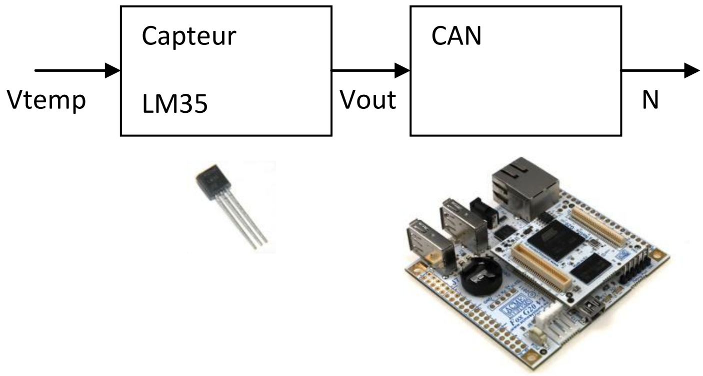
Travail dirigé – Acquisition et conditionnement de l’information

On souhaite faire une acquisition de température dans une salle de classe.
Dans cette salle, la température ne dépasse jamais les 45°C et ne passe jamais en dessous de 0°C.

La solution matérielle choisie est la suivante :

- Capteur de température : LM35
- Convertisseur analogique/numérique : CAN 10bits tolérant une tension d’entrée comprise entre 0V et 3.3V.



Q1. Donner l’étendue de mesure du capteur LM35. Justifier le choix de ce capteur.

Q2. Relever la sensibilité du capteur LM35.

Q3. Donner les valeurs extrêmes prises par la tension Vout.

Q4. Tracer la caractéristique d’entrée / sortie de ce capteur. Ce capteur a-t-il un fonctionnement linéaire ?

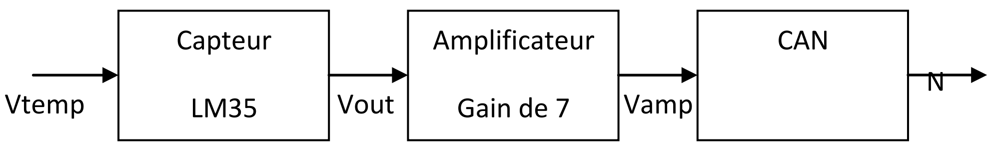
Q5. Indiquer les valeurs décimales puis binaires extrêmes que peut prendre le mot binaire N.

Q6. Calculer quantum q (pas de quantification) du convertisseur analogique / numérique.

Q7. Donner les valeurs extrêmes décimales puis binaires prises par le mot N 10bits issu du convertisseur analogique / numérique.

Q8. Donner l’incertitude (+/- X°C) sur la mesure réalisée. Cette incertitude est-elle optimale ? Proposer une solution.

On préconise la solution suivante, à savoir l’utilisation d’un amplificateur :



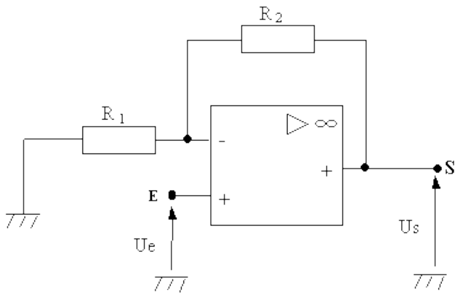
Q9. Tracer la caractéristique d'entrée / sortie de l'amplificateur.

Q10. Donner les valeurs extrêmes prises par la tension Vamp.

Q11. Donner les valeurs extrêmes décimales puis binaires prises par le mot N 10bits issu du convertisseur analogique / numérique.

Q12. Donner la l'incertitude (+/- X°C) sur la mesure réalisée. Commenter.

Q13. Voici le schéma structurel de l'amplificateur. Le gain est défini par la relation : G = 1 + R2/R1 = Us / Ue. Calculer la valeur de R2 sachant que R1 vaut 1000 ohms :



Q14. On souhaite faire évoluer la solution, afin de la rendre moins sensible aux brusques variations de température lors de l'ouverture d'une fenêtre par exemple (parasites). Proposer une solution technique.

Documentation LM35 :

National Semiconductor

December 1994

LM35/LM35A/LM35C/LM35CA/LM35D Precision Centigrade Temperature Sensors

LM35/LM35A/LM35C/LM35CA/LM35D
Precision Centigrade Temperature Sensors

General Description

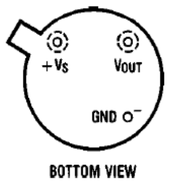
The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 thus has an advantage over linear temperature sensors calibrated in ° Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Centigrade scaling. The LM35 does not require any external calibration or trimming to provide typical accuracies of $\pm\frac{1}{4}$°C at room temperature and $\pm\frac{3}{4}$°C over a full −55 to +150°C temperature range. Low cost is assured by trimming and calibration at the wafer level. The LM35's low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy. It can be used with single power supplies, or with plus and minus supplies. As it draws only 60 μA from its supply, it has very low self-heating, less than 0.1°C in still air. The LM35 is rated to operate over a −55° to +150°C temperature range, while the LM35C is rated for a −40° to +110°C range (−10° with improved accuracy). The LM35 series is available packaged in hermetic TO-46 transistor packages, while the LM35C, LM35CA, and LM35D are also available in the plastic TO-92 transistor package. The LM35D is also available in an 8-lead surface mount small outline package and a plastic TO-202 package.

Features

- Calibrated directly in ° Celsius (Centigrade)
- Linear + 10.0 mV/°C scale factor
- 0.5°C accuracy guaranteeable (at +25°C)
- Rated for full −55° to +150°C range
- Suitable for remote applications
- Low cost due to wafer-level trimming
- Operates from 4 to 30 volts
- Less than 60 μA current drain
- Low self-heating, 0.08°C in still air
- Nonlinearity only $\pm\frac{1}{4}$°C typical
- Low impedance output, 0.1 Ω for 1 mA load

Connection Diagrams

TO-46
Metal Can Package*

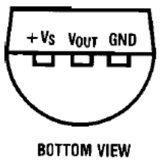


TL/H/5516–1

*Case is connected to negative pin (GND)

Order Number LM35H, LM35AH, LM35CH, LM35CAH or LM35DH
See NS Package Number H03H

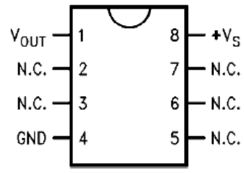
TO-92
Plastic Package



TL/H/5516–2

Order Number LM35CZ, LM35CAZ or LM35DZ
See NS Package Number Z03A

SO-8
Small Outline Molded Package



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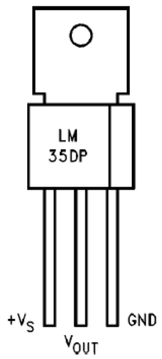
Top View

N.C. = No Connection

Order Number LM35DM
See NS Package Number M08A

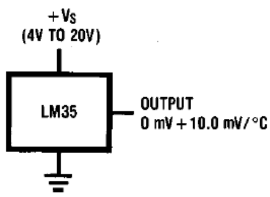
TO-202
Plastic Package



TL/H/5516–24

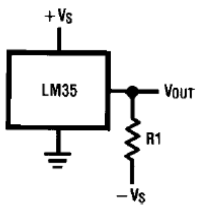
Order Number LM35DP
See NS Package Number P03A

Typical Applications



TL/H/5516–3

FIGURE 1. Basic Centigrade Temperature Sensor (+2°C to +150°C)



TL/H/5516–4

Choose $R_1 = -V_S/50\ \mu A$

$V_{OUT} = +1{,}500$ mV at +150°C
$= +250$ mV at +25°C
$= -550$ mV at −55°C

FIGURE 2. Full-Range Centigrade Temperature Sensor

Absolute Maximum Ratings (Note 10)

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

Supply Voltage		+35V to −0.2V
Output Voltage		+6V to −1.0V
Output Current		10 mA
Storage Temp.,	TO-46 Package,	−60°C to +180°C
	TO-92 Package,	−60°C to +150°C
	SO-8 Package,	−65°C to +150°C
	TO-202 Package,	−65°C to +150°C
Lead Temp.:		
	TO-46 Package, (Soldering, 10 seconds)	300°C
	TO-92 Package, (Soldering, 10 seconds)	260°C
	TO-202 Package, (Soldering, 10 seconds)	+230°C
SO Package (Note 12):		
	Vapor Phase (60 seconds)	215°C
	Infrared (15 seconds)	220°C
ESD Susceptibility (Note 11)		2500V
Specified Operating Temperature Range: T_{MIN} to T_{MAX} (Note 2)		
	LM35, LM35A	−55°C to +150°C
	LM35C, LM35CA	−40°C to +110°C
	LM35D	0°C to +100°C

Electrical Characteristics (Note 1) **(Note 6)**

Parameter	Conditions	LM35A			LM35CA			Units (Max.)
		Typical	Tested Limit (Note 4)	Design Limit (Note 5)	Typical	Tested Limit (Note 4)	Design Limit (Note 5)	
Accuracy (Note 7)	$T_A = +25°C$	±0.2	±0.5		±0.2	±0.5		°C
	$T_A = -10°C$	±0.3			±0.3		±1.0	°C
	$T_A = T_{MAX}$	±0.4	±1.0		±0.4	±1.0		°C
	$T_A = T_{MIN}$	±0.4	±1.0		±0.4		±1.5	°C
Nonlinearity (Note 8)	$T_{MIN} \le T_A \le T_{MAX}$	**±0.18**		**±0.35**	**±0.15**		**±0.3**	°C
Sensor Gain (Average Slope)	$T_{MIN} \le T_A \le T_{MAX}$	**+10.0**	**+9.9, +10.1**		**+10.0**		**+9.9, +10.1**	mV/°C
Load Regulation (Note 3) $0 \le I_L \le 1$ mA	$T_A = +25°C$	±0.4	±1.0		±0.4	±1.0		mV/mA
	$T_{MIN} \le T_A \le T_{MAX}$	**±0.5**		**±3.0**	**±0.5**		**±3.0**	mV/mA
Line Regulation (Note 3)	$T_A = +25°C$	±0.01	±0.05		±0.01	±0.05		mV/V
	$4V \le V_S \le 30V$	**±0.02**		**±0.1**	**±0.02**		**±0.1**	mV/V
Quiescent Current (Note 9)	$V_S = +5V, +25°C$	56	67		56	67		μA
	$V_S = +5V$	**105**		**131**	**91**		**114**	μA
	$V_S = +30V, +25°C$	56.2	68		56.2	68		μA
	$V_S = +30V$	**105.5**		**133**	**91.5**		**116**	μA
Change of Quiescent Current (Note 3)	$4V \le V_S \le 30V, +25°C$	0.2	1.0		0.2	1.0		μA
	$4V \le V_S \le 30V$	**0.5**		**2.0**	**0.5**		**2.0**	μA
Temperature Coefficient of Quiescent Current		**+0.39**		**+0.5**	**+0.39**		**+0.5**	μA/°C
Minimum Temperature for Rated Accuracy	In circuit of *Figure 1*, $I_L = 0$	+1.5		+2.0	+1.5		+2.0	°C
Long Term Stability	$T_J = T_{MAX}$, for 1000 hours	±0.08			±0.08			°C

Note 1: Unless otherwise noted, these specifications apply: $-55°C \le T_J \le +150°C$ for the LM35 and LM35A; $-40° \le T_J \le +110°C$ for the LM35C and LM35CA; and $0° \le T_J \le +100°C$ for the LM35D. $V_S = +5Vdc$ and $I_{LOAD} = 50$ μA, in the circuit of *Figure 2*. These specifications also apply from +2°C to T_{MAX} in the circuit of *Figure 1*. Specifications in **boldface** apply over the full rated temperature range.

Note 2: Thermal resistance of the TO-46 package is 400°C/W, junction to ambient, and 24°C/W junction to case. Thermal resistance of the TO-92 package is 180°C/W junction to ambient. Thermal resistance of the small outline molded package is 220°C/W junction to ambient. Thermal resistance of the TO-202 package is 85°C/W junction to ambient. For additional thermal resistance information see table in the Applications section.