	5x0.4	16.0	± 0.2	14.4	-0.19
500	100	32 2316	100	97	03 2503	1'	5x0.63	22.0	± 0.2	16.0	-0.22
1000	100	32 2313	100	97	03 2504	1'	5x0.63	21.5	± 0.2	18.5	-0.22
1500	100	32 2314	100	97	03 2505	1'	5x0.63	21.0	± 0.2	19.0	-0.22
800	150	32 2317	150	147	03 2506	1'	5x1.0	32.0	± 0.3	23.5	-0.25
1250	150	32 2387	150	147	03 2507	1'	5x1.0	28.0	± 0.3	22.7	-0.25
2250	150	32 2386	150	147	03 2508	1'	5x1.0	26.0	± 0.3	23.0	-0.25

*) see chapter optic mounts for mount dimensions

➤ see next page for **Negative Achromats**

Singlets and Achromats

h (mm)	h′ (mm)	e (mm)	e′ (mm)	$s_{588\,nm}$ (mm)	$s'_{588\,nm}$ (mm)	$f_{486\,nm}$ (mm)	$f_{546\,nm}$ (mm)	$f_{588\,nm}$ (mm)	$f_{633\,nm}$ (mm)	$f_{852\,nm}$ (mm)	$f_{1064\,nm}$ (mm)
3.1	0.6	0.40	7.14	80.50	73.77	80.80	80.85	80.91	80.97	81.30	81.64
2.4	0.5	0.34	5.88	100.48	94.93	100.71	100.76	100.81	100.88	101.27	101.69
2.3	0.2	0.39	6.48	120.25	113.38	119.88	119.84	119.86	119.91	120.28	120.75
1.5	0.6	1.27	4.59	139.04	135.74	140.16	140.25	140.33	140.44	140.99	141.58
1.3	0.5	3.20	4.40	147.29	146.12	150.44	150.51	150.58	150.68	151.25	151.88
1.3	0.5	1.24	4.36	158.61	155.49	159.69	159.77	159.86	159.97	160.59	161.25
1.4	0.1	0.22	5.45	200.33	194.66	200.17	200.09	200.11	200.17	200.76	201.53
1.1	0.1	0.17	5.34	250.49	244.98	250.40	250.29	250.31	250.40	251.13	252.10
0.9	0.1	0.30	6.10	300.65	294.25	300.51	300.34	300.35	300.44	301.27	302.43
0.5	0.2	1.16	3.34	399.78	397.60	400.59	400.74	400.94	401.21	402.70	404.36
0.3	0.2	1.27	3.24	597.28	595.31	598.54	598.42	598.55	598.80	600.69	603.05
0.2	0.1	1.06	3.17	1328.38	1326.27	1330.27	1329.43	1329.44	1329.78	1333.39	1338.44
3.7	0.4	0.22	8.87	90.48	81.83	90.51	90.61	90.70	90.79	91.16	91.48
2.5	0.6	0.97	7.09	119.68	113.56	120.50	120.58	120.65	120.74	121.16	121.55
2.1	0.5	0.89	6.90	143.45	133.67	140.41	140.49	140.57	140.66	141.14	141.58
1.9	0.4	0.85	5.94	159.45	154.36	160.16	160.23	160.31	160.41	160.93	161.44
2.2	0.4	0.26	6.74	181.47	174.98	181.65	181.66	181.72	181.82	182.44	183.18
1.9	0.4	0.56	5.92	200.79	195.43	201.21	201.26	201.35	201.47	202.20	203.02
1.3	0.6	1.71	4.39	248.23	245.54	250.01	249.91	249.93	250.02	250.75	251.70
1.1	0.5	1.82	5.31	298.42	294.92	299.99	300.09	300.23	300.43	301.53	302.77
0.8	0.4	1.69	4.02	398.51	396.18	400.37	400.17	400.20	400.32	401.46	402.97
0.7	0.2	0.85	4.82	447.75	443.78	448.49	448.48	448.61	448.81	449.99	451.20
6.4	1.7	1.49	11.07	78.66	69.09	80.14	80.14	80.16	80.20	80.42	80.65
4.9	1.4	1.37	9.53	100.20	92.04	101.65	101.57	101.57	101.59	101.80	102.06
4.1	1.1	1.13	8.47	120.20	112.86	121.50	121.36	121.33	121.33	121.53	121.82
3.0	0.6	0.57	7.56	200.79	193.80	201.21	201.27	201.36	201.49	202.22	203.05
1.7	0.7	1.92	5.87	298.40	294.45	300.08	300.18	300.33	300.52	301.63	302.86
3.4	1.5	2.08	6.72	157.45	152.80	159.51	159.49	159.53	159.60	160.11	160.72
2.1	1.0	1.97	5.45	248.16	244.68	250.20	250.10	250.13	250.22	250.95	251.90
1.3	0.6	1.94	4.74	398.42	395.62	400.53	400.33	400.36	400.48	401.62	403.14
5.0	1.1	1.71	11.67	148.75	138.80	150.16	150.34	150.47	150.61	151.22	151.74
2.1	0.9	2.39	6.59	398.30	394.10	400.84	400.65	400.69	400.81	401.97	403.48
1.6	0.7	2.49	5.75	497.94	494.68	500.64	500.39	500.43	500.58	502.01	503.90
1.4	0.6	2.47	5.43	597.75	594.79	600.48	600.18	600.22	600.40	602.11	604.38
1.0	0.5	2.40	5.86	800.43	796.96	803.24	802.79	802.82	803.05	805.29	808.31
8.0	2.1	2.43	15.63	157.67	144.47	160.21	160.10	160.10	160.13	160.48	160.89
4.3	1.9	3.09	8.85	307.32	301.56	310.43	310.35	310.41	310.53	311.49	312.69
2.6	1.2	2.79	7.45	497.90	493.23	500.90	500.64	500.68	500.84	502.28	504.17
1.5	0.4	1.48	9.39	998.70	990.79	1000.51	1000.06	1000.17	1000.50	1003.40	1007.17
1.4	0.2	0.06	10.31	1190.12	1179.75	1190.11	1189.46	1189.52	1189.85	1193.15	1197.75
4.2	1.9	3.62	10.55	495.87	488.94	499.63	499.43	499.49	499.66	501.14	503.04
2.4	0.6	1.89	11.84	998.58	988.63	1000.79	1000.36	1000.47	1000.80	1003.72	1007.49
1.6	0.4	1.79	11.60	1500.52	1490.70	1502.88	1502.17	1502.31	1502.78	1507.10	1512.75
5.8	2.7	5.72	14.78	793.44	784.38	799.39	799.06	799.16	799.43	801.79	804.83
4.0	1.3	3.52	14.33	1246.17	1236.17	1251.01	1250.40	1250.50	1250.87	1254.42	1259.20
2.2	0.7	3.33	13.20	2250.48	2240.62	2254.82	2253.65	2253.81	2254.45	2260.80	2269.41

LINOS

Negative Achromats

WinLens

		unmounted	mounted *)								
f (mm)	Ø (mm)	Part No.	Mount	Clear Ø (mm)	Part No.	Centering Accuracy	Surface Quality	dm (mm)	dm Tolerance (mm)	dr (mm)	Ø Tolerance (mm)
-20	8	32 5220	CA	7	◘ 06 3190	10'	3x0.16	2.8	± 0.2	3.6	-0.09
-50	18	32 5221	CA	17	◘ 06 3191	10'	5x0.16	4.7	± 0.2	6.6	-0.11
-100	31.5	32 5222	31.5	30	◘ 06 3271	10'	5x0.25	7.8	± 0.2	10.7	-0.16

*) see chapter optic mounts for mount dimensions
◘ in mount mating directly to microbench

Singlets and Achromats

LINOS

h (mm)	h' (mm)	e (mm)	e' (mm)	$s_{588\,nm}$ (mm)	$s'_{588\,nm}$ (mm)	$f_{488\,nm}$ (mm)	$f_{546\,nm}$ (mm)	$f_{588\,nm}$ (mm)	$f_{633\,nm}$ (mm)	$f_{852\,nm}$ (mm)	$f_{1064\,nm}$ (mm)
0.6	0.2	0.37	1.27	20.45	-21.35	-20.09	-20.08	-20.08	-20.09	-20.14	-20.19
1.4	0.5	0.98	1.87	51.47	-52.37	-50.50	-50.48	-50.49	-50.51	-50.67	-50.87
2.0	0.9	1.66	3.12	102.36	-103.82	-100.71	-100.69	-100.70	-100.74	-101.05	-101.44

Apéndice F

Especificaciones fotodetector y módulo preamplificador

F.1. Especificaciones fotodiodo APD C30902E

LASER COMPONENTS

PerkinElmer optoelectronics

Silicon Avalanche Photodiodes

C30902E, C30902S, C30921E, C30921S

High Speed Solid State Detectors for Fiber Optic and Very Low Light-Level Applications

EVERYTHING IN A NEW LIGHT.

Description

PerkinElmer Type C30902E avalanche photodiode utilizes a silicon detector chip fabricated with a double-diffused "reach-through" structure. This structure provides high responsivity between 400 and 1000 nm as well as extremely fast rise and fall times at all wavelengths. Because the fall time characteristics have no "tail", the responsivity of the device is independent of modulation frequency up to about 800 MHz. The detector chip is hermetically-sealed behind a flat glass window in a modified TO-18 package. The useful diameter of the photosensitive surface is 0.5 mm.

PerkinElmer Type C30921E utilizes the same silicon detector chip as the C30902E, but in a package containing a lightpipe which allows efficient coupling of light to the detector from either a focussed spot or an optical fiber up to 0.25 mm in diameter. The internal end of the lightpipe is close enough to the detector surface to allow all of the illumination exiting the lightpipe to fall within the active-area of the detector. The hermetically-sealed TO-18 package allows fibers to be epoxied to the end of the lightpipe to minimize signal losses without fear of endangering detector stability.

The C30902E and C309021E are designed for a wide variety of uses including optical communications at data rates to 1 GBit/second, laser range-finding, and any other applications requiring high speed and/or high responsivity.

Features

- High Quantum Efficiency 77% Typical at 830 nm
- C30902S and C30921S in Geiger Mode:
  - Single-Photon Detection Probability to 50%
  - Low Dark-Count Rate at 5% Detection Probability - Typically 15,000/second at +22°C
  - 350/second at -25°C
  - Count Rates to 2×10^6/second
- Hermetically Sealed Package
- Low Noise at Room Temperature
  - C30902E, C30921E - 2.3×10^{-13} A/Hz$^{1/2}$
  - C30902S, C30921S - 1.1×10^{-13} A/Hz$^{1/2}$
- High Responsivity - Internal Avalanche Gains in Excess of 150
- Spectral Response Range - (10% Points) 400 to 1000 nm
- Time Response - Typically 0.5 ns
- Wide Operating Temperature Range - -40°C to +70°C

PerkinElmer optoelectronics

C30902E, C30902S, C30921E, C30921S

The C30902S and C30921S are selected C30902E and C30921E photodiodes having extremely low noise and bulk dark-current. They are intended for ultra-low light level applications (optical power less than 1 pW) and can be used in either their normal linear mode ($V_R < V_{BR}$) at gains up to 250 or greater, or as photon counters in the "Geiger" mode ($V_R > V_{BR}$) where a single photoelectron may trigger an avalanche pulse of about 10^8 carriers. In this mode, no amplifiers are necessary and single-photon detection probabilities of up to approximately 50% are possible.

Photon-counting is also advantageous where gating and coincidence techniques are employed for signal retrieval.

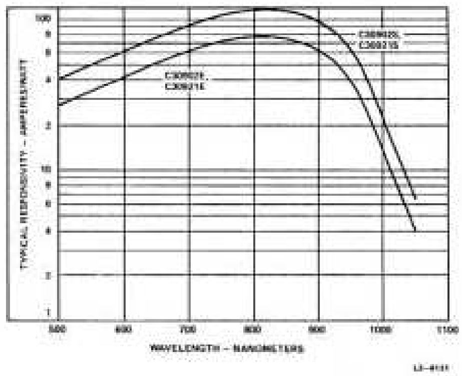


Figure 1. Typical Spectral Responsivity at 22°C

Optical Characteristics

C30902E, C30902S (Figure 13)

Photosensitive Surface:

- Shape ....Circular
- Useful area ....0.2 mm^2
- Useful diameter ....0.5 mm

Field of View:

- Approximate full angle for totally illuminated photosensitive surface ....100 deg

C30921E, C30921S (Figure 14)

Numerical Aperture of Light Pipe 0.55

Refractive Index (n) of Core 1.61

Lightpipe Core Diameter ....0.25 mm

Maximum Ratings, Absolute-Maximum Values (All Types)

Reverse Current at 22°C:	
Average value, continuous operation	200 μA
Peak value (for 1 second duration, non-repetitive)	1 mA
Forward Current, I_F at 22°C:	
Average value, continuous operation	5 mA
Peak value (for 1 second duration, non-repetitive)	50 mA
Maximum Total Power Dissipation at 22°C	60 mW
Ambient Temperature:	
Storage, T_{stg}	-60 to +100°C
Operating, T_A	-40 to +70°C
Soldering (for 5 seconds)	200°C

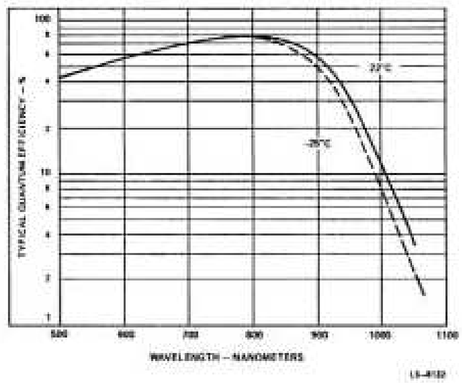


Figure 2. Typical Quantum Efficiency vs. Wavelength

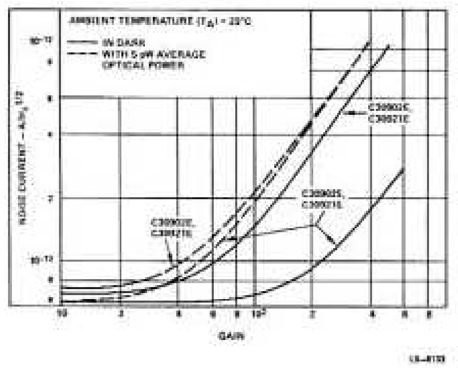


Figure 3. Typical Noise Current vs. Gain

C30902E, C30902S, C30921E, C30921S

Electrical Characteristics[1] at T_A = 22°C

	C30902E, C309021E			C30902S, C30921S			
	Min	Typ	Max	Min	Typ	Max	Units
Breakdown voltage, V_{BR}	-	225	-	-	225	-	V
Temperature Coefficient of V_R for Constant Gain	0.5	0.7	0.8	0.5	0.7	0.8	V/°C
Gain	-	150	-	-	250	-	
Responsivity:							
At 900 nm	55	65	-	92	108	-	A/W
At 830 nm	70	77	-	117	128	-	A/W
Quantum Efficiency:							
At 900 nm	-	60	-	-	60	-	%
At 830 nm	-	77	-	-	77	-	%
Dark Current, I_d	-	1.5×10^{8}	3×10^{8}	-	1×10^{8}	3×10^{8}	A
		(Figure 6)			*(Figure 6)*		
Noise Current, i_n: [2]							
f = 10 kHz, Δf = 1.0 Hz	-	2.3×10^{13}	5×10^{13}	-	1.1×10^{13}	2×10^{13}	$A/Hz^{1/2}$
		(Figure 3)			*(Figure 3)*		
Capacitance, C_d	-	1.6	2	-	1.6	2	pF
Rise Time, t_r:							
R_L = 50Ω, λ = 830 nm,							
10% to 90% points	-	0.5	0.75	-	0.5	0.75	ns
Fall Time:							
R_L = 50Ω, λ = 830 nm,							
90% to 10% points	-	0.5	0.75	-	0.5	0.75	ns
Geiger Mode *(See Appendix)*							
Dark Count Rate at 5% Photon Detection Probability [3] (830 nm):							
22°C	-	-	-	-	15,000	30,000	cps
-25°C	-	-	-	-	350	700	cps
Voltage Above V_{BR} for 5% Photon Detection Probability [3] (830 nm) *(See Figure 8)*	-	-	-	-	2	-	V
Dead-Time Per Event *(See Appendix)*	-	-	-	-	300	-	ns
After-Pulse Ratio at 5% Photon Detection Probability (830 nm) 22°C [4]	-	-	-	-	2	15	%

Note 1. At the DC reverse operating voltage V_R supplied with the device and a light spot diameter of 0.25 mm (C30902E, S) or 0.10 mm (C30921E, S). Note that a specific value of V_R is supplied with each device. When the photodiode is operated at this voltage, the device will meet the electrical characteristic limits shown above. The voltage value will be within the range of 180 to 250 volts.

Note 2. The theoretical expression for shot noise current in an avalanche photodiode is $i_n = (2q\,(I_{ds} + (I_{db}M^2 + P_oRM)\,F)\,B_w)^{1/2}$ where q is the electronic charge, I_{ds} is the dark surface current, I_{db} is the dark bulk current, F is the excess noise factor, M is the gain, P_o is the optical power on the device, and B_w is the noise bandwidth. For these devices F = 0.98 (2-1/M) + 0.02 M. (Reference: PP Webb, RJ McIntyre, JJ Conradi, "RCA Review", Vol. 35 p. 234, (1974)).

Note 3. The C30902S and C30921S can be operated at a substantially higher Detection Probabilities. See Appendix.

Note 4. After-Pulse occurring 1 microsecond to 60 seconds after main pulse.

C30902E, C30902S, C30921E, C30921S

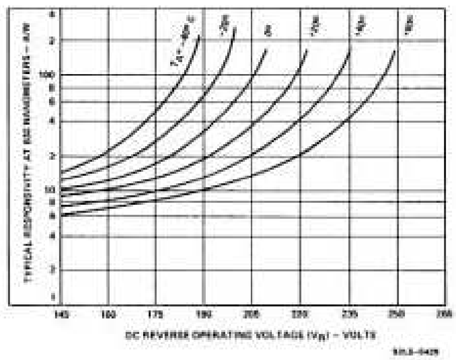


Figure 4. Typical Responsivity at 830 nm vs. Operating Voltage

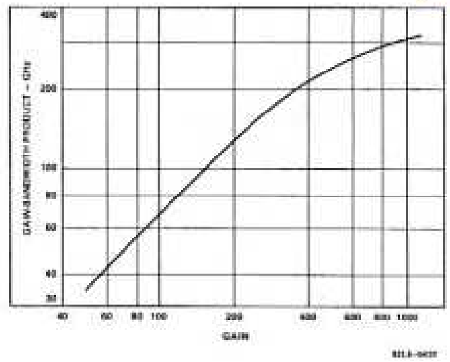


Figure 5. Typical Gain-Bandwidth Product vs. Gain

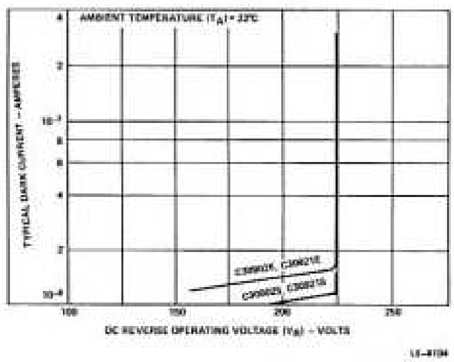


Figure 6. Typical Dark Current vs. Operating Voltage (V < VBR)

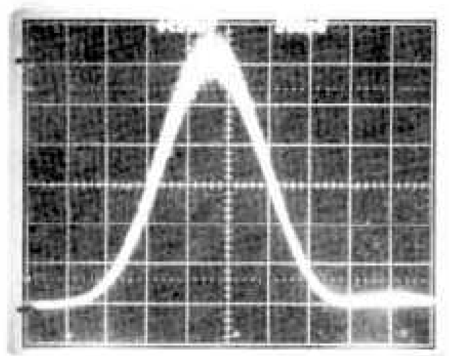


Figure 7. Avalanche Photodiode Response to a 100 ps Laser Pulse as Measured with a 350 ps Sampling Head. (Horizontal Axis: 200 ps/Division)

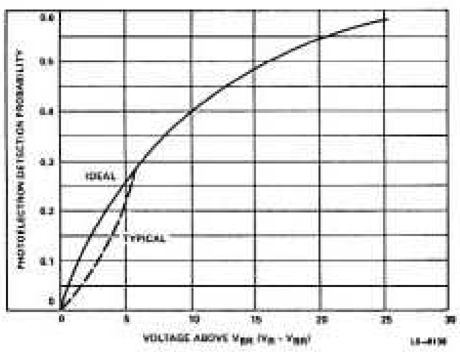


Figure 8. Geiger Mode, Photoelectron Detection Probability vs. Voltage Above VBR (VR > VBR)

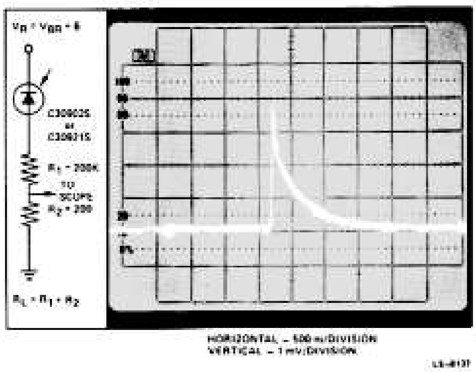


Figure 9. Passively Quenched Circuit and Resulting Pulse Shape

C30902E, C30902S, C30921E, C30921S

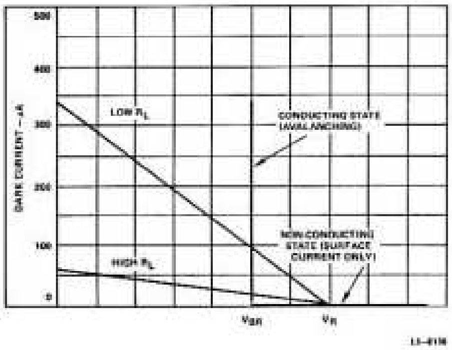


Figure 10. Load Line for C30921S in the Geiger Mode

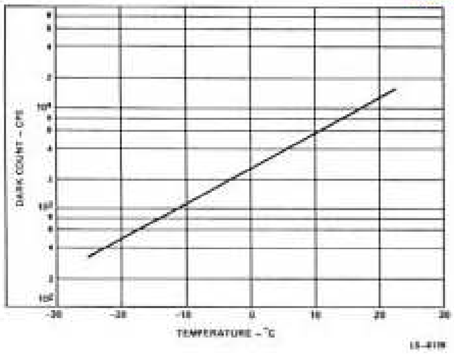


Figure 11. Typical Dark Count vs. Temperature at 5% Photon (830 nm) Detection Efficiency

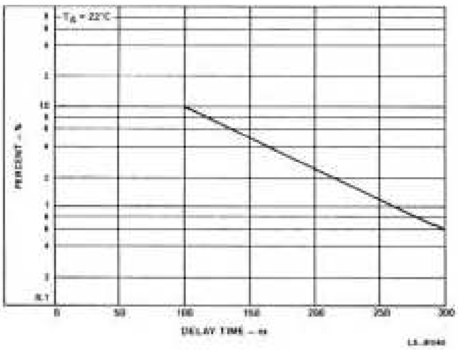
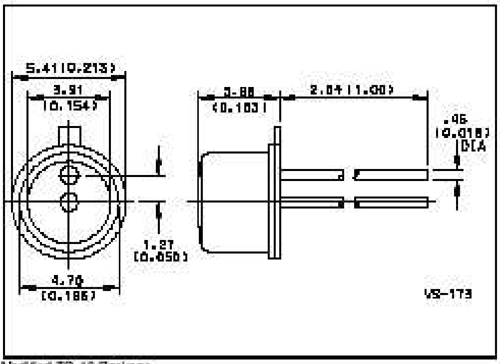


Figure 12. Chance of an After-Pulse within the Next 100 ns vs. Delay-Time in an Actively Quenched Circuit. (Typical for C30902S, C30921S at V_{BR} + 25)



Modified TO-18 Package.
Note: Optical distance is defined as the distance from the surface of the silicon chip to the front surface of the window.
Figure 13. Dimensional Outline - C30902E, C30902S, C30921E, C30921S

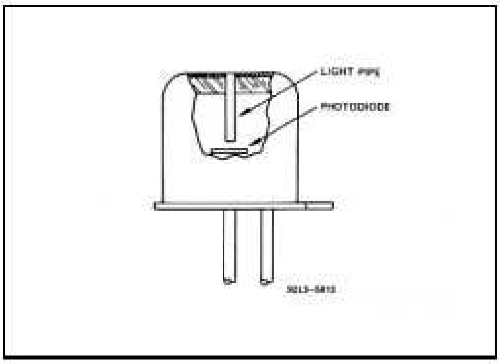


Figure 14. Cutaway of the C30921E, C30921S

Dimensions in millimeters. Dimensions in parentheses are in inches.

F.2. Especificaciones módulo APD-preamplificador

a HEICO company

ANALOG MODULES, INC.

MODEL 713A

BIPOLAR LOW NOISE
PHOTODETECTOR-AMPLIFIER MODULES

HIGH BANDWIDTH, BIPOLAR PHOTODETECTOR-AMPLIFIER MODULE

- LOW NOISE - DOWN TO 100fW/√Hz
- ULTRA HIGH BANDWIDTH - 1kHz TO 200MHz
- HIGH GAIN - UP TO 1.5V/μW
- SILICON OR InGaAs PINS, OR SILICON AVALANCHE PHOTODIODES

DESCRIPTION:

The ***713A Series*** Ultra High Bandwidth Low Noise Photodetector-Amplifier Modules offer a high gain amplifier with the flexibility of incorporating various silicon and InGaAs photodetectors. The design is optimized for high-speed response and has a lower input impedance than the 712A Series, permitting high speed operation from larger capacitance detectors. The *713A Series* is based on the *313A Series* transimpedance amplifier. Consult factory for different detectors.

SPECIFICATIONS:

Input	Silicon or InGaAs photodetector (See table for characteristics.) Other detectors available upon request. Maximum DC light-induced current: 0.5mA
Output	
Load	50Ω
Swing	2V pk
Gain	20kV/A transimpedance Multiply transimpedance gain by detector responsivity at peak wavelength to get V/W in table.
Polarity	Non-Inverting, positive output when flux applied
Power	+15VDC at 100mA typical Internally regulated
Temperature	-20° to +70°C
Connections	
Input	Photodetector inside box
Output	BNC
Power	Filter feed-thru pins and ground lug
Bias	Pin decoupled with 0.01μF, 1kV capacitor. (See figure on reverse.)
Size	3.49" x 1.92" x 0.92"
Weight	3.2 ounces

ISO 9001 CERTIFIED

Specifications subject to change without notice.

APPLICATIONS:

Ultra High Speed, Low Light Level Sensing

126 BAYWOOD AVENUE ♦ LONGWOOD, FLORIDA 32750-3426 ♦ USA
(407) 339-4355 ♦ FAX (407) 834-3806 ♦ E-mail: ami@analogmodules.com
www.analogmodules.com

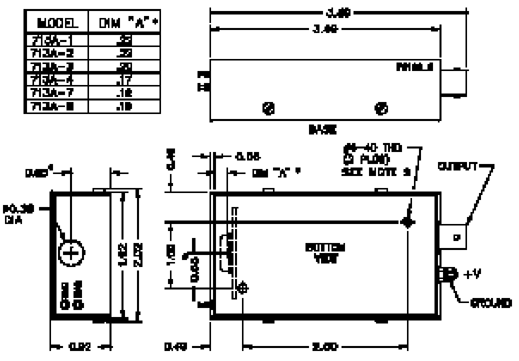
04/2004

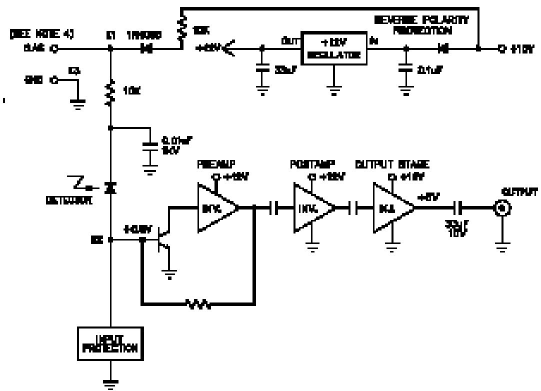
MODEL NO.	PHOTODIODE	DETECTOR PART NO.	ACTIVE AREA DIAMETER	PEAK	OPTIMUM REVERSE BIAS	BANDWIDTH ≤1kHz TO:	NOMINAL GAIN	TYPICAL NOISE (5)
713A-1	Si PIN	C30831E	0.5mm	900nm	+45V (1)	150MHz	12V/mW	15pW/√ Hz
713A-2	Si PIN	C30807E	1.0mm	900nm	+45V (1)	125MHz	12V/mW	16pW/√ Hz
713A-3	Si PIN	FND 100Q	2.5mm	900nm	+90V (1)	100MHz	12V/mW	12pW/√ Hz
713A-4	Si APD	C30902E (3)	0.5mm (4)	830nm	180-250V (2)	200MHz	1.5V/μW	100fW/√ Hz
713A-7	InGaAs PIN	GAP100 (3)	100μm (4)	1.55μm	+5V INTERNAL	200MHz	18V/mW	8pW/√ Hz
713A-8	InGaAs PIN	GAP300 (3)	300μm (4)	1.55μm	+12V INTERNAL	180MHz	18V/mW	9pW/√ Hz

(1) Internal bias provided at +12V. For best bandwidth, use *Model 521* high voltage bias power supply to apply optimum reverse bias. Internal bias is protected by diode when external supply is used.
(2) Adjustable HV supply required. Optional *Model 521* or *522* available(consult factory).
(3) Available in ST or FC receptacle (consult factory).
(4) Available with optical fiber (consult factory).
(5) Actual noise may vary by ±20% due to detector tolerance. Noise is greater with higher capacitance detectors.
(6) Bandwidth tolerance is ±20%.
Note: Equivalent detector may be used.

Typical Part Number: ***713A-7 =***

Transimpedance Gain:	20kV/A
Detector:	GAP100
Optimum gain:	18V/mW
Noise:	8pW/√Hz
3dB frequency:	200MHz
Cut-on frequency:	≤1kHz





NOTES:
1. DIMENSIONS ARE IN INCHES.
2. MAXIMUM THREAD ENTRY 0.14
3. TOLERANCE: +/- 0.01
4. MODEL 713A -7 AND -8 HAVE NO EXTERNAL BIAS.
* DETECTOR POSITION MAY VARY BY +/- 0.12"

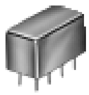
Apéndice G

Especificaciones componentes electrónicos

G.1. Especificaciones Filtros paso bajo PLP5 y PLP50 Mini-Circuits

FILTERS 50 & 75 Ω Plug-In

LOW PASS DC to 1000 MHz



PLP

MODEL NO.	PASSBAND, MHz (loss < 1dB)	fco, MHz Nom. (loss 3dB)	STOP BAND, MHz (loss > 20dB)	STOP BAND, MHz (loss > 40dB)	VSWR, Passband Typ.	VSWR, Stopband Typ.	CAPD DATA (see RF/IF Designer hand-book) Page	CASE STYLE Note B	CONNECTION	PRICE $ Qty. (1-9)
PLP-1.9**	DC-1.9	2.5	3.4-4.7	4.7-200	1.7:1	18:1	8-34	A01	cr	13.95
PLP-2.5**	DC-2.5	2.75	3.8-5.0	5.0-200	1.7:1	18:1	8-34	A01	cr	14.95
PLP-5	DC-5	6	8-10	10-200	1.7:1	18:1	8-12	A01	cr	11.45
■ PLP-7-75	DC-7	8	11-15	15-200	1.7:1	18:1	8-35	A01	cr	12.95
PLP-10.7	DC-11	14	19-24	24-200	1.7:1	18:1	8-12	A01	cr	11.45
■ PLP-10.7-75	DC-11	14	19-24	24-200	1.7:1	18:1	8-35	A01	cr	12.95
PLP-15	DC-15	17	23-32	32-200	1.7:1	18:1	8-35	A01	cr	11.45
■ PLP-15-75	DC-15	17	23-32	32-200	1.7:1	18:1	8-35	A01	cr	12.95
PLP-21.4	DC-22	24.5	32-41	41-200	1.7:1	18:1	8-12	A01	cr	11.45
■ PLP-21.4-75	DC-22	24.5	32-41	41-200	1.7:1	18:1	8-36	A01	cr	12.95
PLP-30	DC-32	35	47-61	61-200	1.7:1	18:1	8-13	A01	cr	11.45
■ PLP-30-75	DC-32	35	47-61	61-200	1.7:1	18:1	8-36	A01	cr	12.95
PLP-50	DC-48	55	70-90	90-200	1.7:1	18:1	8-13	A01	cr	11.45
■ PLP-50-75	DC-48	55	70-90	90-200	1.7:1	18:1	8-36	A01	cr	12.95
PLP-70	DC-60	67	90-117	117-300	1.7:1	18:1	8-13	A01	cr	11.45
PLP-90	DC-81	90	121-157	157-400	1.7:1	18:1	8-14	A01	cr	11.45
PLP-100	DC-98	108	146-189	189-400	1.7:1	18:1	8-14	A01	cr	11.45
■ PLP-100-75	DC-98	108	146-189	189-400	1.7:1	18:1	8-37	A01	cr	12.95
PLP-150	DC-140	155	210-300	300-600	1.7:1	18:1	8-14	A01	cr	11.45
PLP-200	DC-190	210	290-390	390-800	1.7:1	18:1	8-15	A01	cr	11.45
PLP-250	DC-225	250	320-400	400-1200	1.7:1	18:1	8-15	A01	cr	11.45
PLP-300	DC-270	297	410-550	550-1200	1.7:1	18:1	8-15	A01	cr	11.45
PLP-450	DC-400	440	580-750	750-1800	1.7:1	18:1	8-16	A01	cr	11.45
PLP-550	DC-520	570	750-920	920-2000	1.7:1	18:1	8-16	A01	cr	11.45
PLP-600	DC-580	640	840-1120	1120-2000	1.7:1	18:1	8-16	A01	cr	11.45
■ PLP-600-75	DC-580	640	840-1120	1120-2000	1.7:1	18:1	8-37	A01	cr	12.95
PLP-750	DC-700	770	1000-1300	1300-2000	1.7:1	18:1	8-17	A01	cr	11.45
PLP-800	DC-720	800	1080-1400	1400-2000	1.7:1	18:1	8-17	A01	cr	11.45
PLP-850	DC-780	850	1100-1400	1400-2000	1.7:1	18:1	8-17	A01	cr	11.45
■ PLP-850-75	DC-750	850	1150-1490	1490-2000	1.7:1	18:1	8-37	A01	cr	12.95
PLP-1000	DC-900	990	1340-1750	1750-2000	1.7:1	18:1	8-18	A01	cr	11.45
PLP-1200	DC-1000	1200	1620-2100	2100-2500	1.7:1	18:1	8-18	A01	cr	11.45

NOTES:

- * 35 dB for SCLF-380, SCLF-420 and SCLF-550 models
- ** 1db compression at +13dbm input power
- ■ Denotes 75 ohm model.
- ❑ Non-hermetic
- A. General Quality Control Procedures, Environmental Specifications, Hi-Rel and MIL description are given in General Information (section 0).
- B. Connector types and case mounted options, case finishes are given in section 0, see "Case styles & outline drawings".
- C. Prices and specifications subject to change without notice.
- 1. Absolute maximum power, voltage and current rating:
  1a. RF power, 0.5 Watt

NSN GUIDE

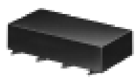
MCL NO.	NSN
PLP-30	5915-01-355-9433
PLP-100	5915-01-332-1091
PLP-150	5915-01-389-3575
PLP-300	5915-01-450-7011
PLP-450	5915-01-389-8302

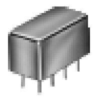
G.2. Especificaciones Filtro PHP50 Mini-Circuits

FILTERS 50 Ω Surface Mount□

HIGH PASS 16.5 MHz to 2.2 GHz

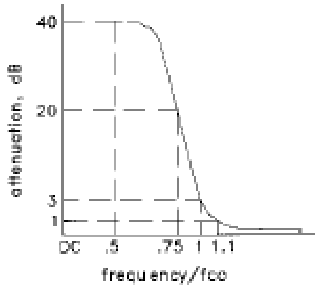
SURFACE MOUNT


SCHF


PHP

MODEL NO.	STOP BAND, MHz (loss > 40dB)	STOP BAND, MHz (loss > 20dB)	fco, MHz Nom. (loss 3dB)	PASSBAND, MHz (loss < 1dB)	VSWR, Stopband Typ.	VSWR, Passband Typ.	CAPD DATA (see RF/IF Designer handbook) Page	CASE STYLE Note B	connection	PRICE $ Qty. (1-9)
NEW SCHF-17	DC-9	9-13	16.5	18-200	1.8:1	1.25:1	—	YY161	cr	15.95
SCHF-25	DC-13	13-19	25	27.5-200	1.8:1	1.3:1	8-41	YY161	cr	14.95
SCHF-300	DC-145	145-190	245	290-1200	1.8:1	1.5:1	8-41	YY161	cr	14.95
PHP-25	DC-13	13-19	25	27.5-200	1.8:1	1.7:1	8-26	A01	cr	16.95
PHP-50	DC-20	20-26	37	41-200	1.7:1	1.5:1	8-26	A01	cr	14.95
PHP-100	DC-40	40-55	82	90-400	1.7:1	1.5:1	8-26	A01	cr	14.95
PHP-150	DC-70	70-95	120	133-400	1.7:1	1.8:1	8-27	A01	cr	14.95
PHP-175	DC-70	70-105	140	160-800	1.7:1	1.5:1	8-27	A01	cr	14.95
PHP-200	DC-90	90-116	164	185-800	1.7:1	1.6:1	8-27	A01	cr	14.95
PHP-250	DC-100	100-190	205	225-1200	1.7:1	1.3:1	8-28	A01	cr	14.95
PHP-300	DC-145	145-170	245	*290-1200	1.7:1	1.7:1	8-28	A01	cr	14.95
PHP-400	DC-210	210-290	380	395-1600	1.7:1	1.7:1	8-28	A01	cr	14.95
PHP-500	DC-280	280-365	454	500-1600	1.7:1	1.9:1	8-29	A01	cr	14.95
PHP-600	DC-350	350-440	545	600-1600	1.7:1	2.0:1	8-29	A01	cr	14.95
PHP-700	DC-400	400-520	640	700-1800	1.7:1	1.6:1	8-29	A01	cr	14.95
PHP-800	DC-445	445-570	710	780-2000	1.7:1	2.1:1	8-30	A01	cr	14.95
PHP-900	DC-520	520-680	820	910-2100	1.7:1	1.8:1	8-30	A01	cr	14.95
PHP-1000	DC-550	550-720	910	1000-2200	1.7:1	1.9:1	8-30	A01	cr	14.95

HIGH PASS
TYPICAL FREQUENCY RESPONSE



NOTES:

- * Insertion loss 1.5 dB maximum
- □ Non-hermetic
- A. General Quality Control Procedures, Environmental Specifications, Hi-Rel and MIL description are given in section 0, see "Mini-Circuits Guarantees Quality" article.
- B. Connector types and case mounted options, case finishes are given in section 0, see "Case styles & outline drawings".
- C. Prices and specifications subject to change without notice.
- 1. Absolute maximum power, voltage and current rating:
  1a. RF power, 0.5 Watt
- 2. Models are available with male/female coax connectors, for other configurations and inter-series versions consult factory. See section 0, case styles and outline drawings.

pin connections

see case style outline drawings

PORT	cr
INPUT	1
OUTPUT	8
GND	2,3,4,5,6,7

NSN GUIDE

MCL NO.	NSN
BHP-25	5915-01-425-7519
SHP-200	5915-01-360-0677

971103

G.3. Especificaciones Mezclador UNCL-R1 Mini-Circuits

FREQUENCY MIXERS

Plug-In

ACTIVE, LOAD INSENSITIVE 10 to 500 MHz

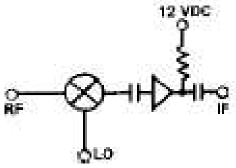
UNCL-X
UNCL-X1MH

UNCL-X1 (+7 dBm LO, up to +1 dBm RF)
UNCL-X1MH (+13 dBm LO, up to +7 dBm RF)

MODEL NO.	FREQUENCY MHz LO/RF f_L-f_U	FREQUENCY MHz IF	CONVERSION GAIN, dB Mid-Band m $\bar{x}$	σ	Min.	Total Range Min.	LO-RF ISOLATION, dB L Typ.	L Min.	M Typ.	M Min.	U Typ.	U Min.	LO-IF ISOLATION, dB L Typ.	L Min.	M Typ.	M Min.	U Typ.	U Min.	INPUT POWER (dBm) 1 dB Comp Typ.	DC POWER Volt	Current (mA)	CAPD DATA (see RF/IF Designer Handbook) Page	CASE STYLE Note B	CONNECTION	Price $ Qty. (1-9)
UNCL-X1	1-500	10-500	1.57	.06	-1.0	-1.0	60	40	30	25	25	20	50	30	30	20	26	18	1	12	36	1-177	A01	a	23.95
UNCL-X1MH	1-500	10-500	2.41	.015	0.5	0	60	40	35	25	30	20	50	30	25	18	18	14	1	12	60	1-181	A01	a	27.95

L = low range [f_L to 10 f_L] M = mid range [10 f_L to f_U/2] U = upper range [f_U/2 to f_U]
m = mid band [2f_L to f_U/2]

features
- 2-tone 3rd-order IM
- insensitive to IF load
- VSWR 1.2:1, IF/RF ports



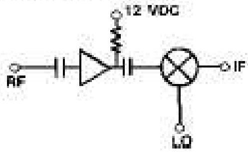
ACTIVE, LOW NOISE (4.3 dB typ.) 10 to 500 MHz

UNCL-R1
UNCL-R1H

UNCL-R1 (+7 dBm LO, up to -10 dBm RF)
UNCL-R1H (+17 dBm LO, up to +1 dBm RF)

MODEL NO.	FREQUENCY MHz LO/RF f_L-f_U	FREQUENCY MHz IF	CONVERSION GAIN, dB Mid-Band m $\bar{x}$	σ	Min.	Total Range Typ.	Total Range Min.	LO-RF ISOLATION, dB L Typ.	L Min.	M Typ.	M Min.	U Typ.	U Min.	LO-IF ISOLATION, dB L Typ.	L Min.	M Typ.	M Min.	U Typ.	U Min.	INPUT POWER (dBm) 1 dB Comp Typ.	DC POWER Volt	Current (mA)	CAPD DATA (see RF/IF Designer Handbook) Page	CASE STYLE Note B	CONNECTION	Price $ Qty. (1-9)
UNCL-R1	10-500	DC-500	5.53	.11	2	5	2	65	45	55	40	47	35	40	30	30	20	25	17	-10	12	35	1-185	A01	b	23.95
UNCL-R1H	10-500	DC-500	6.32	.23	3	6	2	65	45	55	40	47	35	40	30	35	25	28	19	1	12	60	1-183	A01	b	27.95

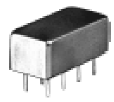
L = low range [f_L to 10 f_L] M = mid range [10 f_L to f_U/2] U = upper range [f_U/2 to f_U]
m = mid band [2f_L to f_U/2]



G.4. Especificaciones VCO POS-50 Mini-Circuits

VOLTAGE CONTROLLED OSCILLATORS *Plug-In*

LINEAR TUNING *15 to 2120 MHz*



POS

MODEL NO.	FREQ. MHz Min.	FREQ. MHz Max.	POWER OUTPUT dBm Typ.	TUNE VOLTAGE V Min.	TUNE VOLTAGE V Max.	PHASE NOISE dBc/Hz SSB @ offset frequencies: Typ. 1 kHz	10 kHz	100 kHz	1 MHz	PULLING MHz pk-pk @12 dBr Typ.	PUSHING MHz/V Typ.	TUNING SENSITIVITY MHz/V Typ.	HARMONICS dBc Typ.	HARMONICS dBc Max.	3 dB MOD. BANDWIDTH kHz Typ.	POWER SUPPLY Voltage V	POWER SUPPLY CURRENT mA Max.	CAPD DATA Page	Case Style Note B	CONNECTION	Price $ Qty (5-49)
POS-25	15	25	+7	1	11	-86	-105	-125	-145	0.06	0.04	1 - 4	-26	-15	60	12	20	15-30	A06	hx	16.95
POS-50	25	50	+8.5	1	16	-88	-110	-130	-150	0.06	0.04	2.0 - 2.6	-19	-12	100	12	20	15-31	A06	hx	11.95
POS-75	37.5	75	+8	1	16	-87	-110	-130	-150	0.15	0.11	3.1 - 3.8	-27	-16	100	12	20	15-31	A06	hx	11.95
POS-100	50	100	+8.3	1	16	-83	-107	-130	-150	0.6	0.2	4.2 - 4.8	-23	-18	100	12	20	15-32	A06	hx	11.95
POS-150	75	150	+9.5	1	16	-80	-103	-127	-147	0.8	0.3	5.8 - 6.7	-23	-17	100	12	20	15-33	A06	hx	11.95
POS-200	100	200	+10	1	16	-80	-102	-122	-142	1.0	0.2	7.1 - 8.6	-24	-20	100	12	20	15-34	A06	hx	11.95
POS-300	150	280	+10	1	16	-78	-100	-120	-140	1.8	0.3	9.5 - 13	-30	-20	100	12	20	15-35	A06	hx	13.95
POS-400	200	380	+9.5	1	16	-76	-98	-120	-140	1.8	0.3	13.7 - 16.9	-28	-20	100	12	20	15-36	A06	hx	13.95
POS-535	300	525	+8.8	1	16	-70	-93	-116	-139	2.0	0.4	10.5 - 24	-26	-20	100	12	20	15-37	A06	hx	13.95
POS-765	485	765	+9.5	1	16	-61	-85	-108	-129	5.0	0.4	18 - 27	-21	-17	100	12	22	15-38	A06	hx	14.95
POS-900W	500	900	+7	1	20	-75	-95	-115	-135	2.0	0.3	16 - 40	-26	-20	100	12	25	15-39	A06	hx	16.95
POS-1000W	500	1000	+7	1	16	-73	-93	-113	-133	6.0	1.5	30 - 42	-26	-20	100	12	20	—	A06	hx	19.95
POS-1025	685	1025	+9	1	16	-65	-84	-104	-124	5.0	0.6	21 - 36	-23	-18	100	12	22	15-40	A06	hx	16.95
POS-1060	750	1060	+12	1	20	-65	-90	-112	-132	50	3.0	18 - 32	-11	--	1000	8	30	15-41	A06	hx	14.95
POS-1400	975	1400	+13	1	20	-65	-95	-115	-135	36	1.5	21-43	-11	--	1000	8	30	15-42	A06	hx	14.95
POS-2000	1370	2000	+10	1	20	-70	-95	-115	-135	28	1.5	30-60	-11	--	1000	8	30	15-43	A06	hx	14.95
NEW POS-2120W	1060	2120	+8	.5	20	-70	-97	-117	-137	27	2.5	35-120	-11	--	1000	12	28	—	A06	hx	21.95

features
- Octave bandwidth range (typ.)
- Linear tuning
- Low phase noise
- Excellent harmonic suppression
- Output suitable for LO drive to mixers
- Low power consumption, typically 190 mW (most models)
- Usable with +15V supply for higher power output, typically 2 dB
- Useful in digital cordless phones, cellular up-and-down converters, CATV distribution and set top converters, wideband frequency synthesizers, test instruments, signal generators and agile communications systems

NOTES:

A. General Quality Control Procedures, Environmental specifications, Hi-Rel, and MIL description are given in General Information (Section 0).
B. Connector types and case mounted options, case finishes are given in section 0, see "Case Styles & Outline Drawings".
C. Prices and Specifications subject to change without notice.
1. Absolute Maximum Supply Voltage (V_{cc}) & Tuning Voltage (V_{tune}):

Model	(V_{cc})	(V_{tune})	Model	(V_{cc})	(V_{tune})
POS-25	+15V	+12V	POS-535	+16V	+18V
POS-50	+16V	+17V	POS-765	+16V	+18V
POS-75	+16V	+18V	POS-900W	+15V	+25V
POS-100	+16V	+18V	POS-1000W	+15V	+20V
POS-200	+16V	+18V	POS-1025	+16V	+18V
POS-150	+16V	+18V	POS-1060	+10V	+22V
POS-200	+16V	+18V	POS-1400	+10V	+22V
POS-300	+16V	+18V	POS-2000	+10V	+22V
POS-400	+16V	+18V	POS-2120W	+15V	+25V

2. Operating Temperature: -55°C to +85°C

DESIGNERS KITS AVAILABLE

KIT NO.	NO. of Units in Kit	Description	Price $ per Kit
K-POS1	10	1 of each: POS-50, 75, 100, 150, 200, 300, 400, 535, 765, 1025	124.95
K-POS2	7	1 of each: POS-50, 100, 200, 400, 535, 765, 1025	79.95
K-POS3	6	2 of each: POS-1060, 1400, 2000	79.95
K-JTOS1	10	1 of each: JTOS-50, 75, 100, 150, 200, 300, 400, 535, 765, 1025	149.95
K-JTOS2	7	1 of each: JTOS-50, 100, 200, 400, 535, 765, 1025	99.95
K-JTOS3	6	2 of each: JTOS-1300, 1650, 1910	114.95

990827

G.5. Especificaciones regulador de tensión POS-50 Linear Technology

LINEAR TECHNOLOGY

LT1021

Precision Reference

FEATURES

- Pin Compatible with Most Bandgap Reference Applications, Including Ref 01, Ref 02, LM368, MC1400 and MC1404 with Greatly Improved Stability, Noise and Drift
- **Ultralow Drift: 5ppm/°C Max Slope**
- Trimmed Output Voltage
- Operates in Series or Shunt Mode
- Output Sinks and Sources in Series Mode
- **Very Low Noise: <1ppm $_{P-P}$ (0.1Hz to 10Hz)**
- >100dB Ripple Rejection
- Minimum Input/Output Differential of 1V
- **100% Noise Tested**

APPLICATIONS

- A/D and D/A Converters
- Precision Regulators
- Digital Voltmeters
- Inertial Navigation Systems
- Precision Scales
- Portable Reference Standard

DESCRIPTION

The LT®1021 is a precision reference with ultralow drift and noise, extremely good long term stability and almost total immunity to input voltage variations. The reference output will both source and sink up to 10mA. Three voltages are available: 5V, 7V and 10V. The 7V and 10V units can be used as shunt regulators (two-terminal zeners) with the same precision characteristics as the three-terminal connection. Special care has been taken to minimize thermal regulation effects and temperature induced hysteresis.

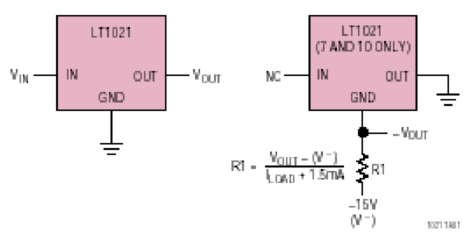
The LT1021 references are based on a buried zener diode structure that eliminates noise and stability problems associated with surface breakdown devices. Further, a subsurface zener exhibits better temperature drift and time stability than even the best bandgap references.

Unique circuit design makes the LT1021 the first IC reference to offer ultralow drift without the use of high power on-chip heaters.

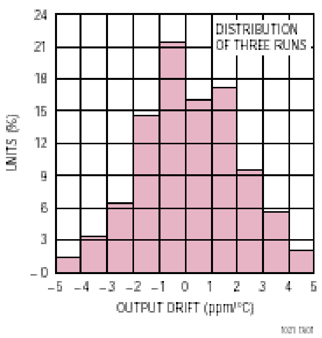
The LT1021-7 uses no resistive divider to set output voltage, and therefore exhibits the best long term stability and temperature hysteresis. The LT1021-5 and LT1021-10 are intended for systems requiring a precise 5V or 10V reference with an initial tolerance as low as ±0.05%.

TYPICAL APPLICATION

Basic Positive and Negative Connections



Typical Distribution of Temperature Drift



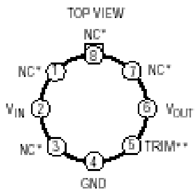
LT1021

ABSOLUTE MAXIMUM RATINGS (Note 1)

Input Voltage 40V
Input/Output Voltage Differential 35V
Output-to-Ground Voltage (Shunt Mode Current Limit)
LT1021-5 .... 10V
LT1021-7 .... 10V
LT1021-10 .... 16V
Trim Pin-to-Ground Voltage
Positive .... Equal to V_{OUT}
Negative .... – 20V

Output Short-Circuit Duration
V_{IN} = 35V .... 10 sec
$V_{IN} \leq$ 20V .... Indefinite
Operating Temperature Range
Commercial .... 0°C to 70°C
Industrial .... –40°C to 85°C
Military .... –55°C to 125°C
Storage Temperature Range .... –65°C to 150°C
Lead Temperature (Soldering, 10 sec) .... 300°C

PACKAGE/ORDER INFORMATION

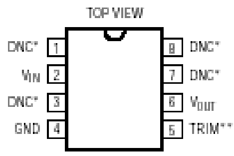


H PACKAGE
8-LEAD TO-5 METAL CAN

*CONNECTED INTERNALLY. DO NOT CONNECT EXTERNAL CIRCUITRY TO THESE PINS
**NO TRIM PIN ON LT1021-7. DO NOT CONNECT EXTERNAL CIRCUITRY TO PIN 5 ON LT1021-7

T_{JMAX} = 150°C, θ_{JA} = 150°C/W, θ_{JC} = 45°C/W

ORDER PART NUMBER
LT1021BCH-5
LT1021BMH-5
LT1021CCH-5
LT1021CMH-5
LT1021DCH-5
LT1021DMH-5
LT1021BCH-7
LT1021BMH-7
LT1021DCH-7
LT1021DMH-7
LT1021BCH-10
LT1021BMH-10
LT1021CCH-10
LT1021CMH-10
LT1021DCH-10
LT1021DMH-10



N8 PACKAGE 8-LEAD PDIP
S8 PACKAGE 8-LEAD PLASTIC SO

*CONNECTED INTERNALLY. DO NOT CONNECT EXTERNAL CIRCUITRY TO THESE PINS
**NO TRIM PIN ON LT1021-7. DO NOT CONNECT EXTERNAL CIRCUITRY TO PIN 5 ON LT1021-7

T_{JMAX} = 130°C, θ_{JA} = 130°C/W (N)
T_{JMAX} = 130°C, θ_{JA} = 150°C/W (S)

ORDER PART NUMBER
LT1021BCN8-5
LT1021CCN8-5
LT1021CIN8-5
LT1021DCN8-5
LT1021DIN8-5
LT1021DCS8-5
LT1021BCN8-7
LT1021DCN8-7
LT1021DCS8-7
LT1021BCN8-10
LT1021CCN8-10
LT1021CIN8-10
LT1021DCN8-10
LT1021DCS8-10
LT1021DIN8-10

S8 PART MARKING
021DC5
021DC7
021DC1

ELECTRICAL CHARACTERISTICS

The ● denotes specifications that apply over the full operating temperature range, otherwise specifications are $T_A = 25°C$, $V_{IN} = 15V$, $I_{OUT} = 0$, unless otherwise noted.

PARAMETER	CONDITIONS		LT1021-10 MIN	TYP	MAX	UNITS
Output Voltage (Note 2)	LT1021C-10		9.995	10.00	10.005	V
	LT1021B-10/LT1021D-10		9.950	10.00	10.050	V
Output Voltage Temperature Coefficient (Note 3)	$T_{MIN} \le T_J \le T_{MAX}$					
	LT1021B-10	●		2	5	ppm/°C
	LT1021C-10/LT1021D-10	●		5	20	ppm/°C
Line Regulation (Note 4)	$11.5V \le V_{IN} \le 14.5V$			1.0	4	ppm/V
		●			6	ppm/V
	$14.5V \le V_{IN} \le 40V$			0.5	2	ppm/V
		●			4	ppm/V
Load Regulation (Sourcing Current)	$0 \le I_{OUT} \le 10mA$			12	25	ppm/mA
	(Note 4)	●			40	ppm/mA
Load Regulation (Shunt Mode)	$1.7mA \le I_{SHUNT} \le 10mA$			50	100	ppm/mA
	(Notes 4, 5)	●			150	ppm/mA
Supply Current (Series Mode)				1.2	1.7	mA
		●			2.0	mA
Minimum Current (Shunt Mode)	V_{IN} is Open			1.1	1.5	mA
		●			1.7	mA
Output Voltage Noise (Note 6)	$0.1Hz \le f \le 10Hz$			6.0		μV_{P-P}
	$10Hz \le f \le 1kHz$			3.5	6	μV_{RMS}
Long Term Stability of Output Voltage (Note 7)	Δt = 1000Hrs Noncumulative			15		ppm
Temperature Hysteresis of Output	$\Delta T = \pm 25°C$			5		ppm

Note 1: Absolute Maximum Ratings are those values beyond which the life of a device may be impaired.

Note 2: Output voltage is measured immediately after turn-on. Changes due to chip warm-up are typically less than 0.005%.

Note 3: Temperature coefficient is measured by dividing the change in output voltage over the temperature range by the change in temperature. Separate tests are done for hot and cold; T_{MIN} to 25°C and 25°C to T_{MAX}. Incremental slope is also measured at 25°C.

Note 4: Line and load regulation are measured on a pulse basis. Output changes due to die temperature change must be taken into account separately. Package thermal resistance is 150°C/W for TO-5 (H), 130°C/W for N and 150°C/W for the SO-8.

Note 5: Shunt mode regulation is measured with the input open. With the input connected, shunt mode current can be reduced to 0mA. Load regulation will remain the same.

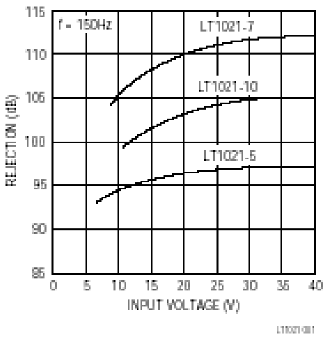
Note 6: RMS noise is measured with a 2-pole highpass filter at 10Hz and a 2-pole lowpass filter at 1kHz. The resulting output is full-wave rectified and then integrated for a fixed period, making the final reading an average as opposed to RMS. Correction factors are used to convert from average to RMS and correct for the non-ideal bandpass of the filters.

Peak-to-peak noise is measured with a single highpass filter at 0.1Hz and a 2-pole lowpass filter at 10Hz. The unit is enclosed in a still-air environment to eliminate thermocouple effects on the leads. Test time is 10 seconds.

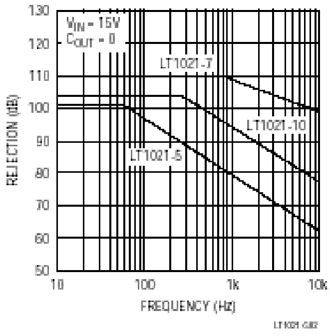
Note 7: Consult factory for units with long term stability data.

TYPICAL PERFORMANCE CHARACTERISTICS

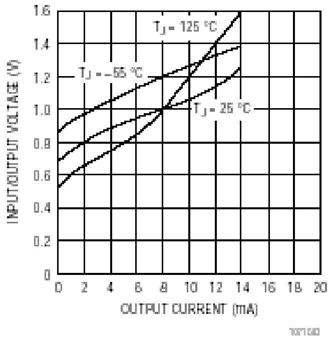
Ripple Rejection



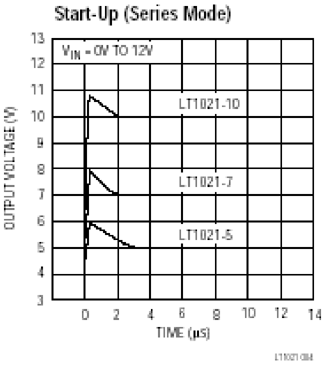
Ripple Rejection



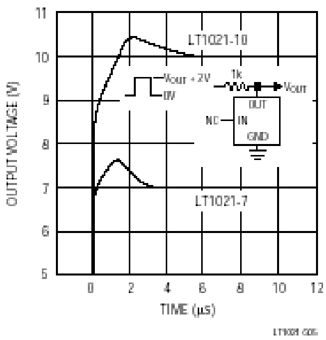
Minimum Input/Output Differential LT1021-7, LT1021-10



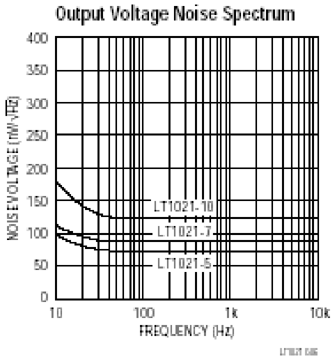
Start-Up (Series Mode)



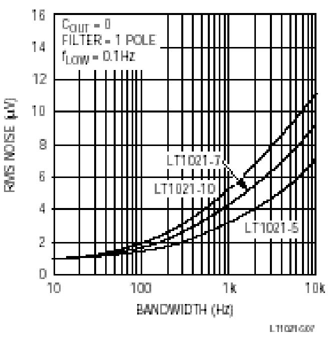
Start-Up (Shunt Mode) LT1021-7, LT1021-10



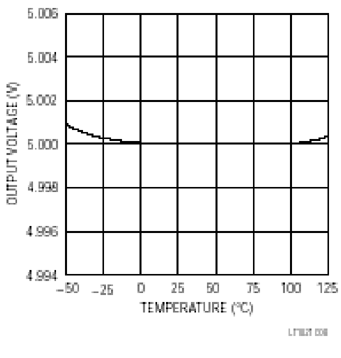
Output Voltage Noise Spectrum



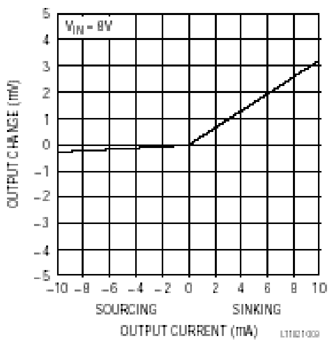
Output Voltage Noise



Output Voltage Temperature Drift LT1021-5

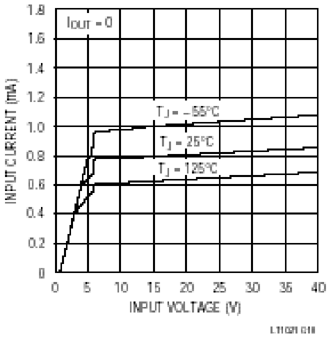


Load Regulation LT1021-5

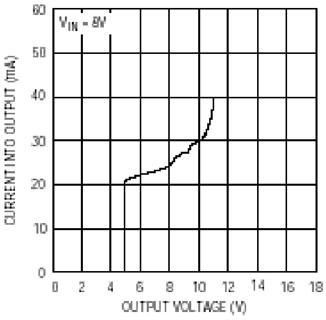


TYPICAL PERFORMANCE CHARACTERISTICS

Quiescent Current LT1021-5

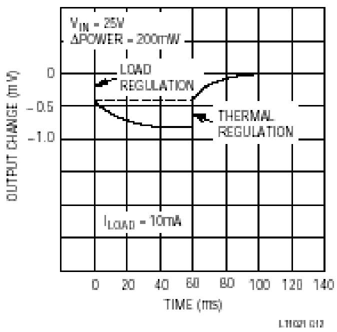


Sink Mode* Current Limit LT1021-5

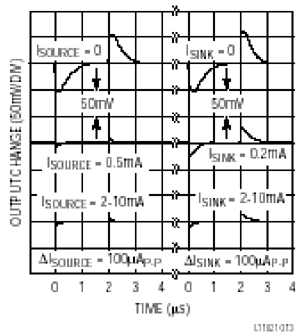


*NOTE THAT AN INPUT VOLTAGE IS REQUIRED FOR 5V UNITS.

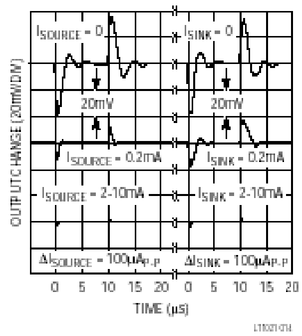
Thermal Regulation LT1021-5



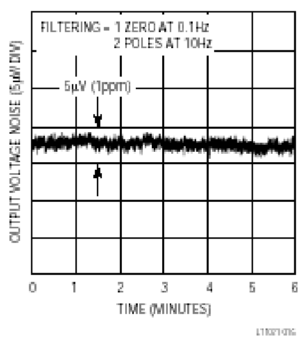
Load Transient Response LT1021-5, C_{LOAD} = 0



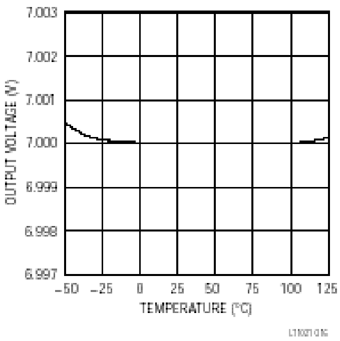
Load Transient Response LT1021-5, C_{LOAD} = 1000pF



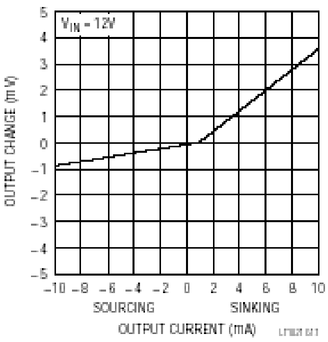
Output Noise 0.1Hz to 10Hz LT1021-5



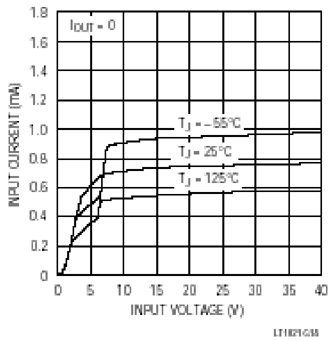
Output Voltage Temperature Drift LT1021-7



Load Regulation LT1021-7, LT1021-10

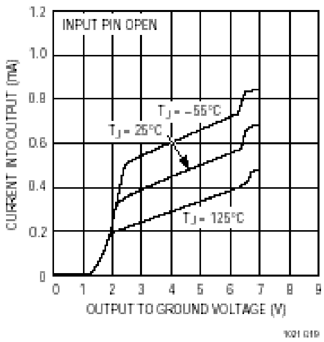


Quiescent Current LT1021-7

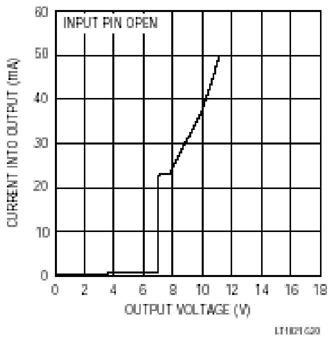


TYPICAL PERFORMANCE CHARACTERISTICS

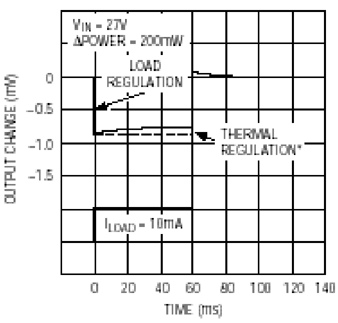
Shunt Characteristics LT1021-7



Shunt Mode Current Limit LT1021-7

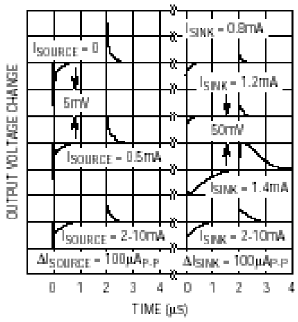


Thermal Regulation LT1021-7



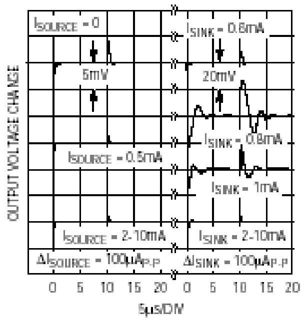
*INDEPENDENT OF TEMPERATURE COEFFICIENT

Load Transient Response LT1021-7, C_{LOAD} = 0



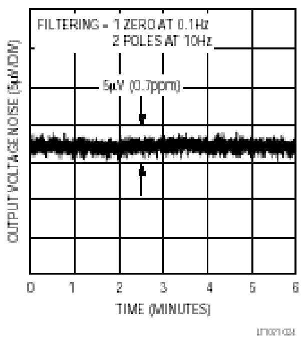
NOTE VERTICAL SCALE CHANGE BETWEEN SOURCING AND SINKING

Load Transient Response LT1021-7, C_{LOAD} = 1000pF

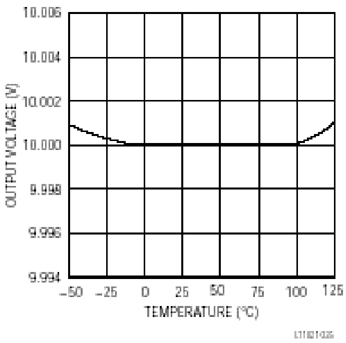


NOTE VERTICAL SCALE CHANGE BETWEEN SOURCING AND SINKING

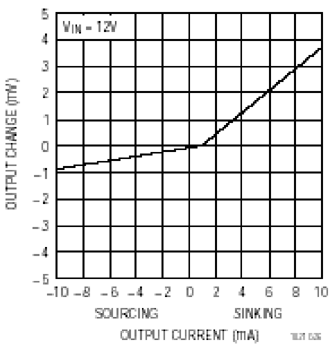
Output Noise 0.1Hz to 10Hz LT1021-7



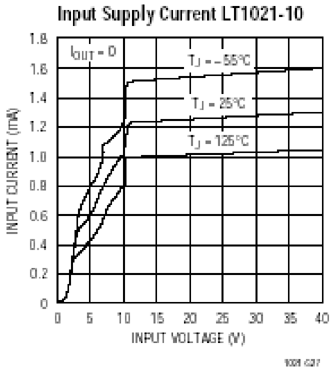
Output Voltage Temperature Drift LT1021-10



Load Regulation LT1021-7, LT1021-10

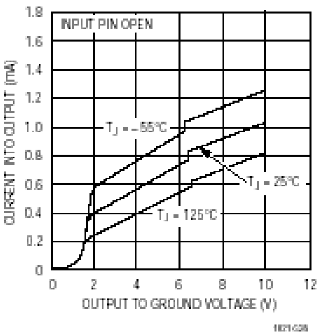


Input Supply Current LT1021-10

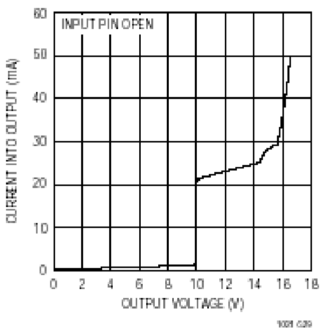


TYPICAL PERFORMANCE CHARACTERISTICS

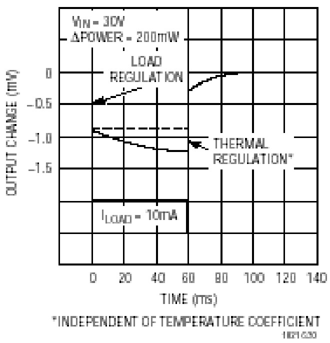
Shunt Characteristics LT1021-10



Shunt Mode Current Limit LT1021-10

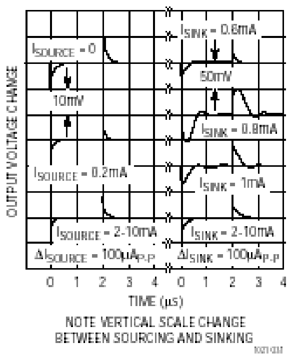


Thermal Regulation LT1021-10



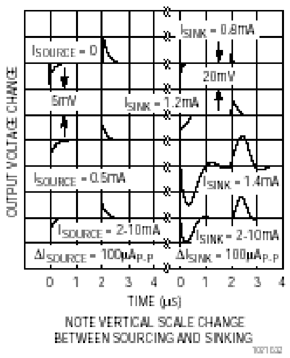
*INDEPENDENT OF TEMPERATURE COEFFICIENT

Load Transient Response LT1021-10, C_{LOAD} = 0



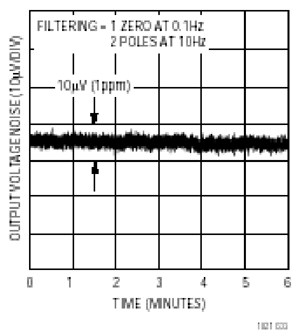
NOTE VERTICAL SCALE CHANGE BETWEEN SOURCING AND SINKING

Load Transient Response LT1021-10, C_{LOAD} = 1000pF



NOTE VERTICAL SCALE CHANGE BETWEEN SOURCING AND SINKING

Output Noise 0.1Hz to 10Hz LT1021-10



G.6. Especificaciones filtro paso bajo LMF60 de National Semiconductor

National Semiconductor

May 1996

LMF60 High Performance 6th-Order Switched Capacitor Butterworth Lowpass Filter

LMF60 High Performance 6th-Order Switched Capacitor Butterworth Lowpass Filter

General Description

The LMF60 is a high performance, precision, 6th-order Butterworth lowpass active filter. It is fabricated using National's LMCMOS process, an improved silicon-gate CMOS process specifically designed for analog products. Switched-capacitor techniques eliminate external component requirements and allow a clock-tunable cutoff frequency. The ratio of the clock frequency to the low-pass cutoff frequency is internally set to 50:1 (LMF60-50) or 100:1 (LMF60-100). A Schmitt trigger clock input stage allows two clocking options, either self-clocking (via an external resistor and capacitor) for stand-alone applications, or for tighter cutoff frequency control, a TTL or CMOS logic compatible clock can be directly applied. The maximally flat passband frequency response together with a DC gain of 1V/V allows cascading LMF60 sections for higher-order filtering. In addition to the filter, two independent CMOS op amps are included on the die and are useful for any general signal conditioning applications. The LMF60 is pin- and functionally-compatible with the MF6, but provides improved performance.

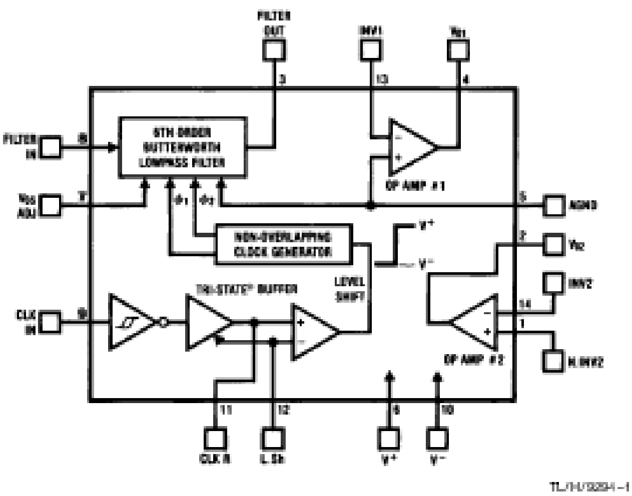
Features

- Cutoff frequency range of 0.1 Hz to 30 kHz
- Cutoff frequency accuracy of ±1.0%, maximum
- Low offset voltage ±100 mV, maximum, ±5V supply
- Low clock feedthrough of 10 mV_{p-p}, typical
- Dynamic range of 88 dB, typical
- Two uncommitted op amps available
- No external components required
- 14-pin DIP or 14-pin wide-body S.O. package
- Single/Dual Supply Operation: +4V to +14V (±2V to ±7V)
- Cutoff frequency set by external or internal clock
- Pin-compatible with the MF6

Applications

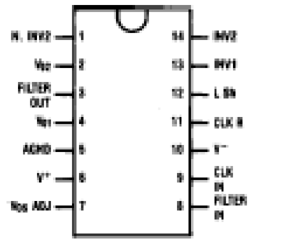
- Communication systems
- Audio filtering
- Anti-alias filtering
- Data acquisition noise filtering
- Instrumentation
- High-order tracking filters

Block and Connection Diagrams



TL/H/9294–1

All Packages



TL/H/9294–2

Top View

Order Number LMF60CMJ-50, (5962-9096 701MCA or LMF60CMJ50/883), LMF60CMJ-100, or (5962-9096 702MCA or LMF60CMJ100/883) See NS Package Number J14A

Order Number LMF60CIWM-50 or LMF60CIWM-100 See NS Package Number M14B

Order Number LMF60CIN-50 or LMF60CIN-100 See NS Package Number N14A

Absolute Maximum Ratings (Note 1)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

Supply Voltage ($V^+ - V^-$) (Note 2)	15V
Voltage at Any Pin	$V^+ + 0.2V$ $V^- - 0.2V$
Input Current at Any Pin (Note 3)	5 mA
Package Input Current (Note 3)	20 mA
Power Dissipation (Note 4)	500 mW
Storage Temperature	−65°C to +150°C
ESD Susceptibility (Note 5)	2000V
CLK IN Pin	1700V

Soldering Information:

• N Package: 10 sec.	260°C
• J Package: 10 sec.	300°C
• SO Package: Vapor Phase (60 sec.)	215°C
Infrared (15 sec.) (Note 6)	220°C

Operating Ratings (Note 1)

Temperature Range	$T_{Min} \leq T_A \leq T_{Max}$
LMF60CIN-50, LMF60CIN-100 LMF60CIJ-50, LMF60CIJ-100, LMF60CIWM-50, LMF60CIWM-100	$-40°C \leq T_A \leq +85°C$
LMF60CMJ-50, LMF60CMJ-100, LMF60CMJ50/883, LMF60CMJ100/883	$-55°C \leq T_A \leq +125°C$
Supply Voltage ($V^+ - V^-$)	4V to 14V

Filter Electrical Characteristics

The following specifications apply for f_{CLK} = 500 kHz (Note 7) unless otherwise specified. **Boldface limits apply for $T_A = T_J = T_{MIN}$ to T_{MAX};** all other limits $T_A = T_J = 25°C$.

Symbol	Parameter	Conditions	Typical (Note 8)	Limits (Note 9)	Units (Limits)
$V^+ = +5V, V^- = -5V$					
f_{CLK}	Clock Frequency Range (Note 16)		5	**1.5**	Hz (Min) MHz (Max)
I_S	Total Supply Current			7.0 / **12.0**	mA (Max)
	Clock Feedthrough	V_{IN} = 0V Filter Opamp	10 5		mVp-p mVp-p
H_o	DC Gain	$R_{Source} \leq 2\ k\Omega$		0.10 / **0.10** −0.26 / **−0.30**	dB (Max) dB (Min)
f_{CLK}/f_C	Clock to Cutoff Frequency Ratio (Note 10) LMF60-50			49.00 ± 0.8% / **49.00 ± 1.0%**	(Max)
	LMF60-100			98.10 ± 0.8% / **98.10 ± 1.0%**	(Max)
	Temperature Coefficient of f_{CLK}/f_C		4		ppm/°C
A_{MIN}	Stopband Attenuation	At 2 × f_C		**36**	dB (Min)
V_{OS}	DC Offset Voltage LMF60-50 LMF60-100			**±100** **±150**	mV (Max) mV (Max)
V_{OUT}	Output Voltage Swing (Note 2)			+3.9 / **+3.7** −4.2 / **−4.0**	V (Min) V (Max)
I_{SC}	Output Short Circuit Current (Note 11)	Source Sink	90 2.2		mA mA
	Dynamic Range (Note 12)		88		dB
	Additional Magnitude Response Test Points (Note 13) LMF60-50	f_{IN} = 12 kHz		−9.45 ±0.46 / **−9.45 ± 0.50**	dB
		f_{IN} = 9 kHz		−0.87 ±0.16 / **−0.87 ± 0.20**	dB
	LMF60-100	f_{IN} = 6 kHz		−9.30 ±0.46 / **−9.30 ± 0.50**	dB
		f_{IN} = 4.5 kHz		−0.87 ±0.16 / **−0.87 ± 0.20**	dB

Filter Electrical Characteristics (Continued)

The following specifications apply for f_{CLK} = 250 kHz (Note 7) unless otherwise specified. **Boldface limits apply for T_A = T_J = T_{MIN} to T_{MAX};** all other limits T_A = T_J = 25°C.

Symbol	Parameter	Conditions	Typical (Note 8)	Limits (Note 9)	Units (Limits)
V^+ = +2.5V, V^- = −2.5V					
f_{CLK}	Clock Frequency Range (Note 16)		5	**750**	Hz (Min) kHz (Max)
I_S	Total Supply Current			5.0 / **6.5**	mA (Max)
	Clock Feedthrough (Peak to Peak)	V_{IN} = 0V Filter Opamp	6 3		mV mV
H_o	DC Gain (with R_{Source} ≤ 2 kΩ)	f_{CLK} = 250 kHz		0.10 / **0.10** −0.26 / **−0.30**	dB (Max) dB (Min)
		f_{CLK} = 500 kHz	−0.08		dB
f_{CLK}/f_C	Clock to Cutoff Frequency Ratio (Note 10) LMF60-50	f_{CLK} = 250 kHz		49.00 ±0.8% /**49.00 ± 1.0%**	(Max)
		f_{CLK} = 500 kHz	49.00 ±0.6%		
	LMF60-100	f_{CLK} = 250 kHz		98.10 ±0.8% /**98.10 ± 1.0%**	(Max)
		f_{CLK} = 500 kHz	98.10 ±0.6%		
	Temperature Coefficient of f_{CLK}/f_C		4		ppm/°C
A_{MIN}	Stopband Attenuation	At 2 × f_C		**36**	dB (Min)
V_{OS}	DC Offset Voltage LMF60-50 LMF60-100			**±60** **±90**	mV (Max) mV (Max)
V_{OUT}	Output Voltage Swing (Note 2)	R_L = 5 kΩ		+1.4 / **+1.2** −2.0 / **−1.8**	V (Min) V (Max)
I_{SC}	Output Short Circuit Current (Note 11)	Source Sink	42 0.9		mA mA
	Dynamic Range (Note 12)		81		dB
	Additional Magnitude Response Test Points (Note 13) LMF60-50	f_{IN} = 6 kHz		−9.45 ±0.46 /**−9.45 ±0.50**	dB
		f_{IN} = 4.5 kHz		−0.87 ±0.16 /**−0.87 ±0.20**	dB
	LMF60-100	f_{IN} = 3 kHz		−9.30 ±0.46 /**−9.30 ±0.50**	dB
		f_{IN} = 2.25 kHz		−0.87 ±0.16 /**−0.87 ±0.20**	dB

Op Amp Electrical Characteristics

Boldface limits apply for $T_A = T_J = T_{MIN}$ to T_{MAX}; all other limits $T_A = T_J = 25°C$.

Symbol	Parameter	Conditions	Typical (Note 8)	Limits (Note 9)	Units (Limits)
$V^+ = +5V, V^- = -5V$					
V_{OS}	Input Offset Voltage			**±20**	mV (Max)
I_B	Input Bias Current		10		pA
CMRR	Common Mode Rejection Ratio (Op Amp #2 Only)	Test Input Range = −2.2V to +1.8V		**55**	dB
V_O	Output Voltage Swing	$R_L = 5\ k\Omega$		3.8 / **3.6** −4.2 / **−4.0**	V (Min) V (Max)
I_{SC}	Output Short Circuit Current (Note 13)	Source Sink	90 2.1		mA mA
SR	Slew Rate		4		V/µs
A_{VOL}	DC Open Loop Gain		80		dB (Min)
GBW	Gain Bandwidth Product		2.0		MHz
$V^+ = +2.5V, V^- = -2.5V$					
V_{OS}	Input Offset Voltage			**±20**	mV (Max)
I_B	Input Bias Current		10		pA
CMRR	Common Mode Rejection Ratio (Op Amp #2 Only)	Test Input Range = −0.9V to +0.5V		**55**	dB
V_O	Output Voltage Swing	$R_L = 5\ k\Omega$		1.3 / **1.1** −1.8 / **−1.6**	V (Min) V (Max)
I_{SC}	Output Short Circuit Current (Note 13)	Source Sink	42 0.9		mA mA
SR	Slew Rate		3		V/µs
A_{VOL}	DC Open Loop Gain		74		dB (Min)
GBW	Gain Bandwidth Product		2.0		MHz

Logic Input-Output Characteristics

The following specifications apply for $V^- = 0V$ (Note 15), L.Sh = 0V unless otherwise specified. **Boldface limits apply for $T_A = T_J = T_{MIN}$ to T_{MAX};** all other limits $T_A = T_J = 25°C$.

Symbol	Parameter	Conditions	Typical (Note 8)	Limits (Note 9)	Units (Limits)
TTL CLOCK INPUT, CLK R PIN (NOTE 14)					
V_{IH} V_{IL}	TTL Input Voltage — Logical "1" Logical "0"	$V^+ = +5V, V^- = -5V$		**2.0** **0.8**	V (Min) V (Max)
V_{IH} V_{IL}	CLK R Input Voltage — Logical "1" Logical "0"	$V^+ = +2.5V, V^- = -2.5V$		**2.0** 0.6 / **0.4**	V (Min) V (Max)
	Maximum Leakage Current at CLK R		2.0		µA

Logic Input-Output Characteristics (Continued)

The following specifications apply for $V^- = 0V$ (Note 15), L.Sh = 0V unless otherwise specified. **Boldface limits apply for $T_A = T_J = T_{MIN}$ to T_{MAX};** all other limits $T_A = T_J = 25°C$.

Symbol	Parameter	Conditions	Typical (Note 8)	Limits (Note 9)	Units (Limits)
SCHMITT TRIGGER					
V_{T+}	Positive Going Input Threshold Voltage	$V^+ = 10V$		6.1 / **6.0** 8.8 / **8.9**	V (Min) V (Max)
		$V^+ = 5V$		3.0 / **2.9** 4.3 / **4.4**	V (Min) V (Max)
V_{T-}	Negative Going Input Threshold Voltage	$V^+ = 10V$		1.4 / **1.3** 3.8 / **3.9**	V (Min) V (Max)
		$V^+ = 5V$		0.7 / **0.6** 1.9 / **2.0**	V (Min) V (Max)
$V_{T+} - V_{T-}$	Hysteresis	$V^+ = 10V$		2.3 / **2.1** 7.4 / **7.6**	V (Min) V (Max)
		$V^+ = 5V$		1.1 / **0.9** 3.6 / **3.8**	V (Min) V (Max)
V_{OH}	Logical "1" Voltage $I_O = -10\ \mu A$, Pin 11	$V^+ = +10V$ $V^+ = +5V$		9.1 / **9.0** 4.6 / **4.5**	V (Min) V (Min)
V_{OL}	Logical "0" Voltage $I_O = -10\ \mu A$, Pin 11	$V^+ = +10V$ $V^+ = +5V$		0.9 / **1.0** 0.4 / **0.5**	V (Max) V (Max)
I_{SOURCE}	Output Source Current, Pin 11	CLK R to V^- $V^+ = +10V$ $V^+ = +5V$		4.9 / **3.7** 1.6 / **1.2**	mA (Min) mA (Min)
I_{SINK}	Output Sink Current, Pin 11	CLK R to V^+ $V^+ = +10V$ $V^+ = +5V$		4.9 / **3.7** 1.6 / **1.2**	mA (Min) mA (Min)

Note 1: Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is functional. Specified Electrical Characteristics do not apply when operating the device outside its specified conditions.

Note 2: All voltages are measured with respect to AGND, unless otherwise specified.

Note 3: When the input voltage (V_{IN}) at any pin exceeds the power supply rails ($V_{IN} < V^-$ or $V_{IN} > V^+$) the absolute value of current at that pin should be limited to 5 mA or less. The 20 mA package input current limits the number of pins that can exceed the power supply boundaries with 5 mA to four.

Note 4: The Maximum power dissipation must be derated at elevated temperatures and is dictated by $T_{J\,Max}$, θ_{JA}, and the ambient temperature T_A. The maximum allowable power dissipation is $PD = (T_{J\,Max} - T_A)/\theta_{JA}$ or the number given in the absolute ratings, whichever is lower. For this device, $T_{J\,Max} = 125°C$, and the typical junction-to-ambient thermal resistance of the LMF60CCN when board mounted is 67°C/W. For the LMF60CIJ this number decreases to 62°C/W. For the LMF60CIWM, $\theta_{JA} = 78°C/W$.

Note 5: Human body model: 100 pF discharged through a 1.5 kΩ resistor.

Note 6: See AN450 "Surface Mounting Methods and Their Effect on Product Reliability" or the section titled "Surface Mount" found in any current Linear Databook for other methods of soldering surface mount devices.

Note 7: The specifications given are for a clock frequency (f_{CLK}) of 500 kHz at +5V and 250 kHz at ±2.5V. Above this frequency, the cutoff frequency begins to deviate from the specified error band over the temperature range but the filter still maintains its amplitude characteristics. See application hints.

Note 8: Typicals are at 25°C and represent the most likely parametric norm.

Note 9: Guaranteed to National's Average Outgoing Quality Level (AOQL).

Note 10: The cutoff frequency of the filter is defined as the frequency where the magnitude response is 3.01 dB less than the DC gain of the filter.

Note 11: The short circuit source current is measured by forcing the output to its maximum positive swing and then shorting that output to the negative supply. The short circuit sink current is measured by forcing the output being tested to its maximum negative voltage and then shorting that output to the positive supply. These are worst case conditions.

Note 12: For ±5V supplies the dynamic range is referenced to 2.62 V_{rms} (3.7V peak), where the wideband noise over a 20 kHz bandwidth is typically 100 µV. For ±2.5V supplies the dynamic range is referenced to 0.849 V_{rms} (1.2V peak), where the wideband noise over a 20 kHz bandwidth is typically 75 μV_{rms}.

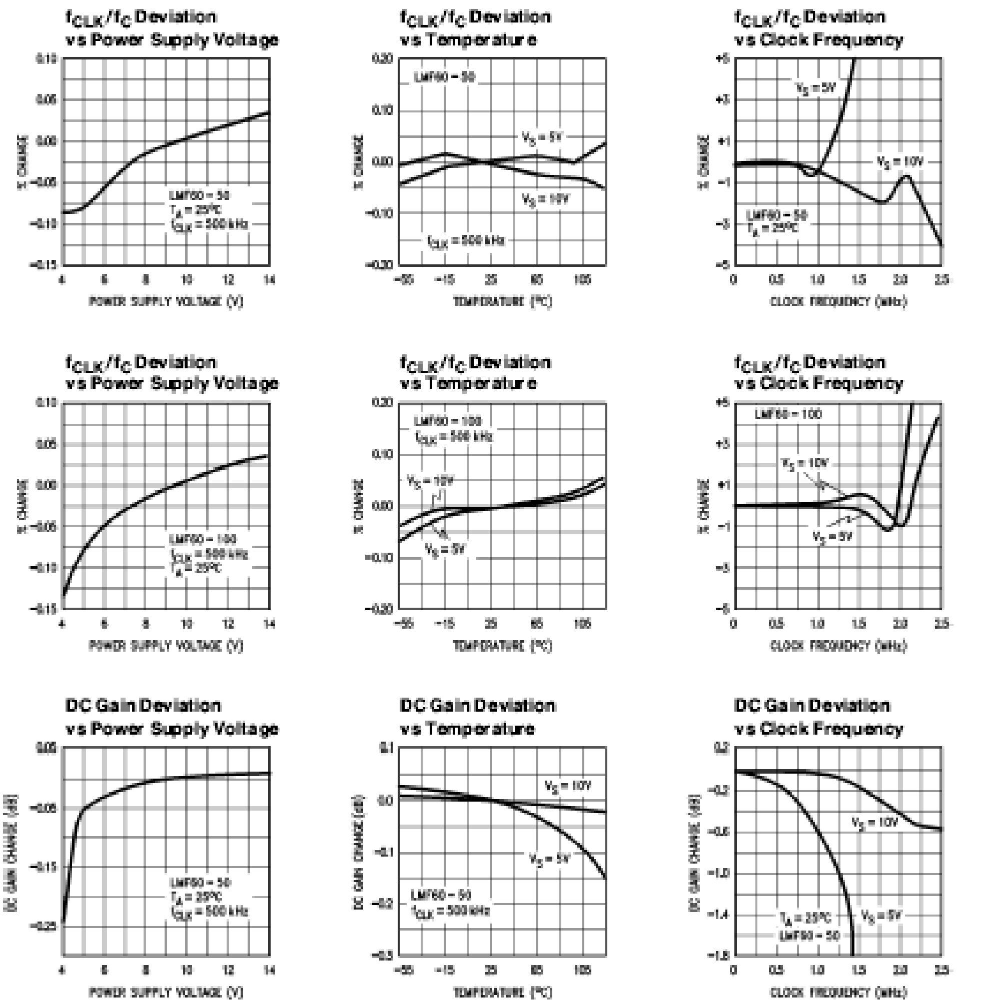
Note 13: The filter's magnitude response is tested at the cutoff frequency, f_C, at $f_{IN} = 2\ f_C$, and at these two additional frequencies.

Note 14: The LMF60 is operated with symmetrical supplies and L.Sh is tied to GND.

Note 15: For simplicity all the logic levels (except for the TTL input logic levels) have been referenced to $V^- = 0V$. The logic levels will scale accordingly for ±5V and ±2.5V supplies.

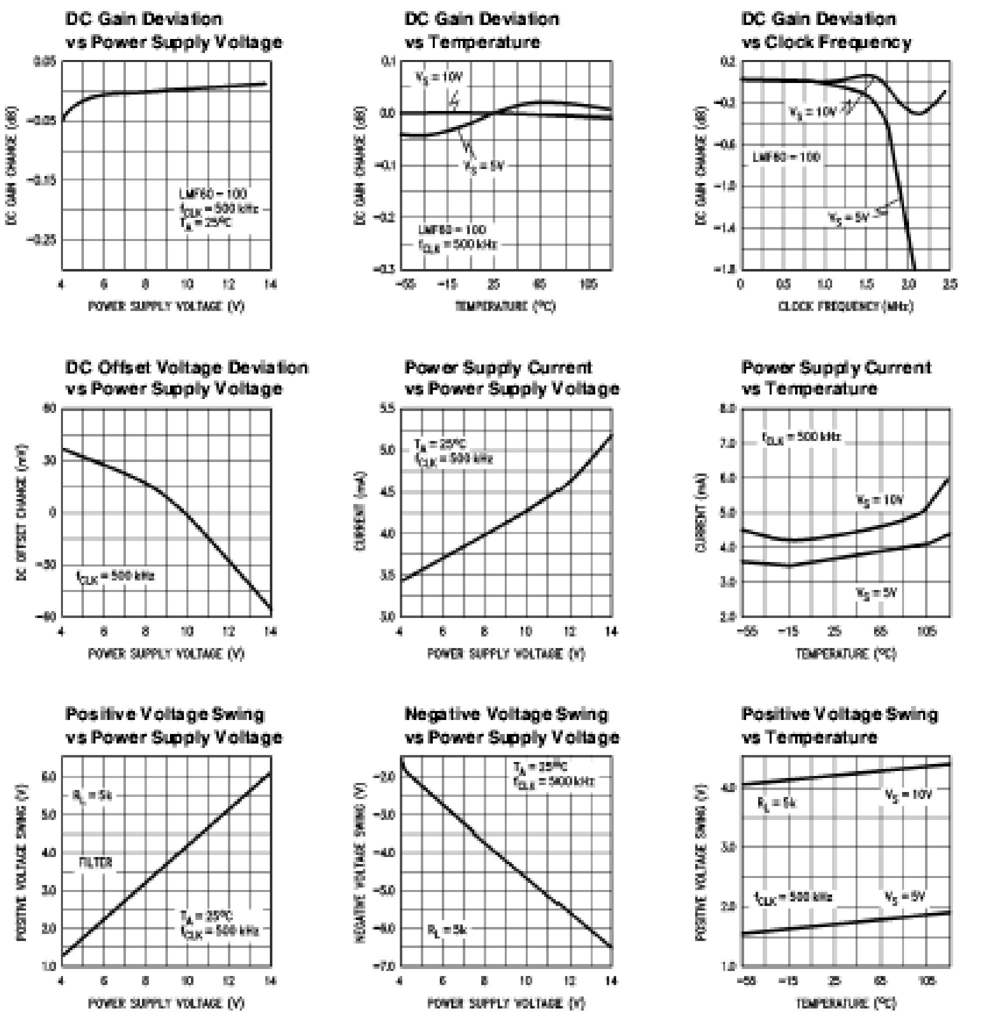
Note 16: The nominal ratio of the clock frequency to the low-pass cutoff frequency is internally set to 50-to-1 (LMF60-50) or 100-to-1 (LMF60-100).

Typical Performance Characteristics



TL/H/11292–3

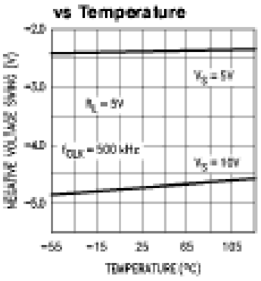
Typical Performance Characteristics (Continued)



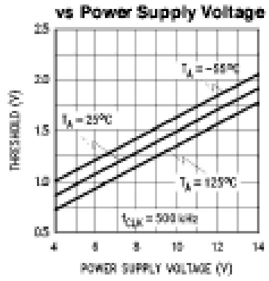
TL/H/9294–4

Typical Performance Characteristics (Continued)

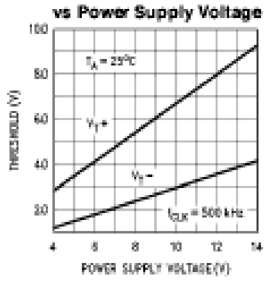
Negative Voltage Swing vs Temperature



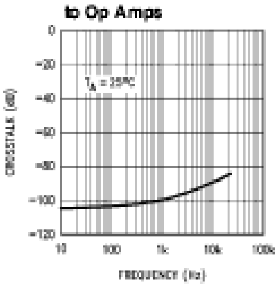
CLK R Trigger Threshold vs Power Supply Voltage



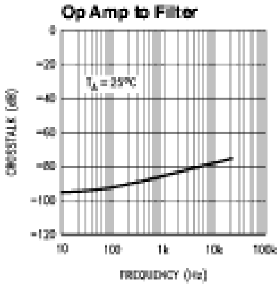
Schmitt Trigger Threshold vs Power Supply Voltage



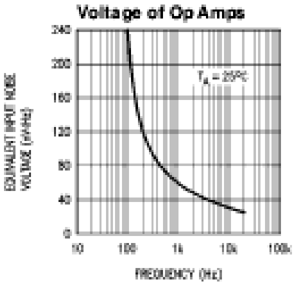
Crosstalk from Filter to Op Amps



Crosstalk from Either Op Amp to Filter



Equivalent Input Noise Voltage of Op Amps



TL/H/9294–5

G.7. Especificaciones amplificador CLC425 de National Semiconductor

National Semiconductor

June 1999

CLC425
Ultra Low Noise Wideband Op Amp

CLC425
Ultra Low Noise Wideband Op Amp

General Description

The CLC425 combines a wide bandwidth (**1.9GHz GBW**) with very low input noise (**1.05nV/√Hz, 1.6pA/√Hz**) and low dc errors (**100μV V_{OS}, 2μV/°C drift**) to provide a very precise, wide dynamic-range op amp offering closed-loop gains of ≥10.

Singularly suited for very wideband high-gain operation, the CLC425 employs a traditional voltage-feedback topology providing all the benefits of balanced inputs, such as low offsets and drifts, as well as a 96dB open-loop gain, a 100dB CMRR and a 95dB PSRR.

The CLC425 also offers great flexibility with its externally adjustable supply current, allowing designers to easily choose the optimum set of power, bandwidth, noise and distortion performance. Operating from ±5V power supplies, the CLC425 defaults to a 15mA quiescent current, or by adding one external resistor, the supply current can be adjusted to less than 5mA.

The CLC425's combination of ultra-low noise, wide gain-bandwidth, high slew rate and low dc errors will enable applications in areas such as medical diagnostic ultrasound, magnetic tape & disk storage, communications and opto-electronics to achieve maximum high-frequency signal-to-noise ratios.

The CLC425 is available in the following versions:

CLC425AJP	-40°C to +85°C	8-pin PDIP
CLC425AJE	-40°C to +85°C	8-pin SOIC
CLC425A8B	-55°C to +125°C	8-pin CERDIP, MIL-STD-883, Level B
CLC425ALC	-40°C to +85°C	dice
CLC425AMC	-55°C to +125°C	dice, MIL-STD-883, Level B
CLC425AJM5	-40°C to +85°C	5-pin SOT

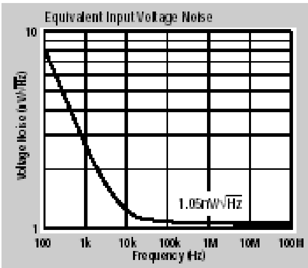
DESC SMD number : 5962-93259.

Features

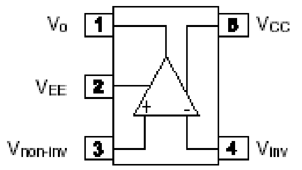
- 1.9GHz gain-bandwidth product
- 1.05nV/√Hz input voltage noise
- 0.8pA/√Hz @ Icc ≤ 5mA
- 100μV input offset voltage, 2μV/°C drift
- 350V/μs slew rate
- 15mA to 5mA adjustable supply current
- Gain range ±10 to ±1,000V/V
- Evaluation boards & simulation macromodel
- 0.9dB NF @ R_S = 700Ω

Applications

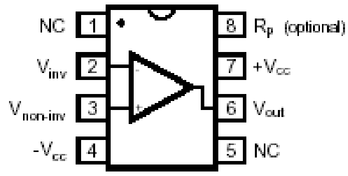
- Instrumentation sense amplifiers
- Ultrasound pre-amps
- Magnetic tape & disk pre-amps
- Photo-diode transimpedance amplifiers
- Wide band active filters
- Low noise figure RF amplifiers
- Professional audio systems
- Low-noise loop filters for PLLs



Pinout
SOT23-5



Pinout
DIP & SOIC



http://www.national.com

CLC425 Electrical Characteristics (V_{cc} = ±5V; A_V = +20; R_f=499Ω; R_g = 26.1Ω; R_L = 100Ω; unless noted)

PARAMETERS	CONDITIONS	TYP	MIN/MAX RATINGS			UNITS	SYMBOL
Ambient Temperature	CLC425 AJ	+25°C	-40°C	+25°C	+85°C		
FREQUENCY DOMAIN RESPONSE							
gain bandwidth product	V_{out} < 0.4V_{pp}	1.9	1.5	1.5	1.0	GHz	GBW
-3dB bandwidth	V_{out} < 0.4V_{pp}	95	75	75	50	MHz	SSBW
	V_{out} < 5.0V_{pp}	40	30	30	20	MHz	LSBW
gain flatness	V_{out} < 0.4V_{pp}						
peaking	DC to 30MHz	0.3	0.7	0.5	0.7	dB	GFP
rolloff	DC to 30MHz	0.1	0.7	0.5	0.7	dB	GFR
linear phase deviation	DC to 30MHz	0.7	1.5	1.5	2.5	°	LPD
TIME DOMAIN RESPONSE							
rise and fall time	0.4V step	3.7	4.7	4.7	7.0	ns	TRS
settling time to 0.2%	2V step	22	30	30	40	ns	TSS
overshoot	0.4V step	5	12	10	12	%	OS
slew rate	2V step	350	250	250	200	V/µs	SR
DISTORTION AND NOISE RESPONSE							
2nd harmonic distortion	1V_{pp}, 10MHz	-53	48	48	46	dBc	HD2
3rd harmonic distortion	1V_{pp}, 10MHz	-75	65	65	60	dBc	HD3
3rd order intermodulation intercept	10MHz	35				dBm	IMD
equivalent noise input							
voltage	1MHz to 100MHz	1.05	1.25	1.25	1.8	nV/√Hz	VN
current	1MHz to 100MHz	1.6	4.0	2.5	2.5	pA/√Hz	ICN
noise figure	R_S = 700Ω	0.9				dB	NF
STATIC DC PERFORMANCE							
open-loop gain	DC	96	77	86	86	dB	AOL
*input offset voltage		± 100	± 1000	± 800	± 1000	µV	VIO
average drift		± 2	8	—	4	µV/°C	DVIO
*input bias current		12	40	20	20	µA	IB
average drift		- 100	- 250	—	- 120	nA/°C	DIB
input offset current		± 0.2	3.4	2.0	2.0	µA	IIO
average drift		± 3	± 50	—	± 25	nA/°C	DIIO
power supply rejection ratio	DC	95	82	88	86	dB	PSRR
common mode rejection ratio	DC	100	88	92	90	dB	CMRR
*supply current	R_L = ∞	15	18	16	16	mA	ICC
MISCELLANEOUS PERFORMANCE							
input resistance	common-mode	2	0.6	1.6	1.6	MΩ	RINC
	differential-mode	6	1	3	3	kΩ	RIND
input capacitance	common-mode	1.5	2	2	2	pF	CINC
	differential-mode	1.9	3	3	3	pF	CIND
output resistance	closed loop	5	50	10	10	mΩ	ROUT
output voltage range	R_L = ∞	± 3.8	± 3.5	± 3.7	± 3.7	V	VO
	R_L=100Ω	± 3.4	± 2.8	± 3.2	± 3.2	V	VOL
input voltage range	common mode	± 3.8	± 3.4	± 3.5	± 3.5	V	CMIR
output current	source	80	70	70	70	mA	IOP
	sink	80	45	55	55	mA	ION

Min/max ratings are based on product characterization and simulation. Individual parameters are tested as noted. Outgoing quality levels are determined from tested parameters.

Absolute Maximum Ratings

V_{cc}	±7V
I_{out} short circuit protected to ground, however maximum reliability is obtained if I_{out} does not exceed...	125mA
common-mode input voltage	±V_{cc}
maximum junction temperature	+150°C
operating temperature range:	
AJ	-40°C to +85°C
storage temperature range	-65°C to +150°C
lead temperature (soldering 10 sec)	+300°C
ESD (human body model)	1000V

Reliability Information

Transistor count	31

Miscellaneous Ratings

Recommended gain range ±10 to ±1,000V/V

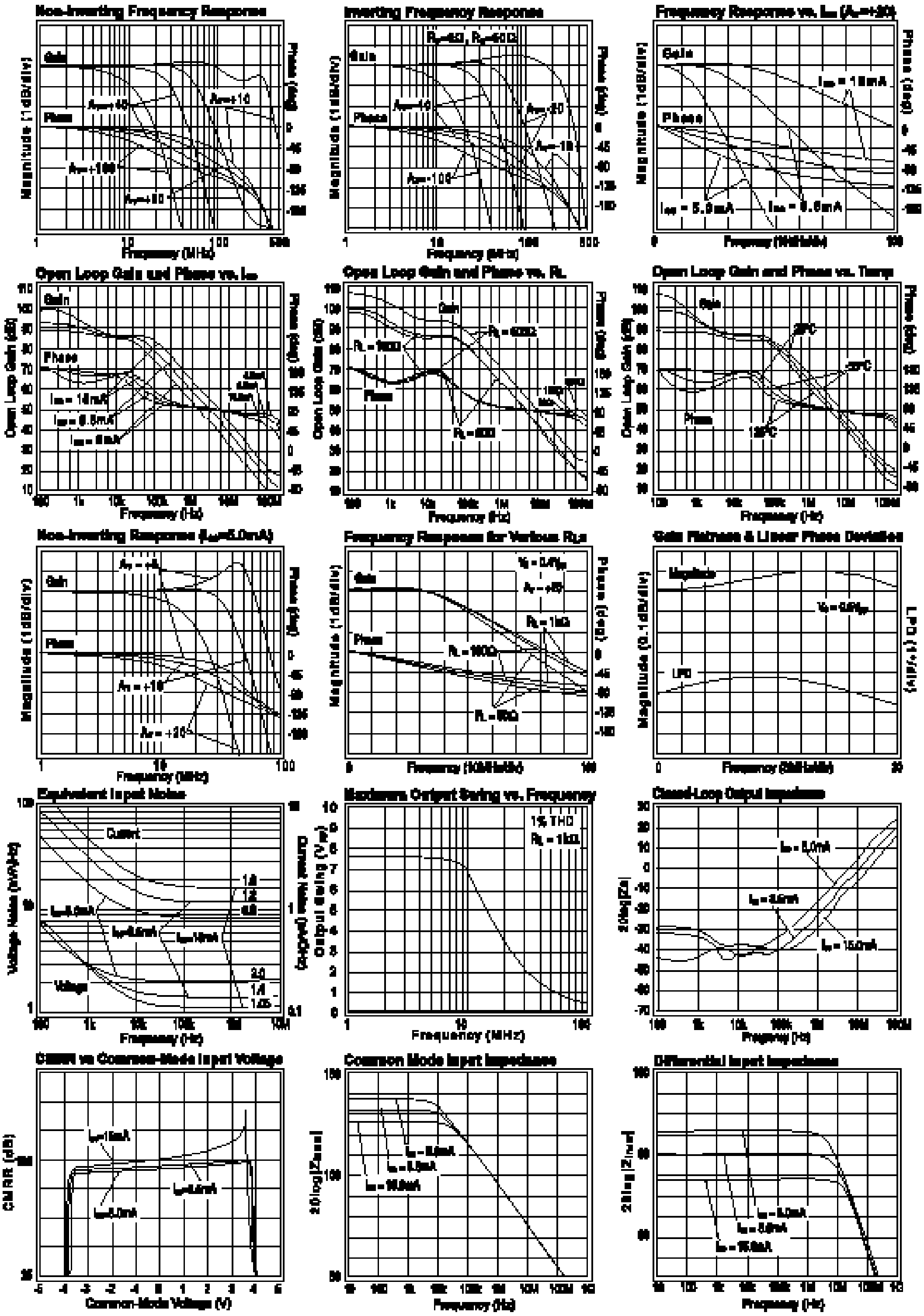
Notes:

* AJ : 100% tested at +25°C.

Package Thermal Resistance

Package	θ_{JC}	θ_{JA}
AJP	70°C/W	125°C/W
AJE	65°C/W	145°C/W
A8B	45°C/W	135°C/W
AJM5	115°C/W	185°C/W

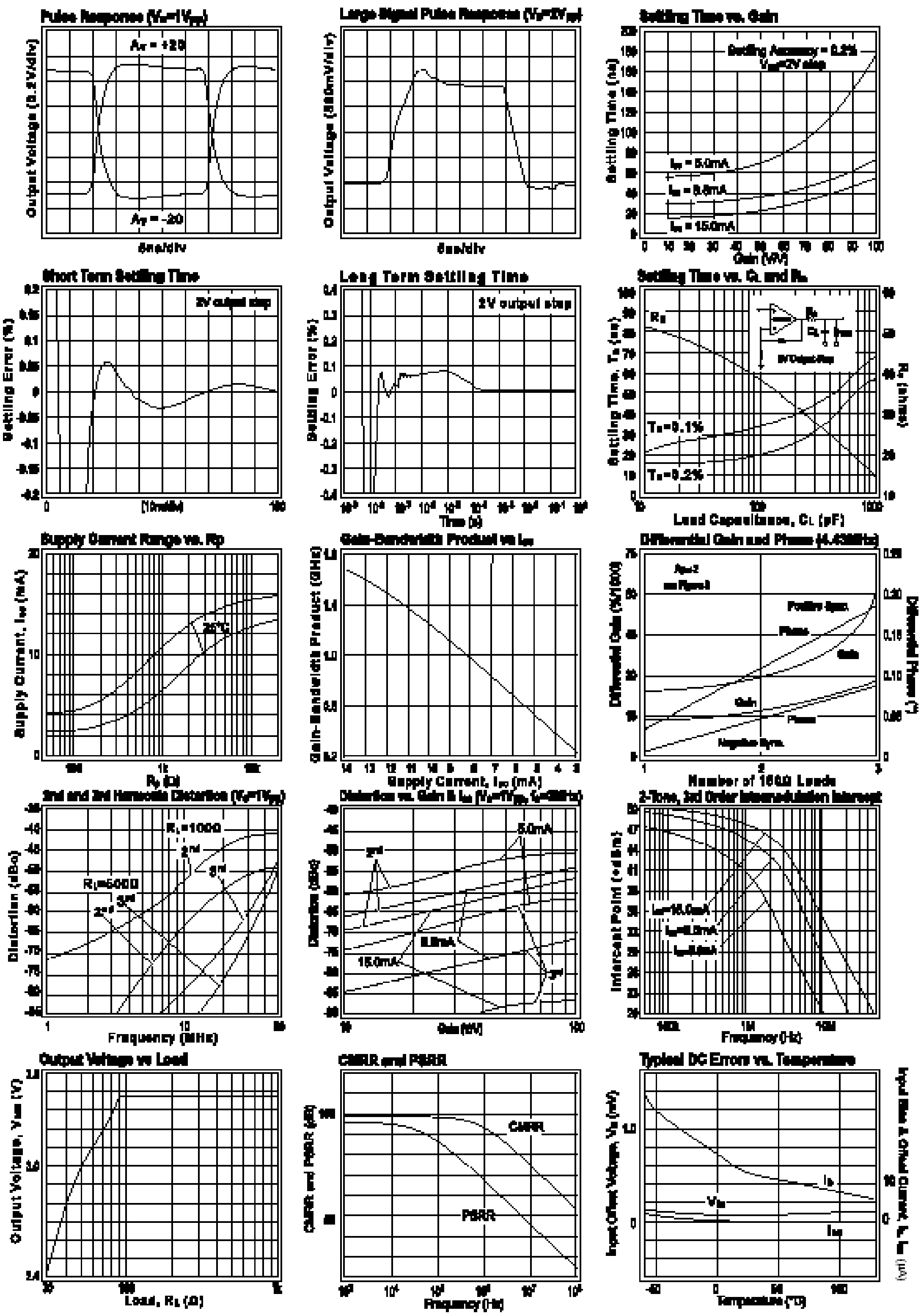
CLC425 Typical Performance (T_A=25°C, V_{cc}=±5V, R_g=26.1Ω, R_f=499Ω, R_L=100Ω, unless noted)



3

http://www.national.com

CLC425 Typical Performance (T_A=25°C, V_{CC}=±5V, R_g=26.1Ω, R_f=499Ω, R_L=100Ω, unless noted)



G.8. Especificaciones comparadores LM239 de National Semiconductor

National Semiconductor

March 2004

LM139/LM239/LM339/LM2901/LM3302
Low Power Low Offset Voltage Quad Comparators

General Description

The LM139 series consists of four independent precision voltage comparators with an offset voltage specification as low as 2 mV max for all four comparators. These were designed specifically to operate from a single power supply over a wide range of voltages. Operation from split power supplies is also possible and the low power supply current drain is independent of the magnitude of the power supply voltage. These comparators also have a unique characteristic in that the input common-mode voltage range includes ground, even though operated from a single power supply voltage.

Application areas include limit comparators, simple analog to digital converters; pulse, squarewave and time delay generators; wide range VCO; MOS clock timers; multivibrators and high voltage digital logic gates. The LM139 series was designed to directly interface with TTL and CMOS. When operated from both plus and minus power supplies, they will directly interface with MOS logic— where the low power drain of the LM339 is a distinct advantage over standard comparators.

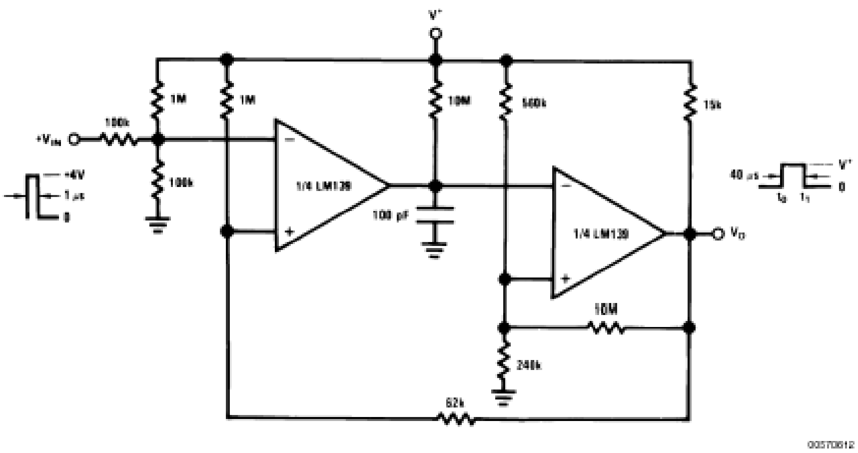
Features

- Wide supply voltage range
- LM139/139A Series 2 to 36 V_{DC} or ±1 to ±18 V_{DC}
- LM2901: 2 to 36 V_{DC} or ±1 to ±18 V_{DC}
- LM3302: 2 to 28 V_{DC} or ±1 to ±14 V_{DC}
- Very low supply current drain (0.8 mA) — independent of supply voltage
- Low input biasing current: 25 nA
- Low input offset current: ±5 nA
- Offset voltage: ±3 mV
- Input common-mode voltage range includes GND
- Differential input voltage range equal to the power supply voltage
- Low output saturation voltage: 250 mV at 4 mA
- Output voltage compatible with TTL, DTL, ECL, MOS and CMOS logic systems

Advantages

- High precision comparators
- Reduced V_{OS} drift over temperature
- Eliminates need for dual supplies
- Allows sensing near GND
- Compatible with all forms of logic
- Power drain suitable for battery operation

One-Shot Multivibrator with Input Lock Out



 www.national.com

Absolute Maximum Ratings (Note 10)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/ Distributors for availability and specifications.

	LM139/LM239/LM339 LM139A/LM239A/LM339A LM2901	LM3302
Supply Voltage, V^+	36 V_{DC} or ±18 V_{DC}	28 V_{DC} or ±14 V_{DC}
Differential Input Voltage (Note 8)	36 V_{DC}	28 V_{DC}
Input Voltage	−0.3 V_{DC} to +36 V_{DC}	−0.3 V_{DC} to +28 V_{DC}
Input Current (V_{IN}<−0.3 V_{DC}), (Note 3)	50 mA	50 mA
Power Dissipation (Note 1)		
Molded DIP	1050 mW	1050 mW
Cavity DIP	1190 mW	
Small Outline Package	760 mW	
Output Short-Circuit to GND, (Note 2)	Continuous	Continuous
Storage Temperature Range	−65˚C to +150˚C	−65˚C to +150˚C
Lead Temperature (Soldering, 10 seconds)	260˚C	260˚C
Operating Temperature Range		−40˚C to +85˚C
LM339/LM339A	0˚C to +70˚C	
LM239/LM239A	−25˚C to +85˚C	
LM2901	−40˚C to +85˚C	
LM139/LM139A	−55˚C to +125˚C	
Soldering Information		
Dual-In-Line Package		
Soldering (10 seconds)	260˚C	260˚C
Small Outline Package		
Vapor Phase (60 seconds)	215˚C	215˚C
Infrared (15 seconds)	220˚C	220˚C

See AN-450 "Surface Mounting Methods and Their Effect on Product Reliability" for other methods of soldering surface mount devices.

ESD rating (1.5 kΩ in series with 100 pF)	600V	600V

Electrical Characteristics

(V^+=5 V_{DC}, T_A = 25˚C, unless otherwise stated)

Parameter	Conditions	LM139A			LM239A, LM339A			LM139			Units
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Input Offset Voltage	(Note 9)		1.0	2.0		1.0	2.0		2.0	5.0	mV_{DC}
Input Bias Current	$I_{IN(+)}$ or $I_{IN(-)}$ with Output in Linear Range, (Note 5), V_{CM}=0V		25	100		25	250		25	100	nA_{DC}
Input Offset Current	$I_{IN(+)}-I_{IN(-)}$, V_{CM}=0V		3.0	25		5.0	50		3.0	25	nA_{DC}
Input Common-Mode Voltage Range	V^+=30 V_{DC} (LM3302, V^+ = 28 V_{DC}) (Note 6)	0		V^+−1.5	0		V^+−1.5	0		V^+−1.5	V_{DC}
Supply Current	R_L = ∞ on all Comparators,		0.8	2.0		0.8	2.0		0.8	2.0	mA_{DC}
	R_L = ∞, V^+ = 36V, (LM3302, V^+ = 28 V_{DC})					1.0	2.5		1.0	2.5	mA_{DC}
Voltage Gain	R_L≥15 kΩ, V^+ = 15 V_{DC} V_O = 1 V_{DC} to 11 V_{DC}	50	200		50	200		50	200		V/mV
Large Signal Response Time	V_{IN} = TTL Logic Swing, V_{REF} = 1.4 V_{DC}, V_{RL} = 5 V_{DC},		300			300			300		ns

Electrical Characteristics (Continued)

(V^+=5 V_{DC}, T_A = 25˚C, unless otherwise stated)

Parameter	Conditions	LM139A			LM239A, LM339A			LM139			Units
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
	R_L = 5.1 kΩ										
Response Time	V_{RL} = 5 V_{DC}, R_L = 5.1 kΩ, (Note 7)		1.3			1.3			1.3		μs
Output Sink Current	$V_{IN(-)}$ = 1 V_{DC}, $V_{IN(+)}$ = 0, V_O ≤ 1.5 V_{DC}	6.0	16		6.0	16		6.0	16		mA_{DC}
Saturation Voltage	$V_{IN(-)}$ = 1 V_{DC}, $V_{IN(+)}$ = 0, I_{SINK} ≤ 4 mA		250	400		250	400		250	400	mV_{DC}
Output Leakage Current	$V_{IN(+)}$ = 1 V_{DC}, $V_{IN(-)}$ = 0, V_O = 5 V_{DC}		0.1			0.1			0.1		nA_{DC}

Electrical Characteristics

(V^+ = 5 V_{DC}, T_A = 25˚C, unless otherwise stated)

Parameter	Conditions	LM239, LM339			LM2901			LM3302			Units
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Input Offset Voltage	(Note 9)		2.0	5.0		2.0	7.0		3	20	mV_{DC}
Input Bias Current	$I_{IN(+)}$ or $I_{IN(-)}$ with Output in Linear Range, (Note 5), V_{CM}=0V		25	250		25	250		25	500	nA_{DC}
Input Offset Current	$I_{IN(+)}-I_{IN(-)}$, V_{CM} = 0V		5.0	50		5	50		3	100	nA_{DC}
Input Common-Mode Voltage Range	V^+ = 30 V_{DC} (LM3302, V^+ = 28 V_{DC}) (Note 6)	0		V^+−1.5	0		V^+−1.5	0		V^+−1.5	V_{DC}
Supply Current	R_L = ∞ on all Comparators,		0.8	2.0		0.8	2.0		0.8	2.0	mA_{DC}
	R_L = ∞, V^+ = 36V, (LM3302, V^+ = 28 V_{DC})		1.0	2.5		1.0	2.5		1.0	2.5	mA_{DC}
Voltage Gain	R_L ≥ 15 kΩ, V^+ = 15 V_{DC}, V_O = 1 V_{DC} to 11 V_{DC}	50	200		25	100		2	30		V/mV
Large Signal Response Time	V_{IN} = TTL Logic Swing, V_{REF} = 1.4 V_{DC}, V_{RL} = 5 V_{DC}, R_L = 5.1 kΩ,		300			300			300		ns
Response Time	V_{RL} = 5 V_{DC}, R_L = 5.1 kΩ, (Note 7)		1.3			1.3			1.3		μs
Output Sink Current	$V_{IN(-)}$= 1 V_{DC}, $V_{IN(+)}$ = 0, V_O ≤ 1.5 V_{DC}	6.0	16		6.0	16		6.0	16		mA_{DC}
Saturation Voltage	$V_{IN(-)}$ = 1 V_{DC}, $V_{IN(+)}$ = 0, I_{SINK} ≤ 4 mA		250	400		250	400		250	500	mV_{DC}
Output Leakage Current	$V_{IN(+)}$ = 1 V_{DC}, $V_{IN(-)}$ = 0, V_O = 5 V_{DC}		0.1			0.1			0.1		nA_{DC}

Electrical Characteristics

(V^+ = 5.0 V_{DC}, (Note 4))

Parameter	Conditions	LM139A			LM239A, LM339A			LM139			Units
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Input Offset Voltage	(Note 9)			4.0			4.0			9.0	mV_{DC}
Input Offset Current	$I_{IN(+)}-I_{IN(-)}$, V_{CM} = 0V			100			150			100	nA_{DC}
Input Bias Current	$I_{IN(+)}$ or $I_{IN(-)}$ with Output in Linear Range, V_{CM} = 0V (Note 5)			300			400			300	nA_{DC}
Input Common-Mode Voltage Range	V^+=30 V_{DC} (LM3302, V^+ = 28 V_{DC}) (Note 6)	0		V^+−2.0	0		V^+−2.0	0		V^+−2.0	V_{DC}

Electrical Characteristics (Continued)

($V^+ = 5.0\ V_{DC}$, (Note 4))

Parameter	Conditions	LM139A			LM239A, LM339A			LM139			Units
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Saturation Voltage	$V_{IN(-)}=1\ V_{DC}$, $V_{IN(+)} = 0$, $I_{SINK} \le 4$ mA			700			700			700	mV_{DC}
Output Leakage Current	$V_{IN(+)} = 1\ V_{DC}$, $V_{IN(-)} = 0$, $V_O = 30\ V_{DC}$, (LM3302, $V_O = 28\ V_{DC}$)			1.0			1.0			1.0	μA_{DC}
Differential Input Voltage	Keep all V_{IN}'s $\ge 0\ V_{DC}$ (or V^-, if used), (Note 8)			36			36			36	V_{DC}

Electrical Characteristics

($V^+ = 5.0\ V_{DC}$, (Note 4))

Parameter	Conditions	LM239, LM339			LM2901			LM3302			Units
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Input Offset Voltage	(Note 9)			9.0		9	15			40	mV_{DC}
Input Offset Current	$I_{IN(+)}-I_{IN(-)}$, $V_{CM} = 0V$			150		50	200			300	nA_{DC}
Input Bias Current	$I_{IN(+)}$ or $I_{IN(-)}$ with Output in Linear Range, $V_{CM} = 0V$ (Note 5)			400		200	500			1000	nA_{DC}
Input Common-Mode Voltage Range	$V^+ = 30\ V_{DC}$ (LM3302, $V^+ = 28\ V_{DC}$) (Note 6)			$V^+-2.0$	0		$V^+-2.0$	0		$V^+-2.0$	V_{DC}
Saturation Voltage	$V_{IN(-)} = 1\ V_{DC}$, $V_{IN(+)} = 0$, $I_{SINK} \le 4$ mA			700		400	700			700	mV_{DC}
Output Leakage Current	$V_{IN(+)} = 1\ V_{DC}$, $V_{IN(-)} = 0$, $V_O = 30\ V_{DC}$, (LM3302, $V_O = 28\ V_{DC}$)			1.0			1.0			1.0	μA_{DC}
Differential Input Voltage	Keep all V_{IN}'s $\ge 0\ V_{DC}$ (or V^-, if used), (Note 8)			36			36			28	V_{DC}

Note 1: For operating at high temperatures, the LM339/LM339A, LM2901, LM3302 must be derated based on a 125°C maximum junction temperature and a thermal resistance of 95°C/W which applies for the device soldered in a printed circuit board, operating in a still air ambient. The LM239 and LM139 must be derated based on a 150°C maximum junction temperature. The low bias dissipation and the "ON-OFF" characteristic of the outputs keeps the chip dissipation very small ($P_D \le 100$ mW), provided the output transistors are allowed to saturate.

Note 2: Short circuits from the output to V^+ can cause excessive heating and eventual destruction. When considering short circuits to ground, the maximum output current is approximately 20 mA independent of the magnitude of V^+.

Note 3: This input current will only exist when the voltage at any of the input leads is driven negative. It is due to the collector-base junction of the input PNP transistors becoming forward biased and thereby acting as input diode clamps. In addition to this diode action, there is also lateral NPN parasitic transistor action on the IC chip. This transistor action can cause the output voltages of the comparators to go to the V^+ voltage level (or to ground for a large overdrive) for the time duration that an input is driven negative. This is not destructive and normal output states will re-establish when the input voltage, which was negative, again returns to a value greater than $-0.3\ V_{DC}$ (at 25°)C.

Note 4: These specifications are limited to $-55°C \le T_A \le +125°C$, for the LM139/LM139A. With the LM239/LM239A, all temperature specifications are limited to $-25°C \le T_A \le +85°C$, the LM339/LM339A temperature specifications are limited to $0°C \le T_A \le +70°C$, and the LM2901, LM3302 temperature range is $-40°C \le T_A \le +85°C$.

Note 5: The direction of the input current is out of the IC due to the PNP input stage. This current is essentially constant, independent of the state of the output so no loading change exists on the reference or input lines.

Note 6: The input common-mode voltage or either input signal voltage should not be allowed to go negative by more than 0.3V. The upper end of the common-mode voltage range is $V^+ -1.5V$ at 25°C, but either or both inputs can go to $+30\ V_{DC}$ without damage (25V for LM3302), independent of the magnitude of V^+.

Note 7: The response time specified is a 100 mV input step with 5 mV overdrive. For larger overdrive signals 300 ns can be obtained, see typical performance characteristics section.

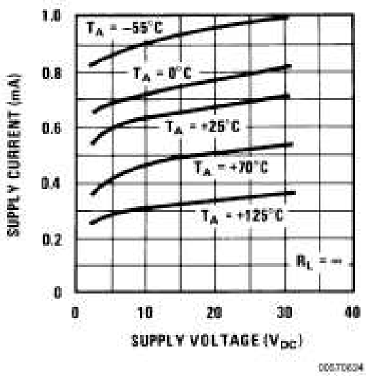
Note 8: Positive excursions of input voltage may exceed the power supply level. As long as the other voltage remains within the common-mode range, the comparator will provide a proper output state. The low input voltage state must not be less than $-0.3\ V_{DC}$ (or $0.3\ V_{DC}$ below the magnitude of the negative power supply, if used) (at 25°C).

Note 9: At output switch point, $V_O = 1.4\ V_{DC}$, $R_S = 0\Omega$ with V^+ from $5\ V_{DC}$ to $30\ V_{DC}$; and over the full input common-mode range ($0\ V_{DC}$ to $V^+ -1.5\ V_{DC}$), at 25°C. For LM3302, V^+ from $5\ V_{DC}$ to $28\ V_{DC}$.

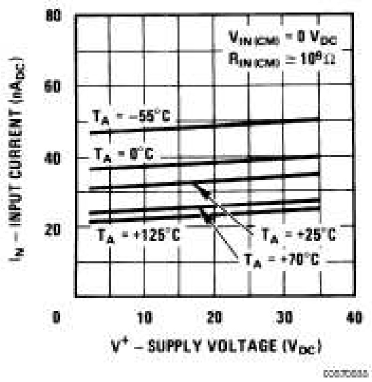
Note 10: Refer to RETS139AX for LM139A military specifications and to RETS139X for LM139 military specifications.

Typical Performance Characteristics LM139/LM239/LM339, LM139A/LM239A/LM339A, LM3302

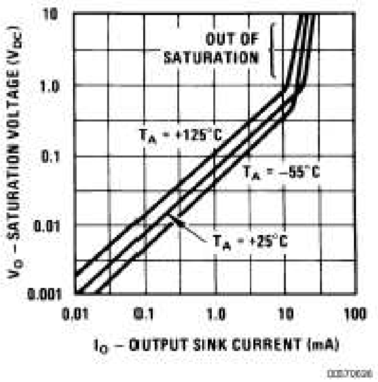
Supply Current



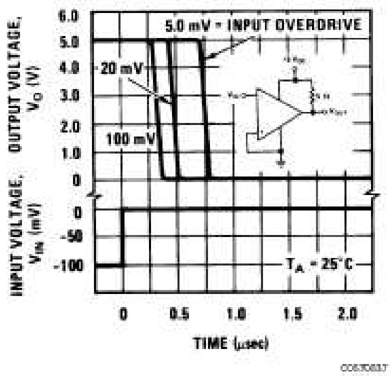
Input Current



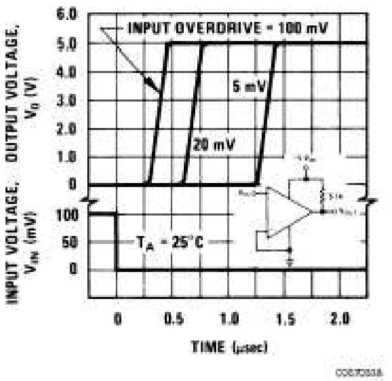
Output Saturation Voltage



Response Time for Various Input Overdrives —Negative Transition

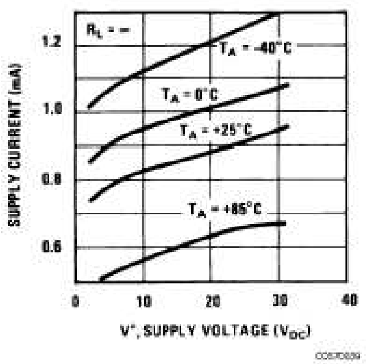


Response Time for Various Input Overdrives —Positive Transition

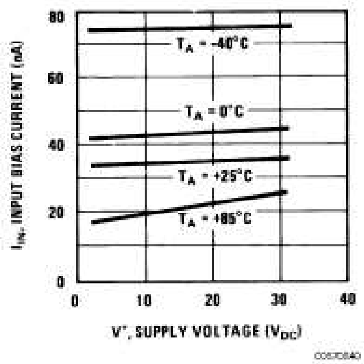


Typical Performance Characteristics LM2901

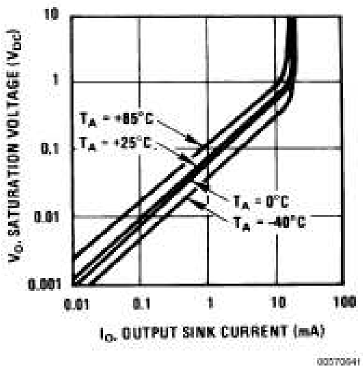
Supply Current



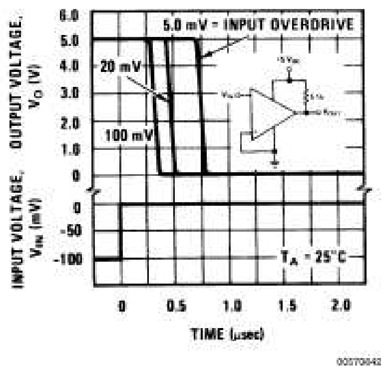
Input Current



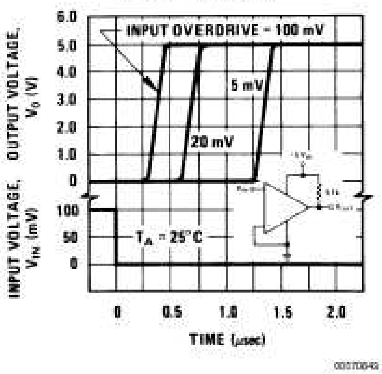
Output Saturation Voltage



Response Time for Various Input Overdrives
—Negative Transition

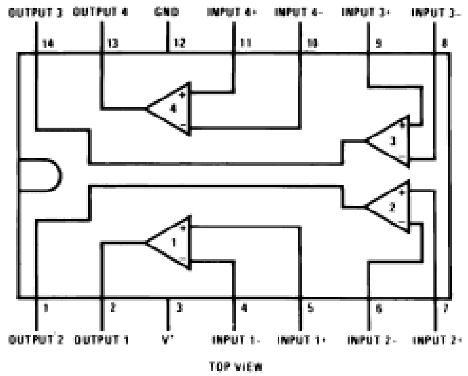


Response Time for Various Input Overdrives
—Positive Transition

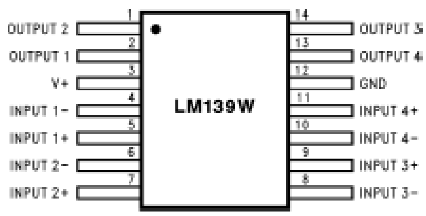


Connection Diagrams

Dual-In-Line Package



Order Number LM139J, LM139J/883 (Note 11), LM139AJ,
LM139AJ/883 (Note 12), LM239J, LM239AJ, LM339J
See NS Package Number J14A
Order Number LM339AM, LM339AMX, LM339M, LM339MX or LM2901M
See NS Package Number M14A
Order Number LM339N, LM339AN, LM2901N or LM3302N
See NS Package Number N14A

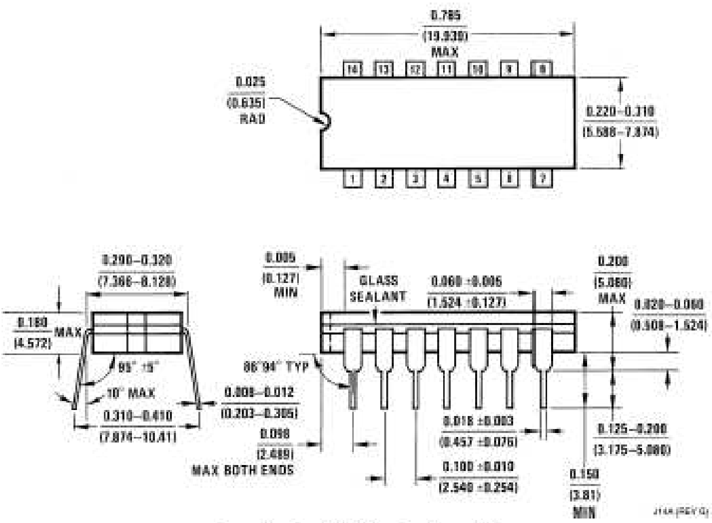


Order Number LM139AW/883 or LM139W/883 (Note 11)
See NS Package Number W14B,
LM139AWGRQMLV (Note 13)
See NS Package Number WG14A

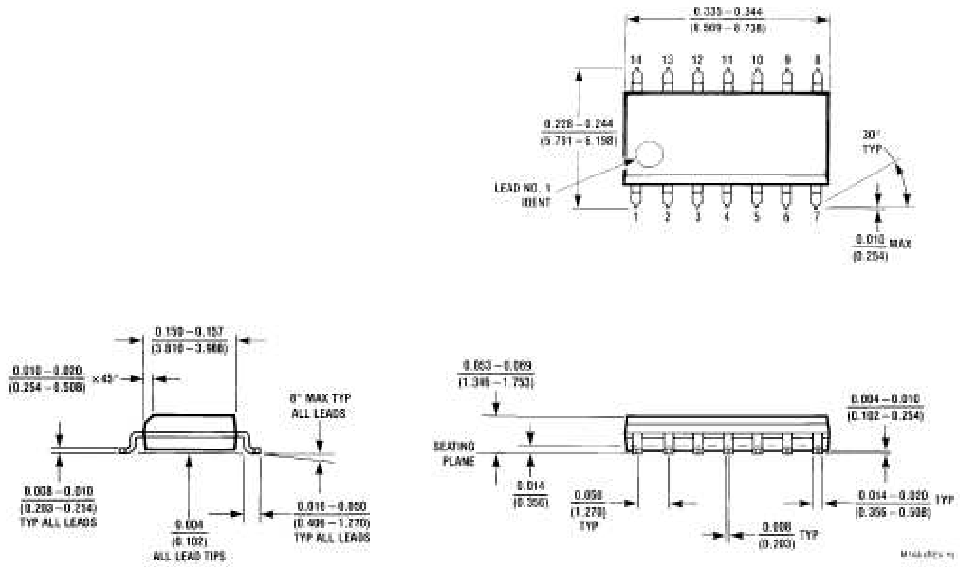
Note 11: Available per JM38510/11201
Note 12: Available per SMD# 5962-8873901
Note 13: See STD Mil Dwg 5962R96738 for Radiation Tolerant Device

LM139/LM239/LM339/LM2901/LM3302

Physical Dimensions inches (millimeters) unless otherwise noted



Ceramic Dual-In-Line Package (J)
Order Number LM139J, LM139J/883, LM139AJ,
LM139AJ/883, LM239J, LM239AJ, LM339J
NS Package Number J14A



S.O. Package (M)
Order Number LM339AM, LM339AMX, LM339M, LM339MX, LM2901M or LM2901MX
NS Package Number M14A

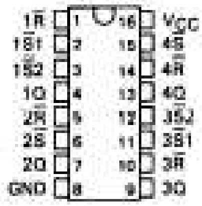
G.9. Especificaciones báscula *RS* 74LS279 de Texas Instruments

TYPES SN74279, SN74LS279A, SN54279, SN54LS279A
QUADRUPLE S̄-R̄ LATCHES

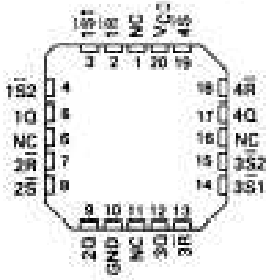
REVISED DECEMBER 1983

- Package Options Include Standard Plastic (N) and Ceramic (J) 300-mil Dual-In-Line Packages, Plastic Small Outline (D) and Ceramic Chip Carrier (FK) Package
- Dependable Texas Instruments Quality and Reliability

SN54279, SN54LS279A ... J PACKAGE
SN74279 ... N PACKAGE
SN74LS279A ... D OR N PACKAGE
(TOP VIEW)



SN54LS279A ... FK PACKAGE
(TOP VIEW)



NC - No internal connection

description

The '279 offers 4 basic S̄-R̄ flip-flop latches in one 16-pin, 300-mil package. Under conventional operation, the S̄-R̄ inputs are normally held high. When the S̄ input is pulsed low, the Q output will be set high. When R̄ is pulsed low, the Q output will be reset low. Normally, the S̄-R̄ inputs should not be taken low simultaneously. The Q output will be unpredictable in this condition.

FUNCTION TABLE
(each latch)

INPUTS		OUTPUT
S̄†	R̄	Q
H	H	Q_0
L	H	H
H	L	L
L	L	H*

H = high level L = low level

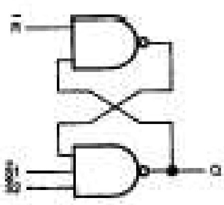
Q_0 = the level of Q before the indicated input conditions were established.

*This configuration is nonstable; that is, it may not persist when the S̄ and R̄ inputs return to their inactive (high) level.

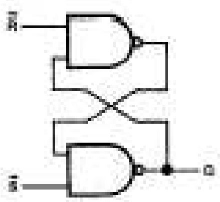
† For latches with double S̄ inputs:
H = both S̄ inputs high
L = one or both S̄ inputs low

logic diagram

(latches 1 and 3)



(latches 2 and 4)

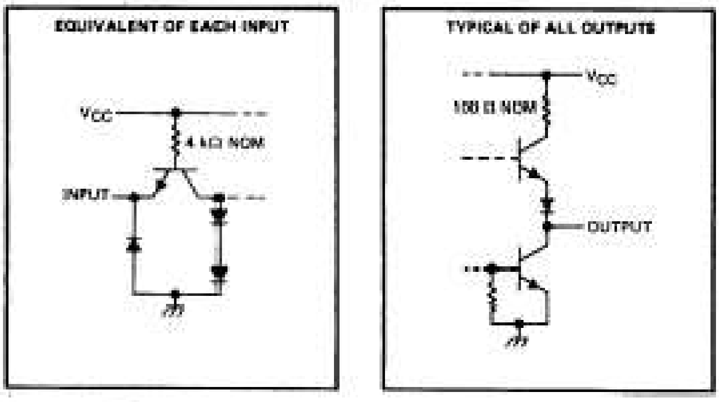


TEXAS INSTRUMENTS

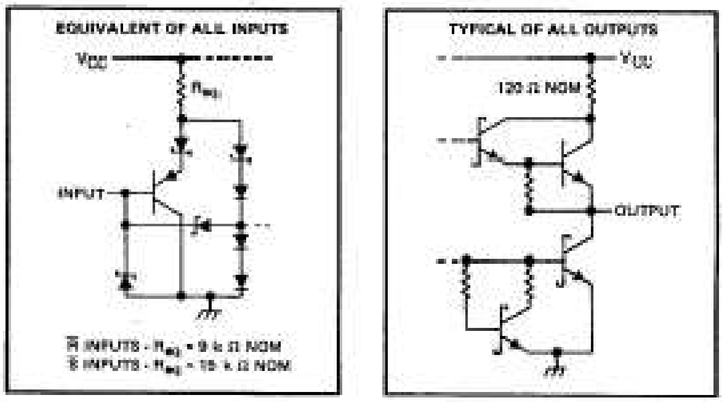
TYPES SN74279, SN74LS279A, SN54279, SN54LS279A
QUADRUPLE $\bar{S}$-$\bar{R}$ LATCHES

schematics of inputs and outputs

'279 CIRCUITS



'LS279A CIRCUITS



absolute maximum ratings over operating free-air temperature range (unless otherwise noted)

Supply voltage, V_{CC} (see Note 1)	7 V
Input voltage: '279	5.5 V
'LS279A	7 V
Operating free-air temperature range: SN54' TYPES	−55°C to 125°C
SN74' TYPES	0°C to 70°C
Storage temperature range	−65°C to 150°C

NOTE 1: Voltage values are with respect to network ground terminal.

TEXAS INSTRUMENTS

TYPES SN74LS279A, SN54LS279A QUADRUPLE $\bar{S}$-$\bar{R}$ LATCHES

recommended operating conditions

		SN54LS279A			SN74LS279A			UNIT
		MIN	NOM	MAX	MIN	NOM	MAX	
V_{CC}	Supply voltage	4.5	5	5.5	4.75	5	5.25	V
V_{IH}	High-level input voltage	2			2			V
V_{IL}	Low-level input voltage			0.7			0.8	V
I_{OH}	High-level output current			− 0.4			− 0.4	mA
I_{OL}	Low-level output current			4			8	mA
t_w	Pulse duration, low	20			20			ns
T_A	Operating free-air temperature	− 55		125	0		70	°C

electrical characteristics over recommended operating free-air temperature range (unless otherwise noted)

PARAMETER	TEST CONDITIONS†			SN54LS279A			SN74LS279A			UNIT
				MIN	TYP‡	MAX	MIN	TYP‡	MAX	
V_{IK}	V_{CC} = MIN,	I_I = − 18 mA				− 1.5			− 1.5	V
V_{OH}	V_{CC} = MIN,	V_{IL} = MAX,	I_{OH} = − 0.4 mA	2.5	3.4		2.7	3.4		V
V_{OL}	V_{CC} = MIN,	V_{IH} = 2 V,	I_{OL} = 4 mA		0.25	0.4		0.25	0.4	V
	V_{CC} = MIN,	V_{IH} = 2 V,	I_{OL} = 8 mA					0.35	0.5	
I_I	V_{CC} = MAX,	V_I = 7 V				0.1			0.1	mA
I_{IH}	V_{CC} = MAX,	V_I = 2.7 V				20			20	µA
I_{IL}	V_{CC} = MAX,	V_I = 0.4 V				− 0.2			− 0.2	mA
I_{OS}§	V_{CC} = MAX			− 20		− 100	− 20		− 100	mA
I_{CC}	V_{CC} = MAX,	See note 2			3.8	7		3.8	7	mA

† For conditions shown as MIN or MAX, use the appropriate value specified under recommended operating conditions.

‡ All typical values are at V_{CC} = 5 V, T_A = 25°C.

§ Not more than one output should be shorted at a time, and the duration of the short circuit should be less than one second.

NOTE 2: I_{CC} is measured with all $\bar{R}$ inputs grounded, all $\bar{S}$ inputs at 4.5 V, and all outputs open.

switching characteristics, V_{CC} = 5 V, T_A = 25°C (see note 3)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	TEST CONDITIONS		MIN	TYP	MAX	UNIT
t_{PLH}	$\bar{S}$	Q	R_L = 2 kΩ,	C_L = 15 pF		12	22	ns
t_{PHL}						13	21	
t_{PHL}	$\bar{R}$	Q				15	27	ns

NOTE 3: See General Information Section for load circuits and voltage waveforms.

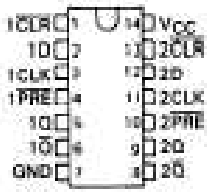
G.10. Especificaciones báscula *D* 74LS74 de Texas Instruments

TYPES SN7474, SN74LS74A, SN74S74
SN5474, SN54LS74A, SN54S74
DUAL D-TYPE POSITIVE-EDGE-TRIGGERED FLIP-FLOPS WITH PRESET AND CLEAR

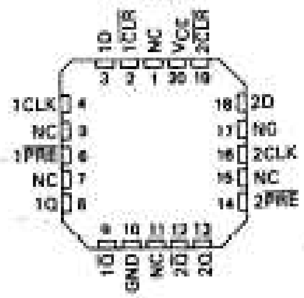
REVISED DECEMBER 1983

- Package Options Include Standard Plastic (N) and Ceramic (J) 300-mil Dual-In-Line Packages, Plastic Small Outline (D) and Ceramic Chip Carrier (FK) Package
- Dependable Texas Instruments Quality and Reliability

SN5474, SN54LS74A, SN54S74... J PACKAGE
SN7474, SN74LS74A, SN74S74... D OR N PACKAGE
(TOP VIEW)



SN54LS74A, SN54S74 . . . FK PACKAGE
(TOP VIEW)



NC - No internal connection

description

These devices contain two independent D-type positive-edge-triggered flip-flops. A low level at the preset or clear inputs sets or resets the outputs regardless of the levels of the other inputs. When preset and clear are inactive (high), data at the D input meeting the setup time requirements are transferred to the outputs on the positive-going edge of the clock pulse. Clock triggering occurs at a voltage level and is not directly related to the rise time of the clock pulse. Following the hold time interval, data at the D input may be changed without affecting the levels at the outputs.

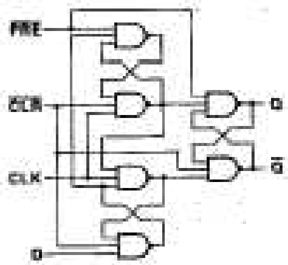
The SN54' family is characterized for operation over the full military temperature range of −55°C to 125°C. The SN74' family is characterized for operation from 0°C to 70°C.

FUNCTION TABLE

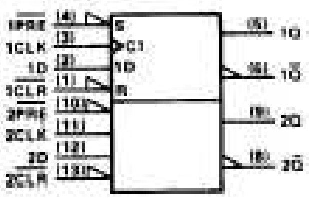
INPUTS				OUTPUTS	
PRE	CLR	CLK	D	Q	Q̄
L	H	X	X	H	L
H	L	X	X	L	H
L	L	X	X	H†	H†
H	H	↑	H	H	L
H	H	↑	L	L	H
H	H	L	X	Q_0	$\overline{Q}_0$

† The output levels in this configuration are not guaranteed to meet the minimum levels in V_{OH} if the lows at preset and clear are near V_{IL} maximum. Furthermore, this configuration is nonstable, that is, it will not persist when either preset or clear returns to its inactive (high) level.

logic diagram



logic symbol

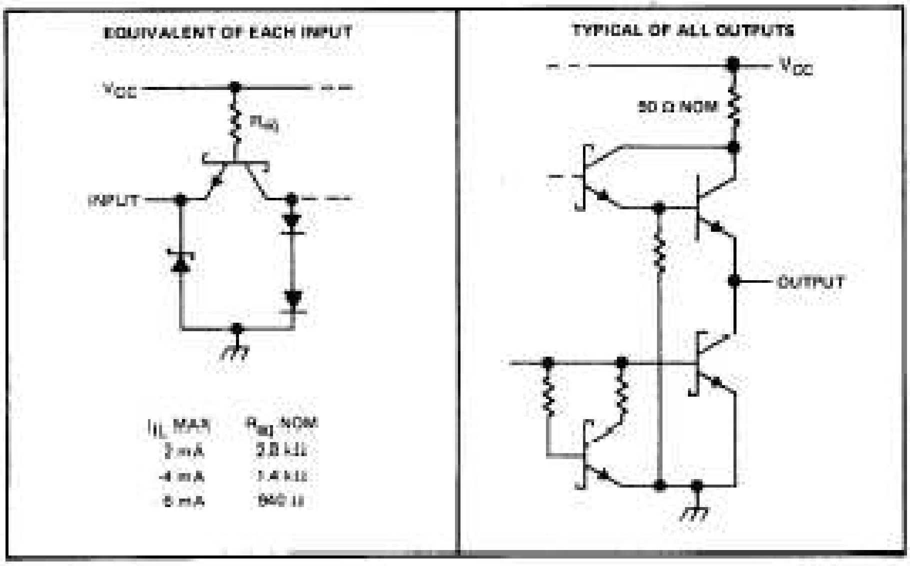


Pin numbers shown on logic notation are for D, J or N packages.

TYPES SN74S74, SN54S74
DUAL D-TYPE POSITIVE-EDGE-TRIGGERED FLIP-FLOPS WITH PRESET AND CLEAR

schematics of inputs and outputs (continued)

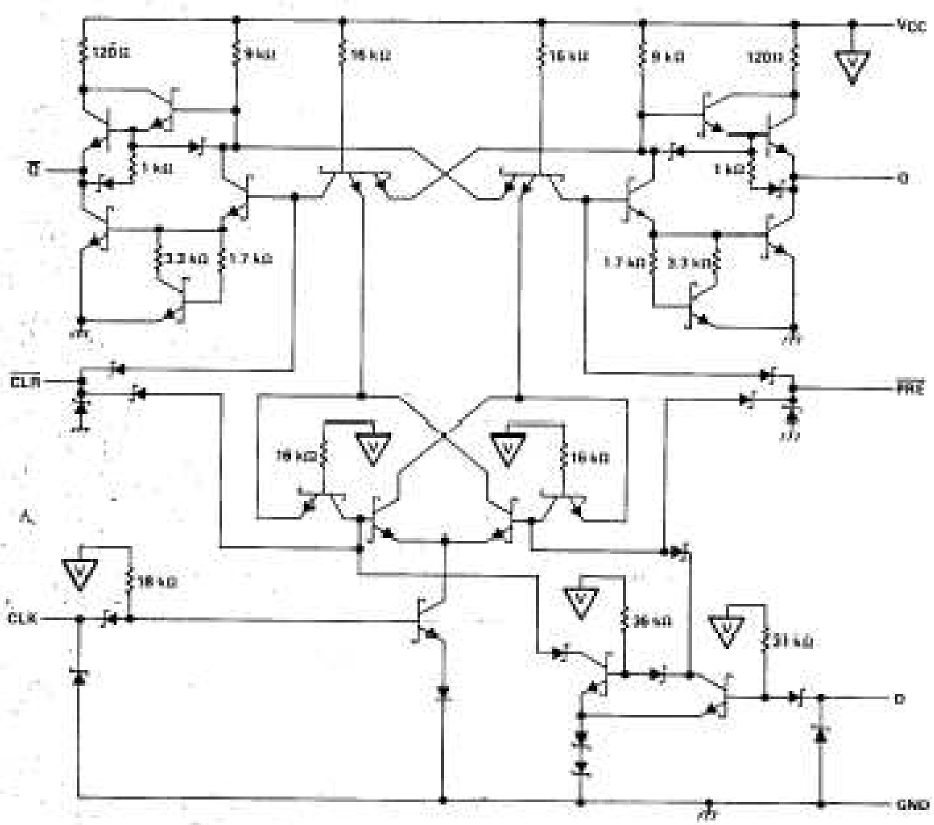
'S74



TYPES SN7474, SN74LS74A, SN74S74
SN5474, SN54LS74A, SN54S74
DUAL D-TYPE POSITIVE-EDGE-TRIGGERED FLIP-FLOPS WITH PRESET AND CLEAR

schematic

'LS74A



absolute maximum ratings over operating free-air temperature range (unless otherwise noted)

Supply voltage, V_{CC} (see Note 1) . . . . . 7 V
Input voltage: '74, 'S74 . . . . . 5.5 V
'LS74A . . . . . 7 V
Operating free-air temperature range: SN54' . . . . . − 55°C to 125°C
SN74' . . . . . 0°C to 70°C
Storage temperature range . . . . . − 65°C to 150°C

NOTE 1. Voltage values are with respect to network ground terminal.

TEXAS INSTRUMENTS

TYPES SN74LS74A, SN54LS74A
DUAL D-TYPE POSITIVE-EDGE-TRIGGERED FLIP-FLOPS WITH PRESET AND CLEAR

recommended operating conditions

			SN54LS74A			SN74LS74A			UNIT
			MIN	NOM	MAX	MIN	NOM	MAX	
V_{CC}	Supply voltage		4.5	5	5.5	4.75	5	5.25	V
V_{IH}	High-level input voltage		2			2			V
V_{IL}	Low-level input voltage				0.7			0.8	V
I_{OH}	High-level output current				−0.4			−0.4	mA
I_{OL}	Low-level output current				4			8	mA
f_{clock}	Clock frequency		0		25	0		25	MHz
t_w	Pulse duration	CLK high	25			25			ns
		$\overline{PRE}$ or $\overline{CLR}$ low	25			25			
t_{su}	Setup time before CLK↑	High-level data	20			20			ns
		Low-level data	20			20			
t_h	Hold time-data after CLK↑		5			5			ns
T_A	Operating free-air temperature		−55		125	0		70	°C

electrical characteristics over recommended operating free-air temperature range (unless otherwise noted)

PARAMETER		TEST CONDITIONS†			SN54LS74A			SN74LS74A			UNIT
					MIN	TYP‡	MAX	MIN	TYP‡	MAX	
V_{IK}		V_{CC} = MIN,	I_I = −18 mA				−1.5			−1.5	V
V_{OH}		V_{CC} = MIN, I_{OH} = −0.4 mA	V_{IH} = 2 V,	V_{IL} = MAX,	2.5	3.4		2.7	3.4		V
V_{OL}		V_{CC} = MIN, I_{OL} = 4 mA	V_{IL} = MAX,	V_{IH} = 2 V,		0.25	0.4		0.25	0.4	V
		V_{CC} = MIN, I_{OL} = 8 mA	V_{IL} = MAX,	V_{IH} = 2 V,					0.35	0.5	
I_I	D or CLK	V_{CC} = MAX,	V_I = 7 V				0.1			0.1	mA
	$\overline{CLR}$ or $\overline{PRE}$						0.2			0.2	
I_{IH}	D or CLK	V_{CC} = MAX,	V_I = 2.7 V				20			20	µA
	$\overline{CLR}$ or $\overline{PRE}$						40			40	
I_{IL}	D or CLK	V_{CC} = MAX,	V_I = 0.4 V				−0.4			−0.4	mA
	$\overline{CLR}$ or $\overline{PRE}$						−0.8			−0.8	
I_{OS}§		V_{CC} = MAX,	See Note 4		−20		−100	−20		−100	mA
I_{CC}		V_{CC} = MAX,	See Note 2			4	8		4	8	mA

† For conditions shown as MIN or MAX, use the appropriate value specified under recommended operating conditions.
‡ All typical values are at V_{CC} = 5 V, T_A = 25°C.
§ Not more than one output should be shorted at a time, and the duration of the short circuit should not exceed one second.
NOTE 2: With all outputs open, I_{CC} is measured with the Q and $\overline{Q}$ outputs high in turn. At the time of measurement, the clock input is grounded.
NOTE 4: For certain devices where state commutation can be caused by shorting an output to ground, an equivalent test may be performed with V_O = 2.25 V and 2.125 V for the 54 family and the 74 family, respectively, with the minimum and maximum limits reduced to one half of their stated values.

switching characteristics, V_{CC} = 5 V, T_A = 25°C (see note 3)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	TEST CONDITIONS		MIN	TYP	MAX	UNIT
f_{max}			R_L = 2 kΩ,	C_L = 15 pF	25	33		MHz
t_{PLH}	$\overline{CLR}$, $\overline{PRE}$ or CLK	Q or $\overline{Q}$				13	25	ns
t_{PHL}						25	40	ns

NOTE 3: See General Information Section for load circuits and voltage waveforms.

TEXAS INSTRUMENTS

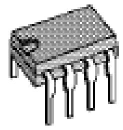
G.11. Especificaciones Amplificador TL082C de SGS-THOMSON

SGS-THOMSON MICROELECTRONICS

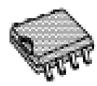
TL082 TL082A - TL082B

GENERAL PURPOSE DUAL J-FET OPERATIONAL AMPLIFIERS

- LOW POWER CONSUMPTION
- WIDE COMMON-MODE (UP TO V_{CC}^{+}) AND DIFFERENTIAL VOLTAGE RANGE
- LOW INPUT BIAS AND OFFSET CURRENT
- OUTPUT SHORT-CIRCUIT PROTECTION
- HIGH INPUT IMPEDANCE J–FET INPUT STAGE
- INTERNAL FREQUENCY COMPENSATION
- LATCH UP FREE OPERATION
- HIGH SLEW RATE : 16V/µs (typ)



N
DIP8
(Plastic Package)



D
SO8
(Plastic Micropackage)

DESCRIPTION

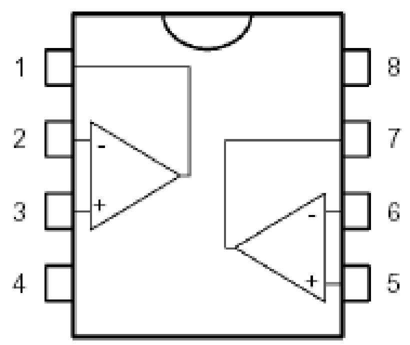
The TL082, TL082A and TL082B are high speed J–FET input dual operational amplifiers incorporating well matched, high voltage J–FET and bipolar transistors in a monolithic integrated circuit.

The devices feature high slew rates, low input bias and offset current, and low offset voltage temperature coefficient.

ORDER CODES

Part Number	Temperature Range	Package	
		N	D
TL082M/AM/BM	–55°C, +125°C	•	•
TL082I/AI/BI	–40°C, +105°C	•	•
TL082C/AC/BC	0°C, +70°C	•	•
Examples : TL082CD, TL082IN			

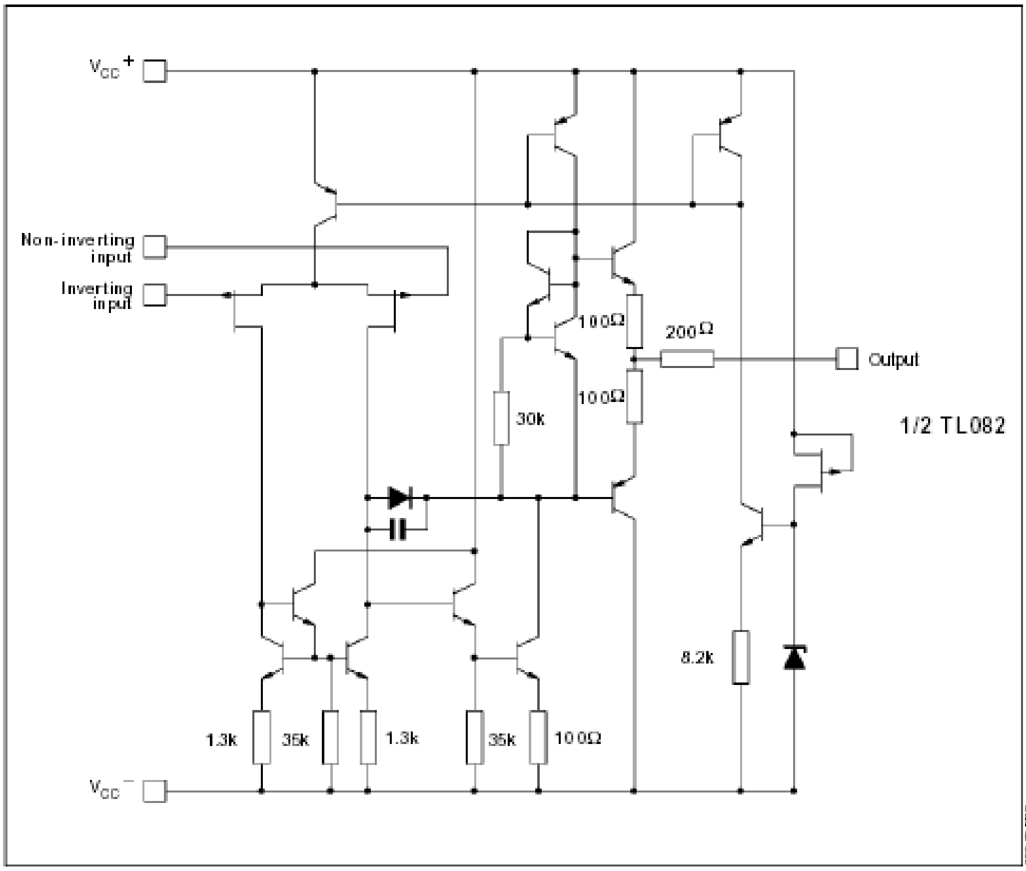
PIN CONNECTIONS (top view)



1 - Output 1
2 - Inverting input 1
3 - Non-inverting input 1
4 - V_{CC}^{-}
5 - Non-inverting input 2
6 - Inverting input 2
7 - Output 2
8 - V_{CC}^{+}

TL082 - TL082A - TL082B

SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter		Value	Unit
V_{CC}	Supply Voltage - (note 1)		±18	V
V_i	Input Voltage - (note 3)		±15	V
V_{id}	Differential Input Voltage - (note 2)		±30	V
P_{tot}	Power Dissipation		680	mW
	Output Short-circuit Duration - (note 4)		Infinite	
T_{oper}	Operating Free Air Temperature Range	TL082C,AC,BC TL082I,AI,BI TL082M,AM,BM	0 to 70 –40 to 105 –55 to 125	°C
T_{stg}	Storage Temperature Range		–65 to 150	°C

Notes :
1. All voltage values, except differential voltage, are with respect to the zero reference level (ground) of the supply voltages where the zero reference level is the midpoint between V_{CC}^+ and V_{CC}^-.
2. Differential voltages are at the non-inverting input terminal with respect to the inverting input terminal.
3. The magnitude of the input voltage must never exceed the magnitude of the supply voltage or 15 volts, whichever is less.
4. The output may be shorted to ground or to either supply. Temperature and /or supply voltages must be limited to ensure that the dissipation rating is not exceeded.

ELECTRICAL CHARACTERISTICS

$V_{CC} = \pm 15V$, $T_{amb} = 25^{\circ}C$ (unless otherwise specified)

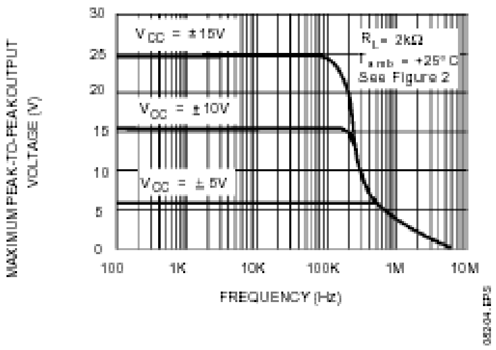
Symbol	Parameter	TL082I,M,AC,AI, AM,BC,BI,BM			TL082C			Unit
		Min.	Typ.	Max.	Min.	Typ.	Max.	
V_{io}	Input Offset Voltage ($R_S = 50\Omega$) $T_{amb} = 25^{\circ}C$ TL082BC,BI,BM $T_{min.} \leq T_{amb} \leq T_{max.}$ TL082BC,BI,BM		3 1	6 3 7 5		3	10 13	mV
DV_{io}	Input Offset Voltage Drift		10			10		µV/°C
I_{io}	Input Offset Current * $T_{amb} = 25^{\circ}C$ $T_{min.} \leq T_{amb} \leq T_{max.}$		5	100 4		5	100 4	pA nA
I_{ib}	Input Bias Current * $T_{amb} = 25^{\circ}C$ $T_{min.} \leq T_{amb} \leq T_{max.}$		20	200 20		20	400 20	pA nA
A_{vd}	Large Signal Voltage Gain ($R_L = 2k\Omega$, $V_O = \pm 10V$) $T_{amb} = 25^{\circ}C$ $T_{min.} \leq T_{amb} \leq T_{max.}$	50 25	200		25 15	200		V/mV
SVR	Supply Voltage Rejection Ratio ($R_S = 50\Omega$) $T_{amb} = 25^{\circ}C$ $T_{min.} \leq T_{amb} \leq T_{max.}$	80 80	86		70 70	86		dB
I_{CC}	Supply Current, per Amp, no Load $T_{amb} = 25^{\circ}C$ $T_{min.} \leq T_{amb} \leq T_{max.}$		1.4	2.5 2.5		1.4	2.5 2.5	mA
V_{icm}	Input Common Mode Voltage Range	±11	+15 -12		±11	+15 -12		V
CMR	Common Mode Rejection Ratio ($R_S = 50\Omega$) $T_{amb} = 25^{\circ}C$ $T_{min.} \leq T_{amb} \leq T_{max.}$	80 80	86		70 70	86		dB
Ios	Output Short-circuit Current $T_{amb} = 25^{\circ}C$ $T_{min.} \leq T_{amb} \leq T_{max.}$	10 10	40	60 60	10 10	40	60 60	mA
$\pm V_{OPP}$	Output Voltage Swing $T_{amb} = 25^{\circ}C$ $R_L = 2k\Omega$ $R_L = 10k\Omega$ $T_{min.} \leq T_{amb} \leq T_{max.}$ $R_L = 2k\Omega$ $R_L = 10k\Omega$	10 12 10 12	12 13.5		10 12 10 12	12 13.5		V
SR	Slew Rate ($V_{in} = 10V$, $R_L = 2k\Omega$, $C_L = 100pF$, $T_{amb} = 25^{\circ}C$, unity gain)	8	16		8	16		V/µs
t_r	Rise Time ($V_{in} = 20mV$, $R_L = 2k\Omega$, $C_L = 100pF$, $T_{amb} = 25^{\circ}C$, unity gain)		0.1			0.1		µs
K_{OV}	Overshoot ($V_{in} = 20mV$, $R_L = 2k\Omega$, $C_L = 100pF$, $T_{amb} = 25^{\circ}C$, unity gain)		10			10		%
GBP	Gain Bandwidth Product (f = 100kHz, $T_{amb} = 25^{\circ}C$, $V_{in} = 10mV$, $R_L = 2k\Omega$, $C_L = 100pF$)	2.5	4		2.5	4		MHz
R_i	Input Resistance		10^{12}			10^{12}		Ω
THD	Total Harmonic Distortion (f = 1kHz, $A_V = 20dB$, $R_L = 2k\Omega$, $C_L = 100pF$, $T_{amb} = 25^{\circ}C$, $V_O = 2V_{PP}$)		0.01			0.01		%
e_n	Equivalent Input Noise Voltage (f = 1kHz, $R_s = 100\Omega$)		15			15		$\frac{nV}{\sqrt{Hz}}$
∅m	Phase Margin		45			45		Degrees
V_{O1}/V_{O2}	Channel Separation ($A_v = 100$)		120			120		dB

082-03.TBL

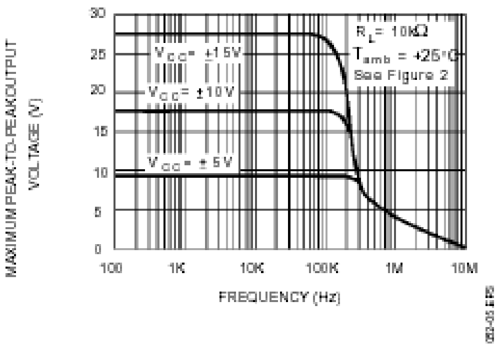
* The input bias currents are junction leakage currents which approximately double for every 10°C increase in the junction temperature.

TL082 - TL082A - TL082B

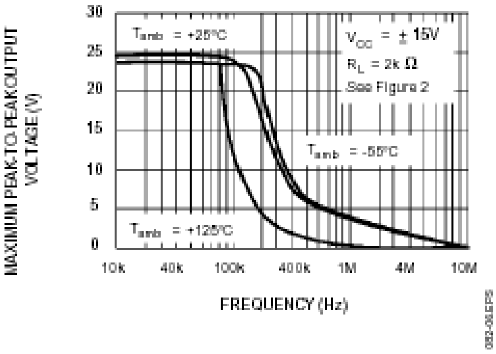
MAXIMUM PEAK-TO-PEAK OUTPUT VOLTAGE VERSUS FREQUENCY



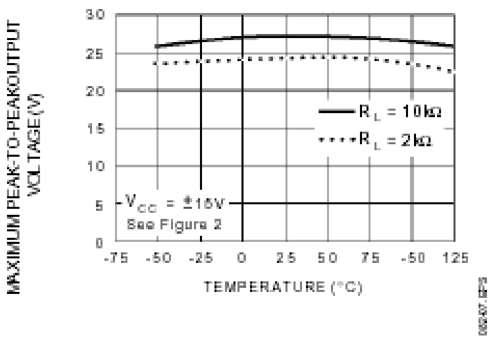
MAXIMUM PEAK-TO-PEAK OUTPUT VOLTAGE VERSUS FREQUENCY



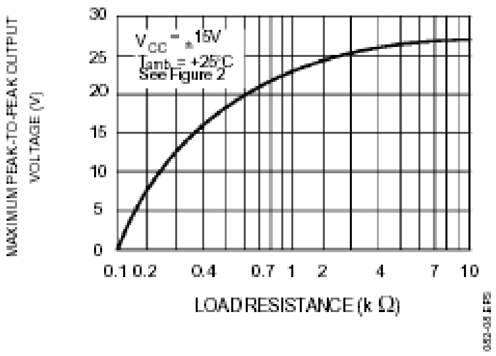
MAXIMUM PEAK-TO-PEAK OUTPUT VOLTAGE VERSUS FREQUENCY



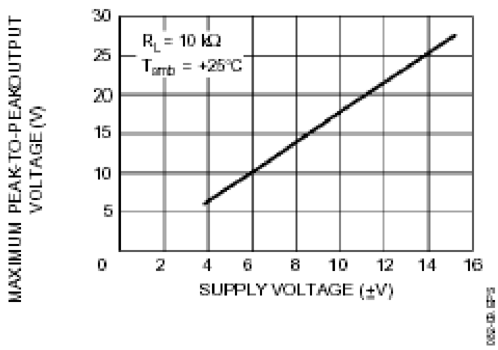
MAXIMUM PEAK-TO-PEAK OUTPUT VOLTAGE VERSUS FREE AIR TEMP.



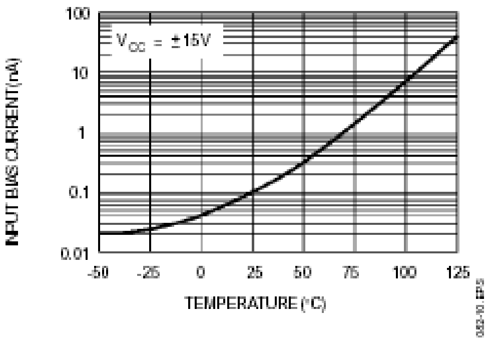
MAXIMUM PEAK-TO-PEAK OUTPUT VOLTAGE VERSUS LOAD RESISTANCE



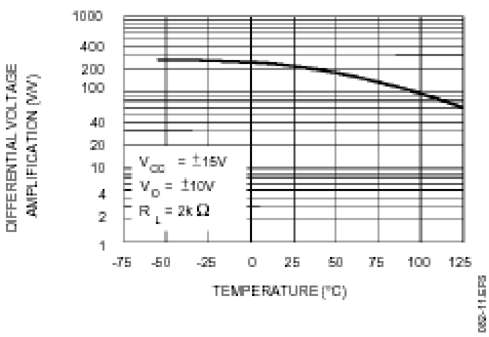
MAXIMUM PEAK-TO-PEAK OUTPUT VOLTAGE VERSUS SUPPLY VOLTAGE



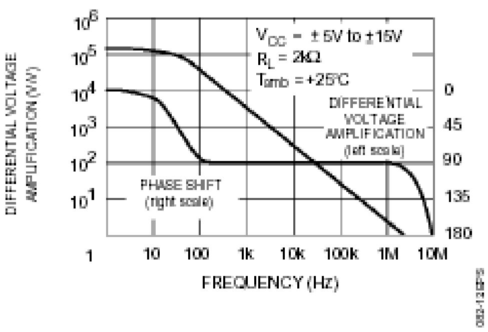
INPUT BIAS CURRENT VERSUS FREE AIR TEMPERATURE



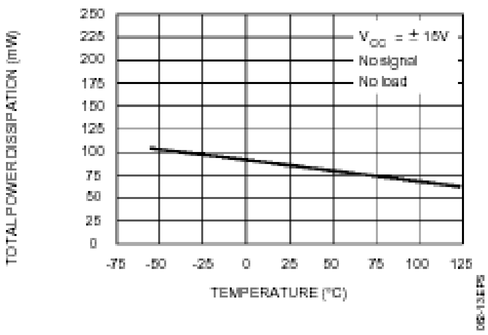
LARGE SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION VERSUS FREE AIR TEMPERATURE



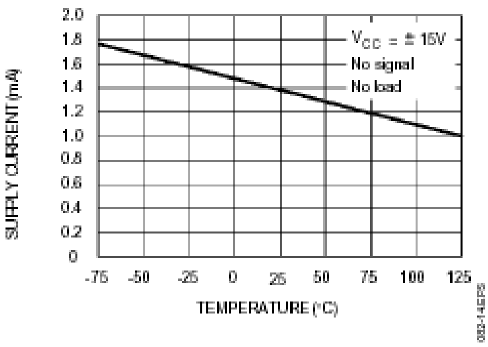
LARGE SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION AND PHASE SHIFT VERSUS FREQUENCY



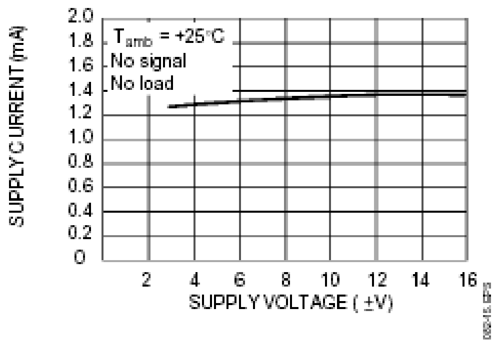
TOTAL POWER DISSIPATION VERSUS FREE AIR TEMPERATURE



SUPPLY CURRENT PER AMPLIFIER VERSUS FREE AIR TEMPERATURE

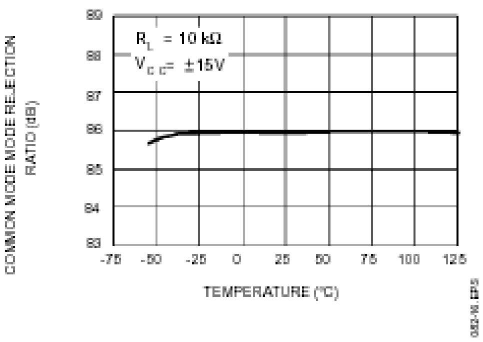


SUPPLY CURRENT PER AMPLIFIER VERSUS SUPPLY VOLTAGE

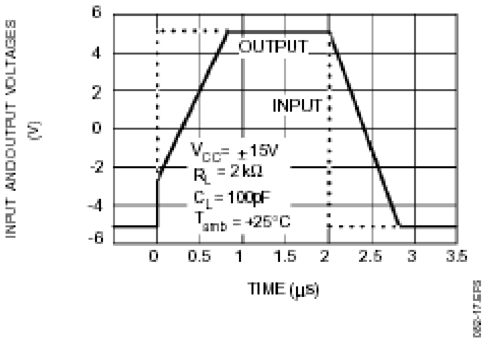


TL082 - TL082A - TL082B

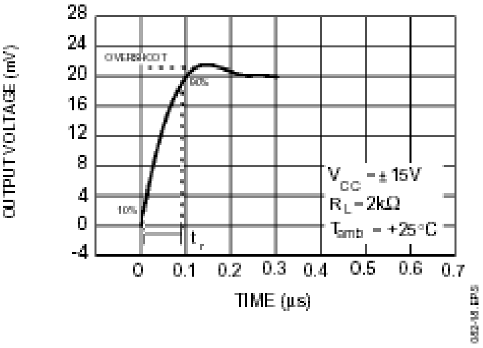
COMMON MODE REJECTION RATIO VERSUS FREE AIR TEMPERATURE



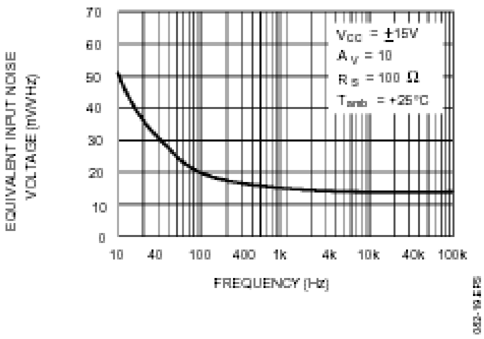
VOLTAGE FOLLOWER LARGE SIGNAL PULSE RESPONSE



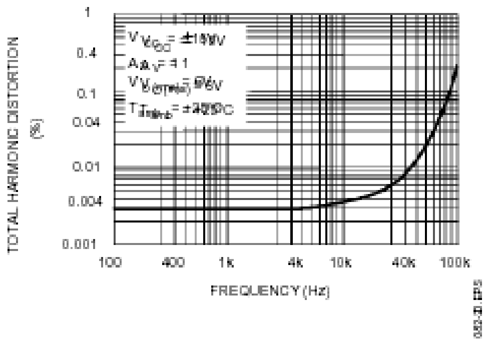
OUTPUT VOLTAGE VERSUS ELAPSED TIME



EQUIVALENT INPUT NOISE VOLTAGE VERSUS FREQUENCY

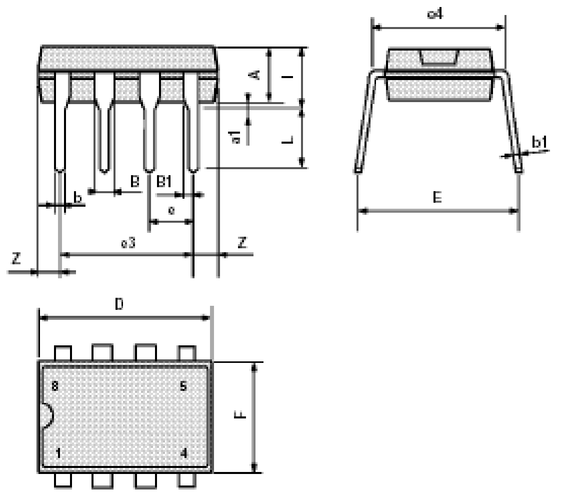


TOTAL HARMONIC DISTORTION VERSUS FREQUENCY



TL082 - TL082A - TL082B

PACKAGE MECHANICAL DATA
8 PINS - PLASTIC DIP



Dimensions	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A		3.32			0.131	
a1	0.51			0.020		
B	1.15		1.65	0.045		0.065
b	0.356		0.55	0.014		0.022
b1	0.204		0.304	0.008		0.012
D			10.92			0.430
E	7.95		9.75	0.313		0.384
e		2.54			0.100	
e3		7.62			0.300	
e4		7.62			0.300	
F			6.6			0260
i			5.08			0.200
L	3.18		3.81	0.125		0.150
Z			1.52			0.060

Apéndice H

Vistas de los montajes del Subsistema Electrónico

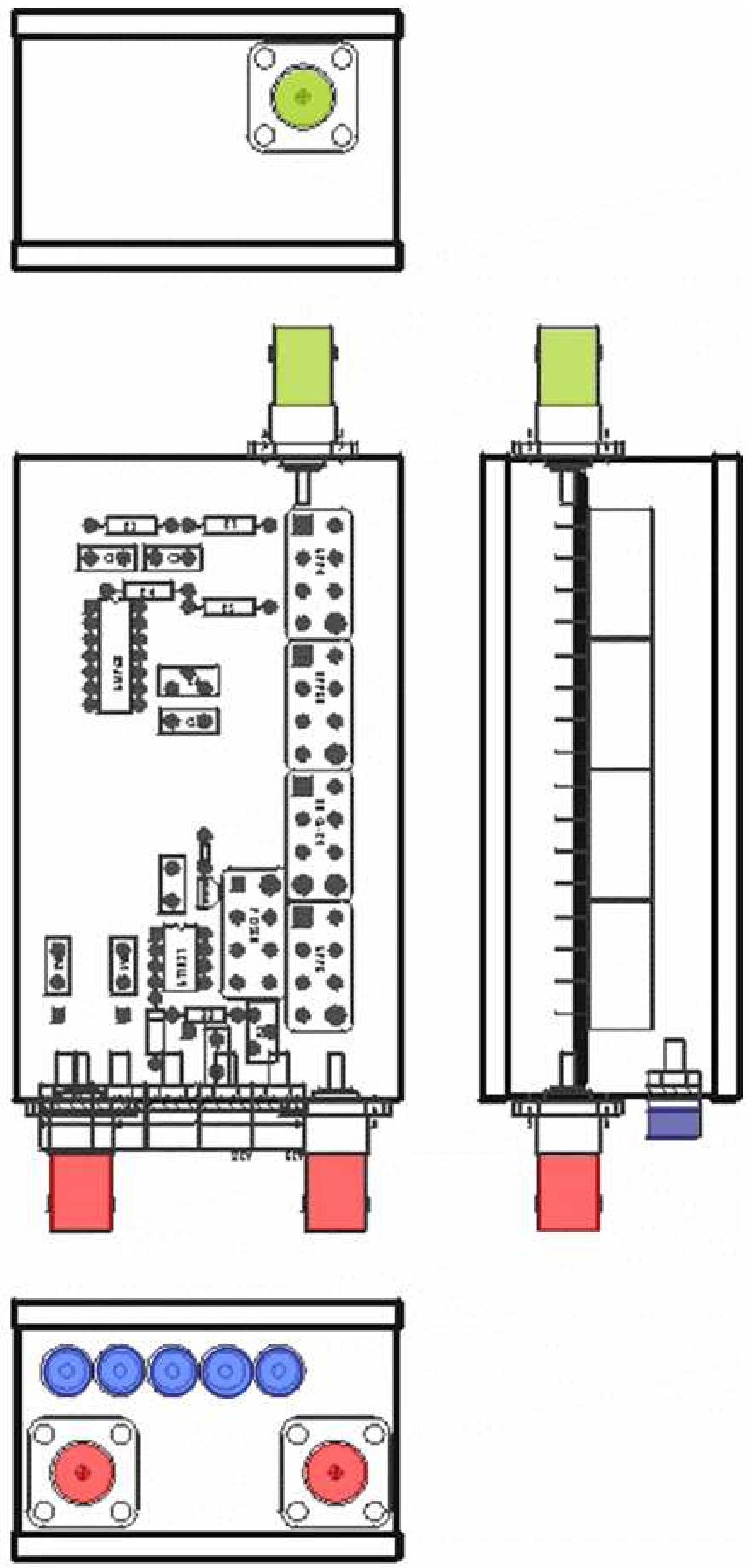


Figura H.1 Vistas del montaje del procesador de señal

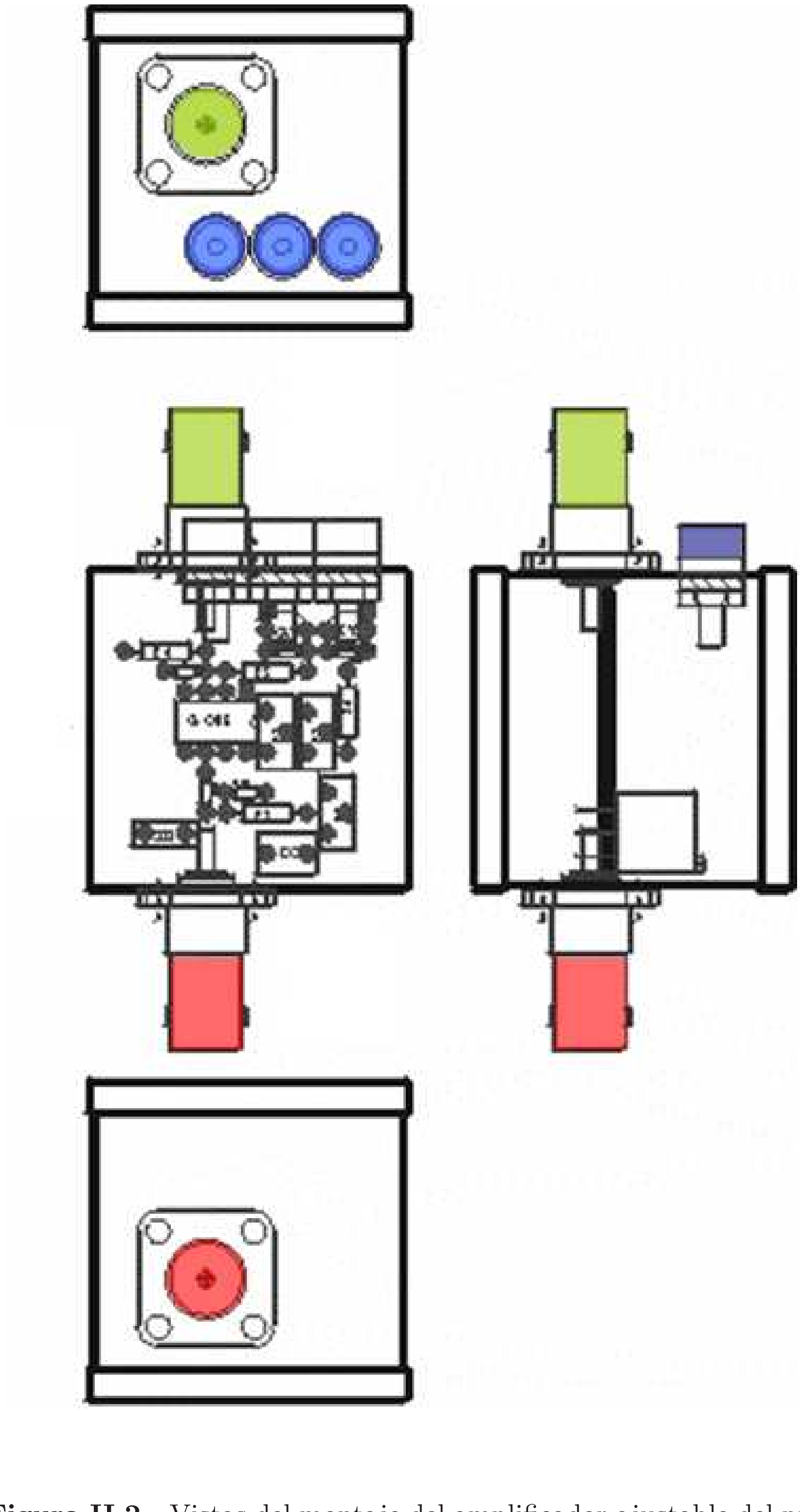


Figura H.2 Vistas del montaje del amplificador ajustable del procesador de señal

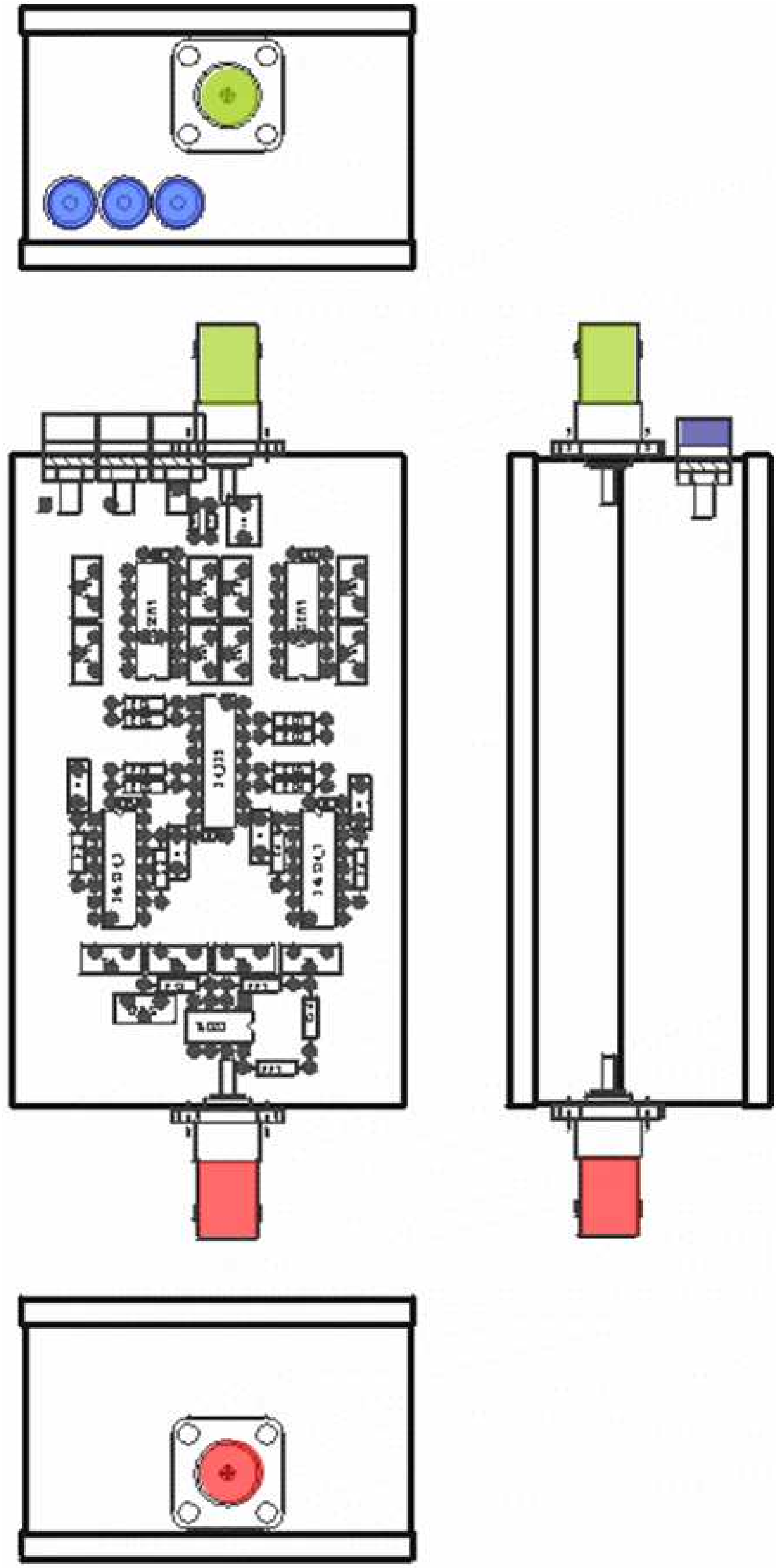


Figura H.3 Vistas del montaje del procesador de pedestal