Conception Électronique
TD / Structures

J. VILLEMEJANE

Liste des structures

Séances	Code	Structure
1	E1	Détection de luminosité ALI en comparateur + LED + Photorésistance
1	C1	Capteur de force et conditionnement ALI + capteur
1 / 2	C2	Capteur de température ALI + capteur + Zener
2	C3	Mise en forme d'un signal sonore ALI + Zener
1	P1	Photodétection montage simple ALI + LED + Photodiode
1 / 2	P2	Photodétection transimpédance ALI + LED + Photodiode
1 / 2	F2	Filtres universels ALI
2	F3	Filtres à capacités commutées ALI + Transistor
1 / 2	N2	Num / Gradateur d'intensité Microcontrôleur + PWM + Transistor + LED
1 / 2	N3	Num / Contrôle de vitesse d'un moteur Microcontrôleur + PWM + Pont en H + Moteur
2	L4	Driver de LED Transistor + LED
2	N4	Num / Pilotage d'une barrette CCD Microcontrôleur + PWM + CCD

Déroulement des séances

Séance 1 Travail en groupe sur la structure (4/5 étudiant.es)

- Définition des mots-clefs
- Fonctionnement des composants
- Découpage en fonction
- Fonctions de transfert

Séance 2 Préparation de la présentation

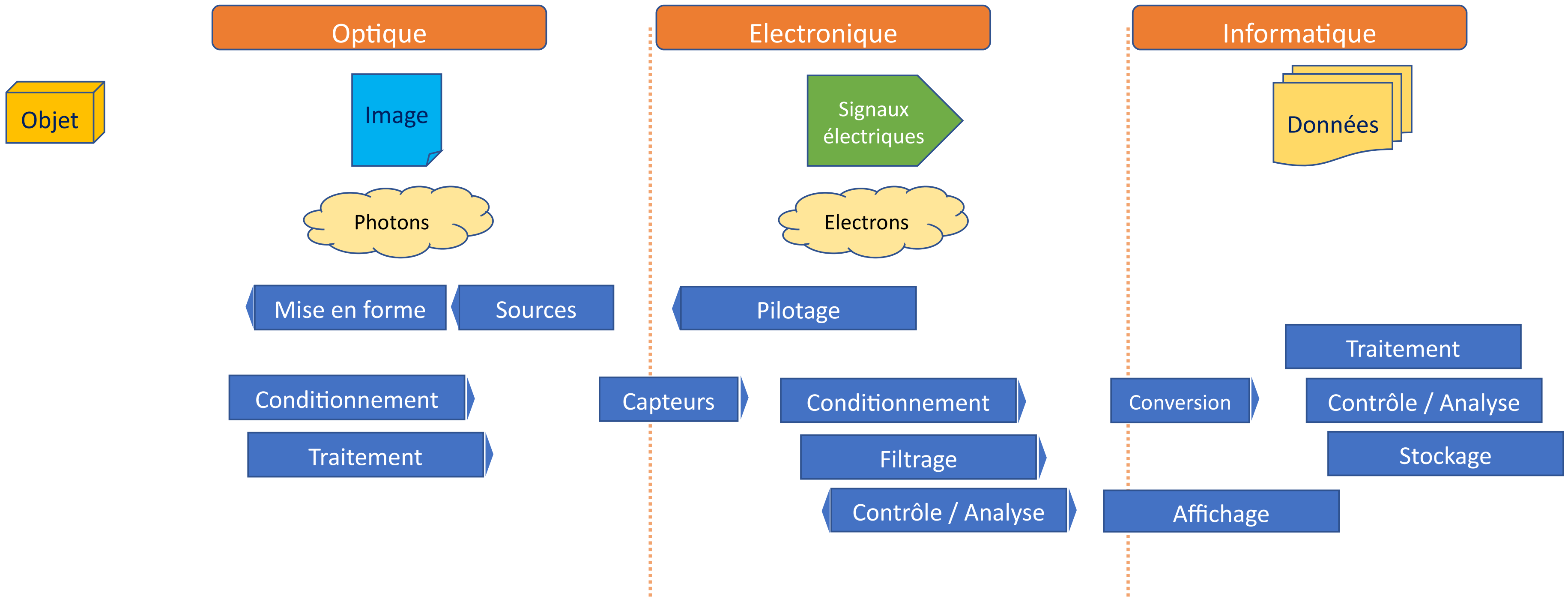
Séance 3 Présentation / 10 min

- Pédagogie / Composants / Fonctions

Séance 4 Retour sur les notions principales

Système imageant

Structure



TL07xx Low-Noise FET-Input Operational Amplifiers

1 Features

- High slew rate: 20 V/μs (TL07xH, typ)
- Low offset voltage: 1 mV (TL07xH, typ)
- Low offset voltage drift: 2 μV/°C
- Low power consumption: 940 μA/ch (TL07xH, typ)
- Wide common-mode and differential voltage ranges
  - Common-mode input voltage range includes V_{CC+}
- Low input bias and offset currents
- Low noise: V_n = 18 nV/$\sqrt{Hz}$ (typ) at f = 1 kHz
- Output short-circuit protection
- Low total harmonic distortion: 0.003% (typ)
- Wide supply voltage: ±2.25 V to ±20 V, 4.5 V to 40 V

2 Applications

- Solar energy: string and central inverter
- Motor drives: AC and servo drive control and power stage modules
- Single phase online UPS
- Three phase UPS
- Pro audio mixers
- Battery test equipment

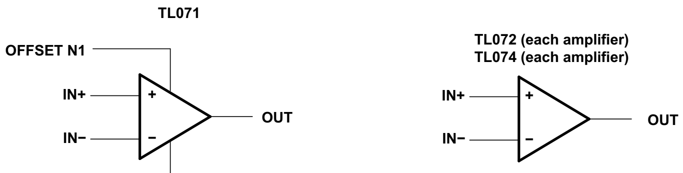
3 Description

The TL07xH (TL071H, TL072H, and TL074H) family of devices are the next-generation versions of the industry-standard TL07x (TL071, TL072, and TL074) devices. These devices provide outstanding value for cost-sensitive applications, with features including low offset (1 mV, typical), high slew rate (20 V/μs), and common-mode input to the positive supply. High ESD (1.5 kV, HBM), integrated EMI and RF filters, and operation across the full –40°C to 125°C enable the TL07xH devices to be used in the most rugged and demanding applications.

Device Information

PART NUMBER[(1)]	PACKAGE	BODY SIZE (NOM)
TL071x	PDIP (8)	9.59 mm × 6.35 mm
	SC70 (5)	2.00 mm × 1.25 mm
	SO (8)	6.20 mm × 5.30 mm
	SOIC (8)	4.90 mm × 3.90 mm
	SOT-23 (5)	1.60 mm × 1.20 mm
TL072x	PDIP (8)	9.59 mm × 6.35 mm
	SO (8)	6.20 mm × 5.30 mm
	SOIC (8)	4.90 mm × 3.90 mm
	SOT-23 (8)	2.90 mm × 1.60 mm
	TSSOP (8)	4.40 mm × 3.00 mm
TL072M	CDIP (8)	9.59 mm × 6.67 mm
	CFP (10)	6.12 mm × 3.56 mm
	LCCC (20)	8.89 mm × 8.89 mm
TL074x	PDIP (14)	19.30 mm × 6.35 mm
	SO (14)	10.30 mm × 5.30 mm
	SOIC (14)	8.65 mm × 3.91 mm
	SOT-23 (14)	4.20 mm × 2.00 mm
	SSOP (14)	6.20 mm × 5.30 mm
	TSSOP (14)	5.00 mm × 4.40 mm
TL074M	CDIP (14)	19.56 mm × 6.92 mm
	CFP (14)	9.21 mm × 6.29 mm
	LCCC (20)	8.89 mm × 8.89 mm

(1) For all available packages, see the orderable addendum at the end of the data sheet.



Logic Symbols

6 Specifications

6.1 Absolute Maximum Ratings: TL07xH

over operating ambient temperature range (unless otherwise noted) [(1)]

		MIN	MAX	UNIT
Supply voltage, $V_S = (V_{CC+}) – (V_{CC–})$		0	42	V
Signal input pins	Common-mode voltage [(3)]	$(V_{CC–}) – 0.5$	$(V_{CC+}) + 0.5$	V
	Differential voltage [(3)]		$V_S + 0.2$	V
	Current [(3)]	–10	10	mA
Output short-circuit [(2)]		Continuous		
Operating ambient temperature, T_A		–55	150	°C
Junction temperature, T_J			150	°C
Storage temperature, T_{stg}		–65	150	°C

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
(2) Short-circuit to ground, one amplifier per package.
(3) Input pins are diode-clamped to the power-supply rails. Input signals that may swing more than 0.5 V beyond the supply rails must be current limited to 10 mA or less.

6.2 Absolute Maximum Ratings: All Devices Except TL07xH

over operating free-air temperature range (unless otherwise noted) [(1)]

		MIN	MAX	UNIT
V_{CC+} - $V_{CC–}$	Supply voltage	–0.3	36	V
V_I	Input voltage [(3)]	$V_{CC–} – 0.3$	$V_{CC–} + 36$	V
I_{IK}	Input clamp current		–50	mA
	Duration of output short circuit[(2)]	Unlimited		
T_J	Operating virtual junction temperature		150	°C
	Case temperature for 60 seconds - FK package		260	°C
	Lead temperature 1.8 mm (1/16 inch) from case for 10 seconds		300	°C
T_{stg}	Storage temperature	–65	150	°C

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions* is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
(2) The output may be shorted to ground or to either supply. Temperature and supply voltages must be limited to ensure that the dissipation rating is not exceeded.
(3) Differential voltage only limited by input voltage.

6.3 ESD Ratings: TL07xH

			VALUE	UNIT
TL074H				
$V_{(ESD)}$	Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001[(1)]	±1500	V
		Charged-device model (CDM), per JEDEC specification JESD22-C101 [(2)]	±1000	
TL072H and TL071H				
$V_{(ESD)}$	Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001[(1)]	±2000	V
		Charged-device model (CDM), per JEDEC specification JESD22-C101 [(2)]	±1000	

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

6.17 Electrical Characteristics: TL07xH

For $V_S = (V_{CC+}) – (V_{CC–})$ = 4.5 V to 40 V (±2.25 V to ±20 V) at T_A = 25°C, R_L = 10 kΩ connected to V_S / 2, $V_{CM} = V_S$ / 2, and $V_{OUT} = V_S$ / 2, unless otherwise noted.

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
OFFSET VOLTAGE							
V_{OS}	Input offset voltage				±1	±4	mV
			T_A = –40°C to 125°C			±5	
dV_{OS}/dT	Input offset voltage drift		T_A = –40°C to 125°C		±2		µV/°C
PSRR	Input offset voltage versus power supply	V_S = 5 V to 40 V, $V_{CM} = V_S$ / 2	T_A = –40°C to 125°C		±1	±10	µV/V
	Channel separation	f = 0 Hz			10		µV/V
INPUT BIAS CURRENT							
I_B	Input bias current				±1	±120	pA
			DCK and DBV packages		±1	±300	pA
			T_A = –40°C to 125°C [1]			±5	nA
I_{OS}	Input offset current				±0.5	±120	pA
			DCK and DBV packages		±0.5	±250	pA
			T_A = –40°C to 125°C [1]			±5	nA
NOISE							
E_N	Input voltage noise	f = 0.1 Hz to 10 Hz			9.2		$µV_{PP}$
					1.4		$µV_{RMS}$
e_N	Input voltage noise density	f = 1 kHz			37		nV/√Hz
		f = 10 kHz			21		
i_N	Input current noise	f = 1 kHz			80		fA/√Hz
INPUT VOLTAGE RANGE							
V_{CM}	Common-mode voltage range			$(V_{CC–})$ + 1.5		(V_{CC+})	V
CMRR	Common-mode rejection ratio	V_S = 40 V, $(V_{CC–})$ + 2.5 V < V_{CM} < (V_{CC+}) – 1.5 V		100	105		dB
CMRR	Common-mode rejection ratio		T_A = –40°C to 125°C	95			dB
CMRR	Common-mode rejection ratio	V_S = 40 V, $(V_{CC–})$ + 2.5 V < V_{CM} < (V_{CC+})		90	105		dB
CMRR	Common-mode rejection ratio		T_A = –40°C to 125°C	80			dB
INPUT CAPACITANCE							
Z_{ID}	Differential				100 || 2		MΩ || pF
Z_{ICM}	Common-mode				6 || 1		TΩ || pF
OPEN-LOOP GAIN							
A_{OL}	Open-loop voltage gain	V_S = 40 V, $V_{CM} = V_S$ / 2, $(V_{CC–})$ + 0.3 V < V_O < (V_{CC+}) – 0.3 V	T_A = –40°C to 125°C	118	125		dB
A_{OL}	Open-loop voltage gain	V_S = 40 V, $V_{CM} = V_S$ / 2, R_L = 2 kΩ, $(V_{CC–})$ + 1.2 V < V_O < (V_{CC+}) – 1.2 V	T_A = –40°C to 125°C	115	120		dB
FREQUENCY RESPONSE							
GBW	Gain-bandwidth product				5.25		MHz
SR	Slew rate	V_S = 40 V, G = +1, C_L = 20 pF			20		V/µs
t_S	Settling time	To 0.1%, V_S = 40 V, V_{STEP} = 10 V , G = +1, CL = 20 pF			0.63		µs
		To 0.1%, V_S = 40 V, V_{STEP} = 2 V , G = +1, CL = 20 pF			0.56		
		To 0.01%, V_S = 40 V, V_{STEP} = 10 V , G = +1, CL = 20 pF			0.91		
		To 0.01%, V_S = 40 V, V_{STEP} = 2 V , G = +1, CL = 20 pF			0.48		
	Phase margin	G = +1, R_L = 10kΩ, C_L = 20 pF			56		°
	Overload recovery time	V_{IN} × gain > V_S			300		ns

6.24 Switching Characteristics: TL07xM

$V_{CC±}$ = ±15 V, T_A = 25°C

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
SR	Slew rate at unity gain	V_I = 10 V, C_L = 100 pF	R_L = 2 kΩ, See Figure 7-1	5	13		V/µs
t_r	Rise-time overshoot factor	V_I = 20 V, C_L = 100 pF	R_L = 2 kΩ, See Figure 7-1		0.1		µs
					20%		
V_n	Equivalent input noise voltage	R_S = 20 Ω	f = 1 kHz		18		nV/√Hz
			f = 10 Hz to 10 kHz		4		µV
I_n	Equivalent input noise current	R_S = 20 Ω	f = 1 kHz		0.01		pA/√Hz
THD	Total harmonic distortion	$V_I$rms = 6 V, R_L ≥ 2 kΩ, f = 1 kHz	A_{VD} = 1, RS ≤ 1 kΩ		0.003%		

6.25 Switching Characteristics: TL07xC, TL07xAC, TL07xBC, TL07xI

$V_{CC±}$ = ±15 V, T_A = 25°C

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
SR	Slew rate at unity gain	V_I = 10 V, C_L = 100 pF	R_L = 2 kΩ, See Figure 7-1	8	13		V/µs
t_r	Rise-time overshoot factor	V_I = 20 V, C_L = 100 pF	R_L = 2 kΩ, See Figure 7-1		0.1		µs
					20%		
V_n	Equivalent input noise voltage	R_S = 20 Ω	f = 1 kHz		18		nV/√Hz
			f = 10 Hz to 10 kHz		4		µV
I_n	Equivalent input noise current	R_S = 20 Ω	f = 1 kHz		0.01		pA/√Hz
THD	Total harmonic distortion	$V_I$rms = 6 V, R_L ≥ 2 kΩ, f = 1 kHz	A_{VD} = 1, RS ≤ 1 kΩ		0.003%		

6.27 Typical Characteristics: All Devices Except TL07xH

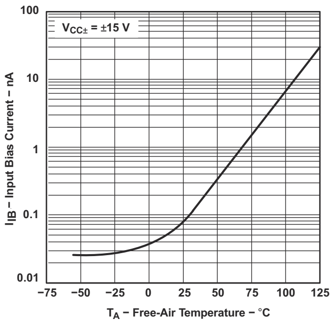


Figure 6-40. Input Bias Current vs Free-Air Temperature

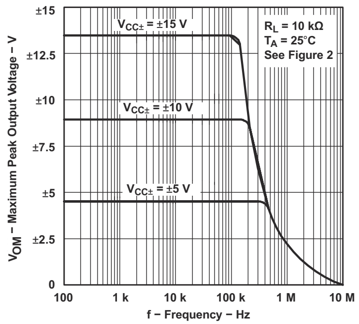


Figure 6-41. Maximum Peak Output Voltage vs Frequency

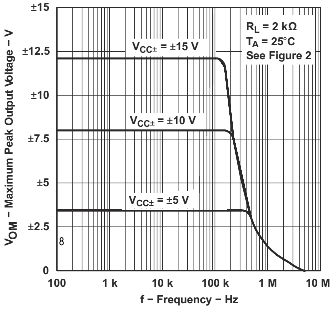


Figure 6-42. Maximum Peak Output Voltage vs Frequency

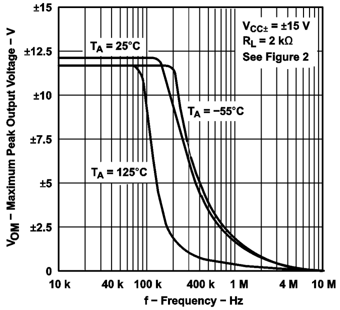


Figure 6-43. Maximum Peak Output Voltage vs Frequency

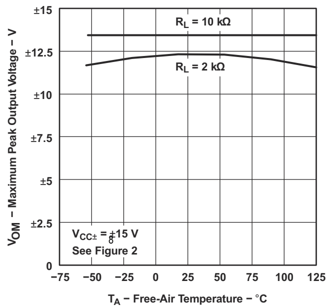


Figure 6-44. Maximum Peak Output Voltage vs Free-Air Temperature

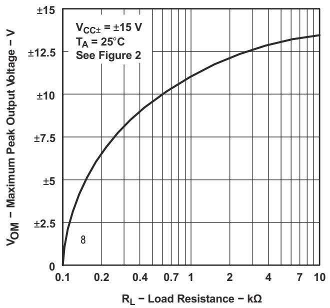


Figure 6-45. Maximum Peak Output Voltage vs Load Resistance

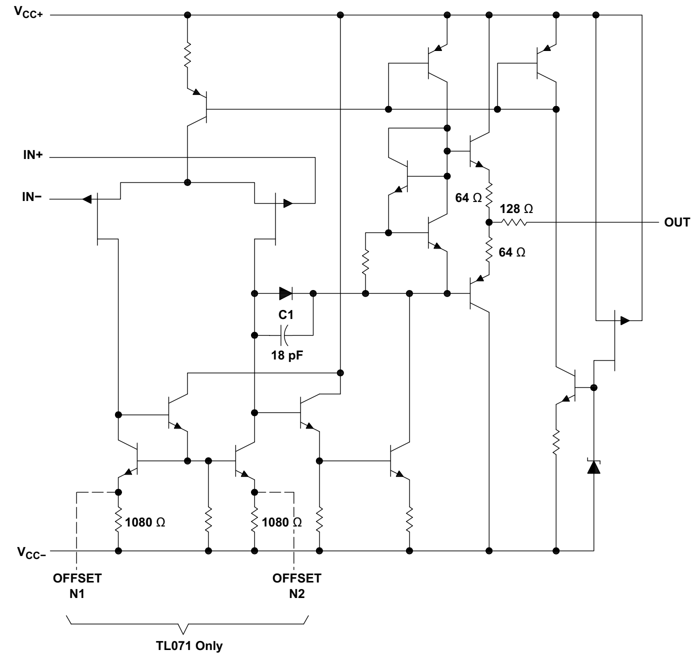
8 Detailed Description

8.1 Overview

The TL07xH (TL071H, TL072H, and TL074H) family of devices are the next-generation versions of the industry-standard TL07x (TL071, TL072, and TL074) devices. These devices provide outstanding value for cost-sensitive applications, with features including low offset (1 mV, typ), high slew rate (25 V/µs, typ), and common-mode input to the positive supply. High ESD (1.5 kV, HBM), integrated EMI and RF filters, and operation across the full –40°C to 125°C enable the TL07xH devices to be used in the most rugged and demanding applications.

The C-suffix devices are characterized for operation from 0°C to 70°C. The I-suffix devices are characterized for operation from −40°C to +85°C. The M-suffix devices are characterized for operation over the full military temperature range of −55°C to +125°C.

8.2 Functional Block Diagram



All component values shown are nominal.

COMPONENT COUNT†			
COMPONENT TYPE	TL071	TL072	TL074
Resistors	11	22	44
Transistors	14	28	56
JFET	2	4	6
Diodes	1	2	4
Capacitors	1	2	4
epi-FET	1	2	4

† Includes bias and trim circuitry

LM339, LM239, LM139, LM2901 Quad Differential Comparators

1 Features

- Wide Supply Ranges
  - Single Supply: 2 V to 36 V (Tested to 30 V for Non-V Devices and 32 V for V-Suffix Devices)
  - Dual Supplies: ±1 V to ±18 V (Tested to ±15 V for Non-V Devices and ±16 V for V-Suffix Devices)
- Low Supply-Current Drain Independent of Supply Voltage: 0.8 mA (Typical)
- Low Input Bias Current: 25 nA (Typical)
- Low Input Offset Current: 3 nA (Typical) (LM139)
- Low Input Offset Voltage: 2 mV (Typical)
- Common-Mode Input Voltage Range Includes Ground
- Differential Input Voltage Range Equal to Maximum-Rated Supply Voltage: ±36 V
- Low Output Saturation Voltage
- Output Compatible With TTL, MOS, and CMOS
- On Products Compliant to MIL-PRF-38535, All Parameters Are Tested Unless Otherwise Noted. On All Other Products, Production Processing Does Not Necessarily Include Testing of All Parameters.

2 Applications

- Industrial
- Automotive
  - Infotainment and Clusters
  - Body Control Modules
- Power Supervision
- Oscillators
- Peak Detectors
- Logic Voltage Translation

3 Description

The LMx39x and the LM2901x devices consist of four independent voltage comparators that are designed to operate from a single power supply over a wide range of voltages. Operation from dual supplies also is possible, as long as the difference between the two supplies is 2 V to 36 V, and V_{CC} is at least 1.5 V more positive than the input common-mode voltage. Current drain is independent of the supply voltage. The outputs can be connected to other open-collector outputs to achieve wired-AND relationships.

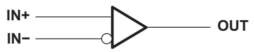
The LM139 and LM139A devices are characterized for operation over the full military temperature range of –55°C to +125°C. The LM239 and LM239A devices are characterized for operation from –25°C to +85°C. The LM339 and LM339A devices are characterized for operation from 0°C to 70°C. The LM2901, LM2901AV, and LM2901V devices are characterized for operation from –40°C to +125°C.

Device Information(1)

PART NUMBER	PACKAGE	BODY SIZE (NOM)
LM139x	CDIP (14)	21.30 mm × 7.60 mm
	LCCC (20)	8.90 mm × 8.90 mm
	CFP (14)	9.20 mm × 6.29 mm
LM139x, LM239x, LM339x, LM2901x	SOIC (14)	8.70 mm × 3.90 mm
LM239, LM339x, LM2901	PDIP (14)	19.30 mm × 6.40 mm
LM239, LM2901	TSSOP (14)	5.00 mm × 4.40 mm
LM339x, LM2901	SO (14)	10.20 mm × 5.30 mm
LM339x	SSOP (14)	6.50 mm × 5.30 mm

(1) For all available packages, see the orderable addendum at the end of the data sheet.

Simplified Schematic



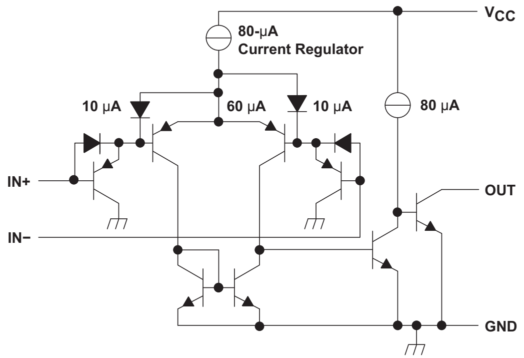
8 Detailed Description

8.1 Overview

The LMx39 and LM2901x are quad comparators with the ability to operate up to an absolute maximum of 36 V on the supply pin. This standard device has proven ubiquity and versatility across a wide range of applications. This is due to very wide supply voltages range (2 V up to 32 V), low Iq, and fast response of the device.

The open-drain output allows the user to configure the output logic low voltage (V_{OL}) and allows the comparator to be used in AND functionality.

8.2 Functional Block Diagram



COMPONENT COUNT	
Epi-FET	1
Diodes	2
Resistors	2
Transistors	30

Figure 6. Schematic (Each Comparator)

8.3 Feature Description

The comparator consists of a PNP Darlington pair input, allowing the device to operate with very high gain and fast response with minimal input bias current. The input Darlington pair creates a limit on the input common-mode voltage capability, allowing the comparator to accurately function from ground to (V_{CC} – 1.5 V) differential input. Allow for (V_{CC} – 2 V) at cold temperature.

The output consists of an open-collector NPN (pulldown or low-side) transistor. The output NPN sinks current when the negative input voltage is higher than the positive input voltage and the offset voltage. The VOL is resistive and scales with the output current. See the *Specifications* section for V_{OL} values with respect to the output current.

8.4 Device Functional Modes

8.4.1 Voltage Comparison

The comparator operates solely as a voltage comparator, comparing the differential voltage between the positive and negative pins and outputting a logic low or high impedance (logic high with pullup) based on the input differential polarity.

9 Application and Implementation

NOTE

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Validate and test the design implementation to confirm system functionality.

9.1 Application Information

Typically, a comparator compares either a single signal to a reference, or to two differnt signals. Many users take advantage of the open-drain output to drive the comparison logic output to a logic voltage level to an MCU or logic device. The wide supply range and high voltage capability makes LMx39 or LM2901x optimal for level shifting to a higher or lower voltage.

9.2 Typical Application

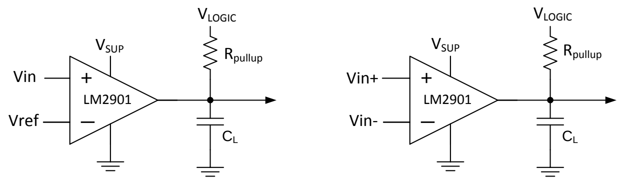


Figure 7. Single-ended and Differential Comparator Configurations

9.2.1 Design Requirements

For this design example, use the parameters listed in Table 1 as the input parameters.

Table 1. Design Parameters

DESIGN PARAMETER	EXAMPLE VALUE
Input Voltage Range	0 V to Vsup-1.5 V
Supply Voltage	4.5 V to V_{CC} maximum
Logic Supply Voltage	0 V to V_{CC} maximum
Output Current (R_{PULLUP})	1 µA to 4 mA
Input Overdrive Voltage	100 mV
Reference Voltage	2.5 V
Load Capacitance (C_L)	15 pF

9.2.2 Detailed Design Procedure

When using the LMx39 in a general comparator application, determine the following:

- Input voltage range
- Minimum overdrive voltage
- Output and drive current
- Response time

9.2.2.1 Input Voltage Range

When choosing the input voltage range, the input common-mode voltage range (V_{ICR}) must be taken in to account. If temperature operation is above or below 25°C the V_{ICR} can range from 0 V to V_{CC}– 2 V. This limits the input voltage range to as high as V_{CC}– 2 V and as low as 0 V. Operation outside of this range can yield incorrect comparisons.

The following list describes the outcomes of some input voltage situations.

- When both IN– and IN+ are both within the common-mode range:
  - If IN– is higher than IN+ and the offset voltage, the output is low and the output transistor is sinking current
  - If IN– is lower than IN+ and the offset voltage, the output is high impedance and the output transistor is not conducting
- When IN– is higher than common mode and IN+ is within common mode, the output is low and the output transistor is sinking current
- When IN+ is higher than common mode and IN– is within common mode, the output is high impedance and the output transistor is not conducting
- When IN– and IN+ are both higher than common mode, the output is low and the output transistor is sinking current

9.2.2.2 Minimum Overdrive Voltage

Overdrive voltage is the differential voltage produced between the positive and negative inputs of the comparator over the offset voltage (V_{IO}). To make an accurate comparison, the overdrive voltage (V_{OD}) must be higher than the input offset voltage (V_{IO}). Overdrive voltage can also determine the response time of the comparator, with the response time decreasing with increasing overdrive. Figure 8 and Figure 9 show positive and negative response times with respect to overdrive voltage.

9.2.2.3 Output and Drive Current

Output current is determined by the load and pullup resistance and logic and pullup voltage. The output current produces a low-level output voltage (V_{OL}) from the comparator, where V_{OL} is proportional to the output current.

The output current can also effect the transient response.

9.2.2.4 Response Time

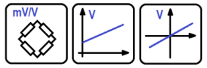
Response time is a function of input over-drive. See the *Typical Characteristics* graphs for typical response times. The rise and fall times can be determined by the load capacitance (C_L), load/pull-up resistance (R_{PULLUP}) and equivalent collector-emitter resistance (R_{CE}).

- The rise time (τ_R) is approximately $\tau_R \sim R_{PULLUP} \times C_L$
- The fall time (τ_F) is approximately $\tau_F \sim R_{CE} \times C_L$
  - R_{CE} can be determined by taking the slope of Figure 3 in its linear region at the desired temperature, or by dividing the V_{OL} by I_{OUT}

FN3000

Capteur de force Traction et Compression

CE



CARACTERISTIQUES

- Applications statiques et dynamiques
- Linéarité 0.1% E.M.
- Version haut niveau (amplificateur intégrée) en option
- Indice de protection IP65 en option

APPLICATIONS

- Contrôle de procédés d'assemblage
- Pesage en environnement sévère
- Bancs d'essais de fatigue
- Régulation de commandes hydrauliques
- Laboratoire de recherche

SPECIFICATIONS

- **Grande robustesse**
- **Etendues de mesure de 10 à 1000 kN [2 à 200 klbf]**
- **Applications statiques et dynamiques**
- **Corps en aluminium ou en acier inoxydable**
- **Indice de protection élevé**
- **Sortie haut niveau avec amplificateur intégré**

Les capteurs d'effort de la série **FN3000** allient solidité et précision. Leur structure et le positionnement des ponts de jauges, les rendent peu sensibles aux efforts transverses. Ils sont particulièrement adaptés aux bancs d'essai comme au procédés d'assemblage et ce même dans des environnements difficiles.

L'indice de protection des capteurs **FN3000** peut être encore augmenté sur demande. La sortie analogique haut niveau intégrée au capteur lui confère une grande polyvalence et une facilité d'utilisation.

Concepteur et producteur de ce capteur, TE CONNECTIVITY propose une vaste gamme d'électroniques de conditionnement et de traitement permettant l'alimentation du capteur, l'amplification du signal et l'affichage de la mesure sur indicateur numérique, pour vous fournir une chaîne de mesure complète, appairée, étalonnée et donc prête à l'emploi.

Afin de vous permettre l'utilisation de nos capteurs avec un maximum d'efficacité et de sécurité, un document d'instruction d'utilisation est disponible sur demande.

ETENDUES DE MESURE (EM)

Etendues en N	10k	25k	50k	100k	200k	500k	1000k
Etendues en lbf	2k	5k	10k	20k	40k	100k	200k
Raideur en N/m	$2.5x10^8$	$5x10^8$	$1x10^9$	$2x10^9$	$3x10^9$	$5x10^9$	$7x10^9$
Raideur en lbf/ft	$1.7x10^7$	$3.4x10^7$	$6.9x10^7$	$1.4x10^8$	$2.1x10^8$	$3.4x10^8$	$4.8x10^8$
Matériau	Aluminium	Acier inoxydable					

CARACTERISTIQUES (valeurs typiques à température 23±3°C)

Paramètres	
Plage d'utilisation en température (PUT)	-20 à 80° C [-4 à 176° F]
Plage de compensation en température (PCT)	0 à 60º C [32 à 140° F]
Dérive du zéro dans la PCT	<0.5% E.M. / 50º C [/100° F]
Dérive de sensibilité dans la PCT	<1% de la valeur lue / 50º C [/100° F]
Surcharge admissible	
Sans altération des performances	1.5 x E.M.
Sans destruction	3 x E.M.
Précision	
Linéarité	±0.1% E.M.
Hystérésis	±0.1% E.M.

Caractéristiques électriques

Modèle	**FN3000** [1]	**FN3000-A1**	**FN3000-A2**
Alimentation	1 à 10 Vcc	10 à 30Vcc	±15Vcc (±12 à ±18Vcc)
Sensibilité à l'E.M. [2]	±2mV/V	±2V ±0.2V	±5V ±0.2V
Décalage initial	±1mV	2.5V ±0.2V	0V ±0.2V
Impédance d'entrée / Consommation	350 à 700Ω	<50mA	50mA
Impédance de sortie	350 à 700Ω	1 kΩ [6]	1 kΩ [6]
Isolement sous 50Vcc	≥100MΩ	≥100MΩ	≥100MΩ

Notes

1. Capteur caractérisé avec une tension d'alimentation 10 Vcc en standard
2. Signal positif en traction en câblage standard. Autres sorties signal sur demande
3. Sortie électrique par embase Jaeger miniature, fiche mobile fournie avec serre-câble.
4. Matériaux: corps en acier inoxydable ou alliage d'aluminium en fonction de l'E.M. capot en aluminium
5. Indice de protection: IP50 (autres indices en option)
6. Impédance de sortie < 100 Ω sur demande
7. Certification CE suivant les normes EN 61010-1, EN 50081-1, EN 50082-1

ENCOMBREMENT ET CABLAGES (METRIQUE)

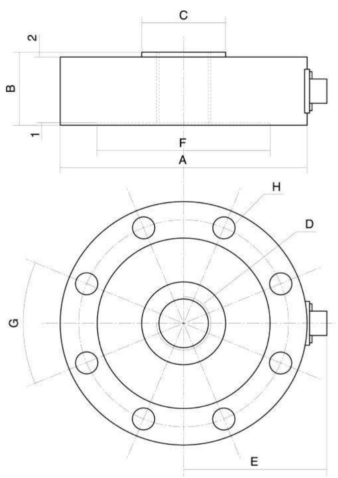
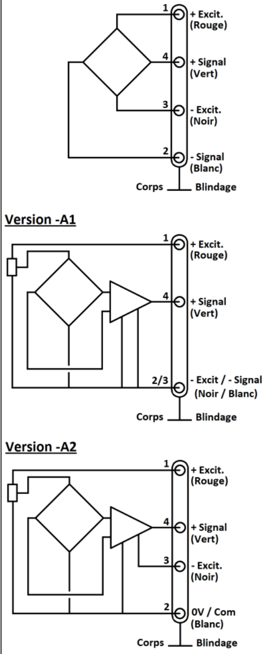
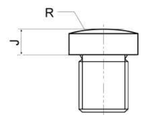


Schéma électrique



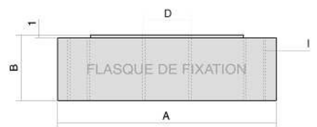
EH: Embout Hémisphérique



Dimensions en mm

E.M	J	R
10 kN	12	80
25 kN	12	80
50 kN	12	80
100 kN	20	250
200 kN	20	250
500 kN	30	400
1000 kN	60	400

FF: Flasque de Fixation



Dimensions en mm [inch]

E.M. en N [en lbf]	10k [2k]	25k [5k]	50k [10k]	100k [20k]	200k [40k]	500k [100k]	1000k [200k]
A	100 [3.94]			150 [5.91]		195 [7.68]	272 [10.71]
B	30 [1.18]			40 [1.57]		60 [2.36]	80 [3.15]
C	34 [1.34]			65 [2.56]		87 [3.43]	120 [4.72]
D (filetage)	M20x1.5			M32x2		M56x2	M80x3
E	65 [2.56]			90 [3.54]		106 [4.17]	150 [5.91]
F	70 [2.76]			100 [3.94]		143 [5.63]	186 [7.32]
G	45°			30°		22.5°	
H	8x8.2 /⇆85			12x10.4 /⇆125		16x16.2 /⇆169	16x24.5 /⇆229
I	M8 /⇆85			M10 /⇆125		M16 /⇆169	M24 /⇆229
Serrage vis (m.kg)	2.2	2.5	2.5	5	5	15	50
Serrage vis (lbf/ft)	15.9	18.1	18.1	36.2	36.2	108.5	361.7

OPTIONS

A1 : Sortie amplifiée Tension avec alimentation en Mono-tension
A2 : Sortie amplifiée Tension avec alimentation en Bi-tension
ET1 : PCT -20 à 100º C [-4 à 212° F] PCT = PUT
ET2 : PCT -40 à 120º C [-40 à 248° F] PCT = PUT
ET3 : PCT -40 à 150º C [-40 à 302° F] PCT = PUT (non compatible avec les options A1 et A2)
PE : Sortie par presse-étoupe avec 2 m [6.5 ft] de câble
PE/L00M : Sortie presse-étoupe avec longueur de câble spéciale, replacer "00" par la longueur totale en mètres

REFERENCE ET CODIFICATION

FN3000 - A1 - 10KN - /PE/ET1

- **Options (ET1, ..)**
- **Etendue de mesure en Newton**
- **Version amplifiée (vide, A1 ou A2)**
- **Modèle**

ACCESSOIRES FOURNIS

EFMX-7M : fiche mobile Jaeger 530-272-006 avec serre-câble 530-371-006 pour standard and ET1
EFMX-7H : fiche mobile Jaeger 530-604-006 et serre-câble 530-693-006 pour les options ET2 or ET3

ACCESSOIRES RECOMMANDES

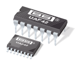
EH : Embout hémisphérique
FF : Flasque de fixation

NORTH AMERICA
Measurement Specialties, Inc.,
a TE Connectivity Company
Phone: +1 800 522 6752
Email: customercare.frmt@te.com

EUROPE
Measurement Specialties (Europe), Ltd.
a TE Connectivity Company
Phone: +31 73 624 6999
Email: customercare.lcsb@te.com

ASIA
Measurement Specialties (China), Ltd.,
a TE Connectivity Company
Phone +86 400 820 6015
Email: customercare.shzn@te.com

TE.com/sensorsolutions



UNIVERSAL ACTIVE FILTER

Check for Samples: UAF42

FEATURES

- VERSATILE:
  - Low-Pass, High-Pass
  - Band-Pass, Band-Reject
- SIMPLE DESIGN PROCEDURE
- ACCURATE FREQUENCY AND Q:
  - Includes On-Chip 1000pF ±0.5% Capacitors

APPLICATIONS

- TEST EQUIPMENT
- COMMUNICATIONS EQUIPMENT
- MEDICAL INSTRUMENTATION
- DATA ACQUISITION SYSTEMS
- MONOLITHIC REPLACEMENT FOR UAF41

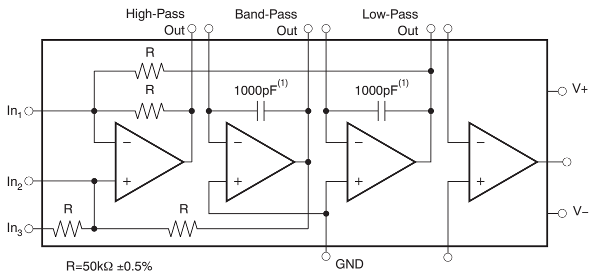
DESCRIPTION

The UAF42 is a universal active filter that can be configured for a wide range of low-pass, high-pass, and band-pass filters. It uses a classic state-variable analog architecture with an inverting amplifier and two integrators. The integrators include on-chip 1000pF capacitors trimmed to 0.5%. This architecture solves one of the most difficult problems of active filter design—obtaining tight tolerance, low-loss capacitors.

A DOS-compatible filter design program allows easy implementation of many filter types, such as Butterworth, Bessel, and Chebyshev. A fourth, uncommitted FET-input op amp (identical to the other three) can be used to form additional stages, or for special filters such as band-reject and Inverse Chebyshev.

The classical topology of the UAF42 forms a time-continuous filter, free from the anomalies and switching noise associated with switched-capacitor filter types.

The UAF42 is available in 14-pin plastic DIP and SOIC-16 surface-mount packages, specified for the –25°C to +85°C temperature range.



NOTE: (1) ±0.5%.

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

ELECTRICAL CHARACTERISTICS

At T_A = +25°C, and V_S = ±15V, unless otherwise noted.

PARAMETER	CONDITIONS	UAF42AP, AU MIN	TYP	MAX	UNIT
FILTER PERFORMANCE					
Frequency Range, f_n			0 to 100		kHz
Frequency Accuracy	f = 1kHz			1	%
vs Temperature			0.01		%/°C
Maximum Q			400		—
Maximum (Q • Frequency) Product			500		kHz
Q vs Temperature	$(f_O \cdot Q) < 10^4$		0.01		%/°C
	$(f_O \cdot Q) < 10^5$		0.025		%/°C
Q Repeatability	$(f_O \cdot Q) < 10^5$		2		%
Offset Voltage, Low-Pass Output				±5	mV
Resistor Accuracy			0.5	1	%
OFFSET VOLTAGE(1)					
Input Offset Voltage			±0.5	±5	mV
vs Temperature			±3		μV/°C
vs Power Supply	V_S = ±6V to ±18V	80	96		dB
INPUT BIAS CURRENT(1)					
Input Bias Current	V_{CM} = 0V		10	50	pA
Input Offset Current	V_{CM} = 0V		5		pA
NOISE					
Input Voltage Noise					
Noise Density: f = 10Hz			25		nV/√Hz
Noise Density: f = 10kHz			10		nV/√Hz
Voltage Noise: BW = 0.1Hz to 10Hz			2		μV_{PP}
Input Bias Current Noise					
Noise Density: f = 10kHz			2		fA/√Hz
INPUT VOLTAGE RANGE(1)					
Common-Mode Input Range			±11.5		V
Common-Mode Rejection	V_{CM} = ±10V	80	96		dB
INPUT IMPEDANCE(1)					
Differential			10^{13} || 2		Ω || pF
Common-Mode			10^{13} || 6		Ω || pF
OPEN-LOOP GAIN(1)					
Open-Loop Voltage Gain	V_O = ±10V, R_L = 2kΩ	90	126		dB
FREQUENCY RESPONSE					
Slew Rate			10		V/μs
Gain-Bandwidth Product	G = +1		4		MHz
Total Harmonic Distortion	G = +1, f = 1kHz		0.1		%
OUTPUT(1)					
Voltage Output	R_L = 2kΩ	±11	±11.5		V
Short Circuit Current			±25		mA

(1) Specifications apply to uncommitted op amp, A_4. The three op amps forming the filter are identical to A_4 but are tested as a complete filter.

APPLICATION INFORMATION

The UAF42 is a monolithic implementation of the proven state-variable analog filter topology. This device is pin-compatible with the popular UAF41 analog filter, and it provides several improvements.

The slew rate of the UAF42 has been increased to 10V/µs, versus 1.6V/µs for the UAF41. Frequency • Q product of the UAF42 has been improved, and the useful natural frequency extended by a factor of four to 100kHz. FET input op amps on the UAF42 provide very low input bias current. The monolithic construction of the UAF42 provides lower cost and improved reliability.

DESIGN PROGRAM

Application report SBFA002 (available for download at www.ti.com) and a computer-aided design program also available from Texas Instruments, make it easy to design and implement many kinds of active filters. The DOS-compatible program guides you through the design process and automatically calculates component values.

Low-pass, high-pass, band-pass and band-reject (notch) filters can be designed. The program supports the three most commonly-used all-pole filter types: Butterworth, Chebyshev and Bessel. The less-familiar inverse Chebyshev is also supported, providing a smooth passband response with ripple in the stop band.

With each data entry, the program automatically calculates and displays filter performance. This feature allows a spreadsheet-like *what-if* design approach. For example, a user can quickly determine, by trial and error, how many poles are required for a desired attenuation in the stopband. Gain/phase plots may be viewed for any response type.

The basic building element of the most commonly-used filter types is the second-order section. This section provides a complex-conjugate pair of poles. The natural frequency, ω_n, and Q of the pole pair determine the characteristic response of the section. The low-pass transfer function is shown in Equation 1:

$$\frac{V_O(s)}{V_I(s)} = \frac{A_{LP}\omega_n^2}{s^2 + s\,\omega_n/Q + \omega_n^2} \qquad (1)$$

The high-pass transfer function is given by Equation 2:

$$\frac{V_{HP}(s)}{V_I(s)} = \frac{A_{HP}s^2}{s^2 + s\,\omega_n/Q + \omega_n^2} \qquad (2)$$

The band-pass transfer function is calculated using Equation 3:

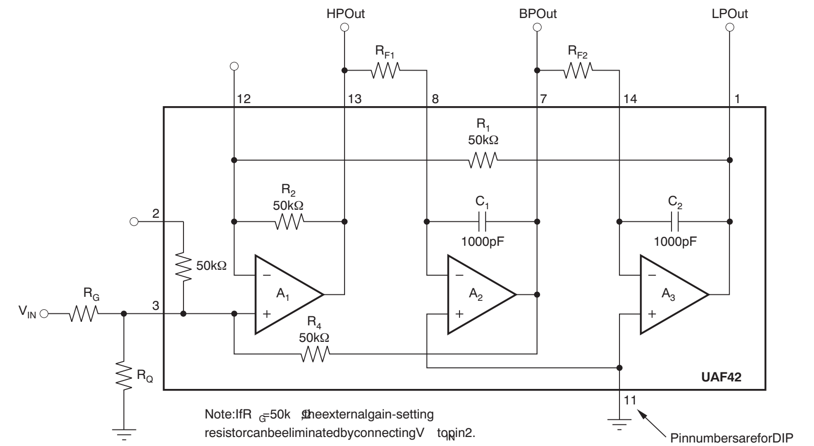
$$\frac{V_{BP}(s)}{V_I(s)} = \frac{A_{BP}(\omega_n/Q)s}{s^2 + s\,\omega_n/Q + \omega_n^2} \qquad (3)$$

A band-reject response is obtained by summing the low-pass and high-pass outputs, yielding the transfer function shown in Equation 4:

$$\frac{V_{BR}(s)}{V_I(s)} = \frac{A_{BR}(s^2 + \omega_n^2)}{s^2 + s\,\omega_n/Q + \omega_n^2} \qquad (4)$$

The most common filter types are formed with one or more cascaded second-order sections. Each section is designed for ω_n and Q according to the filter type (Butterworth, Bessel, Chebyshev, etc.) and cutoff frequency. While tabulated data can be found in virtually any filter design text, the design program eliminates this tedious procedure.

Second-order sections may be noninverting (Figure 1) or inverting (Figure 2). Design equations for these two basic configurations are shown for reference. The design program solves these equations, providing complete results, including component values.



Note: If R_G = 50kΩ, the external gain-setting resistor can be eliminated by connecting V_{IN} to pin 2.

Pin numbers are for DIP package. SOIC-16 pinout is different.

Design Equations

1. $\omega_n^2 = \dfrac{R_2}{R_1 R_{F1} R_{F2} C_1 C_2}$

2. $Q = \dfrac{1 + \dfrac{R_4(R_G + R_Q)}{R_G R_Q}}{1 + \dfrac{R_2}{R_1}} \left(\dfrac{R_2 R_{F1} C_1}{R_1 R_{F2} C_2}\right)^{1/2}$

3. $QA_{LP} = QA_{HP}\left(\dfrac{R_1}{R_2}\right) = A_{BP}\left(\dfrac{R_1 R_{F1} C_1}{R_2 R_{F2} C_2}\right)^{1/2}$

4. $A_{LP} = \dfrac{1 + \dfrac{R_1}{R_2}}{R_G\left(\dfrac{1}{R_G} + \dfrac{1}{R_Q} + \dfrac{1}{R_4}\right)}$

5. $A_{HP} = \dfrac{R_2}{R_1} A_{LP} = \dfrac{1 + \dfrac{R_2}{R_1}}{R_G\left(\dfrac{1}{R_G} + \dfrac{1}{R_Q} + \dfrac{1}{R_4}\right)}$

6. $A_{BP} = \dfrac{R_4}{R_G}$

Figure 1. Noninverting Pole-Pair

GaAs-IR-Lumineszenzdioden
GaAs Infrared Emitters
Lead (Pb) Free Product - RoHS Compliant

SFH 415

Wesentliche Merkmale

- GaAs-LED mit sehr hohem Wirkungsgrad
- Hohe Zuverlässigkeit
- UL Version erhältlich
- Gute spektrale Anpassung an Si-Fotoempfänger
- SFH 415: Gehäusegleich mit SFH 300, SFH 203

Features

- Very highly efficient GaAs-LED
- High reliability
- UL version available
- Spectral match with silicon photodetectors
- SFH 415: Same package as SFH 300, SFH 203

Anwendungen

- IR-Fernsteuerung von Fernseh- und Rundfunkgeräten, Videorecordern, Lichtdimmern
- Gerätefernsteuerungen für Gleich- und Wechsellichtbetrieb
- Rauchmelder
- Sensorik
- Diskrete Lichtschranken

Applications

- IR remote control of hi-fi and TV-sets, video tape recorders, dimmers
- Remote control for steady and varying intensity
- Smoke detectors
- Sensor technology
- Discrete interrupters

Typ Type	Bestellnummer Ordering Code	Strahlstärkegruppierung[1] (I_F = 100 mA, t_p = 20 ms) Radiant Intensity Grouping[1] I_e (mW/sr)
SFH 415	Q62702-P0296	> 25
SFH 415-U	Q62702-P1137	> 40

[1] gemessen bei einem Raumwinkel Ω = 0.01 sr / measured at a solid angle of Ω = 0.01 sr

Grenzwerte (T_A = 25 °C)
Maximum Ratings

Bezeichnung Parameter	Symbol Symbol	Wert Value	Einheit Unit
Betriebs- und Lagertemperatur Operating and storage temperature range	T_{op}; T_{stg}	– 40 … + 100	°C
Sperrspannung Reverse voltage	V_R	5	V
Durchlassstrom Forward current	I_F	100	mA
Stoßstrom, t_p = 10 µs, D = 0 Surge current	I_{FSM}	3	A
Verlustleistung Power dissipation	P_{tot}	165	mW
Wärmewiderstand Thermal resistance	R_{thJA}	450	K/W

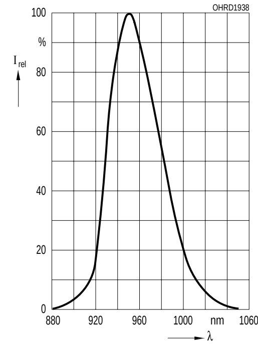
Kennwerte (T_A = 25 °C)
Characteristics

Bezeichnung Parameter	Symbol Symbol	Wert Value	Einheit Unit
Wellenlänge der Strahlung Wavelength at peak emission I_F = 100 mA, t_p = 20 ms	λ_{peak}	950	nm
Spektrale Bandbreite bei 50% von I_{max} Spectral bandwidth at 50% of I_{max} I_F = 100 mA	$\Delta\lambda$	55	nm
Abstrahlwinkel Half angle SFH 415	φ	± 17	Grad
Aktive Chipfläche Active chip area	A	0.09	mm^2
Abmessungen der aktiven Chipfläche Dimensions of the active chip area	$L \times B$ $L \times W$	0.3 × 0.3	mm^2
Abstand Chipoberfläche bis Linsenscheitel Distance chip front to lens top	H	4.2 … 4.8	mm

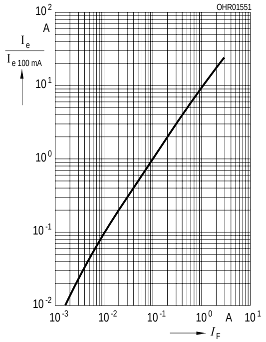
Kennwerte (T_A = 25 °C)
Characteristics (cont'd)

Bezeichnung **Parameter**	**Symbol** **Symbol**	**Wert** **Value**	**Einheit** **Unit**
Schaltzeiten, I_e von 10% auf 90% und von 90% auf 10%, bei I_F = 100 mA, R_L = 50 Ω Switching times, I_e from 10% to 90% and from 90% to 10%, I_F = 100 mA, R_L = 50 Ω	t_r, t_f	0.5	µs
Kapazität Capacitance V_R = 0 V, f = 1 MHz	C_o	25	pF
Durchlassspannung Forward voltage I_F = 100 mA, t_p = 20 ms I_F = 1 A, t_p = 100 µs	 V_F V_F	 1.3 (≤ 1.5) 2.3 (≤ 2.8)	 V V
Sperrstrom Reverse current V_R = 5 V	I_R	0.01 (≤ 1)	µA
Gesamtstrahlungsfluss Total radiant flux I_F = 100 mA, t_p = 20 ms	Φ_e	22	mW
Temperaturkoeffizient von I_e bzw. Φ_e, I_F = 100 mA Temperature coefficient of I_e or Φ_e, I_F = 100 mA	TC_I	– 0.5	%/K
Temperaturkoeffizient von V_F, I_F = 100 mA Temperature coefficient of V_F, I_F = 100 mA	TC_V	– 2	mV/K
Temperaturkoeffizient von λ, I_F = 100 mA Temperature coefficient of λ, I_F = 100 mA	$TC_λ$	+ 0.3	nm/K

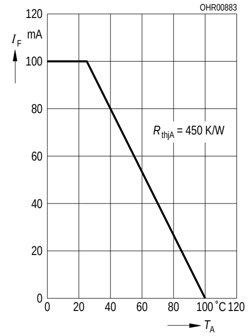
Relative Spectral Emission
$I_{rel} = f(λ)$



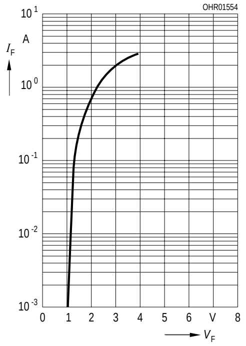
Radiant Intensity $\frac{I_e}{I_{e\,100\,mA}} = f(I_F)$
Single pulse, t_p = 20 µs



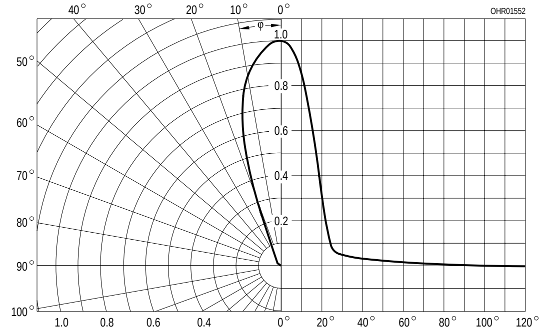
Max. Permissible Forward Current
$I_F = f(T_A)$



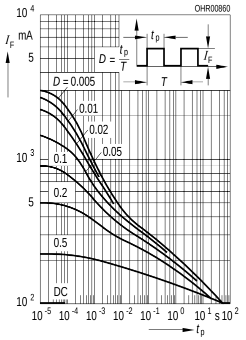
Forward Current
$I_F = f(V_F)$, single pulse, t_p = 20 µs



Radiation Characteristics,
$I_{rel} = f(φ)$



Permissible Pulse Handling Capability $I_F = f(τ)$, T_A = 25 °C
duty cycle D = parameter



Silizium-PIN-Fotodiode mit sehr kurzer Schaltzeit
Silicon PIN Photodiode with Very Short Switching Time
Lead (Pb) Free Product - RoHS Compliant

SFH 229
SFH 229 FA


SFH 229


SFH 229 FA

Wesentliche Merkmale

- Speziell geeignet für Anwendungen im Bereich von 380 nm bis 1100 nm (SFH 229) und bei 880 nm (SFH 229 FA)
- Kurze Schaltzeit (typ. 10 ns)
- 3 mm-Plastikbauform im LED-Gehäuse
- Auch gegurtet lieferbar

Features

- Especially suitable for applications from 380 nm to 1100 nm (SFH 229) and of 880 nm (SFH 229 FA)
- Short switching time (typ. 10 ns)
- 3 mm LED plastic package
- Also available on tape and reel

Anwendungen

- Lichtschranken für Gleich- und Wechselbetrieb
- Industrieelektronik
- „Messen/Steuern/Regeln“

Applications

- Photointerrupters
- Industrial electronics
- For control and drive circuits

Typ Type	Bestellnummer Ordering Code
SFH 229	Q62702P0215
SFH 229 FA	Q62702P0216

Grenzwerte
Maximum Ratings

Bezeichnung Parameter	Symbol Symbol	Wert Value	Einheit Unit
Betriebs- und Lagertemperatur Operating and storage temperature range	T_{op}; T_{stg}	– 40 … + 100	°C
Sperrspannung Reverse voltage	V_R	20	V
Verlustleistung Total power dissipation	P_{tot}	150	mW

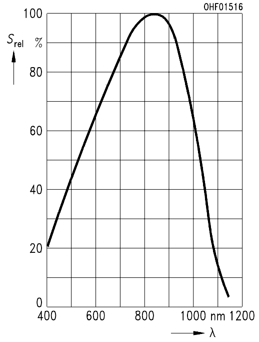
Kennwerte (T_A = 25 °C)
Characteristics

Bezeichnung Parameter	Symbol Symbol	Wert Value		Einheit Unit
		SFH 229	SFH 229 FA	
Fotostrom Photocurrent V_R = 5 V, Normlicht/standard light A, T = 2856 K, E_V = 1000 lx	I_P	28 (≥ 18)	–	µA
V_R = 5 V, λ = 950 nm, E_e = 1 mW/cm^2	I_P	–	20 (≥ 10.8)	µA
Wellenlänge der max. Fotoempfindlichkeit Wavelength of max. sensitivity	$\lambda_{S\,max}$	860	900	nm
Spektraler Bereich der Fotoempfindlichkeit S = 10% von S_{max} Spectral range of sensitivity S = 10% of S_{max}	λ	380 … 1100	730 … 1100	nm
Bestrahlungsempfindliche Fläche Radiant sensitive area	A	0.3	0.3	mm^2
Abmessung der bestrahlungsempfindlichen Fläche Dimensions of radiant sensitive area	$L \times B$ $L \times W$	0.56 × 0.56	0.56 × 0.56	mm × mm
Halbwinkel Half angle	φ	±17	±17	Grad deg.
Dunkelstrom, V_R = 10 V Dark current	I_R	50 (≤5000)	50 (≤5000)	pA
Spektrale Fotoempfindlichkeit, λ = 850 nm Spectral sensitivity	S_λ	0.62	0.60	A/W
Quantenausbeute, λ = 850 nm Quantum yield	η	0.90	0.88	Electrons Photon

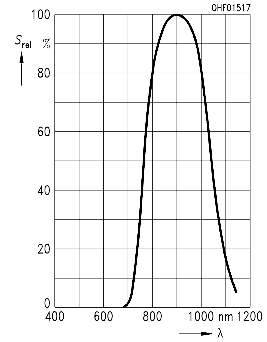
Kennwerte (T_A = 25 °C)
Characteristics (cont'd)

Bezeichnung Parameter	Symbol Symbol	Wert Value		Einheit Unit
		SFH 229	SFH 229 FA	
Leerlaufspannung Open-circuit voltage E_v = 1000 lx, Normlicht/standard light A, T = 2856 K E_e = 0.5 mW/cm², λ = 950 nm	 V_O V_O	 450 (≥ 400) –	 – 420 (≥ 370)	 mV mV
Kurzschlußstrom Short-circuit current E_v = 1000 lx, Normlicht/standard light A, T = 2856 K E_e = 0.5 mW/cm², λ = 950 nm	 I_{SC} I_{SC}	 27 –	 – 9	 µA µA
Anstiegs- und Abfallzeit des Fotostromes Rise and fall time of the photocurrent R_L = 50 Ω; V_R = 10 V; λ = 850 nm; I_p = 800 µA	t_r, t_f	10	10	ns
Durchlaßspannung, I_F = 100 mA, E = 0 Forward voltage	V_F	1.3	1.3	V
Kapazität, V_R = 0 V, f = 1 MHz, E = 0 Capacitance	C_0	13	13	pF
Temperaturkoeffizient von V_O Temperature coefficient of V_O	TC_V	– 2.6	– 2.6	mV/K
Temperaturkoeffizient von I_{SC} Temperature coefficient of I_{SC} Normlicht/standard light A λ = 950 nm	TC_I	 0.18 –	 – 0.2	%/K
Rauschäquivalente Strahlungsleistung Noise equivalent power V_R = 10 V, λ = 850 nm	NEP	6.5×10^{-15}	6.5×10^{-15}	$\frac{W}{\sqrt{Hz}}$
Nachweisgrenze, V_R = 10 V, λ = 850 nm Detection limit	D*	8.4×10^{12}	8.4×10^{12}	$\frac{cm \times \sqrt{Hz}}{W}$

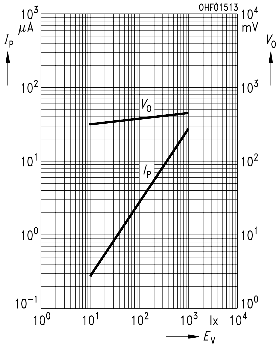
Relative Spectral Sensitivity
$S_{rel} = f(\lambda)$
SFH 229



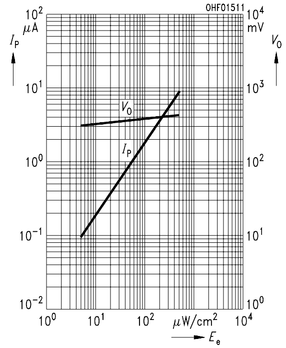
Relative Spectral Sensitivity
$S_{rel} = f(\lambda)$
SFH 229 FA



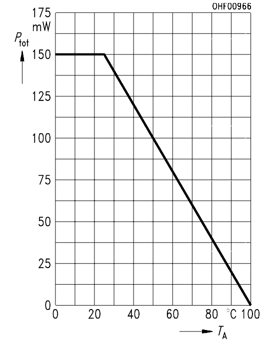
Photocurrent $I_P = f(E_v)$, V_R = 5 V
Open-Circuit Voltage $V_O = f(E_v)$
SFH 229



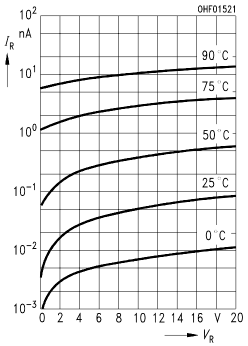
Photocurrent $I_P = f(E_e)$, V_R = 5 V
Open-Circuit Voltage $V_O = f(E_e)$
SFH 229 FA



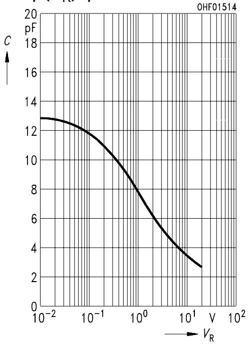
Total Power Dissipation
$P_{tot} = f(T_A)$



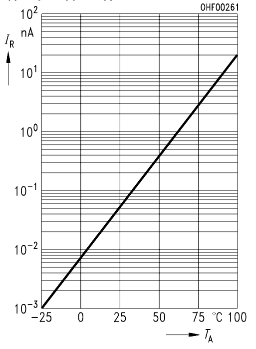
Dark Current
$I_R = f(V_R)$, E = 0



Capacitance
$C = f(V_R)$, f = 1 MHZ, E = 0



Dark Current
$I_R = f(T_A)$, V_R = 10 V, E = 0



Directional Characteristics
$S_{rel} = f(\varphi)$