LM35 Precision Centigrade Temperature Sensors

1 Features

- Calibrated Directly in Celsius (Centigrade)
- Linear + 10-mV/°C Scale Factor
- 0.5°C Ensured Accuracy (at 25°C)
- Rated for Full −55°C to 150°C Range
- Suitable for Remote Applications
- Low-Cost Due to Wafer-Level Trimming
- Operates from 4 V to 30 V
- Less than 60-µA Current Drain
- Low Self-Heating, 0.08°C in Still Air
- Non-Linearity Only ±¼°C Typical
- Low-Impedance Output, 0.1 Ω for 1-mA Load

2 Applications

- Power Supplies
- Battery Management
- HVAC
- Appliances

3 Description

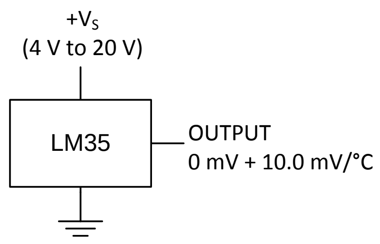
The LM35 series are precision integrated-circuit temperature devices with an output voltage linearly-proportional to the Centigrade temperature. The LM35 device has an advantage over linear temperature sensors calibrated in Kelvin, as the user is not required to subtract a large constant voltage from the output to obtain convenient Centigrade scaling. The LM35 device does not require any external calibration or trimming to provide typical accuracies of ±¼°C at room temperature and ±¾°C over a full −55°C to 150°C temperature range. Lower cost is assured by trimming and calibration at the wafer level. The low-output impedance, linear output, and precise inherent calibration of the LM35 device makes interfacing to readout or control circuitry especially easy. The device is used with single power supplies, or with plus and minus supplies. As the LM35 device draws only 60 µA from the supply, it has very low self-heating of less than 0.1°C in still air. The LM35 device is rated to operate over a −55°C to 150°C temperature range, while the LM35C device is rated for a −40°C to 110°C range (−10° with improved accuracy). The LM35-series devices are available packaged in hermetic TO transistor packages, while the LM35C, LM35CA, and LM35D devices are available in the plastic TO-92 transistor package. The LM35D device is available in an 8-lead surface-mount small-outline package and a plastic TO-220 package.

Device Information(1)

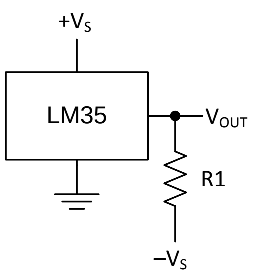
PART NUMBER	PACKAGE	BODY SIZE (NOM)
LM35	TO-CAN (3)	4.699 mm × 4.699 mm
	TO-92 (3)	4.30 mm × 4.30 mm
	SOIC (8)	4.90 mm × 3.91 mm
	TO-220 (3)	14.986 mm × 10.16 mm

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

Basic Centigrade Temperature Sensor (2°C to 150°C)



Full-Range Centigrade Temperature Sensor



Choose $R_1 = –V_S$ / 50 µA
V_{OUT} = 1500 mV at 150°C
V_{OUT} = 250 mV at 25°C
V_{OUT} = –550 mV at –55°C

6.5 Electrical Characteristics: LM35A, LM35CA Limits

Unless otherwise noted, these specifications apply: −55°C ≤ T_J ≤ 150°C for the LM35 and LM35A; −40°C ≤ T_J ≤ 110°C for the LM35C and LM35CA; and 0°C ≤ T_J ≤ 100°C for the LM35D. V_S = 5 Vdc and I_{LOAD} = 50 µA, in the circuit of Full-Range Centigrade Temperature Sensor. These specifications also apply from 2°C to T_{MAX} in the circuit of Figure 14.

PARAMETER	TEST CONDITIONS	LM35A			LM35CA			UNIT
		TYP	TESTED LIMIT [1]	DESIGN LIMIT [2]	TYP	TESTED LIMIT [1]	DESIGN LIMIT [2]	
Accuracy [3]	T_A = 25°C	±0.2	±0.5		±0.2	±0.5		°C
	T_A = –10°C	±0.3			±0.3		±1	
	$T_A = T_{MAX}$	±0.4	±1		±0.4	±1		
	$T_A = T_{MIN}$	±0.4	±1		±0.4		±1.5	
Nonlinearity [4]	$T_{MIN} \le T_A \le T_{MAX}$, –40°C ≤ T_J ≤ 125°C	±0.18		±0.35	±0.15		±0.3	°C
Sensor gain (average slope)	$T_{MIN} \le T_A \le T_{MAX}$	10	9.9		10		9.9	mV/°C
	–40°C ≤ T_J ≤ 125°C	10	10.1		10		10.1	
Load regulation [5] 0 ≤ I_L ≤ 1 mA	T_A = 25°C	±0.4	±1		±0.4	±1		mV/mA
	$T_{MIN} \le T_A \le T_{MAX}$, –40°C ≤ T_J ≤ 125°C	±0.5		±3	±0.5		±3	
Line regulation [5]	T_A = 25°C	±0.01	±0.05		±0.01	±0.05		mV/V
	4 V ≤ V_S ≤ 30 V, –40°C ≤ T_J ≤ 125°C	±0.02		±0.1	±0.02		±0.1	
Quiescent current [6]	V_S = 5 V, 25°C	56	67		56	67		µA
	V_S = 5 V, –40°C ≤ T_J ≤ 125°C	105		131	91		114	
	V_S = 30 V, 25°C	56.2	68		56.2	68		
	V_S = 30 V, –40°C ≤ T_J ≤ 125°C	105.5		133	91.5		116	
Change of quiescent current [5]	4 V ≤ V_S ≤ 30 V, 25°C	0.2	1		0.2	1		µA
	4 V ≤ V_S ≤ 30 V, –40°C ≤ T_J ≤ 125°C	0.5		2	0.5		2	
Temperature coefficient of quiescent current	–40°C ≤ T_J ≤ 125°C	0.39		0.5	0.39		0.5	µA/°C
Minimum temperature for rate accuracy	In circuit of Figure 14, I_L = 0	1.5		2	1.5		2	°C
Long term stability	$T_J = T_{MAX}$, for 1000 hours	±0.08			±0.08			°C

(1) Tested Limits are ensured and 100% tested in production.
(2) Design Limits are ensured (but not 100% production tested) over the indicated temperature and supply voltage ranges. These limits are not used to calculate outgoing quality levels.
(3) Accuracy is defined as the error between the output voltage and 10 mv/°C times the case temperature of the device, at specified conditions of voltage, current, and temperature (expressed in °C).
(4) Non-linearity is defined as the deviation of the output-voltage-versus-temperature curve from the best-fit straight line, over the rated temperature range of the device.
(5) Regulation is measured at constant junction temperature, using pulse testing with a low duty cycle. Changes in output due to heating effects can be computed by multiplying the internal dissipation by the thermal resistance.
(6) Quiescent current is defined in the circuit of Figure 14.

LMx58-N Low-Power, Dual-Operational Amplifiers

1 Features

- Available in 8-Bump DSBGA Chip-Sized Package, (See AN-1112, SNVA009)
- Internally Frequency Compensated for Unity Gain
- Large DC Voltage Gain: 100 dB
- Wide Bandwidth (Unity Gain): 1 MHz (Temperature Compensated)
- Wide Power Supply Range:
  - Single Supply: 3V to 32V
  - Or Dual Supplies: ±1.5V to ±16V
- Very Low Supply Current Drain (500 μA)—Essentially Independent of Supply Voltage
- Low Input Offset Voltage: 2 mV
- Input Common-Mode Voltage Range Includes Ground
- Differential Input Voltage Range Equal to the Power Supply Voltage
- Large Output Voltage Swing
- Unique Characteristics:
  - In the Linear Mode the Input Common-Mode Voltage Range Includes Ground and the Output Voltage Can Also Swing to Ground, even though Operated from Only a Single Power Supply Voltage.
  - The Unity Gain Cross Frequency is Temperature Compensated.
  - The Input Bias Current is also Temperature Compensated.
- Advantages:
  - Two Internally Compensated Op Amps
  - Eliminates Need for Dual Supplies
  - Allows Direct Sensing Near GND and V_{OUT} Also Goes to GND
  - Compatible with All Forms of Logic
  - Power Drain Suitable for Battery Operation

2 Applications

- Active Filters
- General Signal Conditioning and Amplification
- 4- to 20-mA Current Loop Transmitters

3 Description

The LM158 series consists of two independent, high gain, internally frequency compensated operational amplifiers which were designed specifically to operate from a single power supply over a wide range of voltages. Operation from split power supplies is also possible and the low power supply current drain is independent of the magnitude of the power supply voltage.

Application areas include transducer amplifiers, dc gain blocks and all the conventional op-amp circuits which now can be more easily implemented in single power supply systems. For example, the LM158 series can be directly operated off of the standard 3.3-V power supply voltage which is used in digital systems and will easily provide the required interface electronics without requiring the additional ±15V power supplies.

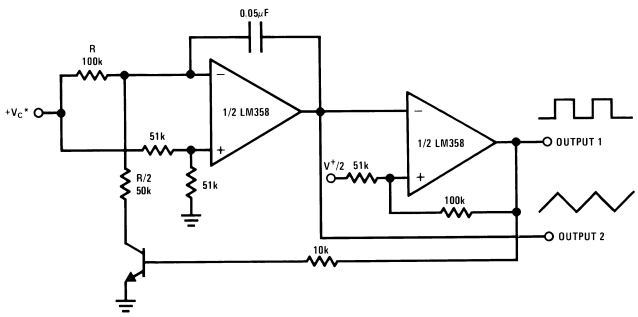
The LM358 and LM2904 are available in a chip sized package (8-Bump DSBGA) using TI's DSBGA package technology.

Device Information(1)

PART NUMBER	PACKAGE	BODY SIZE (NOM)
LM158-N	TO-CAN (8)	9.08 mm x 9.09 mm
	CDIP (8)	10.16 mm x 6.502 mm
LM258-N	TO-CAN (8)	9.08 mm x 9.09 mm
LM2904-N	DSBGA (8)	1.31 mm x 1.31 mm
	SOIC (8)	4.90 mm x 3.91 mm
	PDIP (8)	9.81 mm x 6.35 mm
LM358-N	TO-CAN (8)	9.08 mm x 9.09 mm
	DSBGA (8)	1.31 mm x 1.31 mm
	SOIC (8)	4.90 mm x 3.91 mm
	PDIP (8)	9.81 mm x 6.35 mm

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

Voltage Controlled Oscillator (VCO)



Electrical Characteristics: LM158A, LM358A, LM158, LM258 (continued)

$V^+ = +5.0$ V, See(1), unless otherwise stated

PARAMETER		TEST CONDITIONS	LM158A MIN	LM158A TYP	LM158A MAX	LM358A MIN	LM358A TYP	LM358A MAX	LM158, LM258 MIN	LM158, LM258 TYP	LM158, LM258 MAX	UNIT
Power Supply Rejection Ratio		$V^+ = 5$ V to 30 V (LM2904, $V^+ = 5$ V to 26 V), $T_A = 25°C$	65	100		65	100		65	100		dB
Amplifier-to-Amplifier Coupling		f = 1 kHz to 20 kHz, $T_A = 25°C$ (Input Referred), See (5)		−120			−120			−120		dB
Output Current	Source	$V_{IN}^+ = 1$ V, $V_{IN}^- = 0$ V, $V^+ = 15$ V, $V_O = 2$ V, $T_A = 25°C$	20	40		20	40		20	40		mA
	Sink	$V_{IN}^- = 1$ V, $V_{IN}^+ = 0$ V, $V^+ = 15$ V, $T_A = 25°C$, $V_O = 2$ V	10	20		10	20		10	20		mA
		$V_{IN}^- = 1$ V, $V_{IN}^+ = 0$ V, $T_A = 25°C$, $V_O = 200$ mV, $V^+ = 15$ V	12	50		12	50		12	50		μA
Short Circuit to Ground		$T_A = 25°C$, See (6), $V^+ = 15$ V		40	60		40	60		40	60	mA
Input Offset Voltage		See (2)			4			5			7	mV
Input Offset Voltage Drift		$R_S = 0Ω$		7	15		7	20		7		μV/°C
Input Offset Current		$I_{IN(+)} - I_{IN(-)}$			30			75			100	nA
Input Offset Current Drift		$R_S = 0Ω$		10	200		10	300		10		pA/°C
Input Bias Current		$I_{IN(+)}$ or $I_{IN(-)}$		40	100		40	200		40	300	nA
Input Common-Mode Voltage Range		$V^+ = 30$ V, See (4) (LM2904, $V^+ = 26$ V)	0		$V^+−2$	0		$V^+−2$	0		$V^+−2$	V
Large Signal Voltage Gain		$V^+ = +15$ V ($V_O = 1$ V to 11 V) $R_L ≥ 2$ kΩ	25			15			25			V/mV
Output Voltage Swing	V_{OH}	$V^+ = +30$ V, $R_L = 2$ kΩ	26			26			26			V
		(LM2904, $V^+ = 26$ V), $R_L = 10$ kΩ	27	28		27	28		27	28		V
	V_{OL}	$V^+ = 5V$, $R_L = 10$ kΩ		5	20		5	20		5	20	mV
Output Current	Source	$V_{IN}^+ = +1$ V, $V_{IN}^- = 0$ V, $V^+ = 15$ V, $V_O = 2$ V	10	20		10	20		10	20		mA
	Sink	$V_{IN}^- = +1$ V, $V_{IN}^+ = 0$ V, $V^+ = 15$ V, $V_O = 2$ V	10	15		5	8		5	8		mA

(5) Due to proximity of external components, insure that coupling is not originating via stray capacitance between these external parts. This typically can be detected as this type of capacitance increases at higher frequencies.

(6) Short circuits from the output to V^+ can cause excessive heating and eventual destruction. When considering short circuits to ground, the maximum output current is approximately 40 mA independent of the magnitude of V^+. At values of supply voltage in excess of +15 V, continuous short-circuits can exceed the power dissipation ratings and cause eventual destruction. Destructive dissipation can result from simultaneous shorts on all amplifiers.

Presentación de TM221ME16R/TM221ME16RG

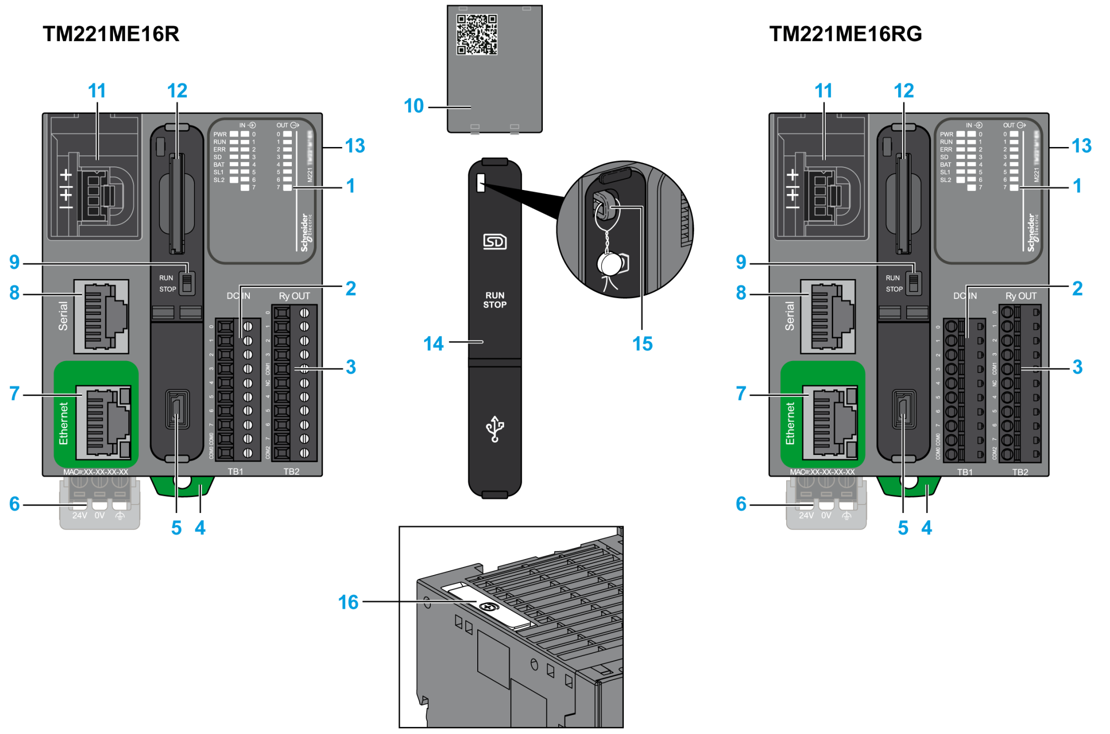
Descripción general

Las siguientes características se integran en los controladores TM221ME16R (tornillo) y TM221ME16RG (resorte):

- 8 entradas digitales
  - 4 entradas normales
  - 4 entradas rápidas (HSC)
- 8 salidas digitales
  - 8 salidas de relé
- 2 entradas analógicas
- Puerto de comunicación
  - 1 puerto de línea serie
  - 1 puerto de programación USB mini-B
  - 1 puerto Ethernet

Descripción

En la siguiente figura se muestran los distintos componentes de los controladores:

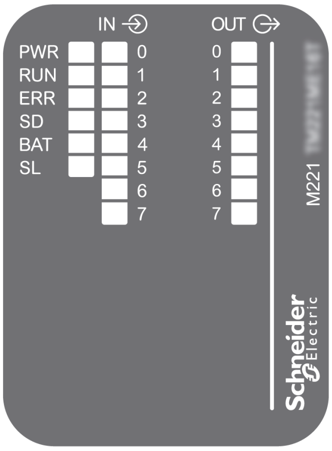


Número	Descripción	Consulte
1	Indicadores LED de estado	–
2	Bloque de terminales extraíble de la entrada	Reglas para el bloque de terminales de tornillo extraíble *(véase página 106)* Reglas para el bloque de terminales de resorte extraíble *(véase página 108)*
3	Bloque de terminales extraíble de la salida	
4	Cierre de clip para segmentos DIN de 35 mm (1,38 pulg.)	Segmento DIN *(véase página 95)*
5	Puerto de programación USB mini-B / para la conexión de terminales a un PC de programación (SoMachine Basic)	Puerto de programación USB mini-B *(véase página 384)*
6	Fuente de alimentación de 24 V CC	Fuente de alimentación *(véase página 112)*
7	Puerto Ethernet / conector RJ-45	Puerto Ethernet *(véase página 386)*
8	Puerto de línea serie 1 / conector RJ-45 (RS-232 o RS-485)	Línea serie 1 *(véase página 389)*

Número	Descripción	Consulte
9	Interruptor Run/Stop	Interruptor Run/Stop *(véase página 69)*
10	Cubierta de entradas analógicas extraíble	–
11	2 entradas analógicas	Entradas analógicas *(véase página 297)*
12	Slot para tarjeta SD	Slot para tarjeta SD *(véase página 72)*
13	Conector de ampliación de E/S	–
14	Cubierta de protección (slot para tarjeta SD, interruptor Ejecutar/Detener y puerto de programación USB mini-B)	–
15	Gancho de sujeción	–
16	Soporte de la batería	Instalación y sustitución de la batería *(véase página 55)*

Indicadores LED de estado

En la figura siguiente se muestran los indicadores LED de estado:



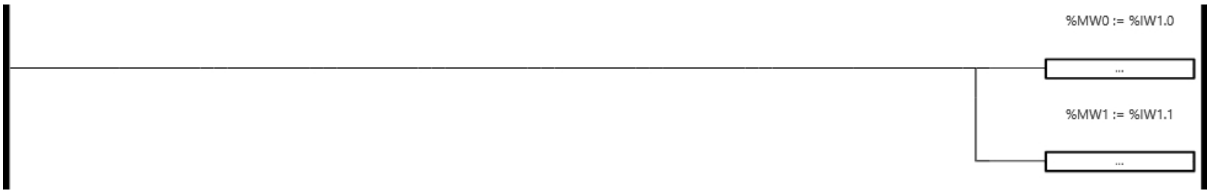
POU

Tarea maestra

1 - POU_01_sensor

Tarea maestra

Rung0



Variables utilizadas:

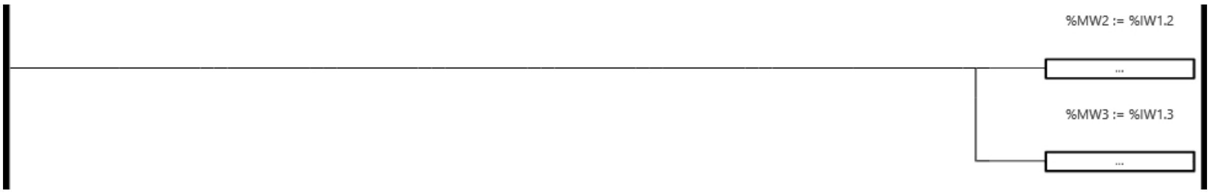
%IW1.0		
%IW1.1		
%MW0	HUM_SUELO	detect: humedad del suelo de riego
%MW1	LLUVIA_MA	detect: lluvia medio ambiental

Rung1

Variables utilizadas:

%MW1	LLUVIA_MA	detect: lluvia medio ambiental
%MW5		

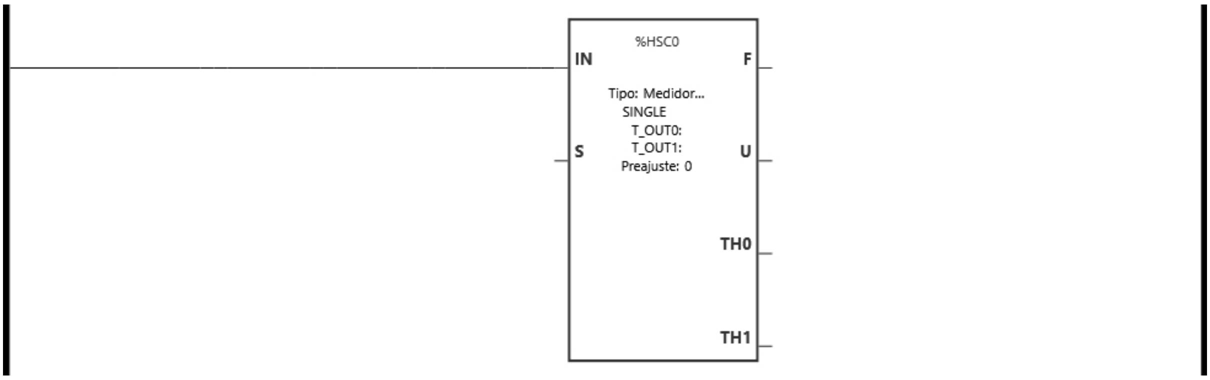
Rung2



Variables utilizadas:

%IW1.2		
%IW1.3		
%MW2	TEMP_AIRE	temperatura ambiental
%MW3	NIVEL_H2O	nivel de llenado del tanque

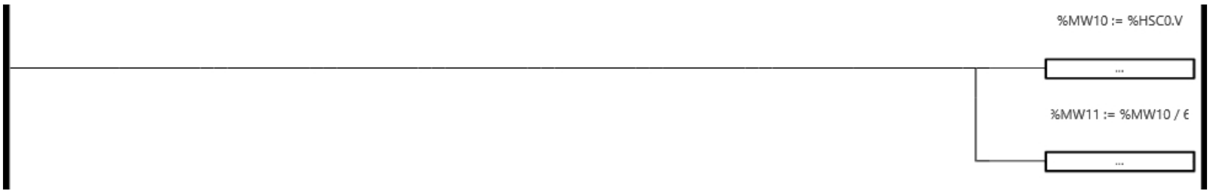
Rung3



<u>Variables utilizadas:</u>

%HSC0	ENTRADA_PULSOS	entrada de pulsos desde el sensor de caudal

Rung4



<u>Variables utilizadas:</u>

%HSC0.V	ENTRADA_PULSOS.V	entrada de pulsos desde el sensor de caudal
%MW10	FRECUEN_PULSOS	frecuencia de pulso en 1seg, pulsos de entrada
%MW11	CAUDAL_H2O	el factor "6" numero especifiado por el fabricante del sensor de caudal

2 - POU_02_contac_IO

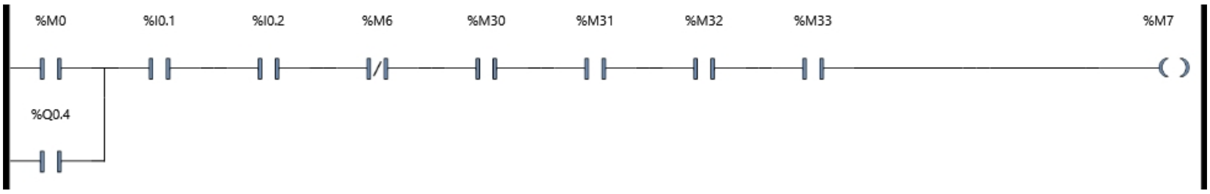
Tarea maestra

Rung0

Variables utilizadas:

%I0.3	INICIO_PROCESS	entrada para el inicio general del proceso
%M0	M0_ARRANQUE_SISTEMA	memoria direccion %M0: pase de arranque al sistema total

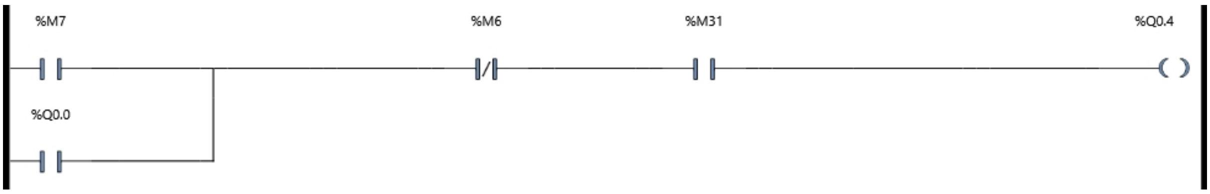
Rung1



Variables utilizadas:

%I0.1	PARO_SISTEMA_GENRAL	entrada digital para el paro generl del proceso
%I0.2	PULSA_PARO_EMERGEN	boton de paro del sistema, por emergencia.
%M0	M0_ARRANQUE_SISTEMA	memoria direccion %M0: pase de arranque al sistema total
%M6	SENIAL_PARO_SISTEMA	tiempo de riego trascurrido (1h y 24min)
%M7		
%M30	COND_TEMP	CONDICION DE ARRANQUE DE RIEGO
%M31	COND_NIVEL	
%M32	COND_HUMED	
%M33	COND_LLUVIA	
%Q0.4	VALV_01	valvula_01 solenoide de flujo con antirretorno de fliuido

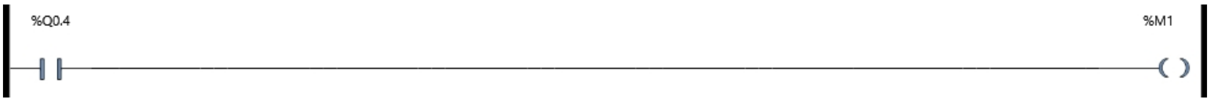
Rung2



Variables utilizadas:

%M6	SENIAL_PARO_SISTEMA	tiempo de riego trascurrido (1h y 24min)
%M7		
%M31	COND_NIVEL	
%Q0.0	BOMB_H2O	motor d bomba d agua H2O
%Q0.4	VALV_01	valvula_01 solenoide de flujo con antirretorno de fliuido

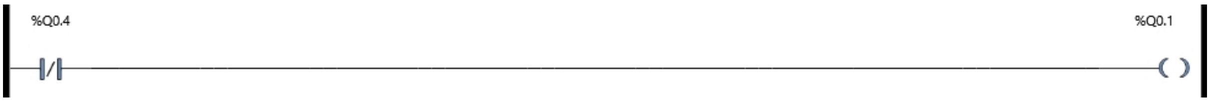
Rung3



Variables utilizadas:

%M1	SENIAL_VALV01	señal de arranque de la valvula solenoide(antiRetro) valv_01
%Q0.4	VALV_01	valvula_01 solenoide de flujo con antirretorno de fliuido

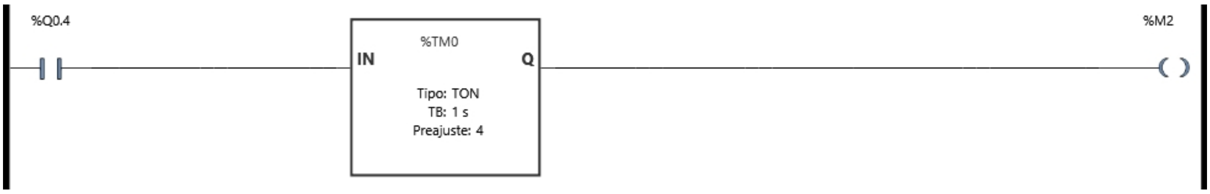
Rung4



Variables utilizadas:

%Q0.1	SENIAL_PANEL	panrel led de señalizacion de inicio de arranque
%Q0.4	VALV_01	valvula_01 solenoide de flujo con antirretorno de fliuido

Rung5



Variables utilizadas:

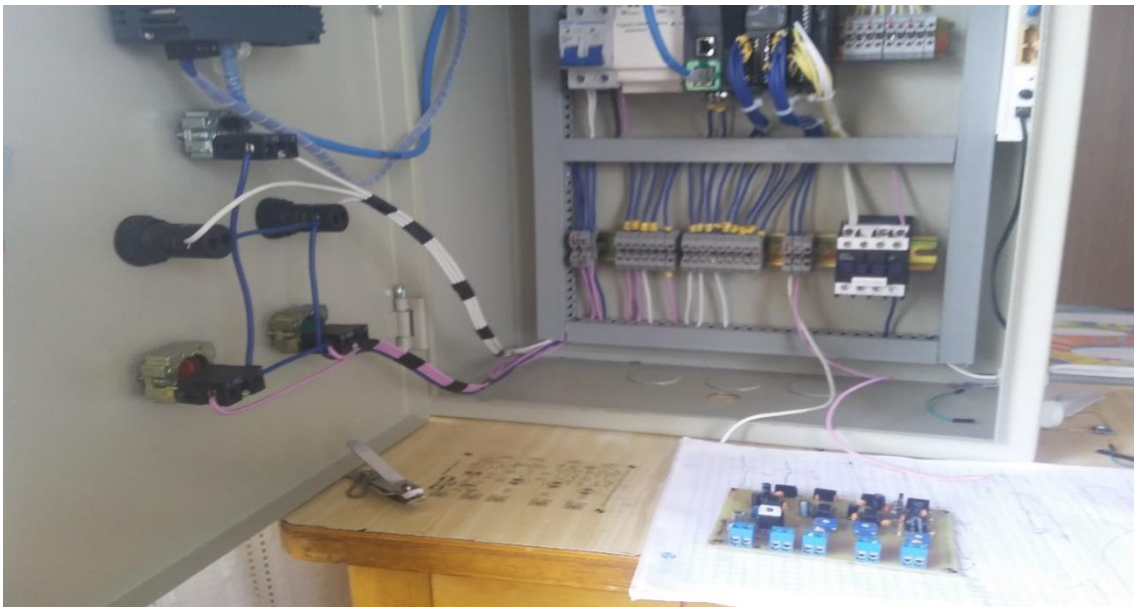
%M2	SENIAL_VALV02	señal de arranque de la valvula solenoide(antiRetro) valv_02
%Q0.4	VALV_01	valvula_01 solenoide de flujo con antirretorno de fliuido
%TM0	TIMER_01	retardo de arranque valv_02

Rung6

Variables utilizadas:

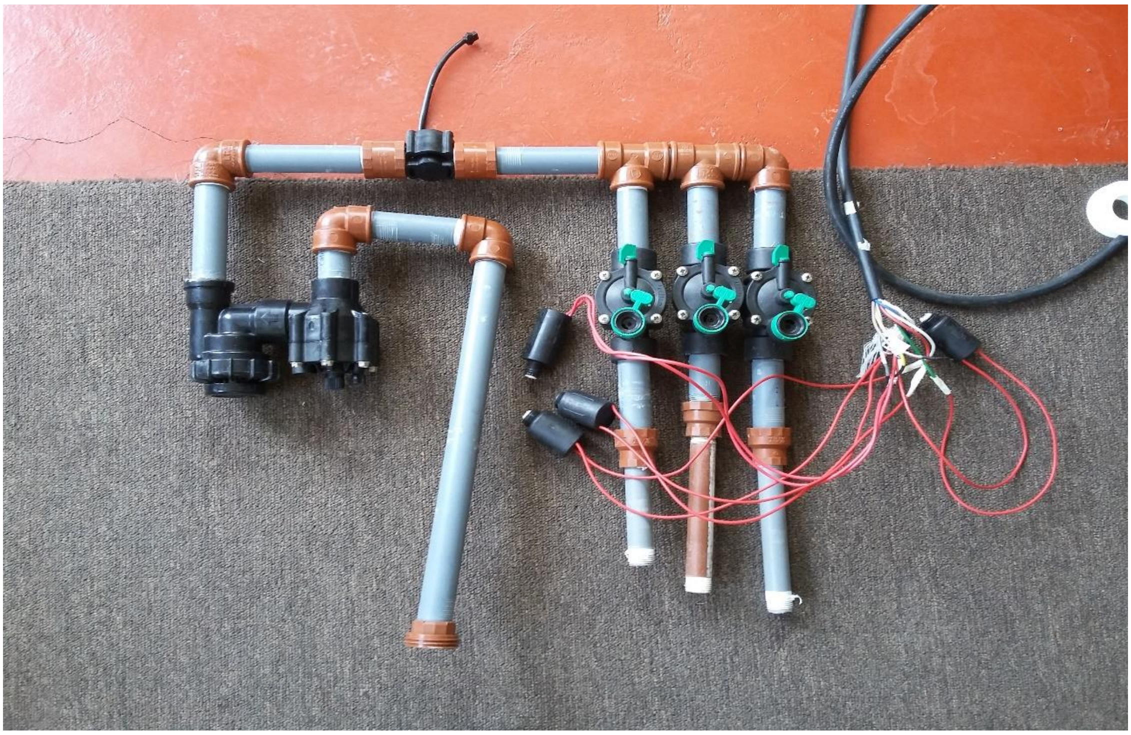
%M2	SENIAL_VALV02	señal de arranque de la valvula solenoide(antiRetro) valv_02
%Q0.5	VALV_02	valvula_02 solenoide de flujo uniderecional

ANEXO 5: Fotografias de los Equipos del Proceso



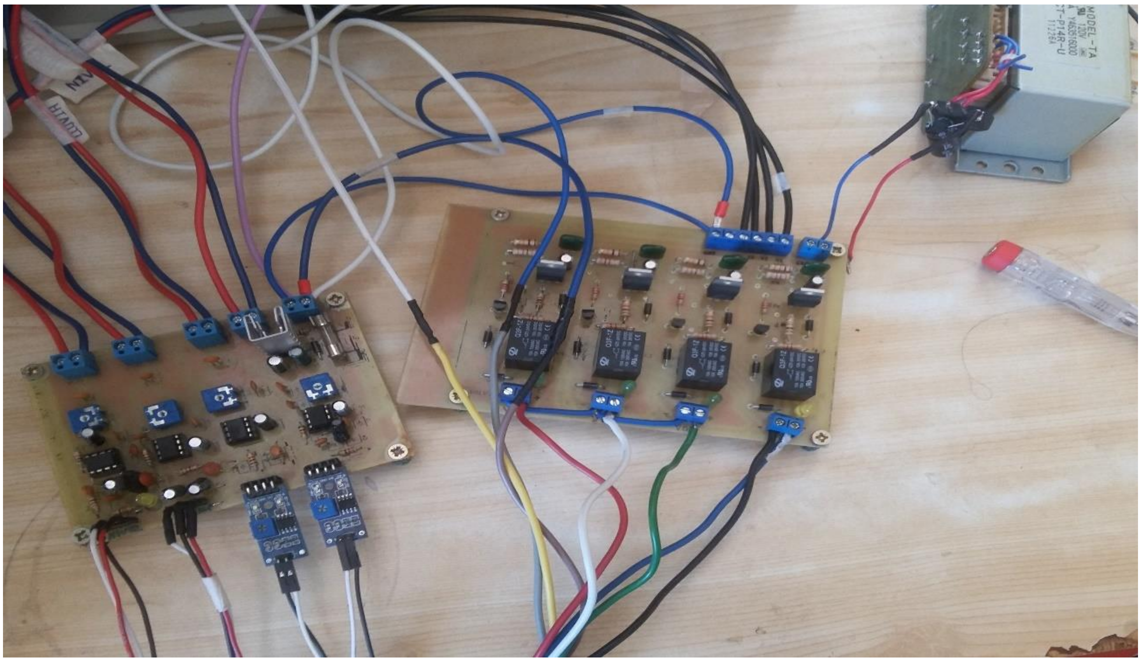
Tablero de control del proceso, fotografía tomada 01/11/2017.

Elaboración: Propia.



Tuberías y actuadores del proceso, fotografía tomada 11/10/2017.

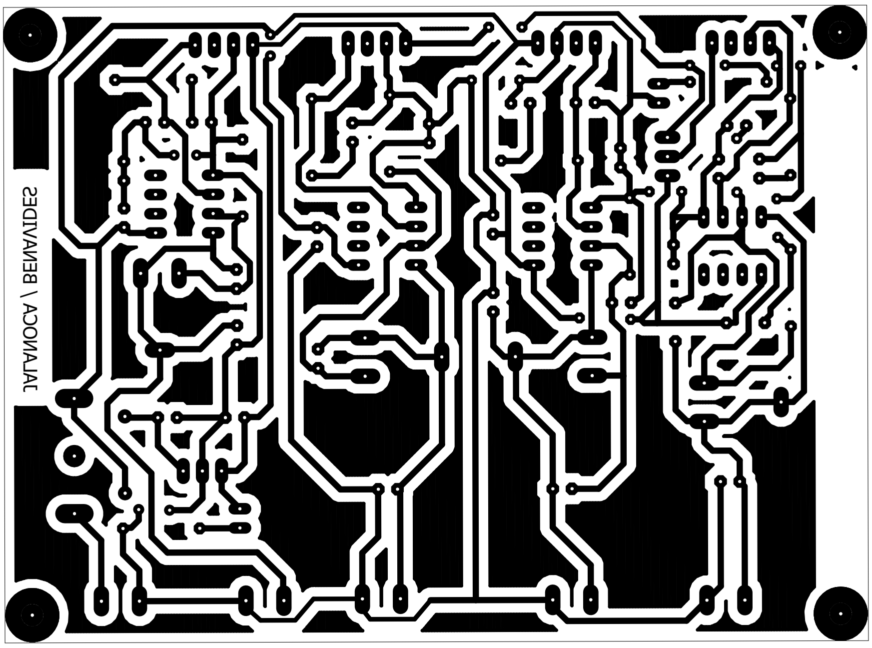
Elaboración: Propia.

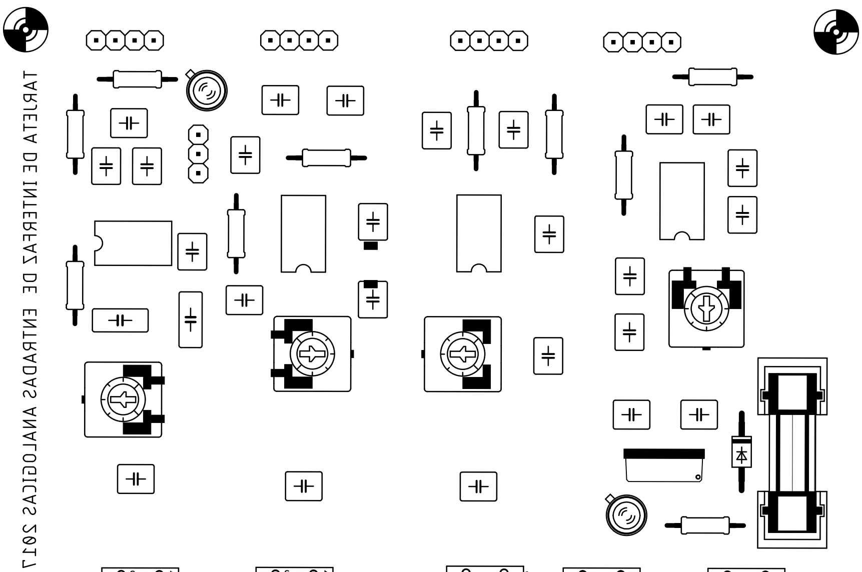


Tarjeta de interface de entradas analógicas, fotografía tomada 30/10/2017.

Elaboración: Propia.

ANEXO 6: PCB Tarjeta De Interfaz Entradas Analógicas





ANEXO 7: PCB Tarjeta Etapa De Potencia Para Los Actuadores