http://DrSatvir.in

LINEAR INTEGRATED CIRCUITS

PART-07

Operational Amplifier ICs

DR SATVIR SINGH
DEPARTMENT OF ECE
IKG PUNJAB TECHNICAL UNIVERSITY
KAPURTHALA-144603 (PB) INDIA

Operational Amplifier

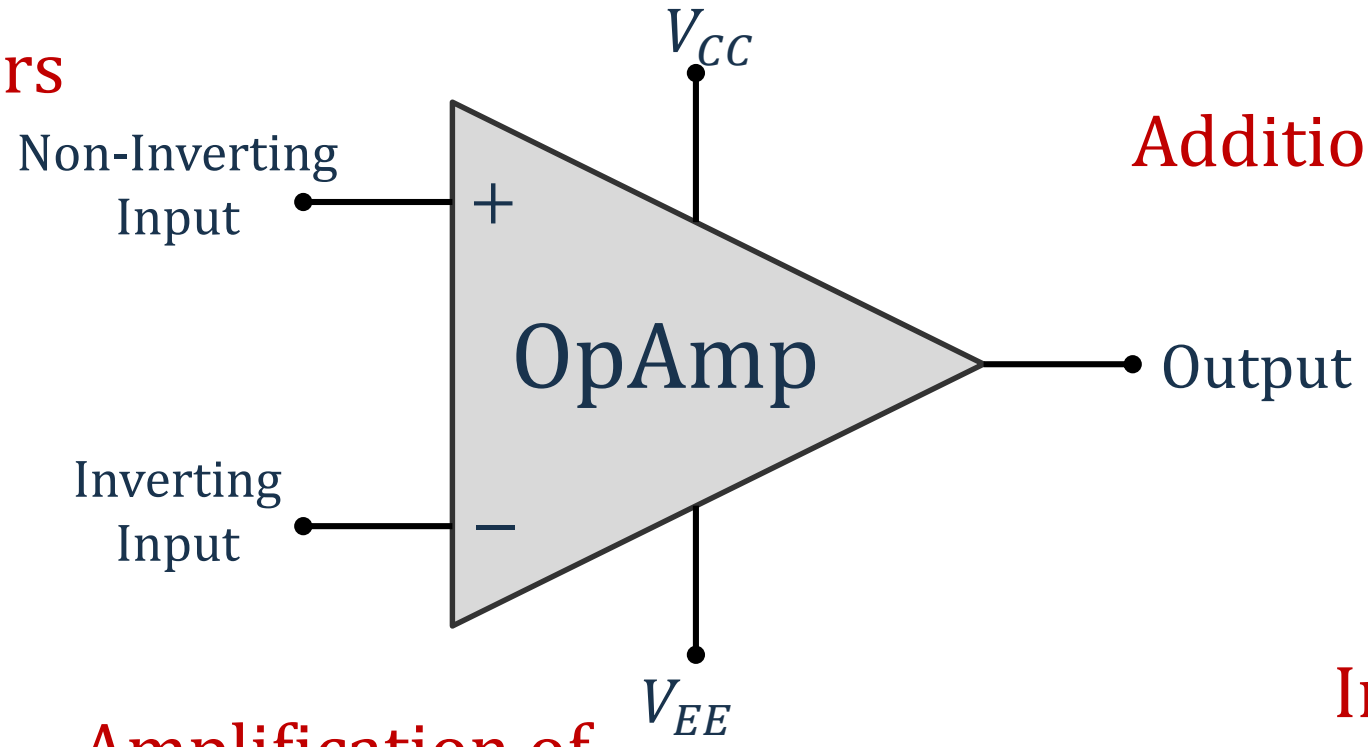
Direct Coupled

Multi-stage

Voltage Amplifier

One or More Differential Amplifiers

Comparators



Addition

Regulators

Subtraction

Active Filters

Multiplication

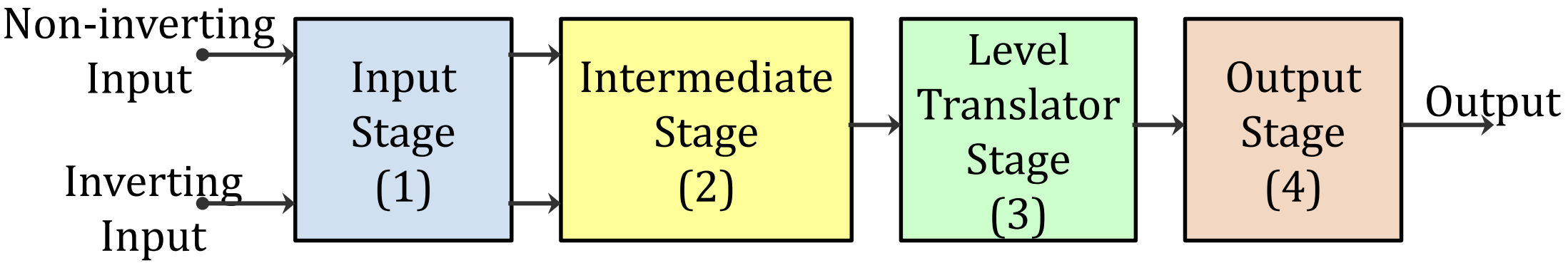
Oscillators

Integration

Amplification of AC & DC Signals

Differentiation

Block Diagram



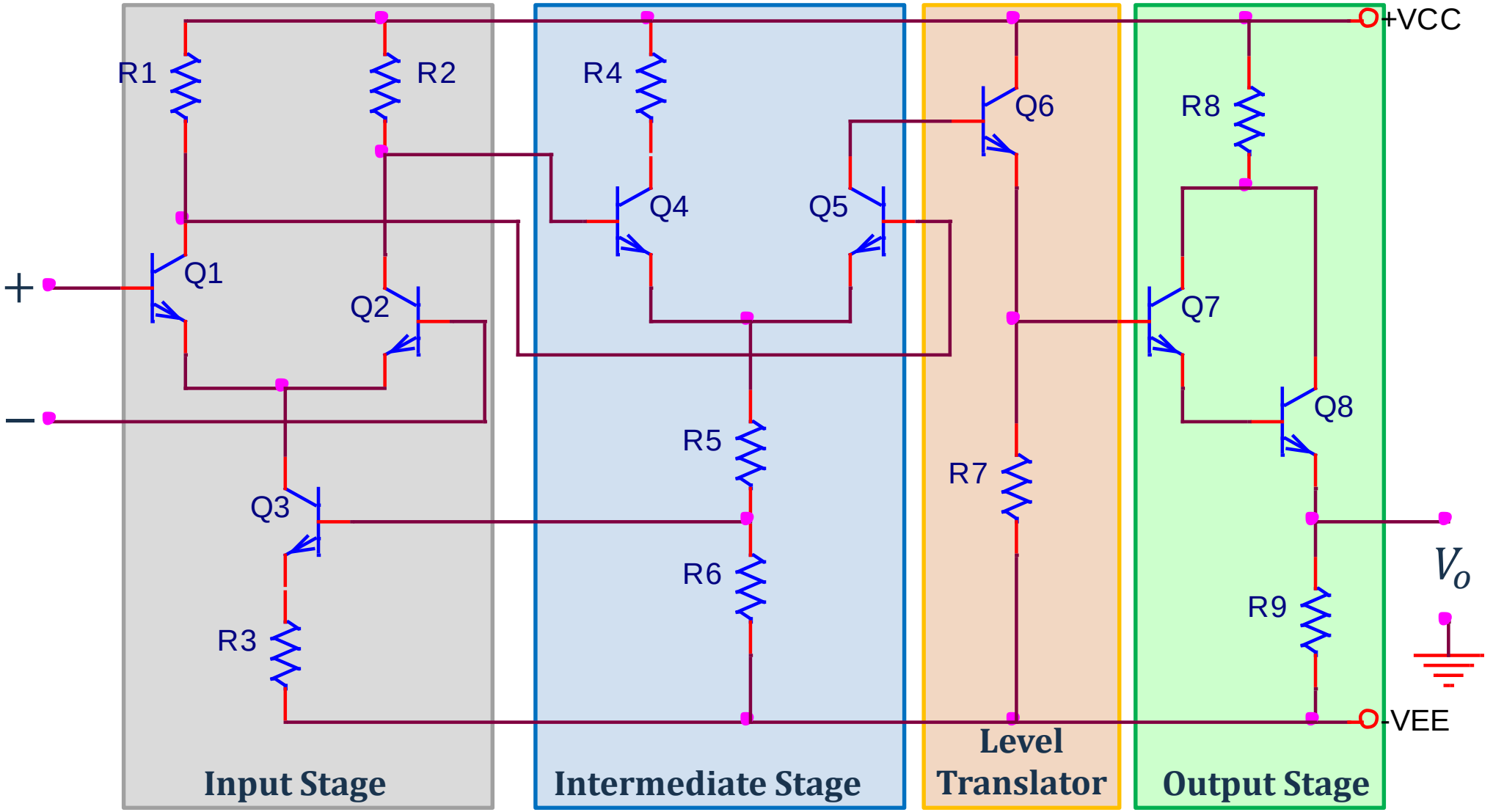
Input Stage: Dual Input Balanced Output Differential Amplifier

Intermediate Stage: Dual Input Unbalanced Output Differential Amplifier

Level Translator/shift Stage: Emitter follower with Constant Current Source

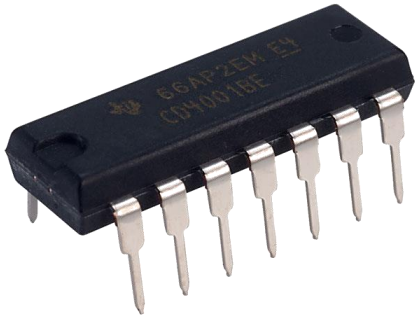
Output Stage: Push-Pull Amplifier

OpAmp Internal Circuit Structure



OpAmp IC Packaging

8-Pin IC



14-Pin IC

(Dual in Line Package)

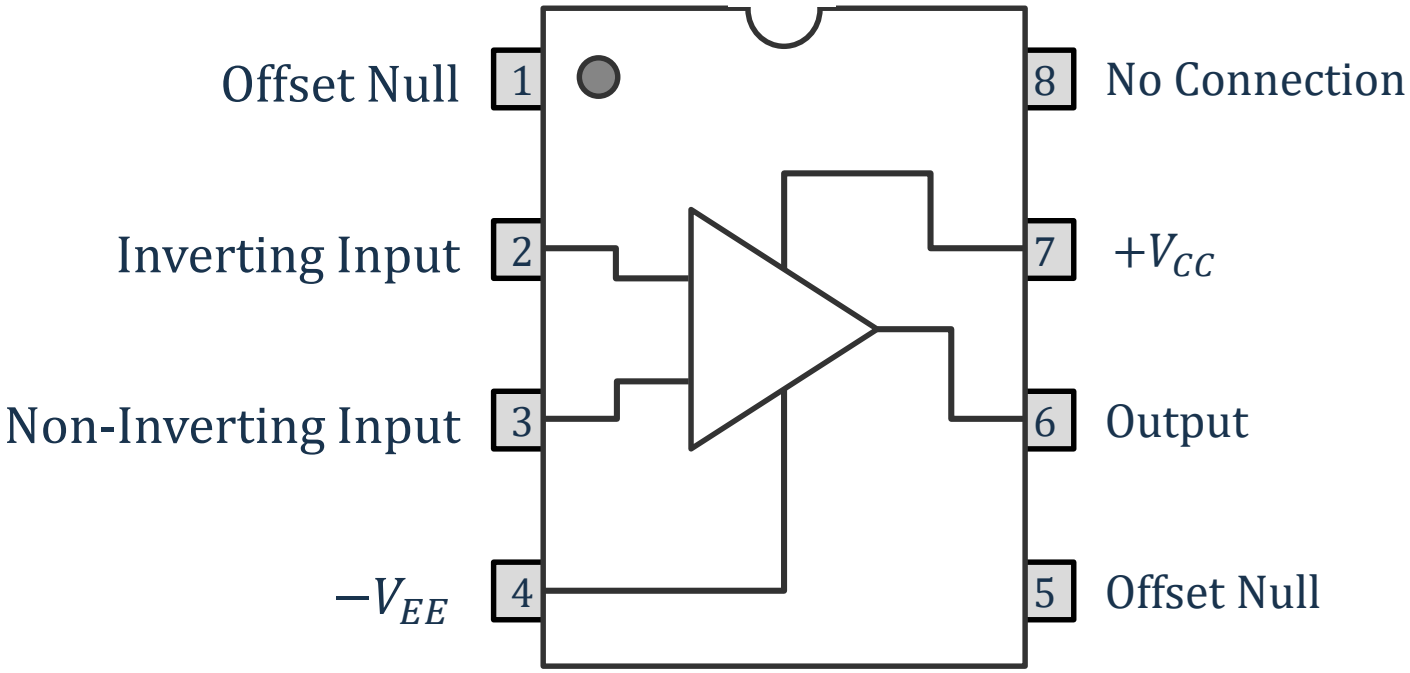
8-Pin

(Metal Can or TO Package)

TA11B 11pin Package

SMD

IC 741 Pin Diagram



Temperature Ranges

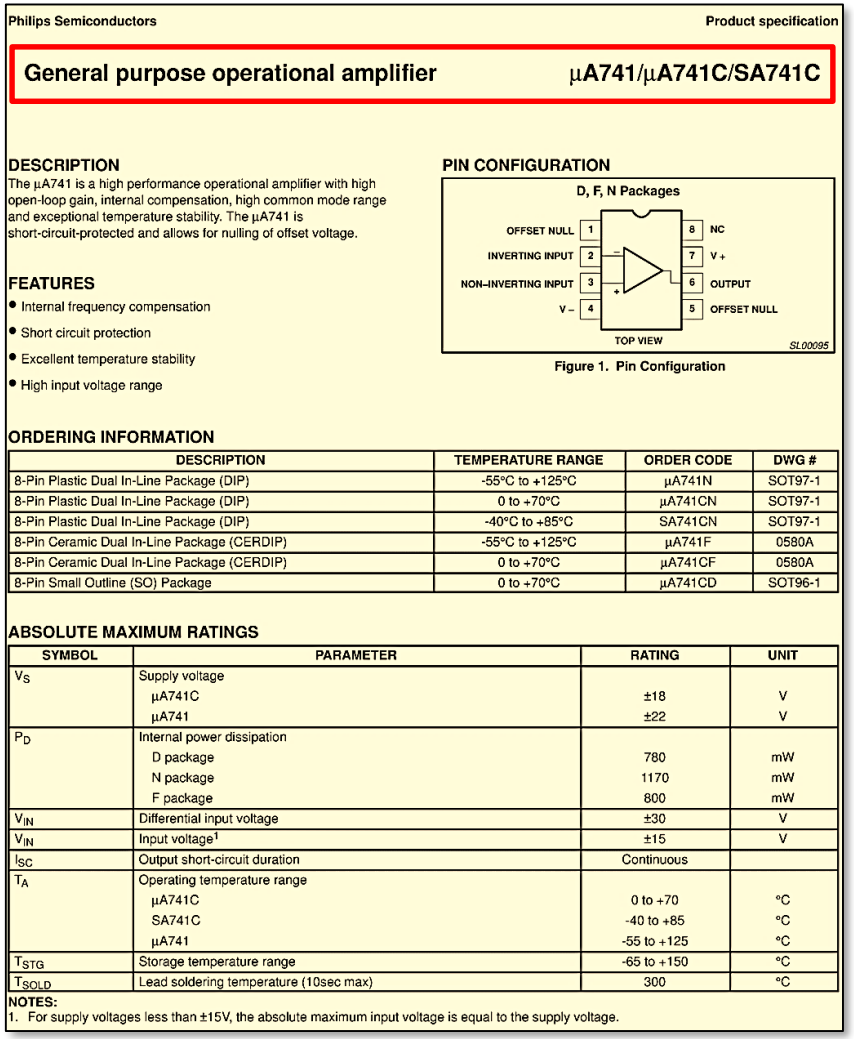
- Performance and cost are important parameters in selecting ICs & other semiconductor. All electronic components can be classified in three temperature ranges:

1.	Military Temperature Range	-55°C	+125°C
2.	Industrial Temperature Range	-20°C	+85°C
3.	Commercial Temperature Range	0°C	+70°C

- Military-grade components are always of superior quality with tightly controlled parameters, therefore, cost more.
- Commercial-grade ICs have worst tolerance among all, hence are cheapest.

Information in Datasheets

1. **Device number & brief description:** On the datasheet is device number and its brief description is given e.g., low power op-amp.



Philips Semiconductors — Product specification

General purpose operational amplifier — μA741/μA741C/SA741C

DESCRIPTION

The μA741 is a high performance operational amplifier with high open-loop gain, internal compensation, high common mode range and exceptional temperature stability. The μA741 is short-circuit-protected and allows for nulling of offset voltage.

FEATURES

- Internal frequency compensation
- Short circuit protection
- Excellent temperature stability
- High input voltage range

PIN CONFIGURATION

D, F, N Packages

Figure 1. Pin Configuration

ORDERING INFORMATION

DESCRIPTION	TEMPERATURE RANGE	ORDER CODE	DWG #
8-Pin Plastic Dual In-Line Package (DIP)	-55°C to +125°C	μA741N	SOT97-1
8-Pin Plastic Dual In-Line Package (DIP)	0 to +70°C	μA741CN	SOT97-1
8-Pin Plastic Dual In-Line Package (DIP)	-40°C to +85°C	SA741CN	SOT97-1
8-Pin Ceramic Dual In-Line Package (CERDIP)	-55°C to +125°C	μA741F	0580A
8-Pin Ceramic Dual In-Line Package (CERDIP)	0 to +70°C	μA741CF	0580A
8-Pin Small Outline (SO) Package	0 to +70°C	μA741CD	SOT96-1

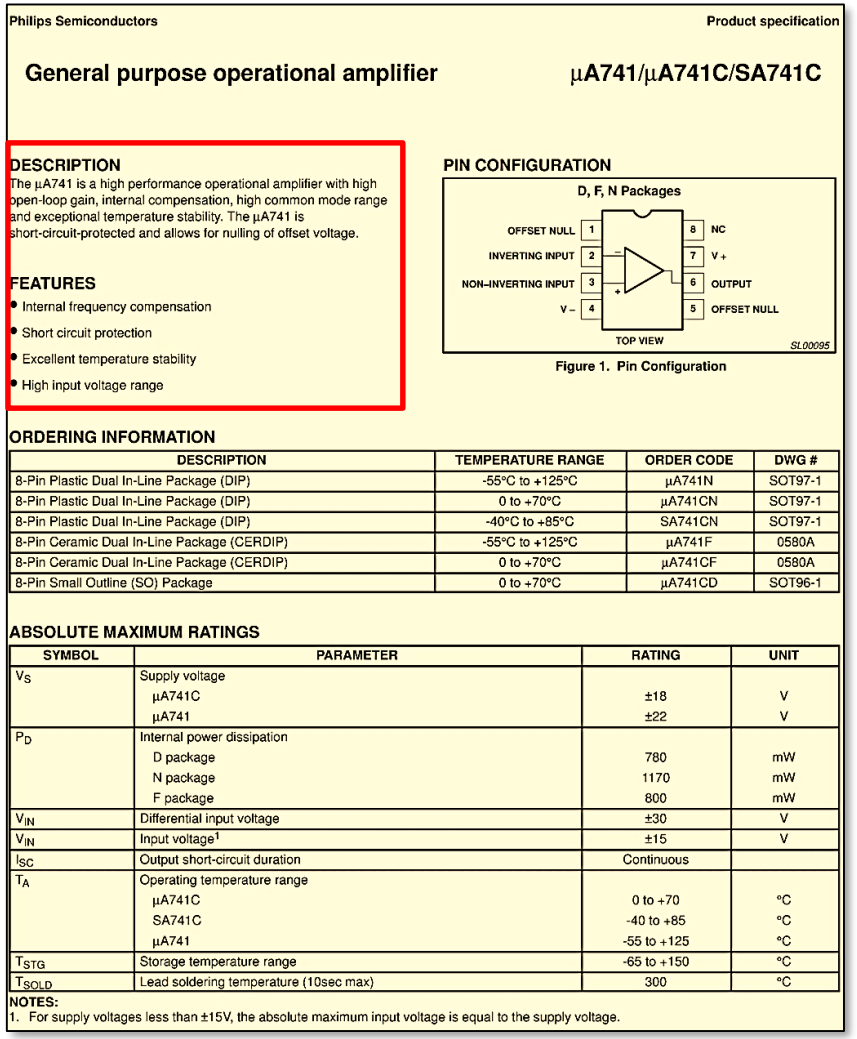
ABSOLUTE MAXIMUM RATINGS

SYMBOL	PARAMETER	RATING	UNIT
V_S	Supply voltage		
	μA741C	±18	V
	μA741	±22	V
P_D	Internal power dissipation		
	D package	780	mW
	N package	1170	mW
	F package	800	mW
V_{IN}	Differential input voltage	±30	V
V_{IN}	Input voltage[1]	±15	V
I_{SC}	Output short-circuit duration	Continuous	
T_A	Operating temperature range		
	μA741C	0 to +70	°C
	SA741C	-40 to +85	°C
	μA741	-55 to +125	°C
T_{STG}	Storage temperature range	-65 to +150	°C
T_{SOLD}	Lead soldering temperature (10sec max)	300	°C

NOTES:
1. For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

Information in Datasheets

1. **Device number & brief description:** On the datasheet is device number and its brief description is given e.g., low power op-amp.
2. **Features & General description:** It includes device construction process, major features & intended applications.



Philips Semiconductors — Product specification

General purpose operational amplifier — **µA741/µA741C/SA741C**

DESCRIPTION

The µA741 is a high performance operational amplifier with high open-loop gain, internal compensation, high common mode range and exceptional temperature stability. The µA741 is short-circuit-protected and allows for nulling of offset voltage.

FEATURES

- Internal frequency compensation
- Short circuit protection
- Excellent temperature stability
- High input voltage range

PIN CONFIGURATION

D, F, N Packages

Figure 1. Pin Configuration

ORDERING INFORMATION

DESCRIPTION	TEMPERATURE RANGE	ORDER CODE	DWG #
8-Pin Plastic Dual In-Line Package (DIP)	-55°C to +125°C	µA741N	SOT97-1
8-Pin Plastic Dual In-Line Package (DIP)	0 to +70°C	µA741CN	SOT97-1
8-Pin Plastic Dual In-Line Package (DIP)	-40°C to +85°C	SA741CN	SOT97-1
8-Pin Ceramic Dual In-Line Package (CERDIP)	-55°C to +125°C	µA741F	0580A
8-Pin Ceramic Dual In-Line Package (CERDIP)	0 to +70°C	µA741CF	0580A
8-Pin Small Outline (SO) Package	0 to +70°C	µA741CD	SOT96-1

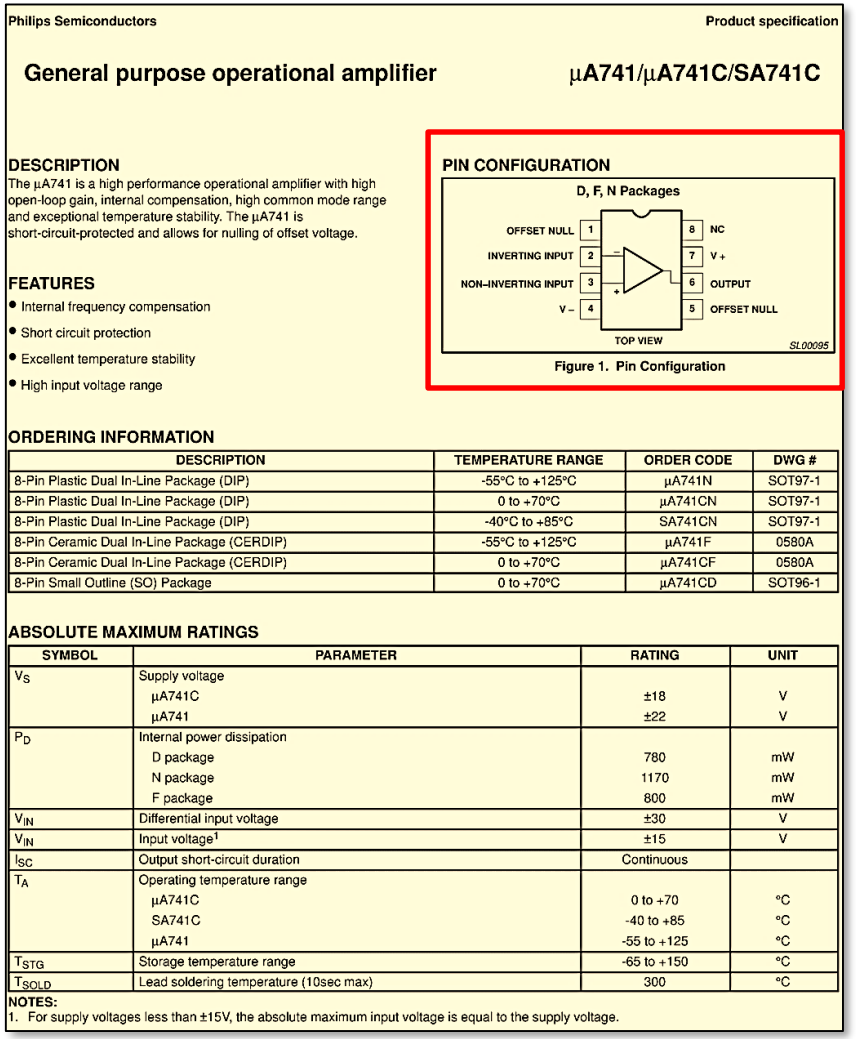
ABSOLUTE MAXIMUM RATINGS

SYMBOL	PARAMETER	RATING	UNIT
V_S	Supply voltage		
	µA741C	±18	V
	µA741	±22	V
P_D	Internal power dissipation		
	D package	780	mW
	N package	1170	mW
	F package	800	mW
V_{IN}	Differential input voltage	±30	V
V_{IN}	Input voltage[1]	±15	V
I_{SC}	Output short-circuit duration	Continuous	
T_A	Operating temperature range		
	µA741C	0 to +70	°C
	SA741C	-40 to +85	°C
	µA741	-55 to +125	°C
T_{STG}	Storage temperature range	-65 to +150	°C
T_{SOLD}	Lead soldering temperature (10sec max)	300	°C

NOTES:
1. For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

Information in Datasheets

1. **Device number & brief description:** On the datasheet is device number and its brief description is given e.g., low power op-amp.
2. **Features & General description:** It includes device construction process, major features & intended applications.
3. **Pin & Packaging:** It describes available IC package types and their pin diagrams.



Philips Semiconductors — Product specification

General purpose operational amplifier — **µA741/µA741C/SA741C**

DESCRIPTION

The µA741 is a high performance operational amplifier with high open-loop gain, internal compensation, high common mode range and exceptional temperature stability. The µA741 is short-circuit-protected and allows for nulling of offset voltage.

FEATURES

- Internal frequency compensation
- Short circuit protection
- Excellent temperature stability
- High input voltage range

PIN CONFIGURATION

D, F, N Packages

Figure 1. Pin Configuration

ORDERING INFORMATION

DESCRIPTION	TEMPERATURE RANGE	ORDER CODE	DWG #
8-Pin Plastic Dual In-Line Package (DIP)	-55°C to +125°C	µA741N	SOT97-1
8-Pin Plastic Dual In-Line Package (DIP)	0 to +70°C	µA741CN	SOT97-1
8-Pin Plastic Dual In-Line Package (DIP)	-40°C to +85°C	SA741CN	SOT97-1
8-Pin Ceramic Dual In-Line Package (CERDIP)	-55°C to +125°C	µA741F	0580A
8-Pin Ceramic Dual In-Line Package (CERDIP)	0 to +70°C	µA741CF	0580A
8-Pin Small Outline (SO) Package	0 to +70°C	µA741CD	SOT96-1

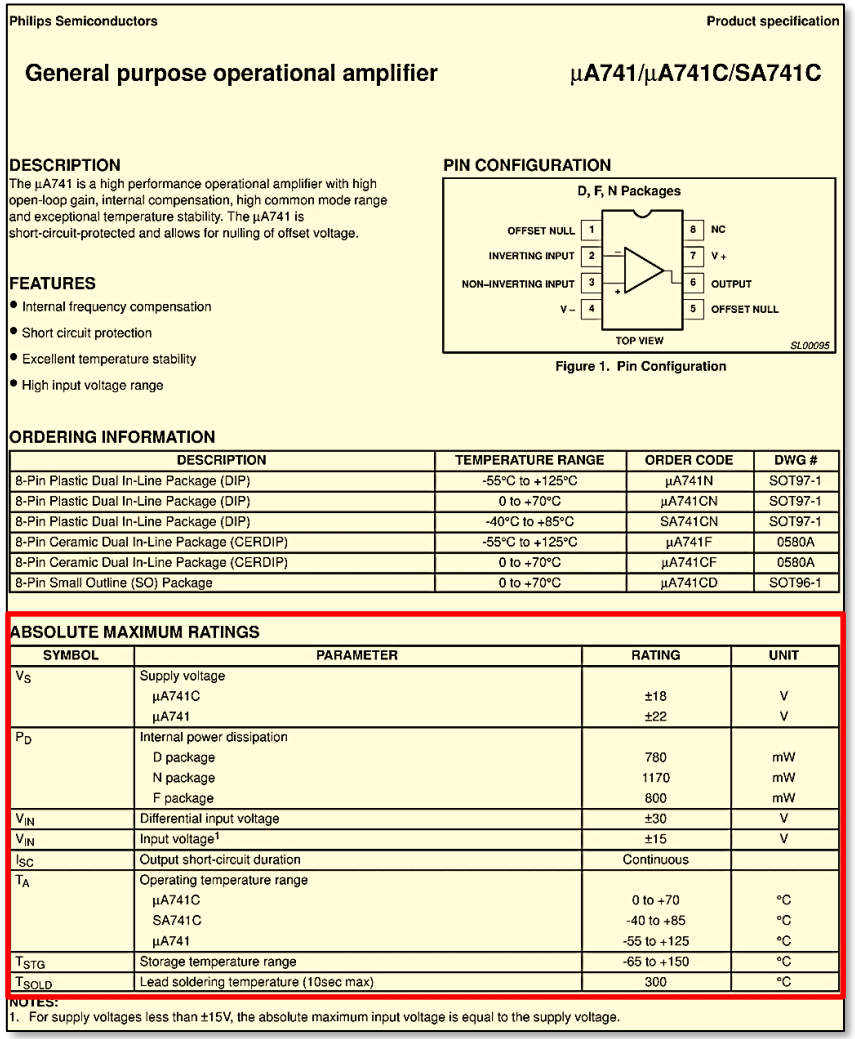
ABSOLUTE MAXIMUM RATINGS

SYMBOL	PARAMETER	RATING	UNIT
V_S	Supply voltage		
	µA741C	±18	V
	µA741	±22	V
P_D	Internal power dissipation		
	D package	780	mW
	N package	1170	mW
	F package	800	mW
V_{IN}	Differential input voltage	±30	V
V_{IN}	Input voltage[1]	±15	V
I_{SC}	Output short-circuit duration	Continuous	
T_A	Operating temperature range		
	µA741C	0 to +70	°C
	SA741C	-40 to +85	°C
	µA741	-55 to +125	°C
T_{STG}	Storage temperature range	-65 to +150	°C
T_{SOLD}	Lead soldering temperature (10sec max)	300	°C

NOTES:
1. For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

Information in Datasheets

1. **Device number & brief description:** On the datasheet is device number and its brief description is given e.g., low power op-amp.
2. **Features & General description:** It includes device construction process, major features & intended applications.
3. **Pin & Packaging:** It describes available IC package types and their pin diagrams.
4. **Ratings:** Absolute maximum ratings are specified for proper operation of the device.



Philips Semiconductors — Product specification

General purpose operational amplifier — **µA741/µA741C/SA741C**

DESCRIPTION

The µA741 is a high performance operational amplifier with high open-loop gain, internal compensation, high common mode range and exceptional temperature stability. The µA741 is short-circuit-protected and allows for nulling of offset voltage.

FEATURES

- Internal frequency compensation
- Short circuit protection
- Excellent temperature stability
- High input voltage range

PIN CONFIGURATION

D, F, N Packages

Figure 1. Pin Configuration

ORDERING INFORMATION

DESCRIPTION	TEMPERATURE RANGE	ORDER CODE	DWG #
8-Pin Plastic Dual In-Line Package (DIP)	-55°C to +125°C	µA741N	SOT97-1
8-Pin Plastic Dual In-Line Package (DIP)	0 to +70°C	µA741CN	SOT97-1
8-Pin Plastic Dual In-Line Package (DIP)	-40°C to +85°C	SA741CN	SOT97-1
8-Pin Ceramic Dual In-Line Package (CERDIP)	-55°C to +125°C	µA741F	0580A
8-Pin Ceramic Dual In-Line Package (CERDIP)	0 to +70°C	µA741CF	0580A
8-Pin Small Outline (SO) Package	0 to +70°C	µA741CD	SOT96-1

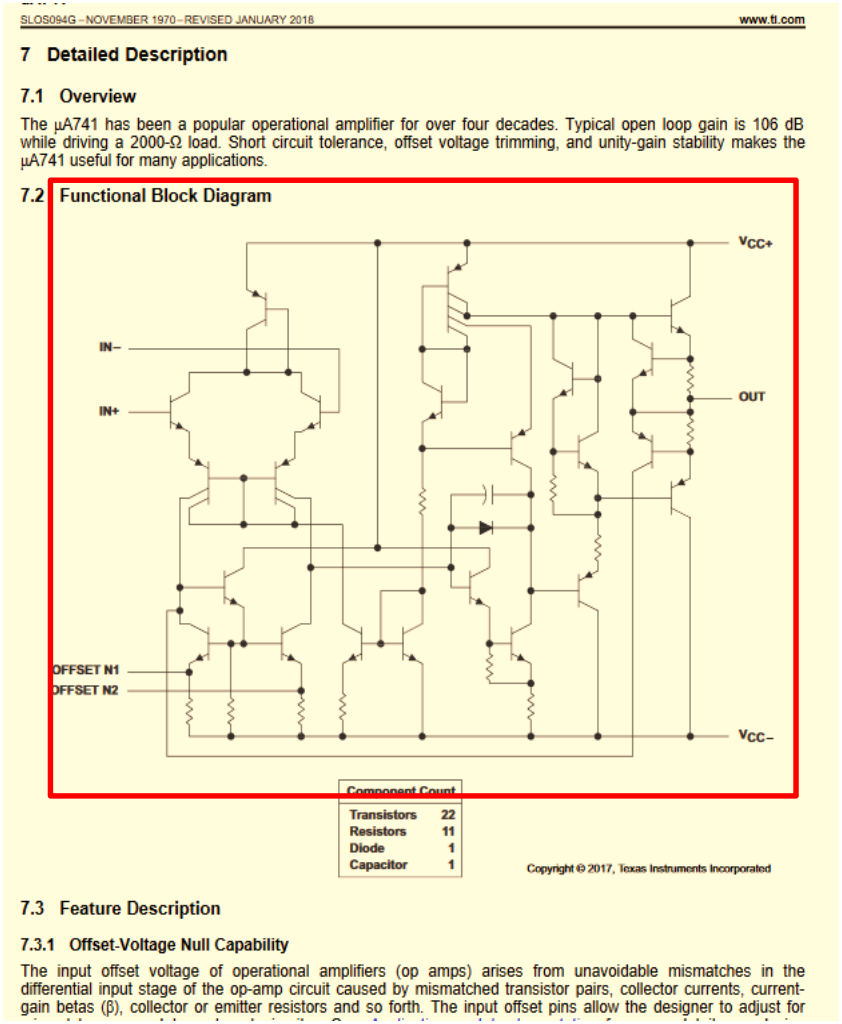
ABSOLUTE MAXIMUM RATINGS

SYMBOL	PARAMETER	RATING	UNIT
V_S	Supply voltage		
	µA741C	±18	V
	µA741	±22	V
P_D	Internal power dissipation		
	D package	780	mW
	N package	1170	mW
	F package	800	mW
V_{IN}	Differential input voltage	±30	V
V_{IN}	Input voltage[1]	±15	V
I_{SC}	Output short-circuit duration	Continuous	
T_A	Operating temperature range		
	µA741C	0 to +70	°C
	SA741C	-40 to +85	°C
	µA741	-55 to +125	°C
T_{STG}	Storage temperature range	-65 to +150	°C
T_{SOLD}	Lead soldering temperature (10sec max)	300	°C

NOTES:
1. For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

Information in Datasheets

5. **Functional Schematic:** Approximate internal circuit is given to explain functionality.



SLOS094G – NOVEMBER 1970 – REVISED JANUARY 2018 www.ti.com

7 Detailed Description

7.1 Overview

The μA741 has been a popular operational amplifier for over four decades. Typical open loop gain is 106 dB while driving a 2000-Ω load. Short circuit tolerance, offset voltage trimming, and unity-gain stability makes the μA741 useful for many applications.

7.2 Functional Block Diagram

Component Count	
Transistors	22
Resistors	11
Diode	1
Capacitor	1

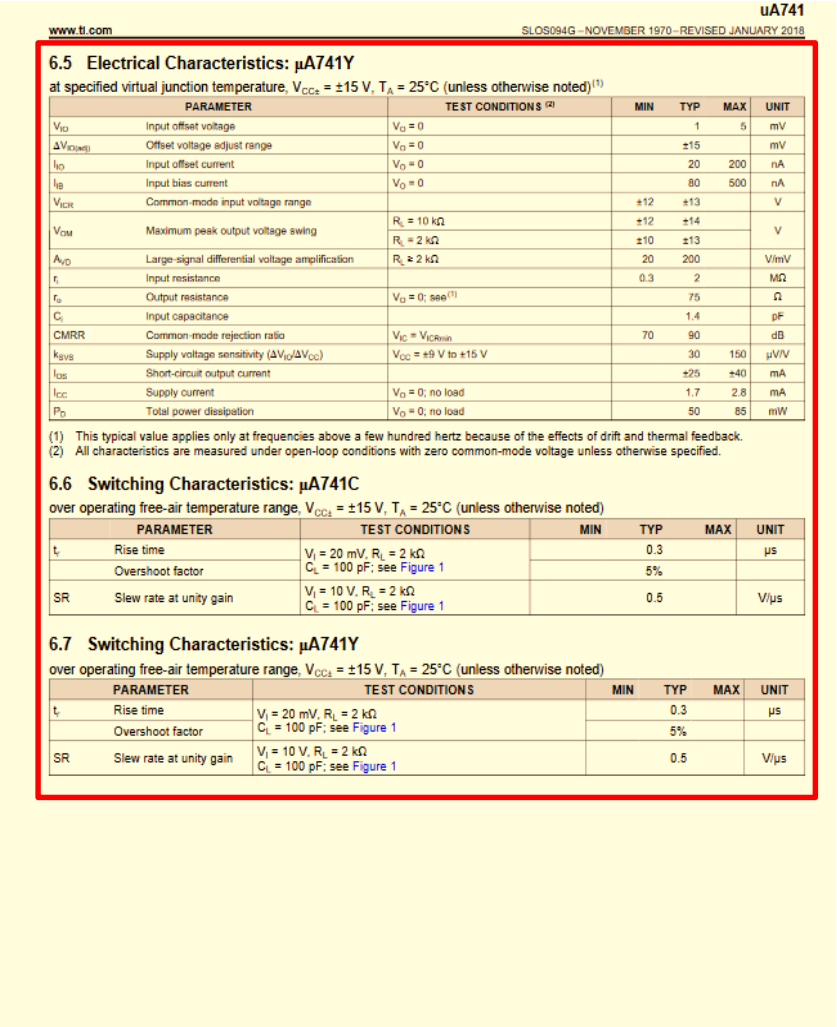
7.3 Feature Description

7.3.1 Offset-Voltage Null Capability

The input offset voltage of operational amplifiers (op amps) arises from unavoidable mismatches in the differential input stage of the op-amp circuit caused by mismatched transistor pairs, collector currents, current-gain betas (β), collector or emitter resistors and so forth. The input offset pins allow the designer to adjust for

Information in Datasheets

5. **Functional Schematic:** Approximate internal circuit is given to explain functionality.
6. **Electrical Characteristics:** Parameter values under specific conditions are tabulated.



6.5 Electrical Characteristics: µA741Y

at specified virtual junction temperature, $V_{CC\pm}$ = ±15 V, T_A = 25°C (unless otherwise noted)(1)

PARAMETER		TEST CONDITIONS (2)	MIN	TYP	MAX	UNIT
V_{IO}	Input offset voltage	V_O = 0		1	5	mV
$\Delta V_{IO(adj)}$	Offset voltage adjust range	V_O = 0		±15		mV
I_{IO}	Input offset current	V_O = 0		20	200	nA
I_{IB}	Input bias current	V_O = 0		80	500	nA
V_{ICR}	Common-mode input voltage range		±12	±13		V
V_{OM}	Maximum peak output voltage swing	R_L = 10 kΩ	±12	±14		V
		R_L = 2 kΩ	±10	±13		
A_{VD}	Large-signal differential voltage amplification	R_L = 2 kΩ	20	200		V/mV
r_i	Input resistance		0.3	2		MΩ
r_o	Output resistance	V_O = 0; see(1)		75		Ω
C_i	Input capacitance			1.4		pF
CMRR	Common-mode rejection ratio	$V_{IC} = V_{ICRmin}$	70	90		dB
k_{SVS}	Supply voltage sensitivity ($\Delta V_{IO}/\Delta V_{CC}$)	V_{CC} = ±9 V to ±15 V		30	150	µV/V
I_{OS}	Short-circuit output current			±25	±40	mA
I_{CC}	Supply current	V_O = 0; no load		1.7	2.8	mA
P_D	Total power dissipation	V_O = 0; no load		50	85	mW

(1) This typical value applies only at frequencies above a few hundred hertz because of the effects of drift and thermal feedback.
(2) All characteristics are measured under open-loop conditions with zero common-mode voltage unless otherwise specified.

6.6 Switching Characteristics: µA741C

over operating free-air temperature range, $V_{CC\pm}$ = ±15 V, T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
t_r	Rise time	V_I = 20 mV, R_L = 2 kΩ, C_L = 100 pF; see Figure 1		0.3		µs
	Overshoot factor			5%		
SR	Slew rate at unity gain	V_I = 10 V, R_L = 2 kΩ, C_L = 100 pF; see Figure 1		0.5		V/µs

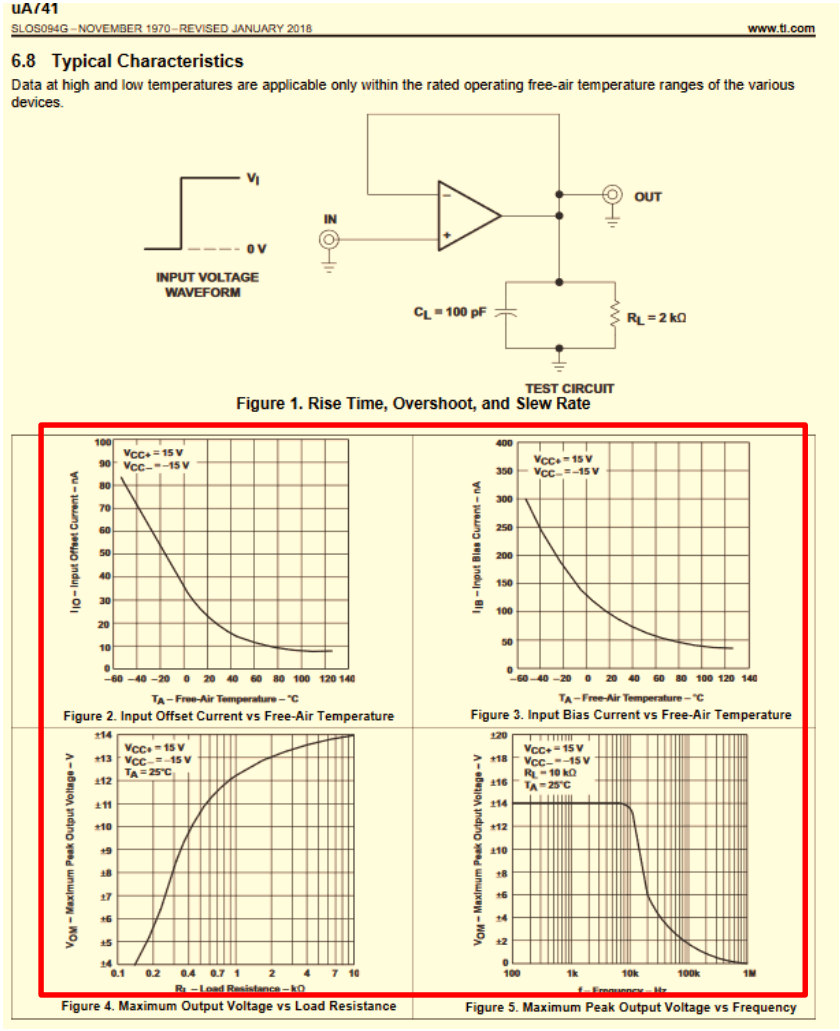
6.7 Switching Characteristics: µA741Y

over operating free-air temperature range, $V_{CC\pm}$ = ±15 V, T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
t_r	Rise time	V_I = 20 mV, R_L = 2 kΩ, C_L = 100 pF; see Figure 1		0.3		µs
	Overshoot factor			5%		
SR	Slew rate at unity gain	V_I = 10 V, R_L = 2 kΩ, C_L = 100 pF; see Figure 1		0.5		V/µs

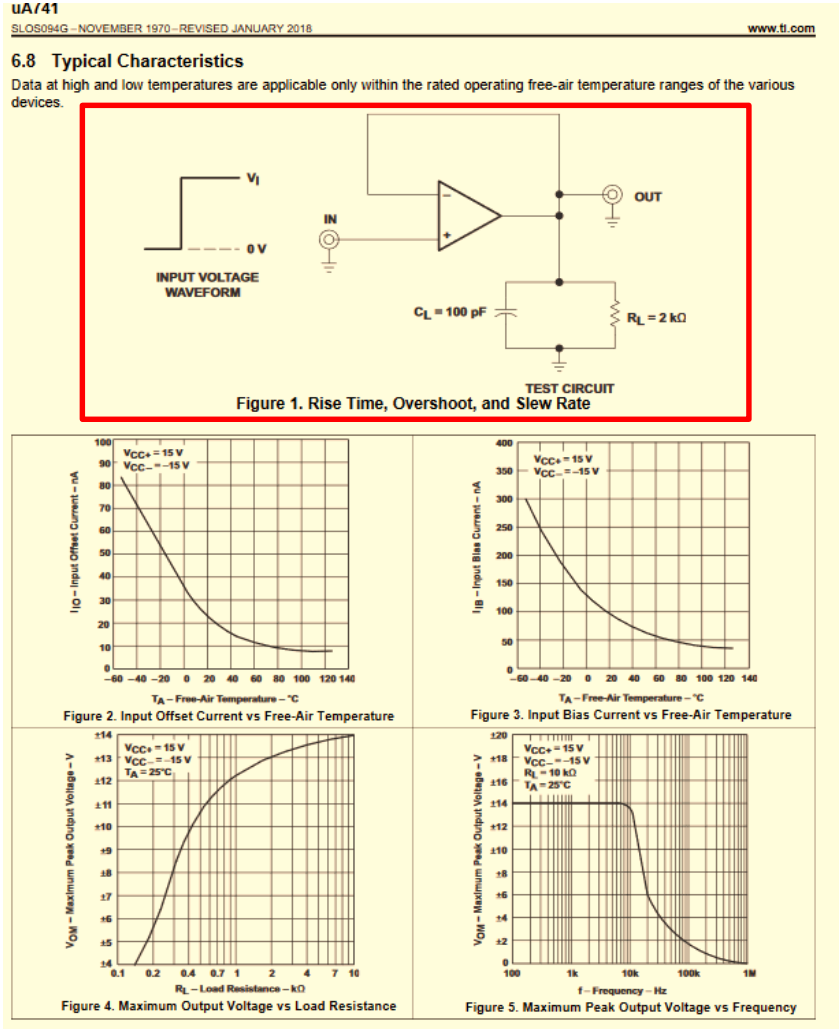
Information in Datasheets

5. **Functional Schematic:** Approximate internal circuit is given to explain functionality.
6. **Electrical Characteristics:** Parameter values under specific conditions are tabulated.
7. **Performance curves:** Parametric changes with respect to supply voltage, frequency and temperature, etc. are described with graphs.



Information in Datasheets

5. **Functional Schematic:** Approximate internal circuit is given to explain functionality.
6. **Electrical Characteristics:** Parameter values under specific conditions are tabulated.
7. **Performance curves:** Parametric changes with respect to supply voltage, frequency and temperature, etc. are described with graphs.
8. **Applications & Test Circuits:** Typical applications & test circuits are illustrated usually in last.



Thank You

DR SATVIR SINGH
DEPARTMENT OF ECE
IKG PUNJAB TECHNICAL UNIVERSITY
KAPURTHALA-144603 (PB) INDIA