		hapter 8, S - The x-Ch	t Ends $-$ T Section 8.1	1	itory, *Opt. Ph	noton. News,	12, 42-45 (<i>i</i>	April 2001)).			
	NoDiToInEfDyToday.TISI	onlinear de istortion in otal harmor termodulat ffect of feed ynamic ran A frequence not noise lii	amplifiers nic distortic tion distorti dback on n nge cy response mit and mi	on on onlinearity e and noise nimizing ad	ded noise							
im fro	SI RO RO RO PORT I	not noise linascode iso egulated (i. postrapping natplotlib tplotlib numpy as	mit and min lation of photosic e. gain-boo g photosic eages/rages/	nimizing additional cases of the capacital module yplot as icker, cm	ded noise apacitance code nce							
im fro fro fro #%/ mp	port of sc. om sc. om sc. om sc. om sc. om sc. om sc. of sc. of plo fig ax. ax.	numpy as ipy impor ipy impor ipy.fft i otlib not arams['fo arams['le t_xy(x, y	rt signal rt integr import ff tebook ont.size' egend.fon //, xlabel lt.subplo //, 'b') el(xlabel	ate t] = 14 tsize'] = , ylabel) ts(figsiz	'large'	.5));						
de	ax.: f plo fig ax.: ax.: ax.: ax.:	<pre>set_ylabe t_2xy(x, , ax = pl plot(x, y plot(x, y set_ylabe set_xlabe grid() legend() legend(logend()</pre>	y1, y2, lt.subplo /1, 'b', /2, 'r', el(ylabel el(xlabel	xlabel, y ts(figsiz label=y1l label=y2l))		ā)) ancybox= Tru	e,					
de	f plo fig ax[ax[ax[ax[ax[ax[t_xy2(x1,	shadow=Tr y1, x1l lt.subplo x1, y1, ' label(y1l) x2, y2, ' label(x1l label(x2l label(y2l	<pre>ue, bbox_ abel, y1l ts(2, fig b') abel) b') abel) abel)</pre>	•	(0.5,1.13) /2, x2label)	L):				
de	fig f plo fig ax[ax[ax[ax[ax[.align_yl t_xy3(x, , ax = pl 0].plot(x 0].set_yl 0].grid() 1].plot(x 1].set_yl	labels(ax y1, y2, lt.subplo (, y1) label(y1l) (, y2) label(y2l	y3, xlabe ts(3, fig abel)	l, y1label, size=(10.0,		y3label):					
de	ax[: ax[1].grid() 2].plot(x 2].set_yl 2].set_xl 2].grid() t_logxy3(, ax = pl 0].semilo 0].set_yl	(, y3) Label(y3l Label(xla) (x, y1, y Lt.subplo Dgx(x, y1 Label(y1l	abel) bel) 2, y3, xl ts(3, fig	abel, y1lak size=(10.0,		l, y3labe	el):				
de	ax[: ax[0].grid() 1].semilo 1].set_yl 1].grid() 2].semilo 2].set_yl 2].set_xl 2].grid() t_logxy(x	ogx(x, y2 label(y2l) ogx(x, y3 label(y3l label(xla) abel) abel) bel)		5))						
de	ax ax ax f plo fig ax ax	<pre>semilogx(grid(); set_xlabe set_ylabe t_log3xy(, ax = pl semilogx(semilogx(</pre>	(x, y, 'bel(xlabelel(ylabel) (x, y1, ylt.subplo (x, y1, 'x, y2, 'x, y2, 'x, y3, 'x, y3, 'x, y3, 'x, x, x	')) 2, y3, xl ts(figsiz b', label r', label g', label	<pre>abel, ylabe e=(10.0, 7.5 =y1label) =y2label) =y3label)</pre>	el, y1label	, y2label	L, y3labe	l):			
de	ax. ax. ax. f plo fig ax.	<pre>set_xlabe grid() legend() legend(lo st_log2xy(, ax = pl semilogx(semilogx(</pre>	oc='uppershadow=Tr (x, y1, y lt.subplo	center', ue, bbox_ 2, xlabel ts(figsiz b', label r', label	ncol=3, fa to_anchor=(, ylabel, y e=(10.0,7.5 =y1label) =y2label)	(0.5,1.13) y1label, y2)					
de	ax. ax. ax. f plo fig ax. ax.	s t_loglog(oc='uppershadow=Tr	center', ue, bbox_ abel, yla ts(figsiz	ncol=2, fa to_anchor=(bel): e=(10.0, 7.	(0.5,1.13)	•					
de	f plo fig ax. ax. ax.	set_ylabe t_loglog2 , ax = pl loglog(x,	el(ylabel 2(x, y1, lt.subplo y1, 'b' y2, 'r' el(ylabel	y2, xlabe ts(figsiz , label=y , label=y)			2label):					
	f plo fig ax. ax. f read	t_xlogy(x, ax = pl semilogy(grid(); set_xlabe set_ylabed_ltspice	shadow=Tr (, y, xla lt.subplo (x, y, 'b el(xlabel el(ylabel	<pre>ue, bbox_ bel, ylab ts(figsiz ');););</pre>	e=(10.0, 7.	(0.5,1.13)						
		<pre>x = [] y = [] z = [] next(dat for line p = x.ap comp y.ap</pre>	ca) # ski e in data line.spl opend(flo olex = p[opend(flo opend(flo	p header :	line ",") ×[0]))							
de	fig ax[ax[ax[ax[ax[ax[it.subplo ogx(x1, y label(y1l) ogx(x2, y label(x1l label(x2l label(y2l	ts(2, fig 1, 'b'); abel) 2, 'b'); abel);	1label, y1 size = (10		bel, y2la	abel):				
de	f plo fig ax[ax[ax[ax[ax[ax[, ax = pl 0].semilo 0].set_xs 0].set_xl 0].set_xt 0].set_xt 0].set_yl	pandwidth lt.subplo pgx(f, RC scale("lo lim(f[0], cicks(np. cicklabel label('Ma itle('Equ	<pre>(f, mag): ts(2, fig _mag) g") f[-1]) logspace(s([]) gnitude [</pre>	size=(10.0, 0.1,4,5))							
	ax[: ax[: ax[: ax[: ax[: ax[: ax[:	1].hlines 1].hlines 1].vlines 1].set_xl 1].set_xt 1].set_xt 1].set_yl	s(1, 0, f s(0, f_en s(f_enb, lim(f[0], scale("lo cicks(np. cicklabel label('Ma label('Fr	<pre>b, f[-1], 0, 1, col f[-1]) g") logspace(</pre>	0\$',r'\$10^1 V/V]')	o:blue') ue')	2\$', r'\$1	LO^3\$', r	'\$1 0^4\$	\$'])		
	fig vn_ ax: n, ax. ax. fig	= plt.fi norm = vn = fig.add bins, red set_xlabe set_ylabe grid() .canvas.d	igure(finoise/ vnd_subplotetangles el(r'Sampel('Proba	(111) = ax.hist le Voltag bility De	.0,7.5)) (vn_norm, k color='b') e [\$v_{n(rm)}	ms)}\$]')		range=(-	3, 3),			
ue	fig k = Rs: F1: F2: F3: ax. ax. ax. ax.	<pre>, ax = pl 1.38e-23 = np.logs = 1 + (en = 1 + (en = 1 + (en semilogx(semilogx(grid(); set_xlabe</pre>	Lt.subplo Space(np. n_vals[0] n_vals[1] n_vals[2] (Rs, 10*n (Rs, 10*n	log10(Rs_ **2+Rs**2 **2+Rs**2 **2+Rs**2 p.log10(F p.log10(F p.log10(F	e=(10.0, 7. min), np.lo *in_vals[0] *in_vals[1] *in_vals[2] 1), 'b', la 2), 'r', la 3), 'g', la ance \$R_s \$NF\$ [\$dB\$]	Dg10(Rs_max]**2)/(4*k*]**2)/(4*k*]**2)/(4*k* abel=r'\$e_{ abel=r'\$e_{ abel=r'\$e_{ [\Omega]\$')), num=20 T_in_K*Rs T_in_K*Rs T_in_K*Rs n1}\$, \$i_ n2}\$, \$i_ n3}\$, \$i_	5) 5) 5) _{n1}\$') _{n2}\$')				
de	f plo fig Rs: e_n. ax. ax.	t_noise_c , ax = pl = np.logs i_2 = 4*k loglog(Rs loglog(Rs loglog(Rs	curve(e_n curve(e_n lt.subplo space(np. c*T*Rs + s, np.sqr s, np.sqr s, e_n*np	ue, bbox_ , i_n, Rs ts(figsiz log10(Rs_ e_n**2 + t(e_ni_2) t(4*k*T*R .ones(np.	ncol=3, fa to_anchor=(_min, Rs_ma e=(10.0, 7. min), np.lo i_n**2*Rs** , 'b', labe s), 'r', la size(Rs)),	(0.5,1.13) ax): .5)) og10(Rs_max*2 el='Total Nabel=r'\$\sq 'g', label), num=20 oise') rt{4kTR_s	s}\$')				
de	ax. ax. ax. ax. f plo fig k = T =	<pre>loglog(Rs grid(); set_xlabe set_ylabe legend() legend(lo s t_bjt_NF(</pre>	s, i_n*Rs el(r'Sour el(r'Equi oc='upper shadow=Tr (beta, r_ lt.subplo	<pre>, 'y', la ce Resist valent In center', ue, bbox_ bb, Rmin,</pre>	bel=r'\$i_n ance \$R_s put Noise ncol=4, fa to_anchor=(Rmax, Imir e=(10.0, 7.5)	R_s\$') [\Omega]\$') [\$V/H ancybox=Tru (0.5,1.13) n, Imax):	z}\$]') e ,					
	<pre>T = q = V_T rs : ic : i_C e_n i_n NF : cp : plt plt</pre>	300 1.602e-1 = k*T/q = np.logs = np.logs , R_S = n _2 = 4*k* _2 = 2*q* = 1 + (e_ = ax.cont .xscale(' .yscale('	space(np. space(np. space(np. np.meshgr *T*(V_T/2 *I_C/beta _n_2 + i_ courf(I_C 'log') 'log') r'Source	log10(Imi id(ic, rs /I_C + r_ _0 n_2*R_S** , R_S, 10	•	10(Imax), n R_S) NF), levels	um = 100)		, num=:	16))		
	plt fig f ffti f = Np: pha: pha: f[1 f[-: ret	<pre>.xlabel(r .colorbar noise(f): np.array = (len(f) ses = np. ses = np. :Np+1] *= 1:-1-Np:- urn np.ff d_limited</pre>	c'Collect c(cp) c(f, dtyp c) - 1) // crandom.r cos(phase c) = phases c1] = np. ft.ifft(f	<pre>e='comple 2 and(Np) * es) + 1j conj(f[1:).real in_freq,</pre>	<pre>t \$I_C\$ [A] x') 2 * np.pi * np.sin(ph Np+1]) max_freq, s</pre>	nases)		era+				
	free f = idx f[i ret f fft fft mag	<pre>qs = np.a np.zeros = np.whe dx] = 1 urn fftno _mag(x, N _sig = f qs = np.l</pre>	abs(np.ff s(samples ere(np.lo Dise(f) N, T, t): fft(x, N) Linspace(N * np.ab	t.fftfreq) gical_and 0.0, 1.0/	max_freq, s (samples, 1 (freqs>=mir (2.0*T), N/ [0:N//2]) #	1/samplerat n_freq, fre	e)) qs<=max_f					
	fig ax.; ax.; ax.; ax.;	, ax = pl plot(1e-3 set_xlim(set_xlabe set_ylabe grid()	lt.subplo 3*freqs, (fmin, fm el('Frequ el('Magni	20*np.log ax) ency [kHz tude [dB]	e = (10.0,7 10(mags),	'b')	lifier [Desig	n			
•	Photod	diodes prod	duce curre	nt in respon voltage that	d optica se to incident can be proce ich produces	t light (i.e. pho	otons absor	litional circ	,	g. filter, ADC	, gain stage	, etc.), w
•	diode : To put photoc	$2qi_d$ this in conditional has a	crete terms a reverse-b	s, assume c iased deple	h that its ther our application tion capacital current with p	n requires a b $100pF$	andwidth o	f $500kHz$				
•	the sho	ot noise (th	nis is a 0.5° nstraint give	$\%$ increase as us an R_f	gibly to the to in the rms c value of to $10\mu A$, thet $500kHz$!	current noise $lpha_f=10$	density, whi $0\cdotrac{4kT}{2qi_d}$	ich could a	dmittedl	y be too exti	reme)	
· Tra	If the r How c	ninimum si an we impr	ignal ampli rove the sit	tude were fo tuation? .mplifie	urther reduce		A			ont a low imp	andanca ta t	ho cana
•	of the The in The id	photodiode put pole is eal transfe	effectively	eliminated of the TIA is	by the amplifi	er feedback ($rac{v_o}{i_d}$ =	kind of) $=R_f$					
•	Unfort S tabilit C_{in} is	y the total ca	apacitance	connected	of R_f contrib $$ to the feedba	ack node, whi	tic pole to t					
TI	C_f ad	dresses the	e stability is	ssue, but w	o the transfer hat about bar e TIA is secon	ndwidth? nd order, and	can be exp	ressed as	ensate f	or the phase	e lag due to .	R_fC_{in}
					e opamp give pole frequen	ncy, the close	1 2500 1 0	~0	/(1+s)	$/s_p)$ and a $oldsymbol{u}$	ınity-gain fre	quency
•		amping fact	tor (or, equ	livalently, th	0		$rac{}{C_f)} = $	dwidth is gi				
•				e "quality" o aved" respo	of both the ste	given by $rac{1}{Q}pprox R_fC_f\cdot$	$\overline{C_f} = \sqrt{\frac{C_f}{R_f(C_i)}}$	dwidth is gi $rac{\omega_t \cdot \omega_{p,cl}}{\omega_t - C_f)}$	ven by	ılly desirable	ϵ to keep Q !	below so
•	critical For a (value (value for a ${ m damping}$ fa ${ m c}_f$ is ap ${ m c}_f$ in order ${ m t}_f$	a "well-beh actor of $\zeta=$ oproximatel	aved" respo $1/\sqrt{2}$ (or y $=1/\sqrt{2}$	$2\zeta=rac{1}{\zeta}$ of both the stephse equivalently,	is given by $rac{1}{Q}pprox R_fC_f$ on and frequent $Q=1/\sqrt{2},$ $\sqrt{rac{2\cdot C_{in}}{R_f\omega_t}}=$ e" the zero from	$\frac{1}{C_f} = \sqrt{\frac{C_f}{R_f(C_i)}}$ $= \sqrt{\frac{C_f}{R_f(C_i)}}$ $= \frac{1}{R_f} \sqrt{\frac{2}{R_f}}$ $= \frac{1}{R_f} \sqrt{\frac{2}{R_f}}$ $= \frac{1}{R_f} \sqrt{\frac{2}{R_f}}$ $= \frac{1}{R_f} \sqrt{\frac{2}{R_f}}$	dwidth is gi $\dfrac{\omega_t}{\omega_t \cdot \omega_{p,cl}}$ ses, and it $\dfrac{\omega_t}{\omega_t}$ $\dfrac{c}{\omega_t}$ $\dfrac{c}{\omega_t}$ $\dfrac{c}{\omega_t}$ $\dfrac{c}{\omega_t}$ $\dfrac{c}{\omega_t}$	is typica $$ onse), ar $$	nd assuming	$C_{in}>>C$	f_f , the re
· ·	That is the "pa So, in of the	value for a damping factor C_f is applying a content of C_f is a content of C_f in order to according to a content of C_f in a content of C_f i	a "well-beh actor of $\zeta=0$ or achieve achieve loop to $\omega_{p,cl}$	aved" response $1/\sqrt{2}$ (or y $\omega_{p,cl}=1$ stability the	$2\zeta=rac{1}{C}$ of both the stephise equivalently, $C_fpprox 2$ exced response $1/R_f(C_f+C_f)$ exclosed-loop entains four not	is given by $rac{1}{Q}pprox R_fC_f$ or and frequency $Q=1/\sqrt{2},$ $\sqrt{rac{2\cdot C_{in}}{R_f\omega_t}}=$ e" the zero frec C_{in}) and the bandwidth calculates sources,	$\frac{1}{C_f)} = \sqrt{\frac{\alpha}{R_f(C_i)}}$ $\frac{1}{R_f} \sqrt{\frac{2}{R_f}}$	dwidth is gi $\dfrac{\omega_t}{\omega_t \cdot \omega_{p,cl}}$ ses, and it $\dfrac{\omega_t}{\omega_t}$ as $\dfrac{R_f C_{in}}{\omega_t}$ seed the parties the shot noise.	is typical onse), ar C_f show ω_t (ω_t rasitic pose of the	and assuming $\omega_z=\sqrt{\omega_{p,cl}}$ to the frequence	$C_{in}>>C$ to the geome $\overline{\omega_t}$)	f_f , the re
·	critical For a i_{na} ca may be	value for a damping factor C_f is applying a control of ω_t in the control of the problems of the problems of the problems of the control of the control of the control of the control of the problems of the control of th	a "well-beh actor of $\zeta=0$ proximatel to achieve loop to $\omega_{p,cl}$ an end of the chieve by checking the chieve by the chie	aved" response $1/\sqrt{2}$ (or y $\omega_{p,cl}=1$ stability the eminimized posing an operators of the sources size sources and the sources are sources.	$2\zeta=rac{1}{C}$ of both the stephise equivalently, $C_fpprox 2$ exced response $1/R_f(C_f+C_f)$ et closed-loop	is given by $\frac{1}{Q} pprox R_f C_f \cdot \frac{1}{Q} pprox R_f C_f \cdot \frac{1}{Q} = 1/\sqrt{2},$ by and frequency $Q = 1/\sqrt{2},$	$\frac{1}{C_f} = \sqrt{\frac{C_f}{R_f(C_i)}}$ $\frac{1}{R_f} \sqrt{\frac{2}{R_f}}$ $\frac{1}{R_f} $	dwidth is gi $\dfrac{\omega_t \cdot \omega_{p,cl}}{\omega_t}$ $\dfrac{\omega_t}{n+C_f}$ ses, and it $\dfrac{R_f C_{in}}{\omega_t}$ set the particle of R_f alue of R_f . JFET- or	is typical onse), ar C_f show a cy ω_t (a crasitic posses of the formula of the composition of the comp	and assuming $\omega_z=\sqrt{\omega_{p,cl}}$ to the frequence of the photodiode chased, with the chase of the	$C_{in}>>C$ to the geome $\overline{\omega_t}$) y $w_{p,cl}$ by the caveat the	etric means $1/f$, the results $1/f$.
·	That is the "part of the bar $i_{na}R_{f}$ and	value for a damping factor C_f is application of C_f is application of ω_t is a control or ω_t in the control of ω_t	a "well-beh actor of $\zeta=0$ proximatel to achieve a le frequence to $\omega_{p,cl}$ and be input-residual "low-noi be input-residual" $10\mu A$, the $10\mu A$ is $10\mu A$.	aved" response $1/\sqrt{2}$ (or y a "well-behave $\omega_{p,cl}=1$ stability the eminimized posing an operator by discovered by discover	$2\zeta=rac{1}{C}$ of both the stephise equivalently, $C_fpprox 2$ aved response $1/R_f(C_f+C_f)$ et closed-loop entains four not dispersally only are appropriately only are appropriately only is are appropriately existence of the stack up for left the stack up for	$\frac{1}{Q} \approx R_f C_f$ spand frequency $Q = 1/\sqrt{2}$, spand frequency $Q = 1/\sqrt{2}$, $\sqrt{\frac{2 \cdot C_{in}}{R_f \omega_t}} = 100 k\Omega$, which is $\frac{1}{Q} = 100 k\Omega$.	$\frac{1}{C_f}$ = $\sqrt{\frac{C_f}{R_f(C_i)}}$ = $\sqrt{\frac{C_f}{R_f(C_i)}}$ = $\frac{1}{R_f}$ $\sqrt{\frac{2}{R_f}}$ = equency ω_z opamp transon only except and widths) and this leave = $\frac{e_{na}}{R_f}$ = $\frac{1.8pA}{\sqrt{\sqrt{\frac{1}{N_f}}}}$ todiode appropriate todiode appropriat	dwidth is given by $\frac{\omega_t}{\omega_t + C_f}$ and it $\frac{\omega_t}{\omega_t} = 1/R_f$ and i	is typical onse), are C_f show and ω_t (and resitic position of the formal of the	Id be equal to $\omega_z = \sqrt{\omega_{p,cl}}$ to the frequence photodiode coased, with the second second coase of the second coase of th	$C_{in}>>C$ to the geome $\overline{\omega_t}$) y $w_{p,cl}$ by the caveat the	etric means $1/f$, the results $1/f$.
·	That is the "pa so, in of the i_{naR_f} in a came may be so assuming the content of the second se	value for a damping factor C_f is application of C_f is a contraction of C_f in C_f is a contraction of C_f in C_f i	a "well-beh actor of $\zeta=0$ proximated to achieve a le frequence to $\omega_{p,cl}$ in pedance at C_f should be actic with the first two note input-restriction $\overline{R}_f \approx .4p$ an opamp where $\overline{R}_f \approx .4p$ in opamp where $\overline{R}_f \approx .4p$ is we increase the same action.	aved" responsive $1/\sqrt{2}$ (or y) a "well-behave $\omega_{p,cl}=1$ stability the stability the stability the stability the stability and z or	$2\zeta=rac{1}{C}$ of both the step onse equivalently, $C_fpprox 2$ aved response $1/R_f(C_f+C_f)$ et closed-loop entains four not dispersively only are appropriately only appropriately only are appropriately only are appropriately only appropriately only are appropriately only appropriately only appropriately appropri	r_{i} given by r_{i} $r_{$	$\frac{1}{C_f} = \sqrt{\frac{R_f(C_i)}{R_f(C_i)}}$ $\frac{1}{R_f} \sqrt{\frac{2}{R_f}}$ $\frac{1}{$	dwidth is given by $\frac{\omega_t}{\omega_t + C_f}$ as seed the parameter of $\frac{\omega_t}{\omega_t}$ and in the contraction of $\frac{\partial C_{in}}{\partial t}$ and ∂C_{i	is typical C_f should resit to possible ω_t (as see of the ample volume to e_n and \overline{Hz}	Id be equal to $z=\sqrt{\omega_{p,cl}}$ be frequenced assed, with the large noise of the contract of z	$C_{in}>>C$ to the geome $\overline{\omega_t}$) y $w_{p,cl}$ by the caveat the	etric means $1/f$ and $1/f$
	That is the "part of the "part	value for a damping factor C_f is appointed an appens as \mathbf{peakir} and \mathbf{peakir}	a "well-beh actor of $\zeta=0$ proximated to achieve a le frequence to $\omega_{p,cl}$ in pedance at C_f should be attic with the first two not be input-residual "low-noi $\overline{R_f}\approx .4p$. In opamp where $\overline{R_f}\approx .4p$. In opamp where $\overline{R_f}\approx .4p$. In opamp where $\overline{R_f}\approx .4p$.	aved" response $1/\sqrt{2}$ (or y a "well-behave $\omega_{p,cl}=1$ stability the eminimized posing an operator operator by discovered by	$2\zeta=rac{1}{C}$ of both the stephise equivalently, $C_fpprox 2$ aved response $1/R_f(C_f+C_f+C_f)$ et closed-loop entains four not dispersively only are appropriately only are appropriately only are appropriately entire in $i_{ne_{na},LF}=i_{ne$	r_{i} given by r_{i} $r_{$	$\frac{1}{C_f} = \sqrt{\frac{R_f(C_i)}{R_f(C_i)}}$ $\frac{1}{R_f} \sqrt{\frac{2}{R_f}}$ $\frac{1}{$	dwidth is given by the input-reference of the part of the input-reference of the input-ref	is typical onse), and C_f show and ω_t (also reasitic points) are of the formula of T_z equencial equencial T_z	Id be equal to $z=\sqrt{\omega_{p,cl}}$ to the frequence of the contraction of	to the geome $\overline{\omega_t}$) y $w_{p,cl}$ by the caveat the e_{na} , which a	etric means $1/f$ in the following square $1/f$ in the square $1/$
	That is the "para ca may be $i_{na}R_{f}$ in a ca may be $i_{na}R_{f}$ the description of the them of	value for a damping factor C_f is appointed an appension of C_f is appointed an appension of C_f and C_f is appointed an appension of C_f and C_f is appointed an appension of C_f and C_f is appendix an appension of C_f and C_f is appendix and C_f in appendix and	a "well-beh at the latter of ζ = opproximated to achieve a proximated to achieve loop to $\omega_{p,cl}$ and the latter with latter with the lat	aved" responsive $1/\sqrt{2}$ (or y) a "well-behave $\omega_{p,cl}=1$ stability the eminimized posing an order latter, but is second to noise, let A/\sqrt{Hz} at $1/R_f(C)$ or z . This give the band of the condition of the z is the band of the z is the	$2\zeta=rac{1}{C}$ of both the stephise equivalently, $C_fpprox 2$ aved response $1/R_f(C_f+C_f+C_f)$ et closed-loop entains four not dispersively only are appropriately only are appropriately only are appropriately entire in $i_{ne_{na},LF}=i_{ne$	r_{i} given by r_{i} $r_{$	$\frac{1}{C_f} = \sqrt{\frac{1}{R_f}} \sqrt{\frac{1}{R_f}}} \sqrt{\frac{1}{R_f}} \sqrt{\frac{1}{R_f}} \sqrt{\frac{1}{R_f}} \sqrt{\frac{1}{R_f}} \sqrt{\frac{1}{R_f}} \sqrt{\frac{1}{R_f}} \sqrt{\frac{1}{R_f}} \sqrt{\frac{1}{R_f}} \sqrt{\frac{1}{R_f}} \sqrt{\frac{1}{R_f}}} \sqrt{\frac{1}{R_f}} \sqrt{\frac{1}{R_f}}} \sqrt{\frac{1}{R_f}} \sqrt$	dwidth is given by the input-reference of the parameters of $\frac{\omega_t}{\omega_t}$ and input-reference extreme the input-reference of $\frac{\partial F}{\partial t}$ of $\frac{\partial F}{\partial t}$ of the input-reference of $\frac{\partial F}{\partial t}$ of $\frac{\partial F}{\partial $	is typical onse), and C_f show and C_f show and C_f show a resition point of the following th	Id be equal to $v_z = \sqrt{\omega_{p,cl}}$ be frequenced assed, with the large noise of the actionship for actionship for the security of the securit	to the geometry $\overline{\omega_t}$ by $w_{p,cl}$ by the caveat the e_{na} , which are	etric means the square $1/f$ of the square f
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Transimpedance Gain [Ω] wise [νν/ν Hz]	The land of the la	value for a damping fa do f C f is aposed for a factor of a factor	included in the control of the cont	any be used at the feedback and width) at $1/R_f(C)$ or of the TIA has be the band and width) at $1/R_f(C)$ or of the TIA has be the band and width) at $1/R_f(C)$ or of the TIA has be the band and width) at $1/R_f(C)$ or of the TIA has be the band and width) at $1/R_f(C)$ or of the TIA has be the band and width) at $1/R_f(C)$ or of the TIA has be the band and width) at $1/R_f(C)$ or of the TIA has be the band and width) at $1/R_f(C)$ or of the TIA has be the band and width and	$2\zeta = \frac{1}{C}$ If both the step of both the step of	Equiver by $\frac{1}{12} \approx R_f C_f$. The pand frequency $\frac{1}{12} \approx R_f C_f$. The pand frequency $\frac{1}{12} \approx R_f \omega_f$ and \frac	$\frac{1}{C_f} = \sqrt{\frac{1}{C_f}}$ $\sqrt{\frac{R_f(C_i)}{R_f(C_i)}}$ $\frac{1}{R_f} = \sqrt{\frac{1}{C_i}}$ $\frac{1}{R_f} = \sqrt{\frac{1}{$	the input of the part of the	is typical for shoul	In the signal of the casco of the signal of the casco of the signal of	to the geometry a to the caveat the cavea	f_f , the reservoir and and output and out
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$\frac{1}{2} \cdot \cdot$	Critical of the state of the s	worse, the care to	The state of the	and the feedback of the feedb	$2\zeta = \frac{1}{C}$ of both the step of both the step of	$\frac{1}{2}$ $\frac{1}$	C_{I} C_{I	which is a search of a search	is typical strong and	Id be equal $C_{a} = \sqrt{\omega_{p,cl}}$ of the signal and C_{a} , resulting an output noise of the signal and C_{a} , resulting and C_{a} ,	to the geometry $w_{p,cl}$ by the caveat th	er ting nois and output akes it to get and and and output akes it to get and and output akes it to get and and and output akes it to get and and and output akes it to get and
Transimpedance Gain [0] as a contput Noise [N///Hz] output Noise [The land of the l	where k is a part of	produced and a second a sec	any well-behavior and well-behavior and well-behavior and with the entitler and well-behavior and wel	$2\zeta = \frac{1}{C}$ If both the step of both the step of both the step of	Equiver by $\frac{1}{Q} \approx R_f C_f$. Equiver by $\frac{1}{Q} \approx R_f C_f$. Equiver by $\frac{1}{Q} \approx R_f C_f$. Equiver by $\frac{1}{Q} \approx 1/\sqrt{2}$, where $\frac{1}{Q} \approx 1/\sqrt{2}$, which is a sources, an appropriate of the source of the	$\frac{1}{R} = \frac{1}{R} = \frac{1}$	which is a servered with a sign of the control of	is typical for should be s	In a second problem of the signal of the si	to the geometry $w_{p,cl}$ by the caveat th	er ting nois and output akes it to get and and and output akes it to get and and output akes it to get and and and output akes it to get and and and output akes it to get and
Transimpedance Gain [O] Output Noise [NV/Hz] Output	The land of the l	worker he had a state of a control of a cont	C C C C C C C C C C	at $1/R_f(C)$ or well-behave a very $a_f(C)$ and $a_f(C)$	$2\zeta = \frac{1}{C}$ If both the step on set of the ste	Equiver by $\frac{1}{Q} \approx R_f C_f$. $\frac{1}{Q} \approx R_f C_f$	$rac{1}{$	$\frac{\omega_t}{\omega_t}$	is typical state of the forms of the following the imputing the imputing the imputing the imputing the impedant of the impedan	In a symmatry of the signal o	$C_{in} >> C_{in}$ to the geometry $C_{in} >> C_{in}$ to the geometry $C_{in} >> C_{in}$ the caveat the eave at the eave a	er eting noise etric me er eting noise etric me er eting noise etric me er etr
Transimpedance Gain [\O] and the contitut Noise [\N/\/Hz] and the	The order of the second of th	the frequency of the fr	the Q_1 has a vertical structure of the architectors and a vertical structure of the architectors are a vertical structure. The architectors are a vertical structure of the architectors are a vertical structure of the architectors are a vertical structure. The architectors are a vertical structure of the architectors are a vertical	well-behard and a well-behard	$2\zeta = \frac{1}{C}$ If both the step onse of the step on	$\frac{1}{Q}$ (and $\frac{1}{Q}$) $\frac{1}{Q}$ (b) $\frac{1}{Q}$ (c) \frac	$rac{T}{T}$ $rac{$	which is a set is compared to the part of	is typical	Id be equal: Id be equal: $J_{2} = \sqrt{\omega_{p,d}}$ Sole frequence a photodiode a pho	to the geometry $\overline{\omega_t}$ by $w_{p,cl}$ by the caveat the end of the caveat the end of the amplified at the amplified end (resulting the resulting the resulting the resulting the caveau of the cavea	er ting noise equency and at 1/f at low and output and
Transimpedance Gain [O] active [NV/Hz] active Gain [O] active [Ontoth Noise [NV/Hz]] active Gain [O] active Ga	Critical of the second of the	that frequency and the service of th	P P P P P P P P P P	acased stage in the feedback i	$2\zeta = \frac{1}{C}$ of both the step on the s	$\frac{1}{2}$ (a) $\frac{1}{2}$ (b) $\frac{1}{2}$ (c)	$\frac{1}{S} \frac{1}{S} \frac{1}$	$\frac{\omega_t}{k} = 1/R_f$ $\frac{\omega_t}{$	is typical is typ	Id assuming Id be equal and $C_d = \sqrt{\omega_{p,d}}$ In photodiode P	$C_{in} > C_{in}$ $C_{in} > C_{in}$ to the general $\overline{\omega_i}$ to the general $\overline{\omega_i}$ $y w_{p,d}$ by the sharp C_{in} the caveal the sharp C_{in} and current makes C_{in} the device C_{in} C_{in} C_{in} the caveal the sharp C_{in} and current makes C_{in} C_{in} C_{in} the caveal the sharp C_{in} and current makes C_{in} $C_{$	er ting noise equal to the among the and output and out
Transimpedance Gain [0] Transi	Consider the second of the se	the frequency of the problem of the	the particular in the bandwidth in the two no be in put in $R_f \approx 4p$. The proximated in the particular in $R_f \approx 4p$. The proximated in the particular in $R_f \approx 4p$. The proximated in the particular in $R_f \approx 4p$. The proximated in $R_f \approx 4p$	and well-behave and well-behav	$2\zeta = \frac{1}{C}$ of both the step on the s	s given by s given by s given by s given by s	$\frac{1}{sC_{d}} = \frac{1}{sC_{d}}$ $\frac{1}$	$\frac{\omega_t}{\kappa}$ and $\frac{\omega_t}{\kappa}$ a	is typical for shoul	and assuming the second of the signature of the signatur	$C_{in} > C_{in}$ $C_{in} > C_{in}$ to the geometry to the geometry $C_{in} > C_{in}$ to the geometry $C_{in} > C_{in}$ the case at the case a	er tric me
Transimpedance Gain [0] Transi	The land of the l	that frequency and the search of the search	the properties of the propert	are the control of th	2 < 0 < 0 < 0 < 0 < 0 < 0 < 0 < 0 < 0 <	given by I given by I given by I $2 \approx R_f C_f$ in I $2 \approx R_f $	$\frac{1}{K} = \frac{1}{K} = \frac{1}$	y split between $\frac{\partial f}{\partial x}$ and it is a single in the parameter $\frac{\partial f}{\partial x}$ and it is a single in the parameter $\frac{\partial f}{\partial x}$ and it is a single in the parameter $\frac{\partial f}{\partial x}$ and it is a single in the parameter $\frac{\partial f}{\partial x}$ and it is a single in the parameter $\frac{\partial f}{\partial x}$ and it is a single in the parameter $\frac{\partial f}{\partial x}$ and it is a single in the parameter $\frac{\partial f}{\partial x}$ and it is a single in the parameter $\frac{\partial f}{\partial x}$ and it is a single in the parameter $\frac{\partial f}{\partial x}$ and it is a single in the parameter $\frac{\partial f}{\partial x}$ and it is a single in the parameter $\frac{\partial f}{\partial x}$ and it is a single in the parameter $\frac{\partial f}{\partial x}$ and it is a single in the parameter $\frac{\partial f}{\partial x}$ and it is a single in the parameter $\frac{\partial f}{\partial x}$ and it is a single in the parameter $\frac{\partial f}{\partial x}$ and it is a single in the parameter $\frac{\partial f}{\partial x}$ and it is a single in the parameter $\frac{\partial f}{\partial x}$ and it is a single in the parameter $\frac{\partial f}{\partial x}$ and it is a single in the parameter $\frac{\partial f}{\partial x}$ and it is a single in the parameter $\frac{\partial f}{\partial x}$ and it is a single in the parameter $\frac{\partial f}{\partial x}$ and it is a single in the parameter $\frac{\partial f}{\partial x}$ and it is a single in the parameter $\frac{\partial f}{\partial x}$ and it is a single in the parameter $\frac{\partial f}{\partial x}$ and it is a single in the parameter $\frac{\partial f}{\partial x}$ and it is a single in the parameter $\frac{\partial f}{\partial x}$ and it is a single in the parameter $\frac{\partial f}{\partial x}$ and it is a single in the parameter $\frac{\partial f}{\partial x}$ and it is a single in the parameter $\frac{\partial f}{\partial x}$ and it is a single in the parameter $\frac{\partial f}{\partial x}$ and it is a single in the parameter $\frac{\partial f}{\partial x}$ and it is a single in the parameter $\frac{\partial f}{\partial x}$ and it is a single in the parameter $\frac{\partial f}{\partial x}$ and it is a single in the parameter $\frac{\partial f}{\partial x}$ and it is a single in the parameter $\frac{\partial f}{\partial x}$ and it is a single in the parameter $\frac{\partial f}{\partial x}$ and it is a single in the parameter $\frac{\partial f}{\partial x}$ and it is a single in the parameter $\frac{\partial f}{\partial x}$ and it is a single in the parameter $\frac{\partial f}{\partial x}$ and it is a single in the parameter $\frac{\partial f}{\partial x}$ and it is a sin	is typical for shoul	and assuming the second of the signal and C_d , respectively. The second of the signal and C_d and C_d are second of the signal and C_d and C_d are second of the signal and C_d are second of the signal and C_d are second of the signal and C_d and C_d are second of the signal and C_d are second of the signal and C_d and C_d are second of the signal and C_d are sec	$C_{in} > C_{in}$ $C_{in} > C_{in}$ to the geometry to the geometry $C_{in} > C_{in}$ to the geometry $C_{in} > C_{in}$ the case of the case o	er can be carried and and and and and and and and and an
Transimpedance Gain [D] Nover in Section in	The solution of the solution	the frequency of the fr	produced and a second a seco	and be used by the frequency of the freq	2 + 2 + 2 + 2 + 2 + 2 + 2 + 2 + 2 + 2 +	given by $\frac{1}{12} \approx R_1 G_1$ $\frac{1}{12} \approx R_2 G_2$ $\frac{1}{12} \approx R_3 G_2$ $\frac{1}{12} \approx$	$\frac{1}{3} \frac{1}{3} \frac{1}$	$\frac{\omega_t}{\kappa} = \frac{1}{R} \frac{R}{\kappa}$	times of the control	and C_d , respectively. If the signature of the signat	$C_{in} >> C$ $C_{in} >> C$ The total periodic $C_{in} >> C$ The periodic $C_{in} >> C$ The total periodic $C_{in} >> C$ The periodic	er control er voltage and of the in and of the in and of the in are the am and of the in are the am and of the in are the am are the
Transimbedance Gain [D] Novie [N/N/Hz] and the Novie [N/N/Hz] and th	The first of the	that the cate of t	and a contribution of the frequency of	and be used by direction (Considered by direct	2 + 2 + 2 + 2 + 2 + 2 + 2 + 2 + 2 + 2 +	Graph of the short of the shor	$\frac{1}{C_f}$ $\frac{1}$	$\frac{\omega_{1}}{\omega_{1}}$ $\frac{\omega_{2}}{\omega_{1}}$ $\frac{\omega_{1}}{\omega_{1}}$ $\frac{\omega_{1}}{\omega_{2}}$ $\frac{\omega_{1}}{\omega_{1}}$ $\frac{\omega_{1}}{\omega_{1}}$ $\frac{\omega_{1}}{\omega_{2}}$ $\frac{\omega_{1}}{\omega_{1}}$ $\frac{\omega_{1}}{\omega$	is typical	and C_d , respectively and a single and a	$C_{in} >> C$ $C_{in} >> C$ The total periodic $C_{in} >> C$ The periodic $C_{in} >> C$ The total periodic $C_{in} >> C$ The periodic	er control er voltage and of the in and of the in and of the in are the am and of the in are the am and of the in are the am are the
Tall sie [IV]/Hz] and thou thou to see [IV]/Hz] and thou thou to see [IV]/Hz] and thou thou to see [IV]/Hz] and thou the see [IV] and thou the see [IV]/Hz] and the see [IV]/Hz] and the see [IV]/Hz and the s	The first of the f	the frequent of the frequent o	and a zero adentification in the same in	and believed as the feedback and	$2 = \frac{1}{10}$ $3 = \frac{1}{10}$	Frequency	$\frac{1}{sC_{f}} = \frac{1}{sC_{f}}$ $\frac{1}$	$\frac{\omega_1}{\omega_1}$ $\frac{\omega_2}{\omega_2}$ $\frac{\omega_1}{\omega_2}$ $\frac{\omega_1}{\omega_1}$ $\frac{\omega_2}{\omega_2}$ $\frac{\omega_1}{\omega_2}$ $\frac{\omega_1}{\omega_1}$ $\frac{\omega_1}{\omega_2}$ $\frac{\omega_1}{\omega_1}$ $\frac{\omega_1}{\omega_2}$	is typical	and C_d , response of the signal and	$C_{in} > C_{in}$ $C_{in} > C_{in}$ $C_{in} > C_{in}$ to the geometry $C_{in} > C_{in}$ to the capentry $C_{in} > C_{in}$ the capentry $C_{in} > C_{in}$ the capentry $C_{in} > C_{in}$ the amplified	f, the received and and and and and and and and and an
Transimpedance Gain [10] as a section of the sectio	The solution of the solution	the frequency of the strength	the Q_1 has been shared and Q_1 has been shared and Q_2 has bee	and be used the feedback of th	$2\zeta = \frac{1}{C}$	$i_{inc,out} = i_{inc}$ $i_{inc,out} = i_{in$	$\frac{1}{G_{f}} = \frac{1}{G_{f}}$	y split between $\frac{1}{2}$	is typical	and C_d , respectively and the imperior of the signal and should be a single of the signal and	$C_{in} > C_{in}$ $C_{in} > C_{in}$ $C_{in} > C_{in}$ The position of the case of the	f, the received and the and the among and th