# HS24LF Resistive Humidity Sensor: Direct Interface Method


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| Release: | Rev0-12/2008 |


## 1. Introduction:

MEAS France / HUMIREL HS24LF resistive sensor is designed for cost sensitive applications such as HVAC, copying machine and weather-forecast station; mostly indoor applications.

In order to reduce the overall cost of the customer system, direct interfacing with MCU is demonstrate by connecting the sensor to the input or output of microcontroller.

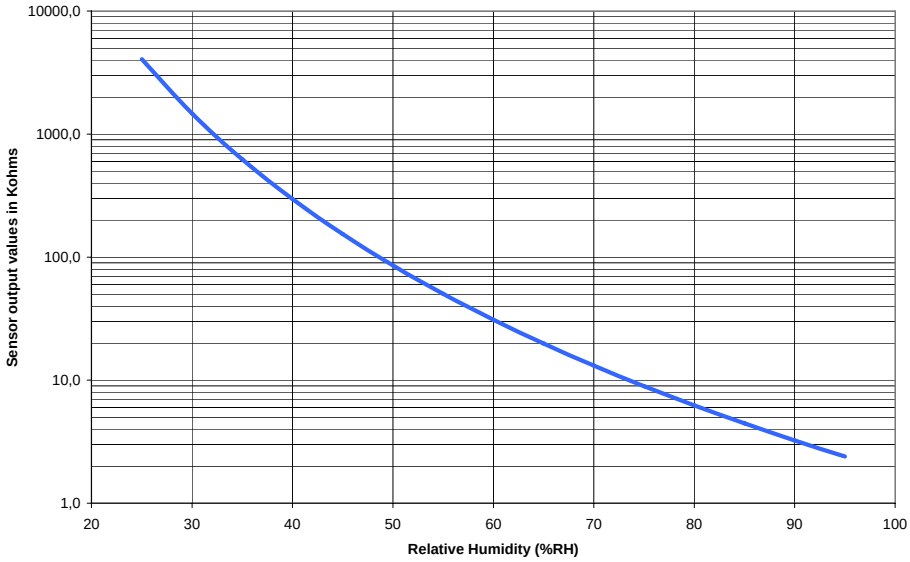
This application note introduces a method for direct interfacing using various resources available on cost effective microcontroller such as Microchip, ST, Freescale, Atmel, Cypress...

## 2. HS24LF overview:

MEAS France / HUMIREL HS24LF are ROHS compliant resistive sensor with rugged characteristics and good metrology behavior. The HS24LF resistive value is a direct function of Relative Humidity.

Typical HS24LF look-up table under test conditions: 25°C; 1 VAC / 1 KHz.

| | HS24LF values in Kohms |
|---|---|
| %RH | Typical |
| 25 | 4067 |
| 30 | 1473 |
| 35 | 624 |
| 40 | 296 |
| 45 | 154 |
| 50 | 85 |
| 55 | 50 |
| 60 | 31 |
| 65 | 19 |
| 70 | 13 |
| 75 | 8 |
| 80 | 6 |
| 85 | 4 |
| 90 | 3 |
| 95 | 2 |




Adding information is available on datasheet HPC133.

## 3. HS24LF measuring method

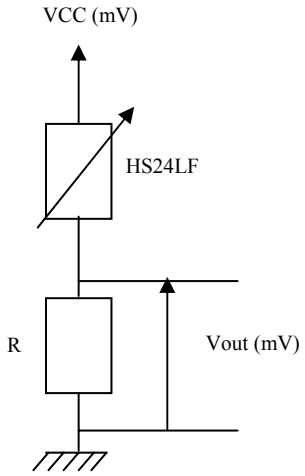
The following measuring method is based on voltage bridge divider circuit.

**1/ Hardware**:

Only one resistor component is required to design HS24LF sensor interfacing circuit.

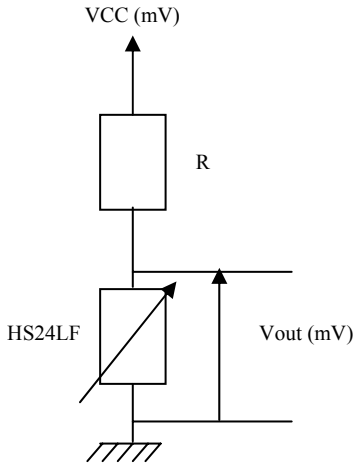
| Bill of Material : | |
|---|---|
| | Resistor: R |
| | HS24LF sensor |

Circuit configurations and equations:




$$Vout\ (mV) = \frac{VCC\ (mV) * R\ (\Omega)}{R\ (\Omega) + HS24LF\ (\Omega)}$$

Pull-Up Configuration




$$Vout\ (mV) = \frac{VCC\ (mV) * HS24LF\ (\Omega)}{R\ (\Omega) + HS24LF\ (\Omega)}$$

Pull-Down Configuration

Meas France / Humirel advices to set resistor R equals to HS24LF nominal value at 60%RH 25°C.(31Kohms 1%)

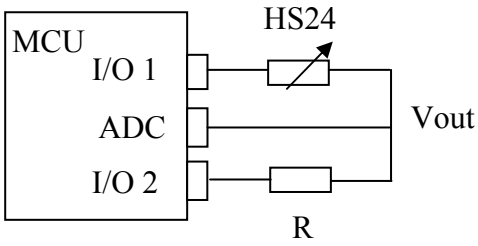
In this way, output characteristics is centered at 60%RH, middle of 25%RH - 95%RH, most common measuring range.

Pull-up provides output characteristics which follow Relative Humidity evolution.

## 2/ Measure algorithm

MCU required resources:

Internal timer
A/D converter
I/O pins




To prevent polarization of the sensor, resistive sensors use symmetrical AC excitation voltage with no DC bias. In this method, AC excitation is generated and managed by microcontroller I/O.

I/O 1 and I/O 2 initiate the excitation of the resistive sensor through R resistor.

When I/O states are in line with hardware configuration, the MCU converts Vout voltage in its internal ADC.

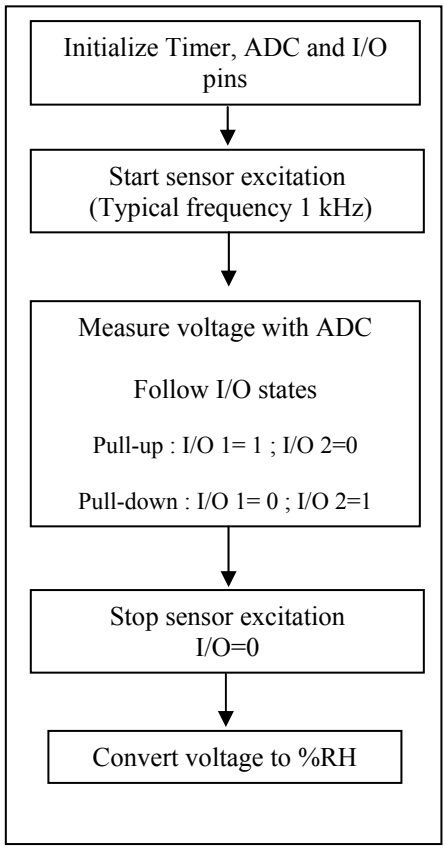
Vout voltage definition:

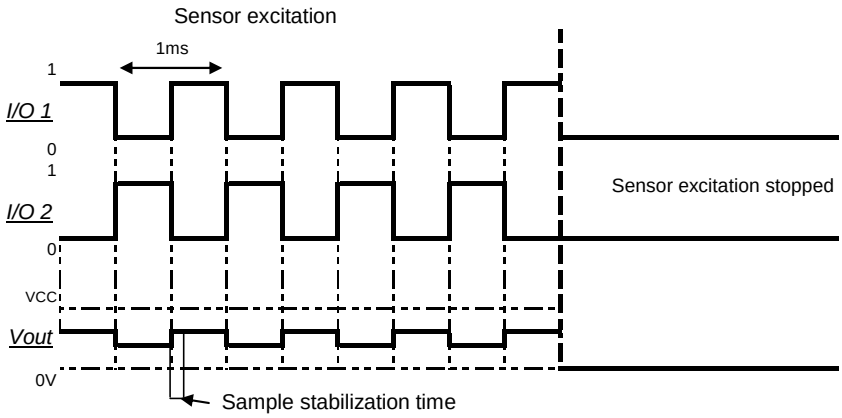
- HS24LF pads for Pull-down configuration.
- R resistor pads for Pull-up configuration.

Sensor excitation is stopped and Vout voltage read is converted in %RH.

Depending on system performance, software filtering could be implemented for better fit in %RH measurement.

Complete algorithm is available on request.




Sensor Measurement chronogram.

| | I/O 1 | I/O 2 | Voltage Measure |
|---|---|---|---|
| Pull-Up | 1 | 0 | R resistor pads |
| Pull-Down | 0 | 1 | HS24LF pads |

I/O states and hardware configuration matrix.

Typical sensor excitation frequency is 1 KHz. Additional investigation demonstrates that sensor frequency excitation value had no impact on Vout for 500Hz-2 KHz frequency range.

Other frequency values could be considered on request.

This measuring method provides ratiometric Vout link to microcontroller voltage supply.

The resolution is correlated to the ADC resolution and bias.
As an example, with a 25%RH-95%RH measuring range and a standard internal 10-bits ADC the minimum resolution which can be expected is 0.3 %RH.

See bellow resolutions matrix associated to microcontroller performances.

| Voltage supply in V | ADC Bit | ADC Step in V | Measuring Range in Volt 25%RH-95%RH | Number of measuring point | Output Slope Mean V/%RH |
|---|---|---|---|---|---|
| 1,8 | 8 | 0,0070 | 1,657 | 236 | 0,024 |
| | 10 | 0,0018 | 1,657 | 943 | 0,024 |
| | 12 | 0,0004 | 1,657 | 3771 | 0,024 |
| 3,3 | 8 | 0,0129 | 3,038 | 236 | 0,043 |
| | 10 | 0,0032 | 3,038 | 943 | 0,043 |
| | 12 | 0,0008 | 3,038 | 3771 | 0,043 |
| 5 | 8 | 0,0195 | 4,603 | 236 | 0,066 |
| | 10 | 0,0049 | 4,603 | 943 | 0,066 |
| | 12 | 0,0012 | 4,603 | 3771 | 0,066 |

## 4. Calibration process

Calibration process is dedicated to adjust circuit response to Relative Humidity reference. Usually, a certain number of boards are calibrated under a well monitored humidity and temperature environment. Those boards are used as reference; their output is the target to reach for boards to be calibrated.

HS24LF are picked over +/-3%RH at nominal 25°C 60%RH and have a typical deviation from response curves of +/-3%RH on measuring range.

Resistor R value tolerances have no significant impact on circuit response, the maximum deviation involved by 1% resistor is less than 0.15%RH.

With taking in account those characteristics several calibration protocols and measurement accuracy associated are available.

One point calibration:

- Using one point calibration at the middle of measuring range, 60%RH 25°C, allows to reach +/-5%RH accuracy on measuring range.
- Method:
  - Get Nominal value at 60%RH 25°C.
  - Adjust Nominal value to Relative Humidity reference value.

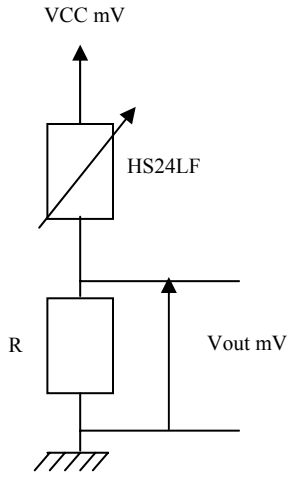
Two points calibration:

- Two points calibration allow to reach +/-3%RH accuracy on measuring range.
- Method:
  - Get Nominal value at 60%RH 25°C and slope values at 35%RH 25°C.
  - Adjust output characteristics nominal value and slope to Relative Humidity reference value.

| | Pull-up Circuit output values in mV @25°C | | |
|---|---|---|---|
| %RH | -5%RH | Typical | +5%RH |
| 25 | 10 | 40 | 105 |
| 30 | 40 | 105 | 240 |
| 35 | 105 | 240 | 475 |
| 40 | 240 | 475 | 840 |
| 45 | 475 | 840 | 1330 |
| 50 | 840 | 1330 | 1905 |
| 55 | 1330 | 1905 | 2500 |
| 60 | 1905 | 2500 | 3050 |
| 65 | 2500 | 3050 | 3510 |
| 70 | 3050 | 3510 | 3880 |
| 75 | 3510 | 3880 | 4160 |
| 80 | 3880 | 4160 | 4370 |
| 85 | 4160 | 4370 | 4525 |
| 90 | 4370 | 4525 | 4640 |
| 95 | 4525 | 4640 | 4725 |

## 5. Relative Humidity conversion: look-up table and reverse equation

Pull-Up Configuration:

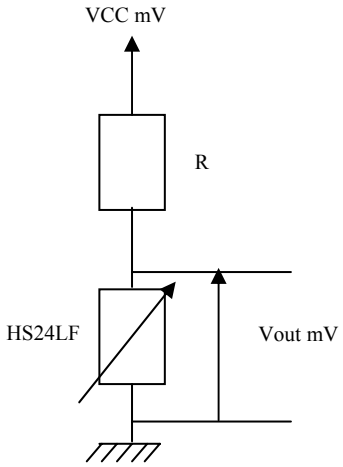



$$Vout\ (mV) = \frac{VCC\ (mV) * R\ (\Omega)}{R\ (\Omega) + HS24LF\ (\Omega)}$$

Look-up table for 5VDC at 25°C:

| Min in mV | Typ in mV | Max in mV | %RH |
|---|---|---|---|
| 10 | 40 | 105 | 25 |
| 40 | 105 | 240 | 30 |
| 105 | 240 | 475 | 35 |
| 240 | 475 | 840 | 40 |
| 475 | 840 | 1330 | 45 |
| 840 | 1330 | 1905 | 50 |
| 1330 | 1905 | 2500 | 55 |
| 1905 | 2500 | 3050 | 60 |
| 2500 | 3050 | 3510 | 65 |
| 3050 | 3510 | 3880 | 70 |
| 3510 | 3880 | 4160 | 75 |
| 3880 | 4160 | 4370 | 80 |
| 4160 | 4370 | 4525 | 85 |
| 4370 | 4525 | 4640 | 90 |
| 4525 | 4640 | 4725 | 95 |

Pull-down Configuration:




$$Vout\ (mV) = \frac{VCC\ (mV) * HS24LF\ (\Omega)}{R\ (\Omega) + HS24LF\ (\Omega)}$$

Look-up table for 5VDC at 25°C:

| Min in mV | Typ in mV | Max in mV | %RH |
|---|---|---|---|
| 4895 | 4960 | 4990 | 25 |
| 4765 | 4895 | 4960 | 30 |
| 4525 | 4765 | 4895 | 35 |
| 4160 | 4525 | 4765 | 40 |
| 3670 | 4160 | 4525 | 45 |
| 3095 | 3670 | 4160 | 50 |
| 2500 | 3095 | 3670 | 55 |
| 1950 | 2500 | 3095 | 60 |
| 1490 | 1950 | 2500 | 65 |
| 1120 | 1490 | 1950 | 70 |
| 840 | 1120 | 1490 | 75 |
| 630 | 840 | 1120 | 80 |
| 475 | 630 | 840 | 85 |
| 360 | 475 | 630 | 90 |
| 275 | 360 | 475 | 95 |

Reverse of equations:

| Measuring Range | Reverse equation type | Pull-Up Vout in mV | Pull-Down Vout in mV |
|---|---|---|---|
| 25%RH-95%RH | 3rd order | $\%RH = 1,52 * 10^{-09} * Vout^3 + 10,3*10^{-06} * Vout^2 + 29,5*10^{-03} * Vout + 26$ | $\%RH = - 1,52 * 10^{-09} * Vout^3 - 12,5*10^{-06} * Vout^2 - 40,6*10^{-03} * Vout + 107$ |
| 35%RH-80%RH | 2nd order | $\%RH = 3,43*10^{-08} *Vout^2 + 1,03*10^{-02} *Vout + 34$ | $\%RH = 3,44*10^{-08} *Vout^2 - 1,06*10^{-02} * Vout + 87$ |

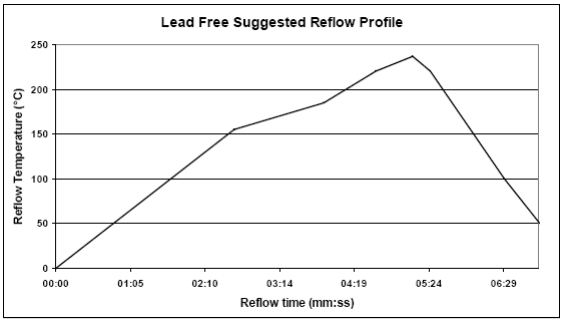
## 6. Lead Free Soldering / RoHS

In addition of hand soldering process, HS24LF humidity sensor has been designed to withstand the harsh conditions met in automated assembly processes, like specific reflow and wave soldering profiles**.**

This chapter introduces requirement and procedures for soldering of MEAS France / HUMIREL humidity sensor HS24LF in order to create good assembling conditions and secure a reliable long term behavior of system.

Reflow process:

- MEAS France / HUMIREL recommend taking specific attention to soldering conditions to get the best performance of MEAS France / Humirel HS24LF sensors.
- On side, suggested reflow profile.




Hand soldering:

- Hand or iron soldering may be applied to HS24LF sensor should be in line with application note:
  HPC054_E Application Note Soldering precautions LF process

## 7. Results

Using MEAS France / HUMIREL HS24LF direct interface method provides keys advantages:

- HS24LF interfacing circuit needs **one** additional resistor.
- **No specific** microcontroller function required.
- Measuring method is fully compatible with **smaller** and **lower cost** microcontroller.
- Accuracy on measuring range from **+/-3%RH** to +/-5%RH depending on calibration method.
- For self powered system, there is no impact of battery discharges on HS24LF system measurement: **ratiometric interface**.
- HS24LF measurement current consumption is less than **55µA** for typical 3.3VDC 10-Bit AD Converter microcontroller.

## 8. Conclusion

MEAS France / HUMIREL proposes a complete and low cost solution for HS24LF direct interface.

In addition of sensor solution, HUMIREL Home Appliance Laboratory team provides full support during all projects steps as product development and validation.