ROTRONIC HygroClip Digital Input / Output

OEM customers that use the HygroClip have the choice of using either the analog humidity and temperature output signals or the digital signal input / output (DIO).

Whenever the application is one that is best implemented by digitally processing the signals (humidity computations, data recording, range and engineering unit conversions, etc.), using the digital output signal of the HygroClip offers the following benefits:

- Higher accuracy due to the elimination of one D/A conversion in the HygroClip and one A/D conversion in the external device (OEM specific).

- Higher resolution: the D/A conversion used to generate the HygroClip analog outputs is limited to a maximum resolution of 12 bits (0.025%rh and 0.06°C). By contrast, the HygroClip reads the signals from both the humidity and temperature sensor with 16-bit resolution and a resolution of 0.004%rh and 0.004°C is available with the digital output. This is of particular interest when working with temperatures in °F and/or in applications that require tight control.

- Generally more reliable communication between the HygroClip and other devices

1. General Description of the HygroClip

The ROTRONIC HygroClip is a humidity-temperature probe which plugs into any matching connector from ROTRONIC. The HygroClip has 5 pins (or wires) corresponding to the following:

- Supply Voltage (+) : 3.5 to 50 VDC
- Ground (-) : reference for supply voltage and output signals
- Humidity Analog Output (+)
- Temperature Analog Output (+)
- DIO: digital input – output

1.1 Internal Subsystems of the HygroClip

Internally. the HygroClip is comprised of two main subsystems:

• AIRCHIP 2000

This ASIC includes the circuitry required to measure the capacitive humidity sensor and the Pt100 RTD and to convert the measurements into digital counts. The ASIC also includes two D/A converters that convert the data from the microcontroller into analog output signals. The ASIC also regulates all supply voltages and generates the reset and clock for the microcontroller.

• Microcontroller / EEPROM

The microcontroller uses the counts measured by the ASIC to compute the value of humidity and temperature. Calibration data, linearization and other sensor data are memorized in the EEPROM. The microcontroller sends data both to the DIO pin (digital output signal) and to the ASIC (analog output signal).

Two way communication between the HygroClip and an external system (for example, a PC) is used to write data to the EEPROM such as calibration data, serial number, etc.

1.2 Operating Modes of the HygroClip

The HygroClip does not require an initialization sequence or “send” command. About 3 seconds after being powered up, the HygroClip automatically sends the first humidity and temperature data and updates all outputs every 0.66 second (measuring cycle).

Essentially, the HygroClip has two operating modes: the send mode (or normal operating mode) and the receive mode.

In the send mode, the HygroClip operates as a conventional humidity and temperature probe with two analog outputs and one digital output. Unless other instructions have been received (see recive mode), the data from both the Pt100 RTD temperature sensor and the capacitive humidity sensor are sent during each measuring cycle (0.66 sec) to both the digital and analog outputs.

In the receive mode, digital commands can be sent to the HygroClip to the purpose of calibrating the HygroClip or to ask for additional information such as the serial number, calibration date, etc.

1.3 The HygroClip One-Wire Digital Interface

Because of the limited number of connections available on the HygroClip, all digital communication between the HygroClip and an external system is done with a single DIO pin that is referenced to ground.

The main characteristics of the HygroClip communications protocol are as follows:

• Bit Definition:

The communication protocol differenciates between logical “1” and logical “0” bits based on the amount of time (pulse width) between two successive transitions. Communication is done without grouping the data into bytes. As opposed to this, communication is a single bit stream with a very short pause between each bit.

• 2-way Communication

Communication is entirely defined by means of time intervals or windows. The HygroClip always assumes the function of master and signals the start of each communication cycle (generally every 0.66 sec.). At the beginning of each communication cycle, the HygroClip goes into the “receive” mode and the external system has a defined time window during which it can begin sending a bit stream. If no bit stream is detected within this time window, the HygroClip automatically switches back to the “send “mode and proceeds with sending the humidity and temperature data.

• Transmission Speed

Data is exchanged at a rate of about 4 to 5 ms per byte.

• Integrity of the Output Data

The protocol makes use of a check sum only for the output of the humidity and temperature data. For all other data, only the number of bits is verified (must be a multiple of 8) and overall verification of data integrity should be done by the external system.

2. Specifications of the Digital Input Output (DIO)

2.1 General

The digital output of the HygroClip (DIO) allows the bi-directional transmission of data (input / output). The electrical connection consists of a single wire plus ground.

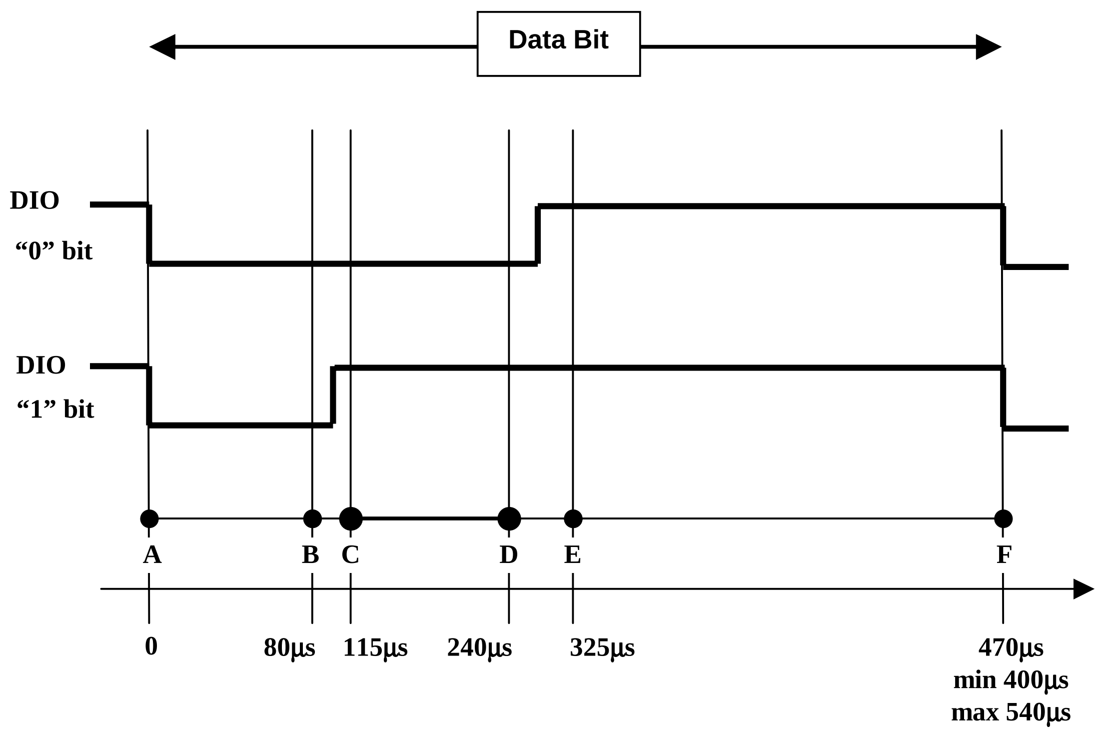
Data is transmitted by means of a stream of pulses with a nominal height of 3.15 V, referred to ground. The current to and from the DIO is internally limited by a 10kΩ resistor.

2.2 Definition of a Data Bit

The HygroClip uses a single DIO pin (referred to ground) for sending and receiving digital data.

When inactive, the state of the DIO is a logical 1. Each individual data bit has a width of 400 µs to 540 µs (470 µs nominal). The transmission of each bit begins with a negative transition of the DIO state from a logical 1 to a logical 0. This transition (A) is used as the time origin (see diagram below).

The length of time during which the state of the DIO is a logical 0 defines whether the data bit is a “1” or a “0”.



Using the above diagram, nominal times are as follows:

t_{AB}	Minimum time for a “1” bit	80µs
t_{AC}	Maximum time for a “1” bit	115µs
t_{BC}	Time window during which a transition is permitted	35µs
t_{AD}	Minimum time for a “0” bit	240µs
t_{AE}	Maximum time for a “0” bit	325µs
t_{DE}	Time window during which a transition is permitted	85µs
t_{AF}	Next “reference” transition – earliest time	400µs
t_{AF}	Next “reference” transition – latest time	540µs

2.3 Description of the Communication Cycle

The start of each communication cycle is set by the HygroClip. The HygroClip begins by generating a “0” bit. The negative transition of this bit (S) is used as the time origin (see diagram below). As already mentioned, data bits have a mimimum width of 400µs and a maximum width of 540µs.

After sending this initial bit, the HygroClip switches from output to input (I - O) and lets the DIO float (receive mode). This allows an external device to set the logical state of the DIO.

The external device must set the DIO to a logical “1” prior to transmitting any data bit (data bits begin with a negative transition). In addition, the negative transition corresponding to the beginning of the first data bit sent by the external device must take place within the time window (R - O).

During the time window (R – O), the HygroClip monitors the logical state of the DIO and looks for a negative transition:

• Case 1: no negative transition is detected within the (R – O) window:

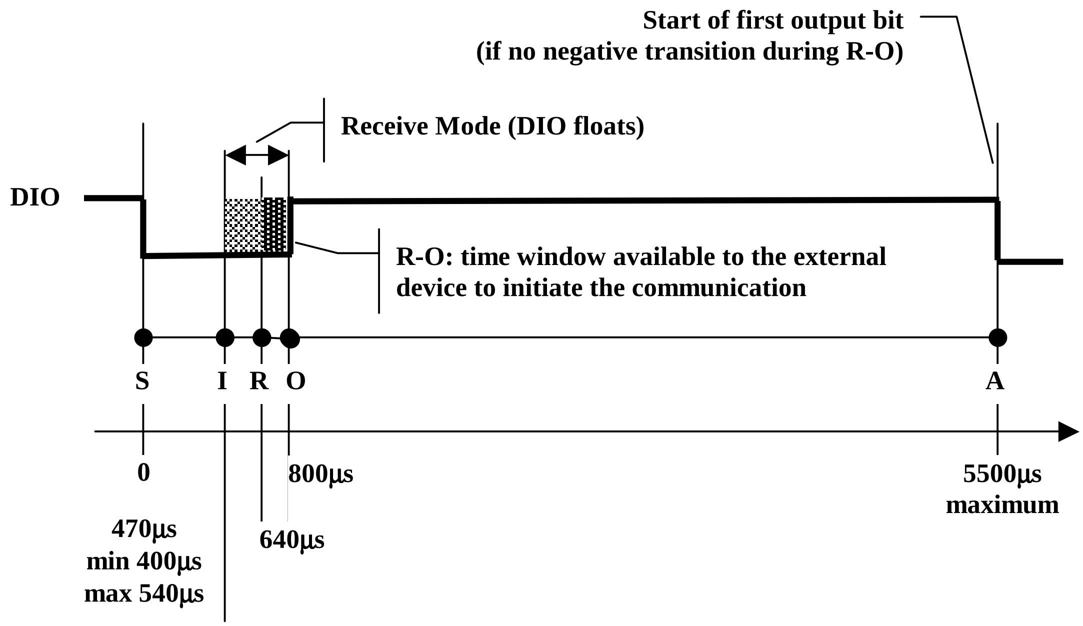
The HygroClip takes control of the DIO and sets it to a logical “1” after 800µs. After a maximum of 5,500µs, the HygroClip starts sending the humidity and temperature data. At this time, the HygroClip generates a negative transition (A) indicating the beginning of the first bit of the temperature and humidity data stream. Each byte is sent with the least significant bit (LSB) first and the most significant bit (MSB) last.

• Case 2: a negative transition is detected within the (R – O) window:

As mentioned earlier, the external device sets the DIO to a logical “1”. Transmission of the first bit by the external device begins with a negative transition (after 640µs at the earliest and 800µs at the latest). After detecting the negative transition, the HygroClip stays in the “receive” mode and takes the incoming bit stream, LSB first and MSB last.

If at any time, the HygroClip does not detect a negative transition over a time period of 540µs (maximum width of a data bit), it automatically returns to the send mode.

During a 2-way communication, the HygroClip does not automatically send the temperature and humidity data. The data sent by the HygroClip depends on the commands received from the external device. Powering the HygroClip off and on restores normal operation (send mode).



2.4 Tolerance to Distortions in the Transmission Line

The different times mentioned earlier are measured directly at the output of the sender. Logical levels of the DIO are defined as <1/3 and >2/3 of the nominal voltage.

Protective circuits in the transmission line as well as signal amplifiers and level adapters can also cause slight changes in the width of the pulses during the transmission of data. The ROTRONIC communication protocol allows the following maximum tolerances regarding the width of a pulse (time elapsed between the negative and positive transitions): -30µs and +15µs.

For the HygroClip as well as for any external device communicating with the HygroClip, this means that the following times should be acceptable:

HygroClip:

t_{AB}	minimum time for a “1” bit	50µs
t_{AC}	maximum time for a “1” bit	130µs
t_{BC}	time window during which a transition is permitted	80µs
t_{AD}	minimum time for of a “0” bit	210µs
t_{AE}	maximum time for of a “0” bit	340µs
t_{DE}	time window during which a transition is permitted	130µs
t_{AF}	Next “reference” transition – earliest time	370µs
t_{AF}	Next “reference” transition – latest time	555µs

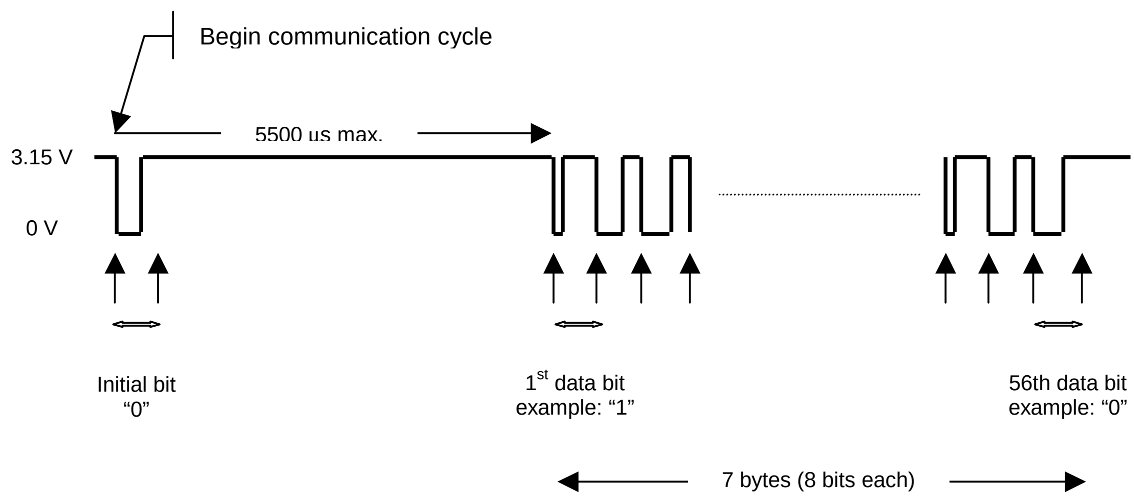
External Device:

t_{SI}	minimum time for a “0” bit	370µs
t_{SI}	maximum time for a “0” bit	555µs
t_{SR}	earliest start of the bit stream	610µs
t_{SO}	latest start of the bit stream	820µs

3. Encoding of the Temperature and Humidity Data

3.1 Structure of the Data String

In the normal mode, the HygroClip sends every 0.66 second a temperature and humidity data string of constant length to the DIO. The data string is made of 7 bytes (8 bits per byte). For each byte, the least significant bit (LSB) is sent first and the most significant bit (MSB) is sent last.



The first 3 bytes are used for temperature, the next 3 bytes for humidity and the last byte is a checksum.

The temperature range of the HygroClip is –50..200°C. In order to eliminate the need for transmitting the minus sign in the case of negative temperatures, the digital value of temperature is offset by +50°C and has a range of 0..250°C. The 50°C offset should be subtracted when computing temperature from its digital value.

The following table shows the structure of the data string (the symbol indicates any hexadecimal value):

Byte #	Hex Value	Description
1	0x54	ASCII character T
2	0x	Decimal portion of temperature [°C / 256] **)
3	0x	Non decimal portion of temperature [°C]
4	0x46	ASCII character F
5	0x	Decimal portion of humidity [%rh / 256] **)
6	0x	Non decimal portion of Humidity [%rh]
7	0x	Checksum

The checksum is defined as the sum of the bytes 1 to 6, modulo 256 (the remainder of the division of the value of the sum by the number 256).

**) for an explanation, see example below

3.2 Example of a Data String

In this example, the HygroClip is sending the following binary data string (starting from the left).

00101010110001010100010001100010001000000011101011111101

As already mentioned, the least significant bit (LSB) of each byte is sent first and the most significant bit (MSB) is sent last. Using the LSB first rule, the binary data sting can be converted as follows, :

Hexadecimal

T	°C dec	°C whole	F	%rh dec	%rh whole	ChkSum
0x54	0xA3	0x22	0x46	0x04	0x5C	0xBF

Decimal

84	163	34	70	4	92	191

The decimal value 84 corresponds to the ASCII character T and the decimal value 70 corresponds to the ASCII character F.

The checksum can be verified as follows:

(84 + 163 + 34 + 70 + 4 + 92) = 447 mod 256 = 191 (OK)

Temperature can be computed as follows:

(163 / 256) + 34 – 50 = -15.637 °C

Humidity can be computed as follows:

(4 / 256) + 92 = 92.016 %rh

Note that the use of 1 byte (8 bits or 256 counts) for the transmission of decimal values provides a resolution of 1 / 256 or 0.004°C or 0.004 %rh.

4. Special Applications

The HygroClip can be calibrated or adjusted, and additional information can be obtained, by sending the appropriate series of commands.

Very few OEM applications should require the use of the 2-way communication capability of the HygroClip.

4.1 Items Accessible by 2-way Communication

1- Raw A to D counts for the temperature channel (resulting from the resistance value of the Pt100 RTD, the value of the reference resistor and the offset voltage).

2- Raw A to D counts for the humidity channel (a pair of values that are averaged)

3- Read and adjust the data used for converting resistance into temperature (used for calibration).

4- Read and adjust the data used for converting capacitance into humidity (used for calibration)

5- Freeze the analog outputs to a constant value and return the outputs to their normal mode (normal operation is also automatically restored when the HygroClip is powered off and on).

6- Set the digital output value of the temperature channel

7- Set the digital output value of the humidity channel

8- Set or adjust the conversion of digital values into analog signals for the temperature channel

9- Set or adjust the conversion of digital values into analog signals for the humidity channel

10- Read the serial number of the HygroClip, the software version number, the date of the latest calibration. Read the data associated with the nominal characteristic curve of the sensors or the compensation.

4.2 Technical Support from Rotronic

On request, OEM customers can get from ROTRONIC an example of a simple circuit that converts the digital signal from the HygroClip into the RS232 format for direct use with the serial port of a PC.

Customers who wish to make use of the 2-way communication feature of the HygroClip should contact ROTRONIC or their local representative for additional information and support.