Operating Manual

Nevzorov hot wire LWC/TWC Probe

(CWCM-U2.3)

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1. INSTRUMENT DESCRIPTION

1.1 The SkyPhysTech Nevzorov probe (CWCM-U2) is designed for airborne measurements of liquid and total (ice plus liquid) water content (LWC and TWC) of clouds and fogs in the range from 0.003 g/m^3 to 3 g/m^3 and air velocities from 10 to 180 ms^{-1}.

1.2 The SkyPhysTech Nevzorov probe belongs to the so-called "hot-wire constant temperature probes". A sensor unit consists of four sensors: LWC collector, LWC reference TWC collector, TWC reference. The principle of operation is based on separate measurements of power required to compensate heat losses caused by evaporation of cloud water and convective losses on the collector sensor and power needed to compensate convective heat losses on a reference sensor.

1.3 The Nevzorov LWC/TWC probe electronics provides output 0 +10V.

1.4 Liquid and total water content are measured by separate LWC and TWC sensors, respectively. Both LWC and TWC sensors are mounted on the same sensor head. The sensor head provides alignment parallel to the airflow in order to compensate changes of the airflow direction during the aircraft pitches and compensate the reference sensors from the impact with cloud particles.

1.5 The SkyPhysTech Nevzorov probe is designed to operate under all weather conditions. With proper installation and operative de-icing heaters, the system can operate indefinitely under conditions of weather research environment.

2. NEVZOROV PROBE SPECIFICATIONS

Sensitivity	0.003 g/m^3
Range of measured LWC/TWC	0.003 - 3 g/m^3
Accuracy	±10%
Air speed range	10 - 180 ms^{-1}
LWC sensor sample area	0.3 cm^2 (may vary from sensor to sensor)
TWC sensor sample area	0.5 cm^2 (may vary from sensor to sensor)
Time constant of the output filter	0.01 s
Output signal	0 to +10 V differential
Power requirements	28 ±2 VDC, 3-12A depending on LWC and TWC, air speed, air pressure and air temperature
Control Box:	
Weight	5.2 kg
Size	25 cm x 39 cm x 7.5 cm
Pillar:	
Size	18.0cm x 6.8cm x 4.7cm
Weight	1.5 kg (including base)
Sensor head deicing	28 W, 28 VDC
Pillar deicing	275 W, 120 VAC

2.1 The SkyPhysTech Nevzorov LWC/TWC Probe consists of:

1). Sensor Head
2). Sensor Head Pillar
3). Control Box
4). Signal Cable
5). Power Cable

2.2 The control box provides the operation of both LWC and TWC sensors.

2.3 Both LWC and TWC sensors consist of two sensors (Fig. 1):

(i) the leading sensor, or collector sensor (CS) has the sampling surface exposed to the airflow and cloud particles,

(ii) the reference sensor (RS) is aerodynamically protected from collision with cloud particles, and it remains dry in clouds.

The reference sensor is used for calculation of dry air heat losses on the collector sensor. Both collector and reference are ventilated by the same airflow. Both the LWC and TWC sensors are mounted on the same vane that provides its alignment parallel to the airflow and protects reference sensors from the impact with the cloud particles (Fig. 2). This increases the stability and accuracy of measurements of cloud water content.

2.3 The leading edge and side surface of the sensor vane has de-icing heaters (Fig.1)

2.4 The sensor head pillar (Fig.2) has de-icing heater with total power 275W 120AC.

3. INSTALLATION

3.1 The power required for the SkyPhysTech Nevzorov LWC/TWC probe is 28 $\pm$ 2 VDC, 3 to 12 Amp capability. The current consumption depends on liquid and ice water content, air speed, air temperature, and air pressure. Normally, in cloud free air at 100 ms^{-1}, temperature $0^{o}C$ and one atmosphere pressure the control box consumes approximately 4 Amp.

3.2 The control box (Fig. 3) should be installed inside fuselage. The temperature range of the operation of the electronics of the control box is from $-30^{o}C$ to $+40^{o}C$.

3.3 The pillar with the sensor head (Fig. 2) should be mounted on the aircraft horizontally in order to allow the vane to remain parallel to the airflow during aircraft pitch changes.

3.4 The connection between the control box and the sensor head is provided by 18-wire cable, which should not exceed 30 meters. Each wire must have a resistance of no more than 0.5 Ohm. If the cable length exceeds 5 meters, the wires should be shielded to mitigate interference with electromagnetic noise. Twisted pairs MUST NOT be used in the cable with the exception of the de-icing heater wires.

4. THEORY OF OPERATION

4.1 The operation of the probe is based on measurements of heat needed for evaporation of dispersed cloud water impacted with the heated collector sensor. The power heat losses on the collector sensor consist of two parts: (i) convective (or dry) heat losses $P_{conv\ col}$, and (ii) heat losses required for evaporation of cloud water from the sensor surface $P_{w\ col}$, i.e.

$$P_{col} = P_{conv\ col} + P_{w\ col} \qquad (1)$$

4.2 Since, the RS is protected from collision with cloud particles, the power consumed by the reference sensor is

$$P_{col} = P_{conv\ col} \qquad (2)$$

4.3 The convective heat losses by CS and RS are a function of the true airspeed (U), air temperature (T_a) and pressure (p). Within certain range of changes of U, T_a, p the changes of the convective heat losses by CS are assumed to be linearly related to the convective heat losses by RS:

$$P_{conv\ col} = k\, P_{conv\ ref} \qquad (3)$$

4.4 Both CS and RS have high coefficient of dependence of its resistance on temperature. CS and RS are the arms of two different bridges. The temperatures of both CS and RS sensors are maintained automatically to be the same and constant. The automatic control of the temperature is provided by direct current in the feedback loops of the bridges of CS and RS maintaining the resistances of CS and RS constant. Therefore the power consumed by CS and RS can be calculated as

$$P_{col} = V_{col} I_{col} \qquad (4)$$

$$P_{ref} = V_{ref} I_{ref} \qquad (5)$$

here V_{col} and V_{ref} are the voltages across CS and RS, respectively; I_{col} and I_{ref} are the currents through CS and RS, respectively.

4.5 The power due to evaporation of the cloud water by the CS can be calculated as

$$P_{w\ col} = WUS_{col}L^{*} \tag{6}$$

Where W is the cloud water content; U is true airspeed; S_{col} is the sample area of the collector sensor, L^{*} is the extended heat of evaporation (see Section 8).

4.6 Combining Eqs. 1-6 yields the measured cloud water content

$$W = \left(V_{col}I_{col} - kV_{ref}I_{ref}\right)/US_{col}L^{*} \tag{7}$$

The coefficient k should be found from Eq. 3 based on measurements of $P_{conv\ col}$ and $P_{conv\ ref}$ in clear sky. Since the coefficient k depends on U, T_a, p it should be determined every time after significant changes of airspeed and altitude

$$k = \frac{V_{col}I_{col}}{V_{ref}I_{ref}} \tag{8}$$

5. ELECTRONICS OPERATION*

The electronic circuit is designed to process electrical signals from the four sensors: LWC collector, TWC collector, LWC reference and TWC reference.

The electronic circuit consists of:

- Four identical Wheatstone Bridges (Figs 6 and 7);and respective amplifiers to keep the bridges in balance and amplify the sensors' signals (Figs 8-12);
- Power supply to deliver the all necessary voltages and currents for the device proper operation (Figs 12-13);
- Alarm system to prevent the LWC or TWC circuits from overloading condition and indicate that such a condition has occurred (Fig 14-16);

The sensor (LWC, TWC / connector, reference) amplifiers are shown on Figs. 5 and 8-12. The sensor circuit includes two wires: the Hot-Wire (sensor wire) and the Constant LWC Wire, which are mounted on the sensor head. The sensor Hot-Wire and Constant LWC Wire are the right arm of the Wheatstone Bridge.

The LWC Collector is a nickel wire resistor, which acts as a temperature sensor, whereas the Constant LWC Wire is a temperature-independent wire resistor, which also works for de-icing of the leading edge of the vane.

The left arm of the bridge consists of the low TCR constant resistor and the precision adjustable knob resistor, which is needed to preset the sensor's temperature. The precision adjustable knob resistor is mounted on the front panel of the control box (Fig. 3).

The feedback loop, consisting of the instrumentation amplifier and two (to double the sensor's current) power amplifiers, keeps in balance the bridge at preset constant temperature.

* Design and circuit diagrams subject to changes without notice for improvements

Two additional instrumentation amplifiers are used to measure the sensor's current and voltage, respectively. Their outputs can be used as a single-ended mode output (low-pass RC filters should be considered).

The power supply (Figs. 12 and 13) provides stabilized, low ripple-noise voltage sources for the Liquid and the Total Water Sensors separately. This allows independent functioning of the Total and Liquid Water circuits. This feature can be used for troubleshooting. In order to disconnect LWC or TWC circuit, remove LWC or TWC fuse on the rear panel of the control box, respectively.

The Alarm System monitors the power supply and the power amplifiers. The red LEDs on the front panel are "ON" if the power is overloaded or the sensors are overheated.

The Heater circuit turns on two deicing side heaters on the sensor head. The green LED on the left side of the control box front panel is "ON", when the heater is activated and the current passes through it.

6. SENSORS

6.1 Both collector and reference sensors have high coefficient resistance with temperature.

6.2 The LWC and TWC sensors consist of close single-layer windings of 0.15 mm nickel wire. For the TWC sensor, the collector winding is cemented to the hollow cone at the end of a textolite cylinder, and the reference sensor is wound within a shallow ring groove around the same cylinder (Fig.1). Both collector and reference sensors for the LWC probe are wound on solid cooper rods and cemented to the opposite edges of a flat textolite plate (Fig 1).

6.3 The diameter of the sampling area of the TWC collector is approximately 8 mm, cone angle being 60^{o}. The dimensions of the cylindrical LWC collector are 1.8 mm diameter by 16 mm length. The resistance of all sensor wires at 90^{o}C is typically from 1.5 to 3.5 Ohm.

6.4 Each sensor probe includes also two cylindrical manganin wire windings both combining two different functions. First, each is connected in series with a sensor to form the power thermostable arm of the sensor bridge, because the temperature dependence of manganin resistivity is four orders less than that of nickel and so may be neglected. This allows to separate cable connection pairs, one only for power feeding of the half-bridge and the other for bridge completing with the rest high-resistance arms, to ensure precise remote adjusting and control of the sensor temperature. Second, they serve as anti-icing heaters on the leading edge of the plate.

6.5 The phase discriminating capability of the LWC and TWC collectors results from the difference in behavior of liquid and solid particles impacting with their surfaces. Small liquid droplets, after collision with the LWC or TWC collector sensors are flattened into a thin surface film and evaporate. At the same time, ice particles will remain inside the conical hollow of the TWC collector until melting and evaporating. In contrast to that, ice particles instantly break away from the convex surface of the LWC collector, with negligible heat expended, relative to that for complete ice evaporation.

6.6 The LWC and TWC sensors are mounted at the same flow vane plate. It remains parallel to the air stream during airplane pitch changes (Fig. 2). This stabilizes the thermodynamics of the sensors and protects the reference sensors from particle impacts.

7. OPERATION

7.1 Preset the temperature of CS and RS

(i) From the calibrating tables (Appendix C) find the values **N_{ref}** and **N_{oper}** for a chosen temperature (70°C, 90°C or 110°C) for the LWC, TWC collector and reference sensors.

(ii) Set **N_{ref}** and **N_{oper}** for the LWC collector using two left potentiometer knobs labeled as “LWC” (see Fig. 3).

(iii) Set **N_{ref}** and **N_{oper}** for the TWC collector using two right potentiometer knobs labeled as “TWC” (see Fig. 3).

(iv) In absence of airflow it is recommended to install the temperature 70° C. The values **N_{ref}** and **N_{oper}** can be calculated for any other operative temperature (see Appendix A). The decrease of the sensor temperature will result in a decrease of the maximum measured (saturation) water content.

> ***CAUTION*:**
> <u>Do not to set sensor temperature higher 140°C</u>.

7.2 Before connecting the control box to the external 28V DC power source ensure that:

- the switch "Power" on the front panel is in position OFF;
- the switch "Heater" on the front panel is in position OFF;
- the sensor head is connected to the pylon
- the sensor cable connects the pylon to the connector “SENSOR” on the rear wall of the control box (Fig.4).

7.3 Connect the control box to the external 28V DC to the connector “POWER” on the rear wall of the control box (Fig.4) following polarity.

7.4 Turn on the power switch. The power LED indicator will light on. The probe is ready for measurements

> ***CAUTION*:**
> The ‘ALARM’ lights on, if the probe electronics is malfunctioning.

7.5 For the quick check the probe operation the following simple test may be fulfilled. Cool the collector sensor by spraying, or by gentle touching of the sensor surface by a watered Q-tip. In this case the needle of the 'OUTPUT' meter of the corresponding sensor will go right and then return back.

7.6 Output LWC and TWC connectors on the rear side of the control box (Fig.4)

A	collector voltage (0 to +10V)
B	collector voltage (0 to -10V)
C	collector current (0 to +10V)
D	collector current (0 to -10V)
E	reference voltage (0 to +10V)
F	reference voltage (0 to -10V)
G	reference current (0 to +10V)
H	reference current (0 to -10V)

The conversion coefficient of the output voltage on the pins C-D and G-H to current is equal to 2, i.e. 1V is equivalent to 0.5A

The gain coefficient of the output voltage on the pins A-B and E-F is equal to 0.5, i.e. 1V is equivalent to 2V on the corresponding sensors

***WARNING*:**

Hailstones in clouds or melting ice in wind tunnels may cause damages of the wires mounted on the sensor head.

8. CALCULATION OF WATER CONTENT

8.1 Liquid clouds

In liquid clouds liquid water content W_w can be calculated from measurements of LWC or TWC sensors as

$$W_w = \frac{P_L}{\varepsilon_{Lw} U S_L L_w^*} \tag{9}$$

or

$$W_T = \frac{P_T}{\varepsilon_{Tw} U S_T L_w^*}, \tag{10}$$

respectively. Here U is true air speed in the vicinity of the sensor head; S_T and S_L are the sample areas of the LWC and TWC collector sensors, respectively; ε_{Lw}, ε_{Tw} are the integral liquid droplets collection efficiencies for LWC and TWC sensors, respectively;

$$L_w^* = (T_e - T_a)C_l + L_w(T_e), \tag{11}$$

are expanded heat for water; C_w is the specific heat of liquid water; L_w is the latent heat of evaporation at temperature T_e; T_a is air temperature; T_e is the temperature of evaporation. The temperature T_e can be assumed to be equal to sensor temperature to a good accuracy. For practical purposes it is convenient to use value L_w^* =2589 J/g, which adds ±5% error to the LWC in the temperature interval from -40°C to +20°C; P_L and P_T are heat losses on LWC and TWC collectors, respectively, associated with evaporation of cloud particles:

$$P_L = V_{L\ col} I_{L\ col} - k_L V_{L\ ref} I_{L\ ref}, \tag{12}$$

$$P_T = V_{T\ col} I_{T\ col} - k_T V_{T\ ref} I_{T\ ref} \tag{13}$$

Here $V_{L\ col}$, $V_{L\ ref}$, $V_{T\ col}$, $V_{T\ ref}$ are the signal output voltages from LWC collector, LWC reference, TWC collector and TWC reference sensors, respectively; $I_{L\ col}$, $I_{L\ ref}$, $I_{T\ col}$, $I_{T\ ref}$ are the signal output voltages from LWC collector, LWC reference, TWC collector and TWC reference sensors, respectively. The values of $V_{L\ col}$, $V_{L\ ref}$, $V_{T\ col}$, $V_{T\ ref}$, $I_{L\ col}$, $I_{L\ ref}$, $I_{T\ col}$, $I_{T\ ref}$ are measured from the output LWC and TWC connectors on the rear panel of the control box (section 7.6). The conversion coefficient of the output voltage (pins D, C, G, and H) to current is equal to 2, i.e. 1V is equivalent to 0.5A.

The powers P_L and P_T can also be calculated as

$$P_L = \frac{V_{L\ col}^2}{R_{L\ col}} - k_L \frac{V_{L\ ref}^2}{R_{L\ ref}}, \tag{14}$$

$$P_T = \frac{V_{T\ col}^2}{R_{T\ col}} - k_T \frac{V_{T\ ref}^2}{R_{T\ ref}} \tag{15}$$

Here $R_{L\ col}$, $R_{L\ ref}$, $R_{T\ col}$, $R_{T\ ref}$ are resistances of LWC collector, LWC reference, TWC collector and TWC reference sensors, respectively, for a chosen temperature. The values $R_{L\ col}$, $R_{L\ ref}$, $R_{T\ col}$, $R_{T\ ref}$ for 70°C and 90°C are given in the calibrating tables for each sensor head. For other temperatures the sensor resistances can be calculated following Appendix A.

The coefficients k_L and k_T in Eqs 12-15 are calculated for the cloud free air using Eq.8.

For droplets with d >5μm the collection efficiency of LWC sensor can be assumed $\varepsilon_{Lw} \approx 1$ with accuracy no worse than 10%.

8.2 Ice clouds

In ice clouds ice water content W_i should be calculated from measurements of theTWC sensor as

$$W_i = \frac{P_T}{\varepsilon_{Ti} U S_T L_i^*}, \tag{16}$$

respectively. Here ε_{Ti} is ice particle collection efficiency for the TWC sensor;

$$L_i^* = (T_0 - T_a)C_i + (T_e - T_0)C_w + L_i + L_w(T_e), \tag{17}$$

is the expanded heat for ice; C_I is the specific heat of ice, L_i is the latent heat of ice melting; T_0 =0°C. For characteristic sizes of ice particles typical for ice clouds (d>25μm) it can be assumed to a good accuracy $\varepsilon_{Ti} \approx 1$.

8.3 Mixed phase clouds

In mixed phase clouds the heat losses on LWC and TWC collectors associated with evaporation of cloud particles can be written as

$$P_L = \beta W_i L_i^* S_L U + \varepsilon_{Lw} W_w L_w^* S_L U \tag{18}$$

$$P_T = \varepsilon_{Ti} W_i L_i^* S_T U + \varepsilon_{Tw} W_w L_w^* S_T U \tag{19}$$

Combining Eqs. 18 and 19 yields

$$W_w = \frac{P_L - P_T \dfrac{\beta S_L}{\varepsilon_{Ti} S_T}}{L_w^* S_L U \left(\varepsilon_{Lw} - \dfrac{\beta \varepsilon_{Tw}}{\varepsilon_{Ti}} \right)} \tag{20}$$

$$W_i = \frac{P_T - P_L \dfrac{\varepsilon_{Tw} S_T}{\varepsilon_{Lw} S_L}}{L_i^* S_T U \left(\varepsilon_{Ti} - \dfrac{\beta \varepsilon_{Tw}}{\varepsilon_{Lw}} \right)} \tag{21}$$

Here β is the residual effect of ice (or collection efficiency of ice particles) for the LWC collector. The coefficient β is a function of ice particle shape, size, and air speed. In average at 100m/s for typical ice particles in tropospheric ice and mixed clouds $\beta \approx 0.11$.

The value $S_L R_{L\ col}$, $S_T R_{T\ col}$, $R_{L\ ref}$, $R_{T\ ref}$, for T=70°, 90° and 110°C are given in calibration tables (Appendix C). For other T the resistances may be calculated based on Appendix A.

APPENDIX A

CALCULATION OF N_{oper} AND N_{ref} FOR DIFFERENT TEMPERATURES

The resistance of the sensor R_T at temperature T can be calculated as

$$R_T = R_0 + K_0 R_0 (T - T_0) \quad (1A)$$

For T_0=0C, Eq.1A yields

$$R_T = R_0 (1 + K_0 T) \quad (2A)$$

Thus, if the resistance of the sensor R_m was measured at temperature T_m, its resistance R_T at the temperature T can be calculated as

$$R_T = R_m \frac{1 + K_0 T}{1 + K_0 T_m} \quad (3A)$$

The coefficient K_0 should be calculated separately for LWC and TWC wires, since the material used for these wires may be different and have slightly different characteristics. The coefficient K_0 can be derived from the measurement of the resistance at two temperatures, for example 0C and 100C as

$$K_0 = \frac{R_1 - R_0}{(T_1 - T_0) R_0} = \frac{R(100) - R(0)}{100 R(0)} \quad (4A)$$

In this case the coefficient K_0 is anchored for the temperature T=0C.

The resistance R_0 has to be measured in laboratory conditions. Since the sensor's resistance (1-4 Ohm) may be comparable with the resistance of contacts, it should be measured using 4-wire line. The sensor during measurements has to be placed in a thermostable environment with a circulating air (or liquid) in order to prevent a cushion of warm air (liquid) around the sensor. The fluctuations of temperature during measurements and the accuracy of temperature measurements should be no worse than 0.3°C.

For practical purposes in order to calculate the sensor resistance at different temperature you can simply extrapolate or interpolate the resistance based on three resistances at T=0°, 70° and 90°C indicated in the calibration table.

The values N_{oper} and N_{ref} are derived from the equations

$$N_{oper} = \frac{R_{col}}{R_{const\ col}} \tag{5A}$$

$$N_{ref} = \frac{R_{ref}}{R_{const\ ref}} \tag{6A}$$

The resistances $R_{const\ col}$ and $R_{const\ ref}$ are parts of the bridge and are mounted on the sensor head. The schematic of connections of the resistance R_{col} , R_{ref}, $R_{const\ col}$ and $R_{const\ ref}$ is shown in the wiring diagram. In the calibration sheets the resistances $R_{const\ col}$ and $R_{const\ ref}$ are indicated as R_1 and R_4, respectively.

APPENDIX B

REPLACEMENT OF A SENSOR HEAD

To replace the sensor head remove two screws from the sensor holder mounted on the top of the pillar. The sensor holder consists of two parts. To split it, remove two screws on cylindrical side of the sensor holder. Put the sensor head between two pieces of the sensor holder and tight the screws. Mount the sensor head on the top of the pillar and fix the sensor holder by two screws. The sequence of operation on the installation of the sensor head is shown in Fig.5.

***WARNING*:**
Change $\mathbf{N_{ref}}$ and $\mathbf{N_{oper}}$ in the front panels of both LWC and TWC control boxes after each replacement of a sensor head.

APPENDIX C

CALIBRATION TABLES OF SENSORS

FIGURES AND DIAGRAMS

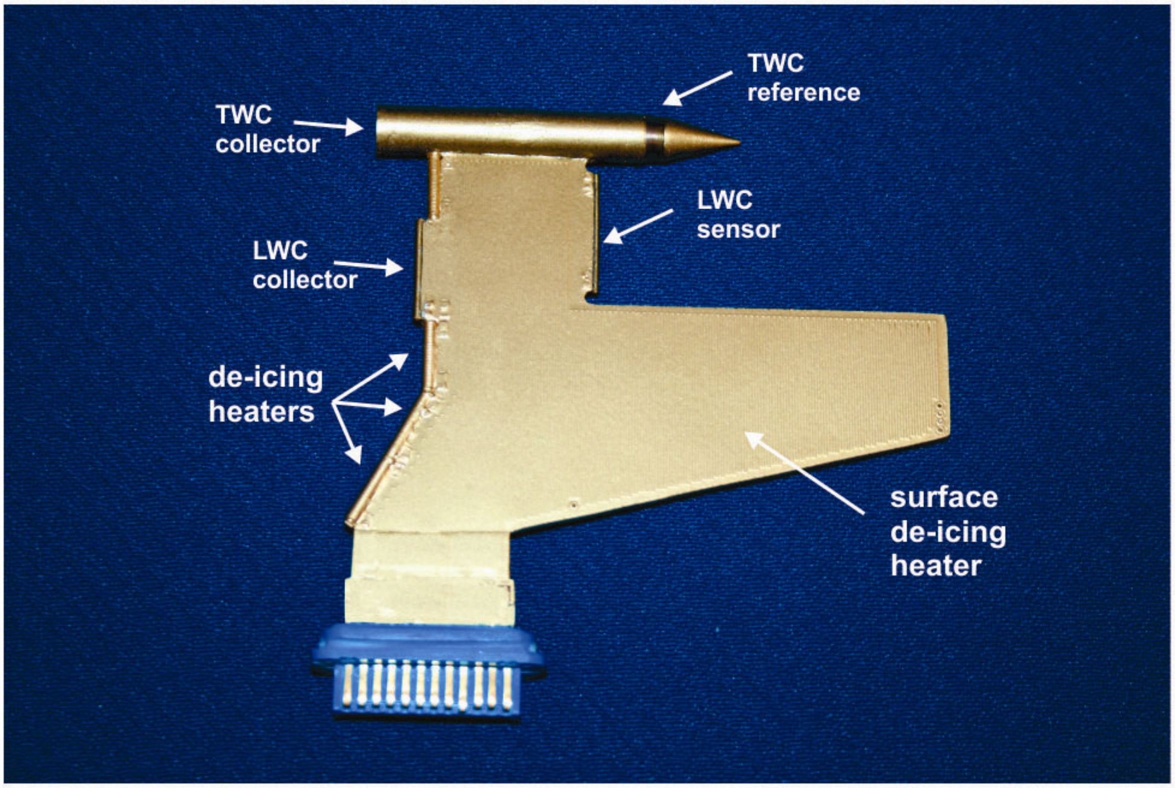

TWC
reference
TWC
collector
LWC
sensor
LWC
collector
de-icing
heaters
surface
de-icing
heater

Figure 1

Figure 2


CWCM
POWER
ON
OFF
Sky Tech Instruments
LWC
COLLECTOR
REFERENCE
DC MILLIAMPERES
ALARM
3 3 5
2 9 3
TWC
COLLECTOR
REFERENCE
DC MILLIAMPERES
ALARM
2 5 5
2 7 8
HEATER
ON
OFF

Figure 3

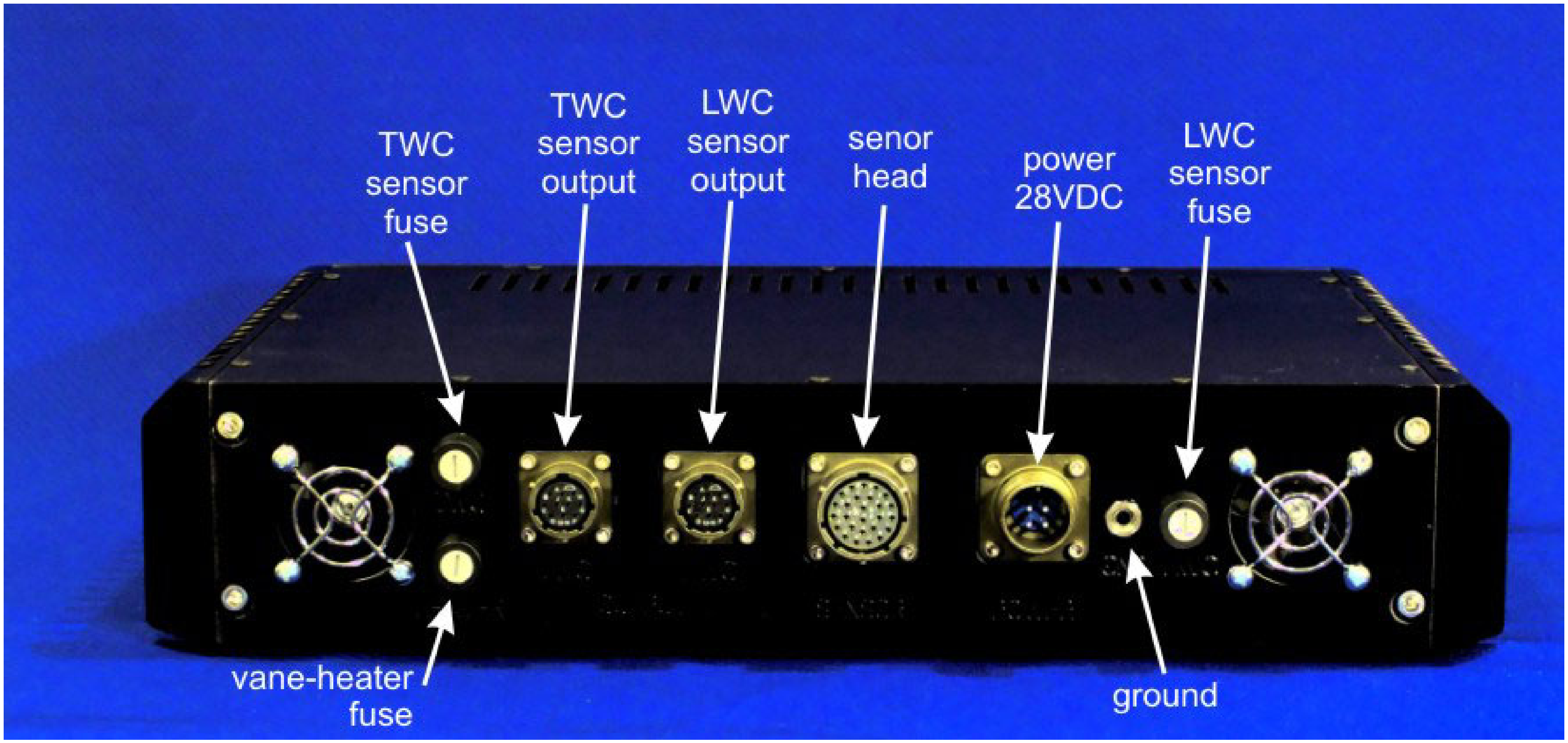

TWC sensor fuse
TWC sensor output
LWC sensor output
senor head
power 28VDC
LWC sensor fuse
vane-heater fuse
ground

Figure 4

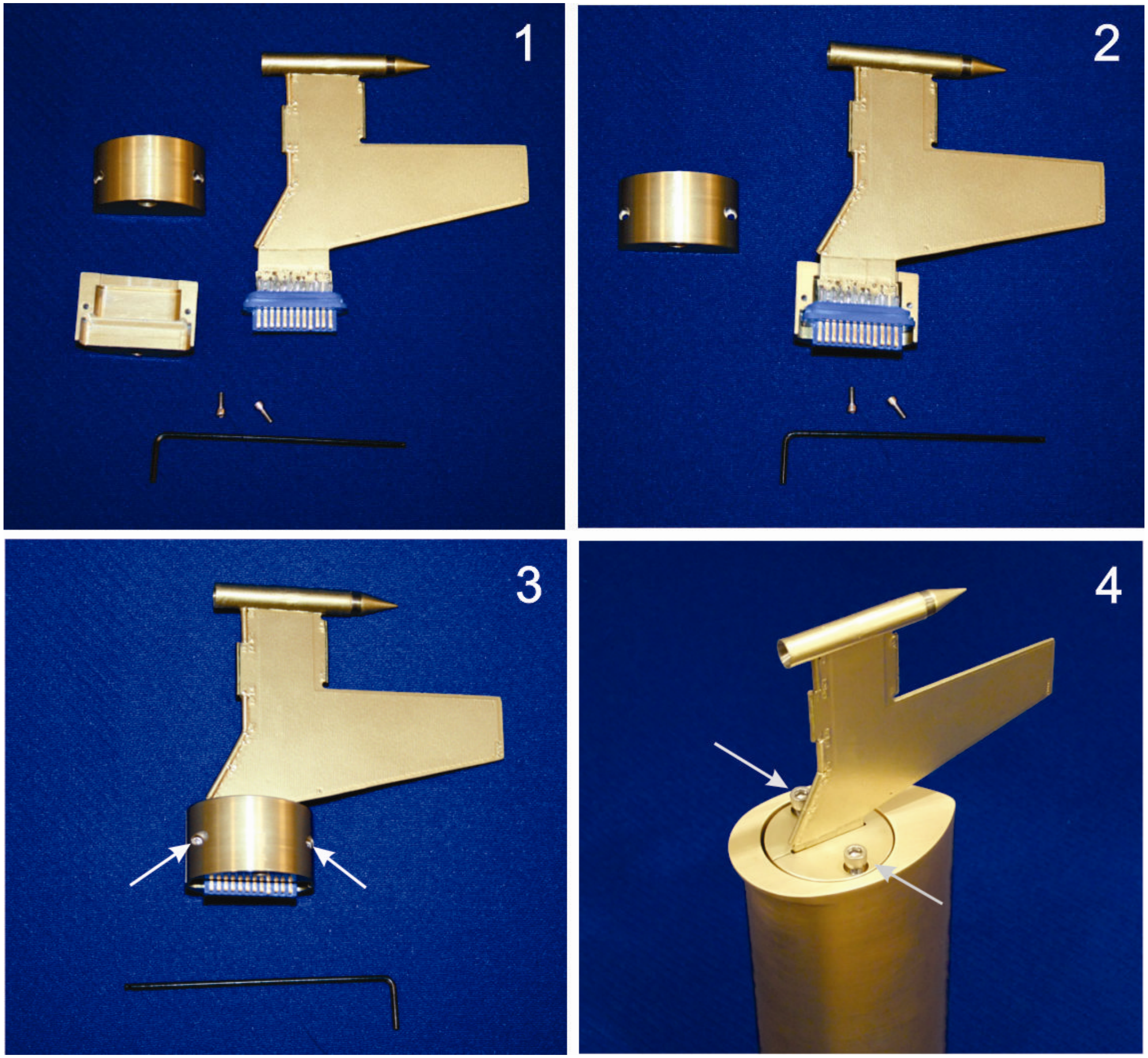


Figure 5

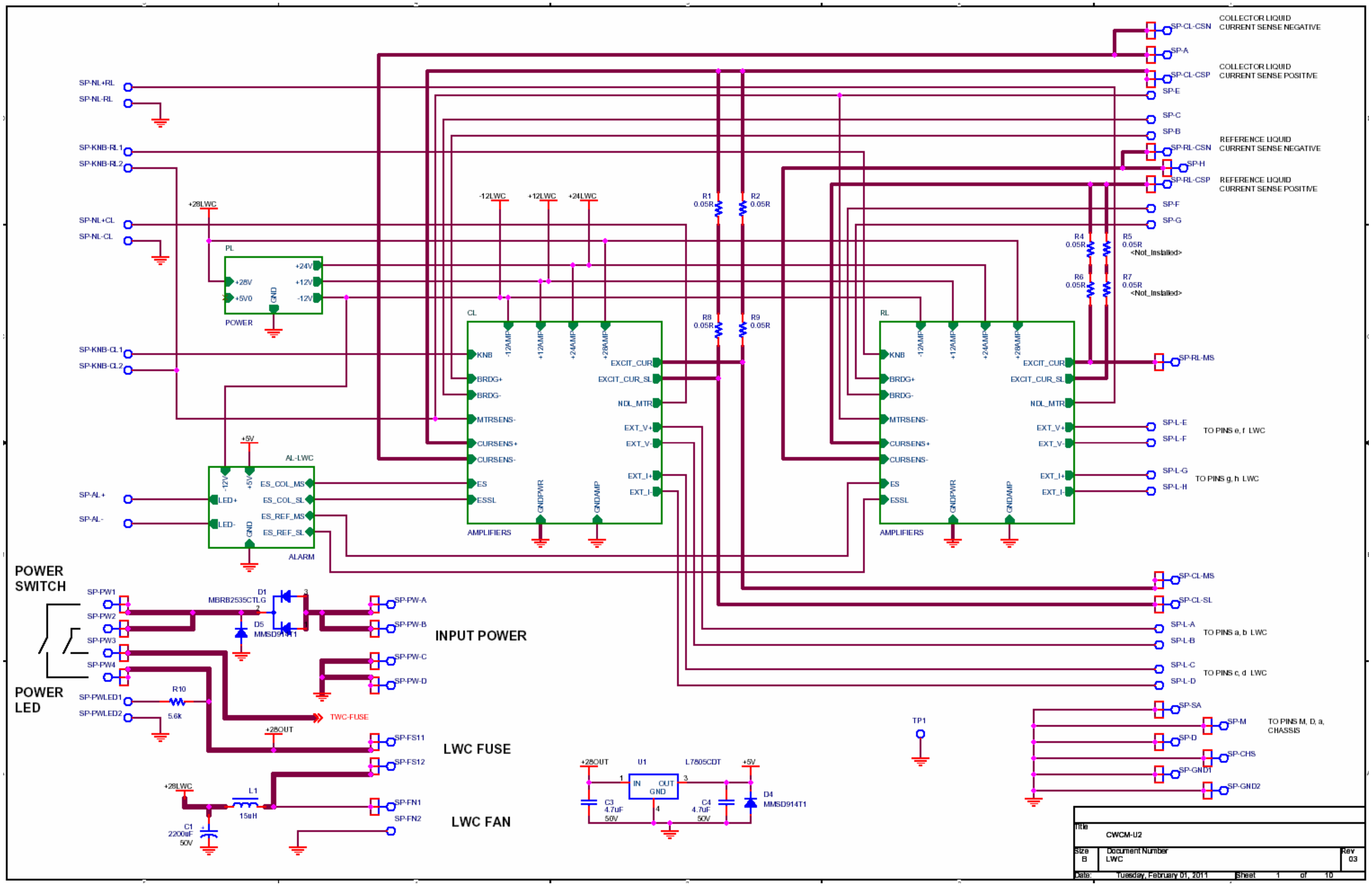
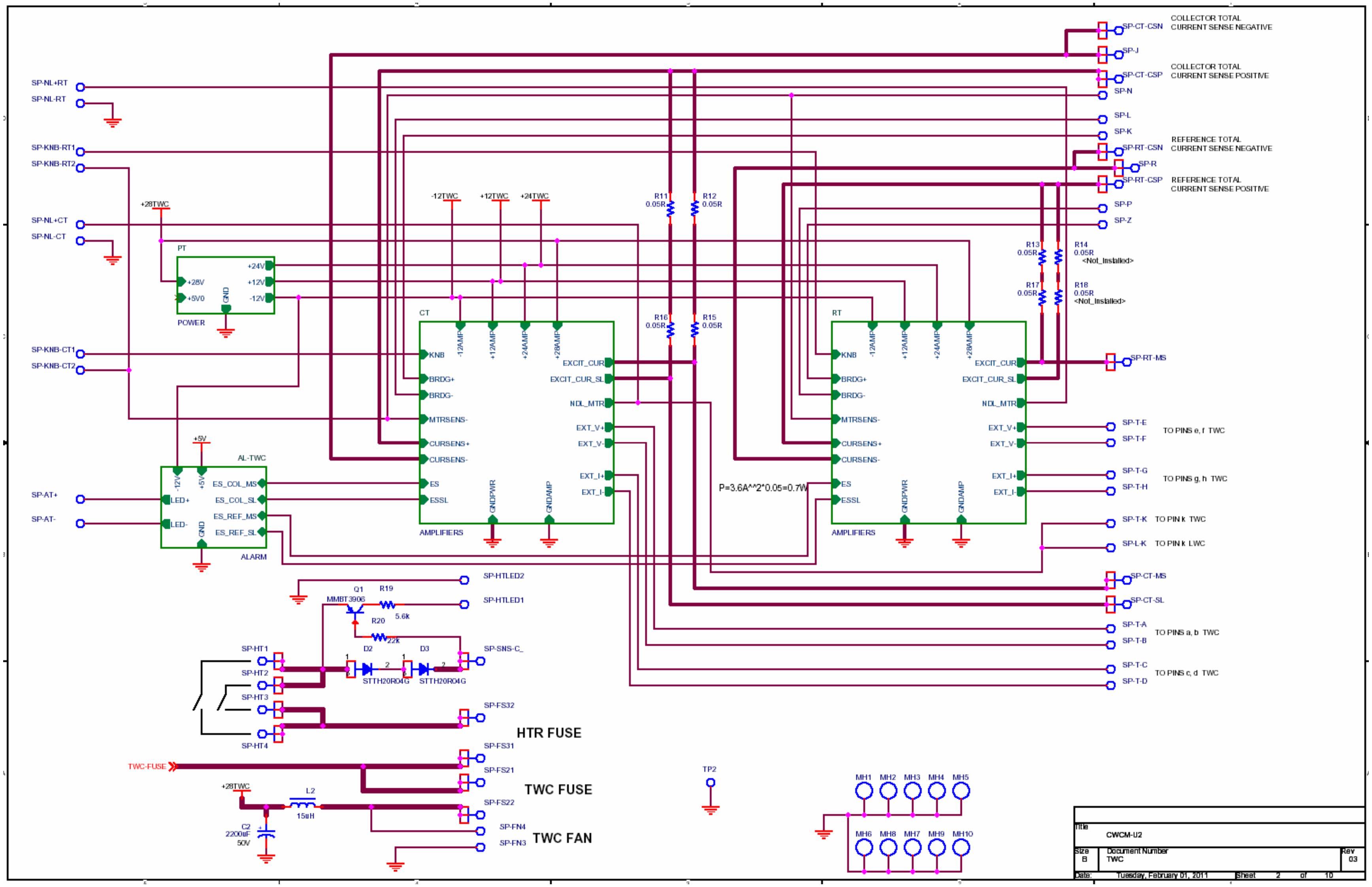

COLLECTOR LIQUID CURRENT SENSE NEGATIVE
COLLECTOR LIQUID CURRENT SENSE POSITIVE
REFERENCE LIQUID CURRENT SENSE NEGATIVE
REFERENCE LIQUID CURRENT SENSE POSITIVE
POWER SWITCH
POWER LED
INPUT POWER
LWC FUSE
LWC FAN
AMPLIFIERS
POWER
ALARM
TO PINS e, f LWC
TO PINS g, h LWC
TO PINS a, b LWC
TO PINS c, d LWC
TO PINS M, D, a, CHASSIS
CWCM-U2
LWC
Tuesday, February 01, 2011

Figure 6



COLLECTOR TOTAL CURRENT SENSE NEGATIVE
COLLECTOR TOTAL CURRENT SENSE POSITIVE
REFERENCE TOTAL CURRENT SENSE NEGATIVE
REFERENCE TOTAL CURRENT SENSE POSITIVE
SP-CT-CSN
SP-J
SP-CT-CSP
SP-N
SP-L
SP-K
SP-RT-CSN
SP-R
SP-RT-CSP
SP-P
SP-Z
SP-NL+RT
SP-NL-RT
SP-KNB-RT1
SP-KNB-RT2
SP-NL+CT
SP-NL-CT
SP-KNB-CT1
SP-KNB-CT2
SP-AT+
SP-AT-
+28TWC
-12TWC
+12TWC
+24TWC
PT
POWER
CT
RT
AMPLIFIERS
AL-TWC
ALARM
R11 0.05R
R12 0.05R
R15 0.05R
R16 0.05R
R13 0.05R
R14 0.05R <Not_Installed>
R17 0.05R
R18 0.05R <Not_Installed>
P=3.6A^^2*0.05=0.7W
SP-RT-MS
SP-T-E
SP-T-F
TO PINS e, f TWC
SP-T-G
SP-T-H
TO PINS g, h TWC
SP-T-K
TO PIN k TWC
SP-L-K
TO PIN k LWC
SP-CT-MS
SP-CT-SL
SP-T-A
SP-T-B
TO PINS a, b TWC
SP-T-C
SP-T-D
TO PINS c, d TWC
SP-HTLED2
SP-HTLED1
Q1 MMBT3906
R19 5.6k
R20 22k
D2 STTH20R04G
D3 STTH20R04G
SP-SNS-C_
SP-HT1
SP-HT2
SP-HT3
SP-HT4
SP-FS32
HTR FUSE
TWC-FUSE
SP-FS31
SP-FS21
TWC FUSE
SP-FS22
L2 15uH
C2 2200uF 50V
SP-FN4
SP-FN3
TWC FAN
TP2
MH1 MH2 MH3 MH4 MH5
MH6 MH8 MH7 MH9 MH10
Title CWCM-U2
Size B
Document Number TWC
Rev 03
Date: Tuesday, February 01, 2011
Sheet 2 of 10

Figure 7

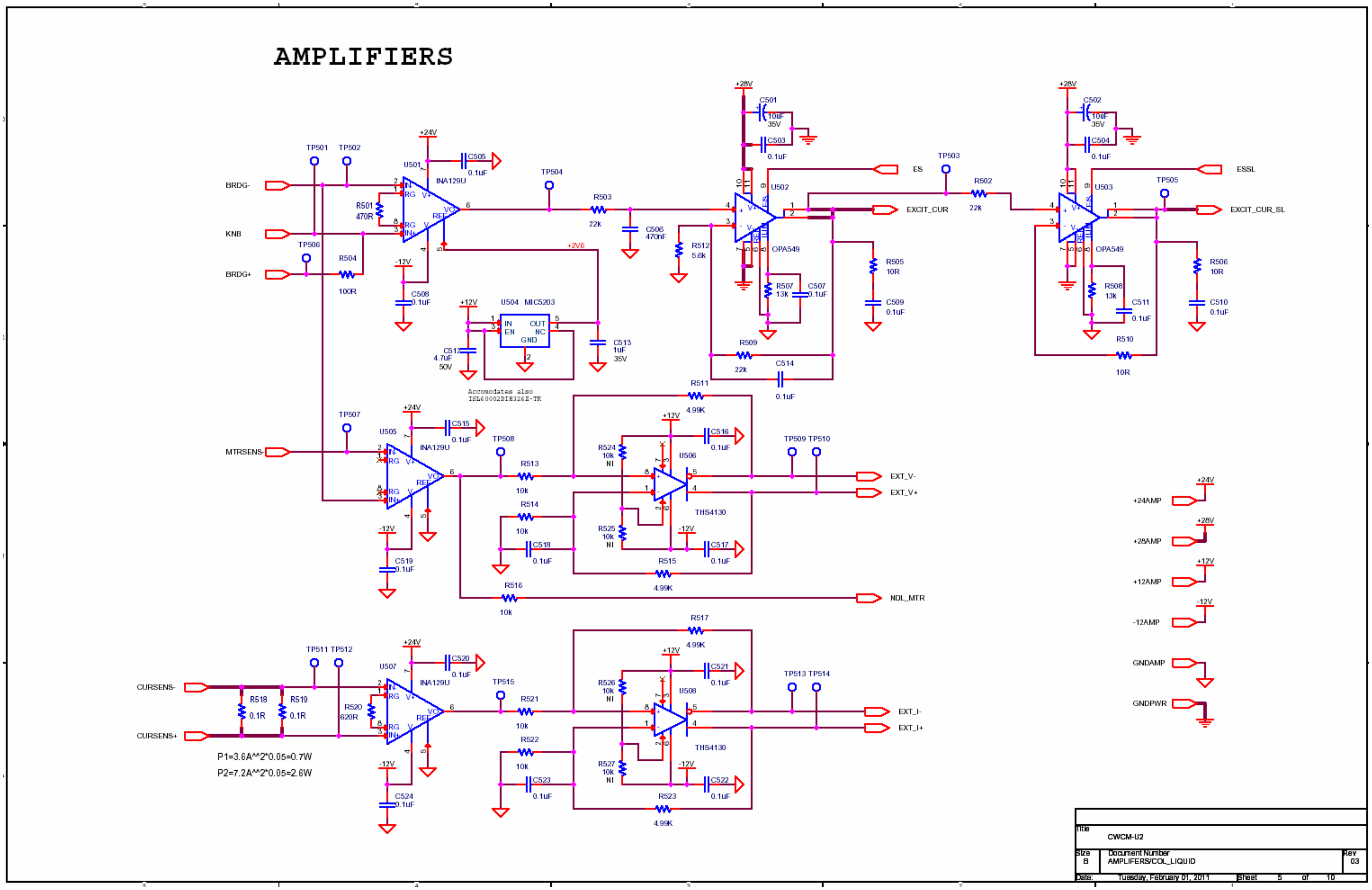

AMPLIFIERS
BRDG-
KNB
BRDG+
MTRSENS-
CURSENS-
CURSENS+
P1=3.6A^2*0.05=0.7W
P2=7.2A^2*0.05=2.6W
U501 INA129U
U502 OPA549
U503 OPA549
U504 MIC5203
U505 INA129U
U506 THS4130
U507 INA129U
U508 THS4130
Accomodates also
ES
EXCIT_CUR
ESSL
EXCIT_CUR_SL
EXT_V-
EXT_V+
NDL_MTR
EXT_I-
EXT_I+
+24AMP
+28AMP
+12AMP
-12AMP
GNDAMP
GNDPWR
Title
CWCM-U2
Size
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Figure 8

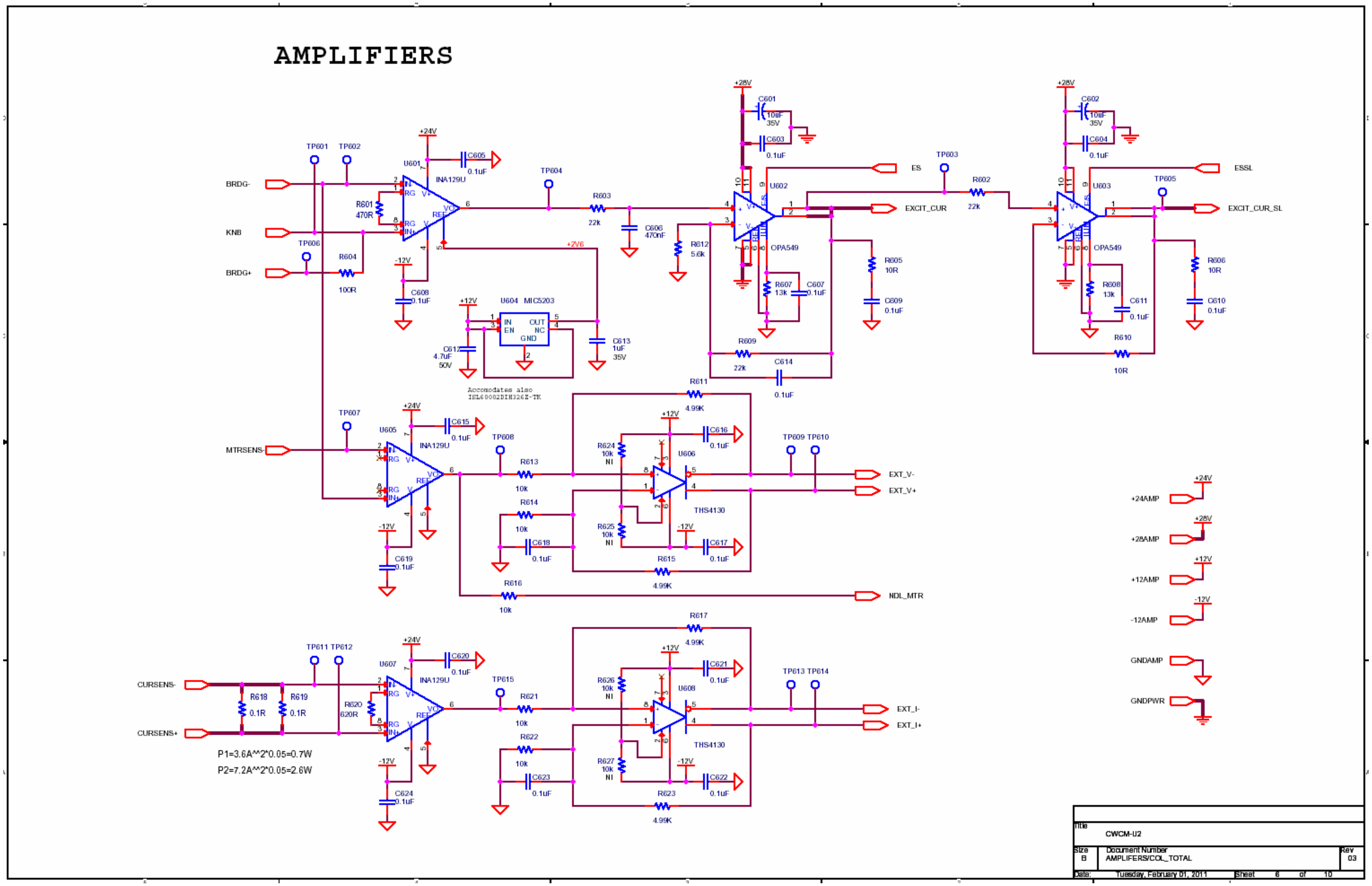
AMPLIFIERS
BRDG-
KNB
BRDG+
MTRSENS-
CURSENS-
CURSENS+
P1=3.6A^^2*0.05=0.7W
P2=7.2A^^2*0.05=2.6W
ES
ESSL
EXCIT_CUR
EXCIT_CUR_SL
EXT_V-
EXT_V+
NDL_MTR
EXT_I-
EXT_I+
+24AMP
+28AMP
+12AMP
-12AMP
GNDAMP
GNDPWR
Accomodates also
ISL60002DIH326Z-TK
Title
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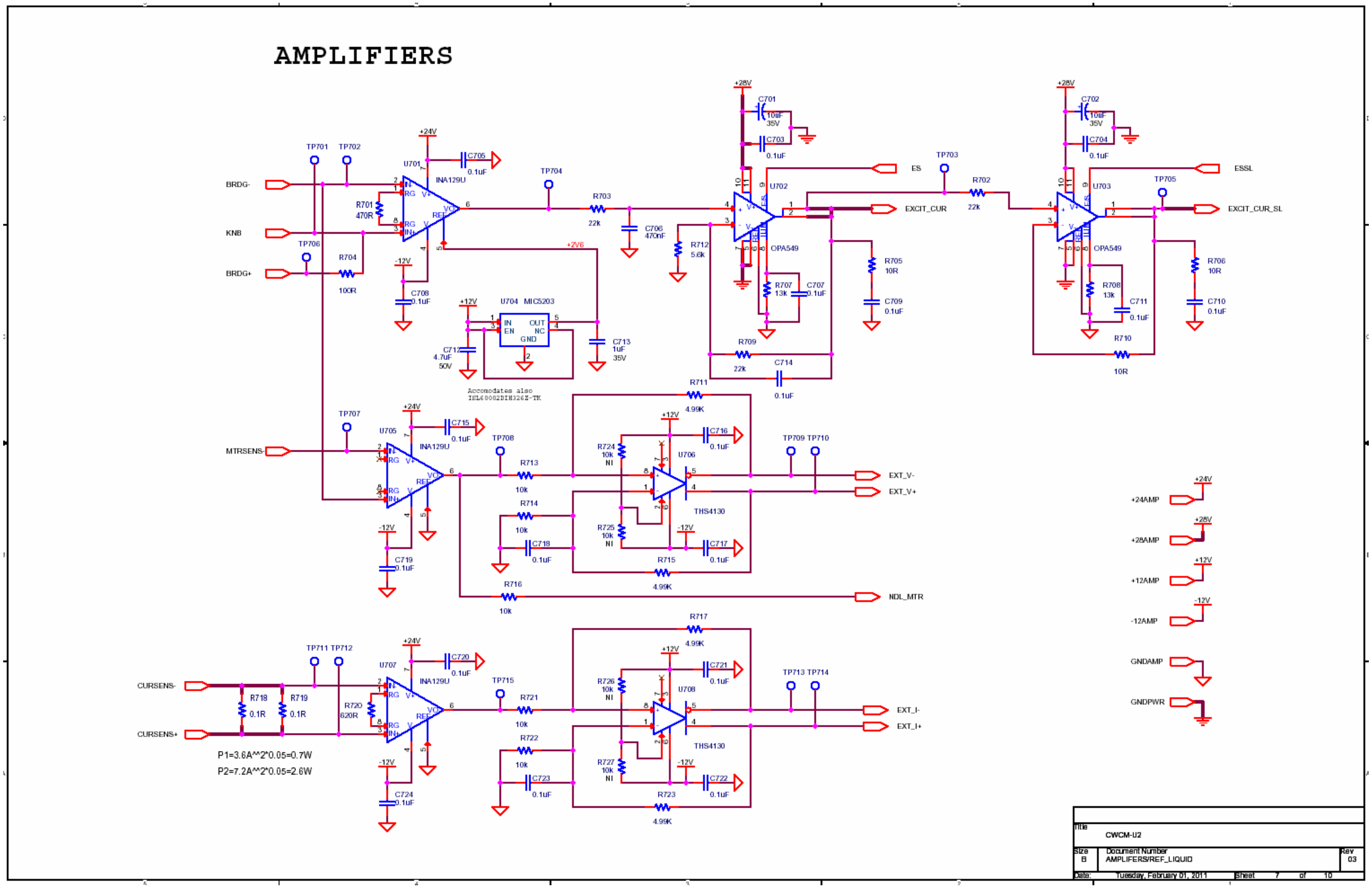
Figure 9



AMPLIFIERS
BRDG-
KNB
BRDG+
MTRSENS-
CURSENS-
CURSENS+
EXCIT_CUR
EXCIT_CUR_SL
ES
ESSL
EXT_V-
EXT_V+
NDL_MTR
EXT_I-
EXT_I+
INA129U
OPA549
THS4130
U704 MIC5203
Accomodates also ISL60002DIH326Z-TK
P1=3.6A^^2*0.05=0.7W
P2=7.2A^^2*0.05=2.6W
+24AMP
+28AMP
+12AMP
-12AMP
GNDAMP
GNDPWR
CWCM-U2
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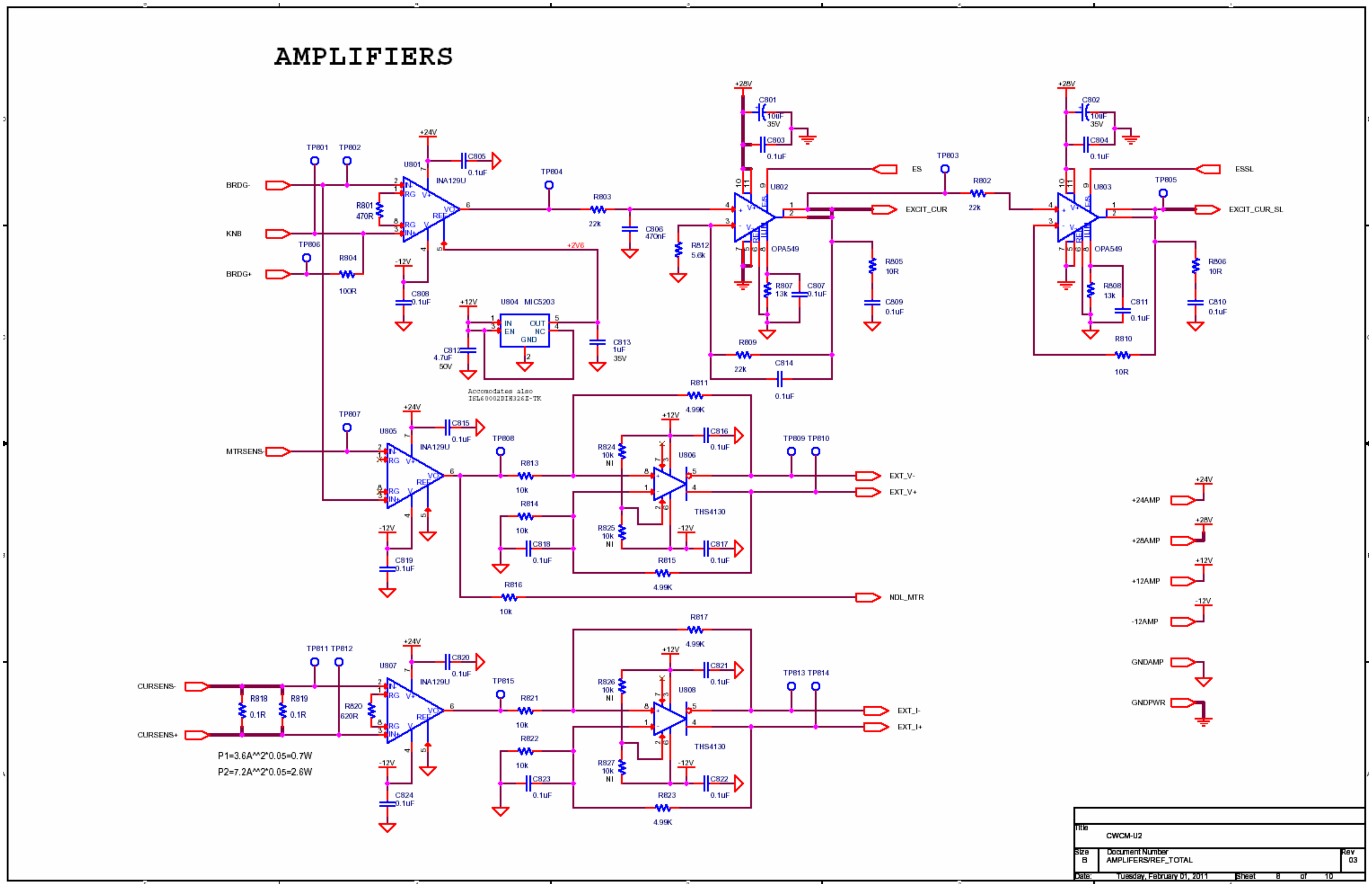
Figure 10



AMPLIFIERS
BRDG-
KNB
BRDG+
MTRSENS-
CURSENS-
CURSENS+
P1=3.6A^2*0.05=0.7W
P2=7.2A^2*0.05=2.6W
ES
EXCIT_CUR
ESSL
EXCIT_CUR_SL
EXT_V-
EXT_V+
NDL_MTR
EXT_I-
EXT_I+
+24AMP
+28AMP
+12AMP
-12AMP
GNDAMP
GNDPWR
U801 INA129U
U802 OPA549
U803 OPA549
U804 MIC5203
U805 INA129U
U806 THS4130
U807 INA129U
U808 THS4130
CWCM-U2
AMPLIFERS/REF_TOTAL
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Figure 11

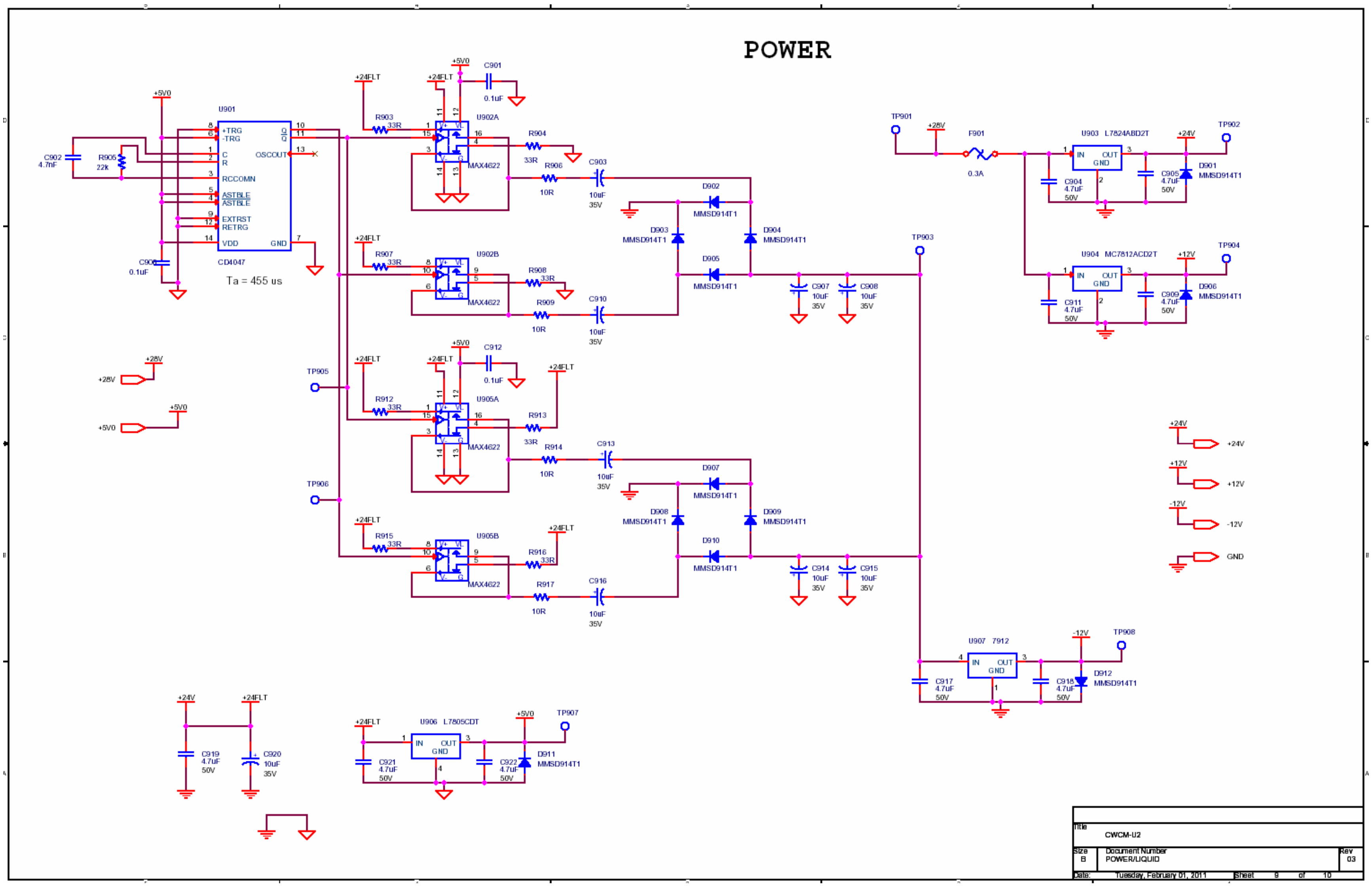
POWER
U901
CD4047
Ta = 455 us
+TRG
-TRG
OSCOUT
RCCOMN
ASTBLE
EXTRST
RETRG
VDD
GND
C902
4.7nF
R905
22K
C906
0.1uF
+5V0
+28V
+24FLT
+24V
+12V
-12V
GND
TP901
TP902
TP903
TP904
TP905
TP906
TP907
TP908
F901
0.3A
U903 L7824ABD2T
U904 MC7812ACD2T
U906 L7805CDT
U907 7912
C904
C905
C909
C911
C917
C918
C919
C921
C922
4.7uF
50V
C901
C912
0.1uF
U902A
U902B
U905A
U905B
MAX4622
R903
R904
R907
R908
R912
R913
R915
R916
33R
R906
R909
R914
R917
10R
C903
C907
C908
C910
C913
C914
C915
C916
C920
10uF
35V
D901
D902
D903
D904
D905
D906
D907
D908
D909
D910
D911
D912
MMSD914T1
Title
CWCM-U2
Size
B
Document Number
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Figure 12

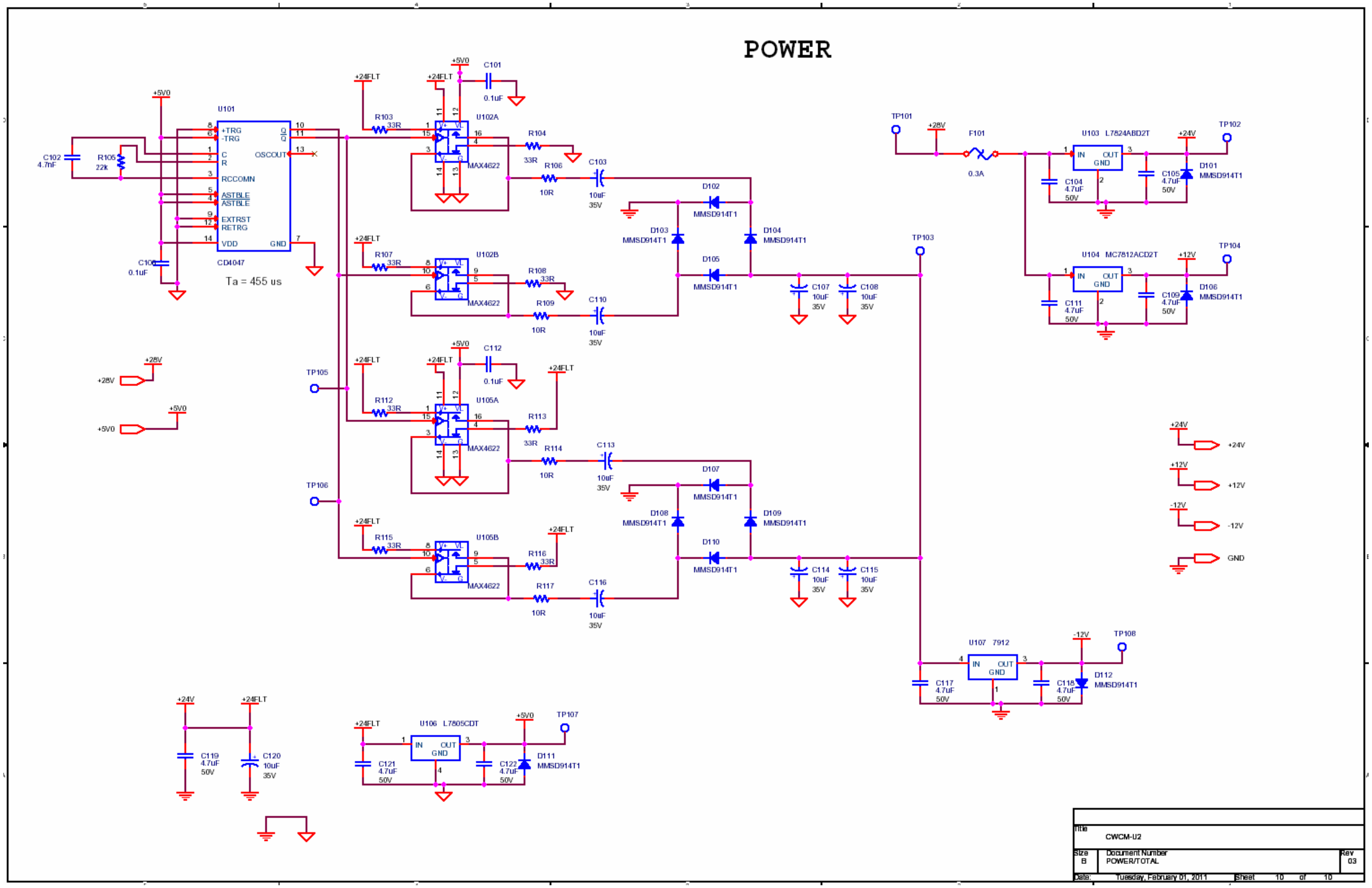
POWER
U101
CD4047
Ta = 455 us
+TRG
-TRG
C
R
RCCOMN
ASTBLE
ASTBLE
EXTRST
RETRG
VDD
GND
OSCOUT
C102 4.7nF
R105 22k
C106 0.1uF
+5V0
+28V
+24FLT
+24V
+12V
-12V
GND
U102A
U102B
U105A
U105B
MAX4622
C101 0.1uF
C112 0.1uF
R103 33R
R104 33R
R106 10R
R107 33R
R108 33R
R109 10R
R112 33R
R113 33R
R114 10R
R115 33R
R116 33R
R117 10R
C103 10uF 35V
C110 10uF 35V
C113 10uF 35V
C116 10uF 35V
D102 MMSD914T1
D103 MMSD914T1
D104 MMSD914T1
D105 MMSD914T1
D107 MMSD914T1
D108 MMSD914T1
D109 MMSD914T1
D110 MMSD914T1
C107 10uF 35V
C108 10uF 35V
C114 10uF 35V
C115 10uF 35V
TP101
TP102
TP103
TP104
TP105
TP106
TP107
TP108
F101 0.3A
U103 L7824ABD2T
U104 MC7812ACD2T
U106 L7805CDT
U107 7912
IN
OUT
GND
C104 4.7uF 50V
C105 4.7uF 50V
C109 4.7uF 50V
C111 4.7uF 50V
C117 4.7uF 50V
C118 4.7uF 50V
C119 4.7uF 50V
C120 10uF 35V
C121 4.7uF 50V
C122 4.7uF 50V
D101 MMSD914T1
D106 MMSD914T1
D111 MMSD914T1
D112 MMSD914T1
Title
CWCM-U2
Size
B
Document Number
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Figure 13

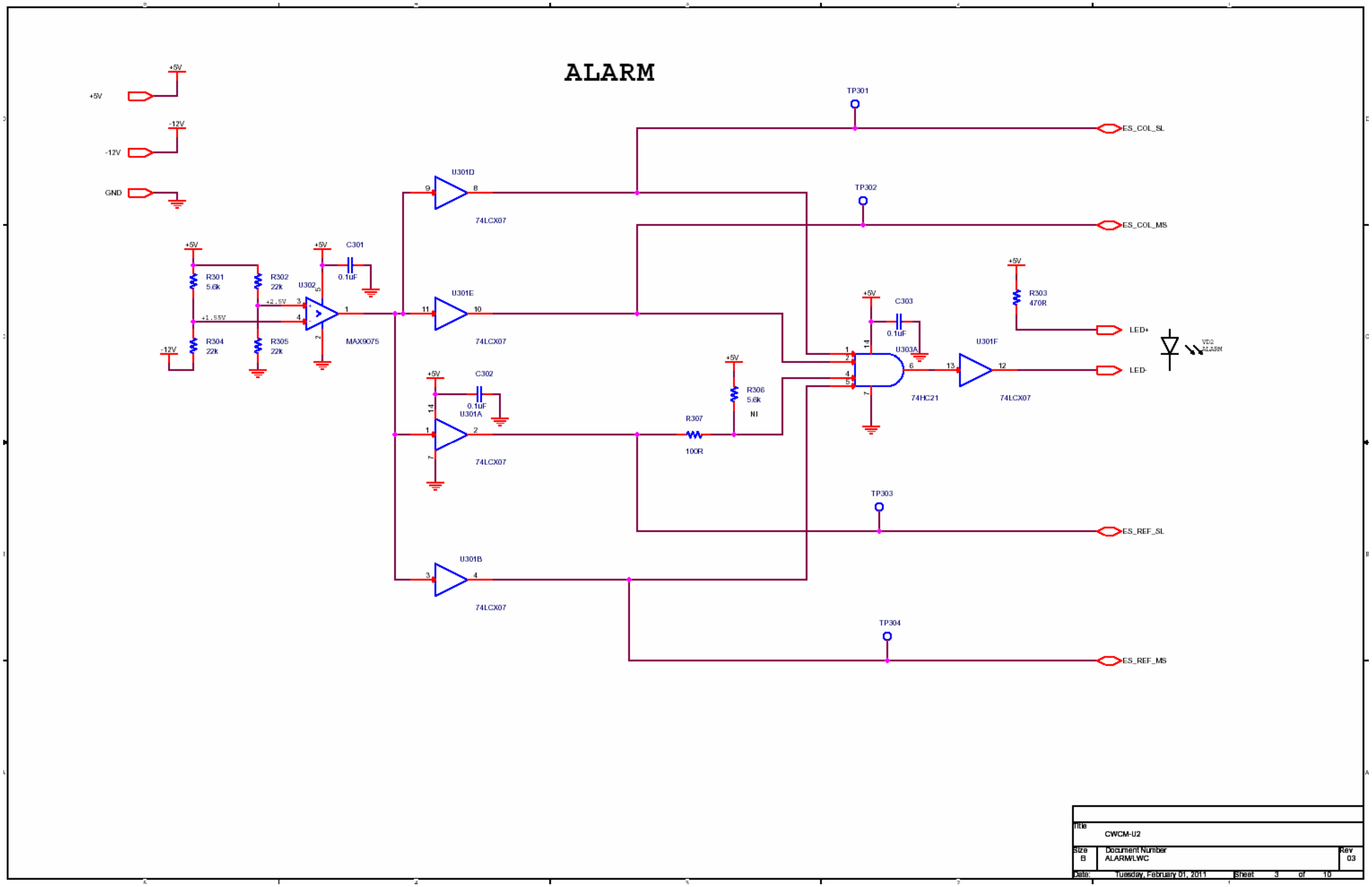
ALARM
+5V
-12V
GND
R301
5.6k
R302
22k
R304
22k
R305
22k
+2.5V
+1.55V
U302
MAX9075
C301
0.1uF
U301D
U301E
U301A
U301B
74LCX07
C302
0.1uF
R306
5.6k
NI
R307
100R
U303A
74HC21
C303
0.1uF
U301F
R303
470R
LED+
LED-
VD2
ALARM
TP301
TP302
TP303
TP304
ES_COL_SL
ES_COL_MS
ES_REF_SL
ES_REF_MS
Title
CWCM-U2
Size
B
Document Number
ALARM/LWC
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Figure 14

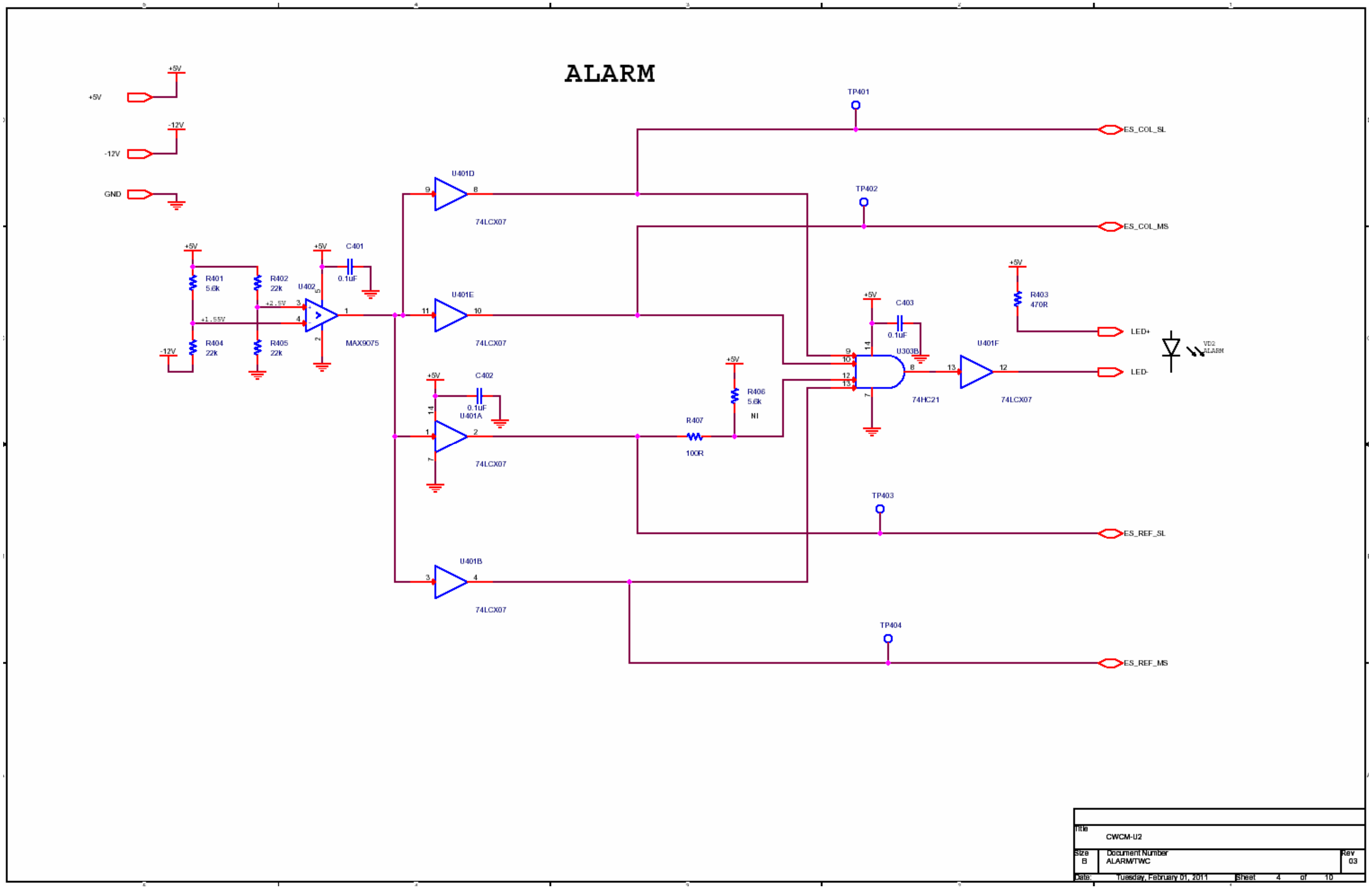
ALARM
+5V
-12V
GND
R401
5.6k
R402
22k
R404
22k
R405
22k
U402
MAX9075
+2.5V
+1.55V
C401
0.1uF
U401D
U401E
U401A
U401B
74LCX07
C402
0.1uF
R407
100R
R406
5.6k
NI
U303B
74HC21
C403
0.1uF
U401F
R403
470R
LED+
LED-
VD2
ALARM
TP401
TP402
TP403
TP404
ES_COL_SL
ES_COL_MS
ES_REF_SL
ES_REF_MS
Title
CWCM-U2
Size
B
Document Number
ALARM/TWC
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Figure 15

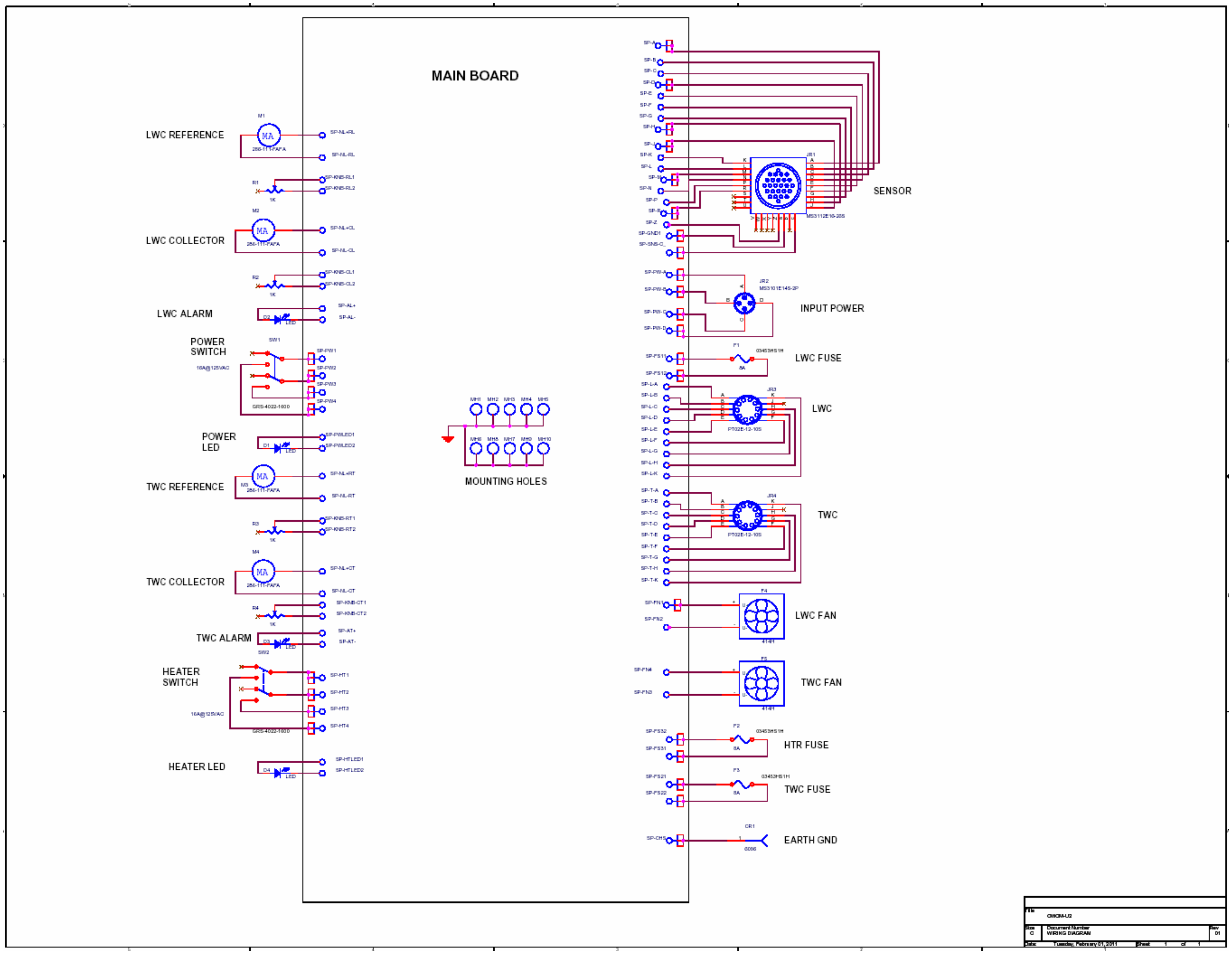
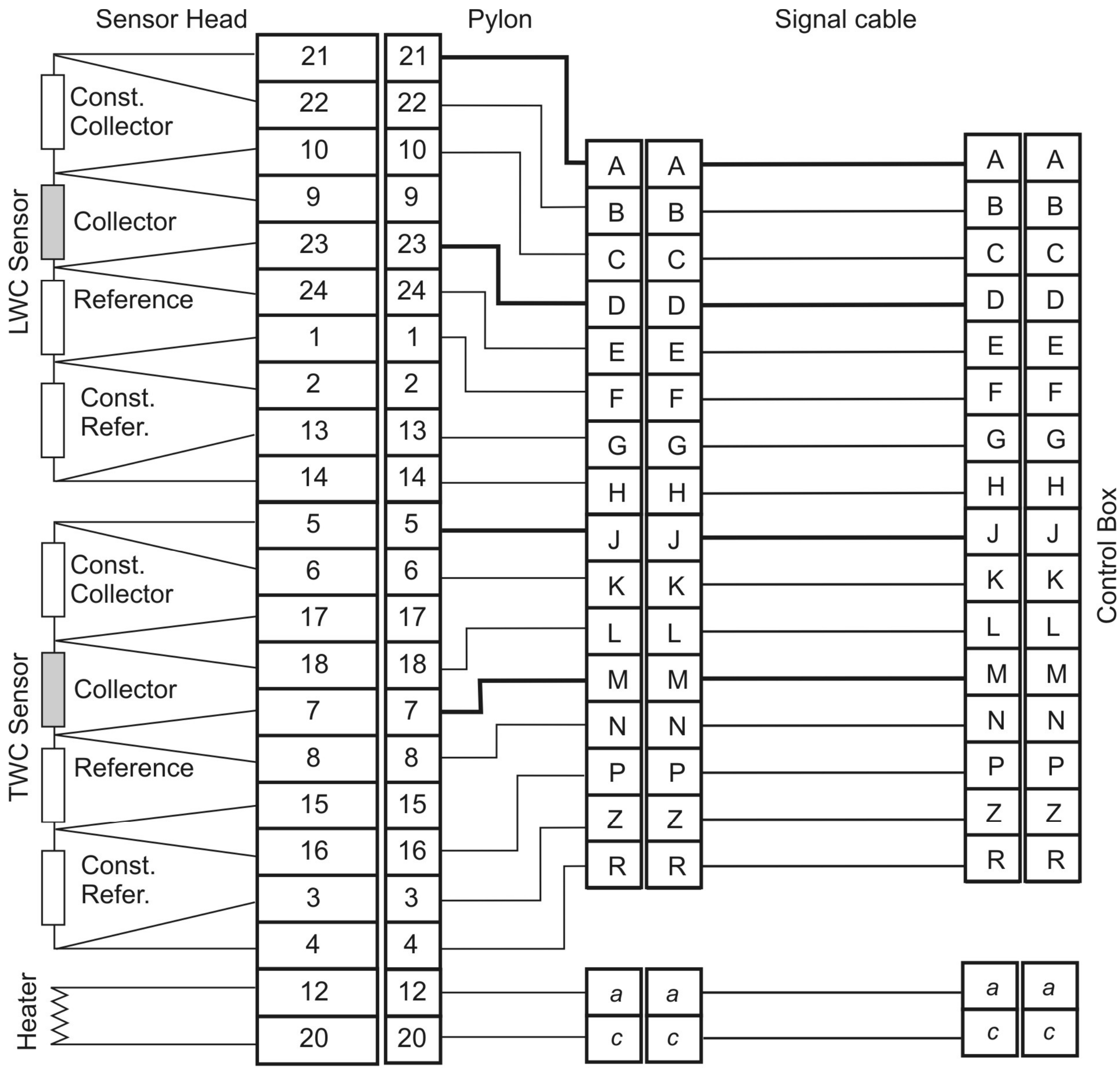

MAIN BOARD
LWC REFERENCE
LWC COLLECTOR
LWC ALARM
POWER SWITCH
POWER LED
TWC REFERENCE
TWC COLLECTOR
TWC ALARM
HEATER SWITCH
HEATER LED
MOUNTING HOLES
SENSOR
INPUT POWER
LWC FUSE
LWC
TWC
LWC FAN
TWC FAN
HTR FUSE
TWC FUSE
EARTH GND

Figure 16



Nevzorov Probe Wiring Diagram

Nevzorov Probe Control Box