TURTLE PROJECT

VALIANT Designs LTD

TITLE

TEST SPECIFICATION FOR MK IV TURTLE CONTROLLER BOARD

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TEST SPECIFICATION FOR MK IV TURTLE CONTROLLER BOARD

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I N D E X

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1.0 INTRODUCTION

The purpose of this document is to define the test procedures for the MK IV Turtle Controller Board.

The document is split into three sections - A,B, and C:
Section A relates to individual circuit testing on a block by block basis;
Section B relates to functional testing, where the board may be tested in conjunction with a representative Turtle test chassis, or as a fully built production Turtle;
Section C relates to the dynamic behaviour of those circuit functions or elements not sufficiently covered in the previous two sections.

2.0 FUNCTIONAL DESCRIPTION

2.1 Turtle Robot

The Turtle Robot is a remotely controlled educational instrument which performs as a perfect slave to commands transmitted from the Host Computer System.

The unit receives commands via an infra-red link, and, following decoding, will activate its stepper motors, as appropriate, to provide unit motion, or its pen motor to either lift or lower a pen in order to provide drawing control.

The unit is powered via a nicad battery pack and fast charge facility is provided in order to minimise down time.

2.2 Turtle Controller Board

The Turtle Controller board provides all of the circuitry necessary to facilitate the functions described in 2.1 above.
Figure 1 is a block schematic of the board showing the major constituent parts and inter-connections.

The charge controller is used only during battery charging and is powered only during this mode - selected by the Turtle three position power switch. The circuit permits unit fast charging until such time as the on-board monitoring circuitry detects a charged stack status, causing reversion to a slow charge condition, which may be maintained indefinitely.
The charger supply is the same power unit as used to power the Communicator.

The Infra-Red Receiver performs the task of I.R. detection and amplification in order that the signal be digitised prior to input to the Detection Gate.

The Detection Gate 'opens' under microcomputer control at specific times in order to search and store infra-red detections. At the end of the gating period, the microcomputer reads the status of the circuit and then resets it in readiness for the next detection period.

The microcomputer reads and decodes the input I.R. command read from the Detection Gate and powers the Pen Motor or Stepper Motor drive circuits accordingly.

SECTION A: CIRCUIT TESTS

3.0 POWER SUPPLY AND CONSUMPTION TEST

Special Note: Power supply application should be implemented on a short duration power application basis in order to prevent component burn up. Special consideration must be attributed to the Pen Motor Drive Circuit which is toleranced for short drive durations (of order of 1 second).

3.1 Short IC5 Pins 1,2,3,4 to 0V in order to disable Pen Motor Drive Circuits.

3.2 Apply 12 Volts D.C. $\pm$ 0.1 between PL2/6 (positive) and PL2/2 with current limit set to 200mA.

3.3 Confirm that current consumption lies between 60mA and 140mA.

3.4 Confirm that voltage between IC1 Pin 40 and main ground plane is +5V $\pm$0.25V.

3.5 Confirm that voltage between PSR2 output terminal and main ground plane is 6V $\pm$0.4V.

3.6 Confirm that voltage at R6/R22 node with respect to main ground plane is T.B.A.

3.7 Turn off supply - end of test.

4.0 BATTERY STATUS CIRCUIT TEST

4.1 Connect PL3/2 to PL3/1.

4.2 Short IC5 Pins 1,2,3,4 to 0V ground plane in order to disable the Pen Motor Drive Circuits.

4.3 Apply +12V between PL2/6 (positive) and PL2/2 with current limit set to 200mA.

4.4 Confirm that the voltage at IC8 Pin 7 w.r.t. ground plane is less than 0.4 Volts.

4.5 Reduce supply to 10 Volts $\pm$ 0.1 Volts.

4.6 Confirm that the voltage at IC8 Pin 7 w.r.t. ground plane is 10 Volts $\pm$ 0.1 Volts.

4.7 Turn off supply volts.

5.0 CHARGER CIRCUIT TEST

Special Note: To enable testing of this circuit, constant voltage source of 12V with current sink capability of up to 0.7 Amp is required in order to simulate the Turtle battery pack. Refer to Figure 2 for details of wiring inter-connection.

5.1 Unloaded Charger Circuit Test

5.1.1 Apply short circuit between PL2/4 and PL2/3.

5.1.2 Apply 12.0 ± 0.1 Volts between PL2/5 (positive) and PL2/2 with current limit set to 25mA.

5.1.3 Confirm that the voltage at IC7 Pin 2 w.r.t. 0V ground plane is 5.5V ± 0.5V.

5.1.4 Confirm that the voltage at IC7 Pin 1 w.r.t. 0V is less than 1 Volt.

5.1.5 Open circuit connection between PL2/4 and PL2/3.

5.1.6 Confirm that the voltage at IC7 Pin 2 w.r.t. 0V is between 0.5 Volts and 0.7 Volts.

5.1.7 Confirm that the voltage at IC7 Pin 1 is greater than 10 Volts.

5.1.8 Confirm that the voltage at IC7 Pin 3 is 12.0 ± 0.1 Volts.

5.1.9 Turn off supply and disconnect.

5.2 Loaded Charger Circuit Test

5.2.1 Short PL2/4 to PL2/3.

5.2.2 Connect 12V voltage source/sink between PL2/5 (positive) and PL2/2.

5.2.3 Connect 17V D.C. source (output capability 0.7 Amp max.) between PL2/1 (positive) via limiter resistor 5R6 4W and PL2/2 (Refer to Figure 2).

5.2.4 Confirm that the current dump out of terminal PL2/5 is 0.5 Amp ± 0.1 Amp.

5.2.5 Open circuit PL2/3 from PL2/4.

5.2.6 Confirm that the current dump out of terminal PL2/5 is 60mA ± 20mA.

5.2.7 Turn off supply and disconnect voltage source - end of test.

6.0 INFRA-RED RECEIVER TEST

Special Note: The following test assumes the availability of an I.R. Reference source producing two levels of infra-red radiation at the detection diodes mounted on the board under test.

6.1 D.C. Measurements

6.1.1 Short IC5 Pins 1,2,3,4 to 0V ground plane in order to disable the Pen Motor Drive Circuit.

6.1.2 Apply 12.0 $\pm$ 0.1 Volts between PL2/6 (positive) and PL2/2 with current limit set to 200mA.

6.1.3 With the infra-red source turned off, confirm that the voltage w.r.t. 0V ground plane at IC8 Pin 2 is between 2.0 and 3.1 Volts.

6.1.4 Confirm that the voltage at IC8 Pin 3 is 0.955 $\pm$ 2% of the voltage measured in 6.1.3

6.1.5 Confirm that the noise level at IC8 Pin 2 is between 80mV pk-pk and 120mV pk-pk (2 σ level).

6.1.6 Confirm that the output at IC8 Pin 1 is logic '0'.

6.2 Non-Saturating Receiver Test

6.2.1 With circuit board already powered from 6.1, turn on I.R. Reference Source and set to low level output position.

6.2.2 Confirm that negative going pulses of approx. 5 microsecond duration and amplitide of 500 + 100mV are present at IC8 Pin 2 (Refer to Figure 4 Trace 4).

6.2.3 Confirm that positive going pulses of 5 microsecond duration are output from IC8 Pin 1.

6.3 Saturating Receiver Test

6.3.1 With circuit board already powered and I.R. Reference Source on, set I.R. Reference output level to high.

6.3.2 Confirm that the voltage at IC8 Pin 3 has reduced to less than 1.5V w.r.t. ground plane potential.

6.3.3 Test completed - turn off I.R. Reference Source and turn off power to board.

7.0 DETECTION GATE TEST

7.1 Short IC5 Pins 1,2,3,4 to 0V ground plane in order to disable the Pen Motor Drive Circuits.

7.2 Short IC1 Pin 4 to 0V on order to disable the micro-computer.

7.3 Apply 12V $\pm$ 0.1V between PL2/6 and PL2/2.

7.4 Confirm that IC1 Pin 36 is logic 1.

7.5 Confirm that IC1 Pin 39 is logic 1.

7.6 Confirm that IC3 Pin 3 is logic 0.

7.7 Set IC1 Pin 36 to logic 0.

7.8 Apply momentary short across R55 in order to generate a positive going TTL pulse at IC3 Pin 3.

7.9 Confirm that IC1 Pin 39 is logic 0.

7.10 Set IC1 Pin 36 to logic 1.

7.11 Confirm that IC1 Pin 39 is logic 1.

7.12 Remove power - end of test.

The Pen Motor Drive Circuit provides the power amplification and bi-directional drive output required to rotate the pen motor in either direction in order to achieve the 'pen lift' or 'pen lower' operations.

The Stepper Motor Drive Circuits provide the power amplification and drive outputs required to function the port and starboard stepper motors.

The Indicator Led provides a function similar to its equivalent on the Communicator Board, by essentially providing the user with a means of assessing certain operational states.

The Battery Status Circuit provides the function of continuously monitoring the charge state of the battery stack. It provides an output drive which illuminates the Turtle Eyes, mounted at the 'head' of the unit, extinguishing these only when the level of charge approaches a discharged state.

8.0 PEN MOTOR DRIVE CIRCUIT TEST

Special Note: This test must be carried out on a short duration basis because of the power dissipations involved. It is recommended that testing of each driver be limited to less than one second.

8.1 Short to 0V ground plane IC5 Pins 1,2,3,4.

8.2 Short to 0V ground plane IC1 Pin 4 to disable the processor.

8.3 Apple 12V supply between PL2/6 (positive) and PL2/2.

8.4 Confirm that the differential voltage across R39 is less than 10mV.

8.5 Repeat 8.4, but for R40.

8.6 Allow IC5 Pins 1 and 2 to float.

8.7 Confirm that the differential voltage across R39 is greater than 10.5 volts. (Note that current consumption in this on-condition is approximateley 0.5 Amps).

8.8 Short IC5 Pins 1 and 2 to 0V.

8.9 Allow IC5 Pins 3 and 4 to float.

8.10 Confirm that the differential voltage across R40 is greater than 10.5 volts.

8.11 Short IC5 Pins 3 and 4 to 0V.

8.12 Remove power from board.

9.0 STEPPER MOTOR DRIVE CIRCUIT TEST

Special Note: In order to test each of the stepper motor drive circuits, each output requires to be loaded externally to the board via a resistor up to 12Vp. The resistor value should be 47R and wattage rating of 1 watt, based on a maximum per line test duration of 0.25 seconds. Current = 0.25A approx.

9.1 Short IC5 Pins 1,2,3,4 to 0V.

9.2 Short IC1 Pin 4 to 0V.

9.3 Apply 12V to board between PL2/6 and PL2/2.

9.4 For each of the stepper drive lines, confirm

a) that the output voltage w.r.t. 0V is less than 1 volt when the corresponding input is floating (high);

b) that the output voltage w.r.t. 0V is at the supply voltage of 12 volts when the corresponding input is shorted to 0V.

Inputs versus outputs are tabulated below:

Input	Output
IC1 Pin 27	PL5/2
IC1 Pin 28	PL5/5
IC1 Pin 29	PL5/1
IC1 Pin 30	PL5/4
IC1 Pin 31	PL4, 2
IC1 Pin 32	PL4/5
IC1 Pin 33	PL4/1
IC1 Pin 34	PL4/4

10.0 INDICATOR TEST

10.1 Short IC5 Pins 1,2,3,4 to 0V.

10.2 Short IC1 Pin 4.

10.3 Apply 12V between PL2/6 and PL2/2.

10.4 Confirm that IC5 Pin 12 is within 0.4 volts of 0V.

10.5 Short IC1 Pin 38 to 0V.

10.6 Confirm that IC5 Pin 12 is at the supply level of 12 volts.

10.7 Remove supply - end of test.

SECTION B: FUNCTIONAL TESTS

Note: This section of the document assumes the availability of a Turtle Test Chassis fitted electrically in such a manner as to provide, as far as possible, a simulation of the true chassis.
It is assumed that the Charger test has been sufficiently completed at the in-circuit stage so as not to require testing in this stage.
Conversely, the Loaded Charger test (section 5.2) may be re-allocated or repeated as a Functional Test according to test equipment capabilities.
For the same reasons, the Battery Status test need not be repeated in both sections.

Functional Testing is therefore limited to testing those circuits that either provide command signals to, or are provided with control signals from, the microcomputer. Functional Testing therefore requires the transmission of defined I.R. commands from a Communicator in order to stimulate the required functions within the Turtle Controller.

11.0 POWER-UP INITIALISATION

11.1 Apply 12 volts between PL2/6 and PL2/2.

11.2 Confirm that the Pen Drive circuit activates for approx. 1 second following initialisation and causes the Pen System to set itself to the 'Up' condition. Accordingly, drive output lines from IC5 Pins 14 and 15 are pulled to within 0.4V of 0V for the duration.

11.3 Confirm that the red Indicator Led D2 is illuminated.

11.4 Check that the stepper motor drives are turned off: this may be carried out by checking for free wheel movement.

11.5 Confirm that the eyes are illuminated.

12.0 PEN CONTROL

12.1 Output the command code 10H from the Host Computer connected to the Communicator.

12.2 Confirm that the Pen Motor Circuit activates for approx. 1 second in such a manner as to cause the Pen to move to the 'DOWN' position: accordingly, drive output lines IC5 Pins 13 and 16 are pulled to within 0.4V of 0V for the duration.

12.3 Confirm that D2 is turned out.

12.4 Output code 00H from the Host System.

12.5 Confirm that the pen state reverts again to the 'UP' position.

12.6 Confirm that D2 is turned on.

13.0 <u>STEPPER MOTOR CONTROL</u>

13.1 Output from the Host Computer command codes as defined in column 1 of the table below, and confirm that the response is as defined in columns 2 and 3.

INPUT ACTION	OUTPUT LINE STATUS IC 4/10	IC 4/11	IC 4/12	IC 4/13	IC 4/14	IC 4/15	IC 4/16	IC 5/10	OUTPUT ACTION
TURN ON BOARD (INITIALISED)	1	1	1	1	1	1	1	1	MOTORS OFF
TX CODE 76H	1	0	0	1	0	1	1	0	FWD 1 STEP
TX CODE 76H	1	0	1	0	1	0	1	0	FWD 1 STEP
TX CODE 76H	0	1	1	0	1	0	0	1	FWD 1 STEP
TX CODE 76H	0	1	0	1	0	1	0	1	FWD 1 STEP
TX CODE 76H	1	0	0	1	0	1	1	0	FWD 1 STEP
TX CODE 70H	1	1	1	1	1	1	1	1	MOTORS OFF

1 = Drive off, voltage high

0 = Drive on, voltage low

SECTION C: DYNAMIC PERFORMANCE

This section details the dynamic operation of the unit under normal operating conditions.

14.0 SYSTEM CLOCK

All system (firmware) operations are timed against the ALE output clock from IC1 Pin 11.
This clock is itself derived from a GMHz oscillator circuit formed by the on-chip IC1 circuitry and externally connected crystal.

The ALE output is required to be of a 2.5 microsecond $\pm$ 0.05% period, with a high to low ratio of approx. 1 to 4.

15.0 INFRA-RED RECEIVER

15.1 Infra-Red Receiver Circuit

With reference to Figure 3, it may be seen that the infra-red receiver circuit may be split into a number of discrete functional blocks.

15.1.1 Receiver Diodes

The series of fast infra-red pulses output from the Communicator are converted back to electrical signals by an array of p.i.n. photo-diodes mounted on the Turtle Controller board.
These signals comprise of current pulses directly proportional to the intensity of the infra-red wavelengths received by the diodes.
Refer to Figure 4 Trace 1 for an example of the signal type to be found at the output of this receiving stage for a repetitive 5us I.R. pulse signal.

15.1.2 First Stage Amplifier

The current pulses from the receiver diodes are capacitively coupled to the input of the first stage amplifier.
This amplifier is of transconductance type, exhibiting low input impedance and required to convert the current input into a voltage output.
The transconductance gain = 9.8K typical.
Refer to Trace 2 of Figure 4 for typical output from this stage.

15.1.3 Second Stage Amplifier

The second stage amplifier receives as input the output voltage from the first stage.
The voltage gain of the circuit is 25, typically.

15.1.4 Third Stage Amplifier

The third stage common emitter amplifier receives as a capacitively coupled input the output voltage from the second stage.
The voltage gain of this amplifier is 20, typically.

15.1.5 Auto-Reference Level Circuit

The output from the third stage amplifier is fed to a high input impedance voltage comparator via the Auto-Reference Level Circuit. The purpose of this circuit is to provide a nominal reference level to the comparator which is potted down from the third stage quiescent d.c. output: however, for large amplitude pulse signals, a pulldown transistor TR1 conducts in order to, in voltage terms, reduce the threshold voltage; in thresholding terms, the circuit sensitivity is reduced, decreasing the probability of random noise interference.

15.1.6 Comparator

The comparator receives as inputs the direct signal output from the third stage amplifier and the reference level from the Auto-Reference Level Circuit.
The circuit digitises the I.R. pulses received to TTL compatible levels suitable for input to the Detection Gate Flip-Flop.

15.2 Band Width

The amplifier band width is typically 10MHz with band stop below 100kHz.

15.3 Amplifier Noise Output

The amplifier output noise measured at IC8 Pin 2 is typically 100mV pk-pk under normal indoor lighting conditions.

16.0 DETECTION GATE CIRCUIT

This circuit is based on a single D-type flip-flop.
The purpose of the circuit in conjunction with control (reset) signals from the microcomputer is to sense and record the presence of I.R. inputs during defined 'gating' periods.
The relationship of detected signal against gate period is analysed by the microcomputer in order to decode the digital command.

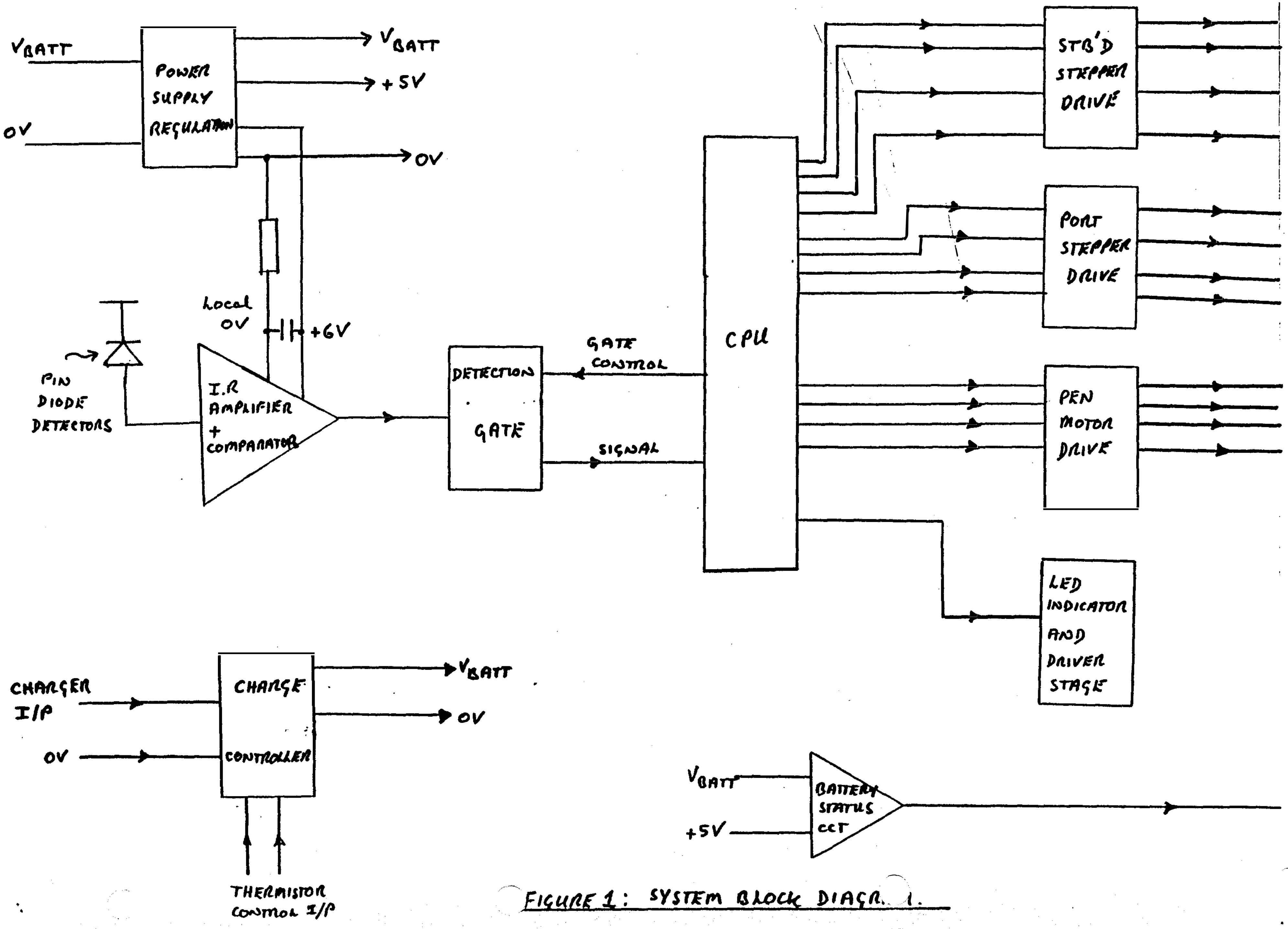


FIGURE 1: SYSTEM BLOCK DIAGR. 1.

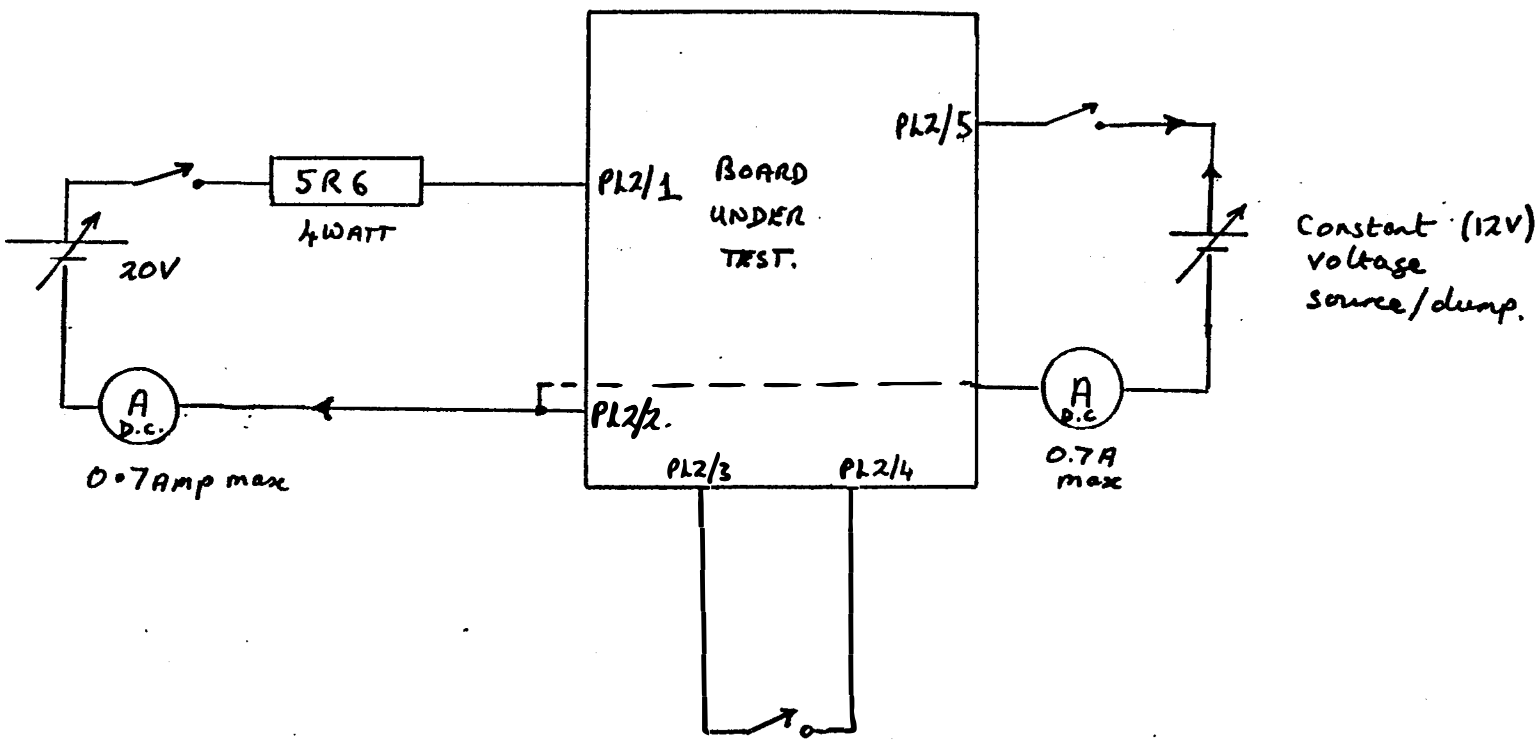


FIGURE 2: CHARGER TEST SCHEME.

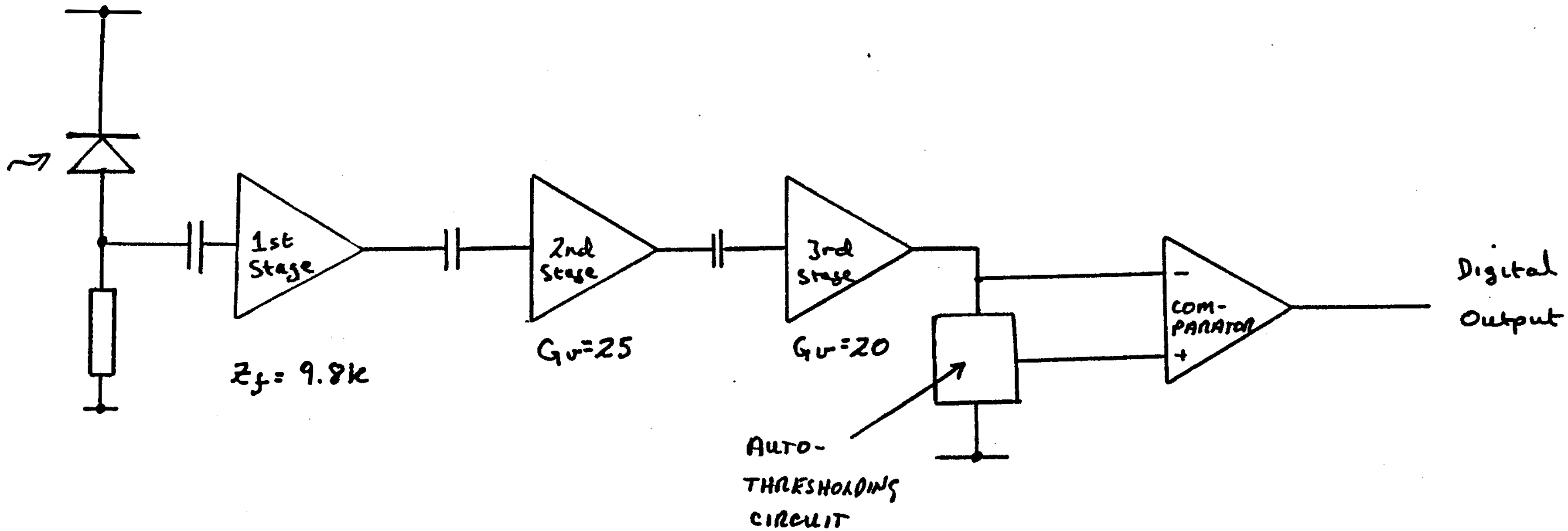
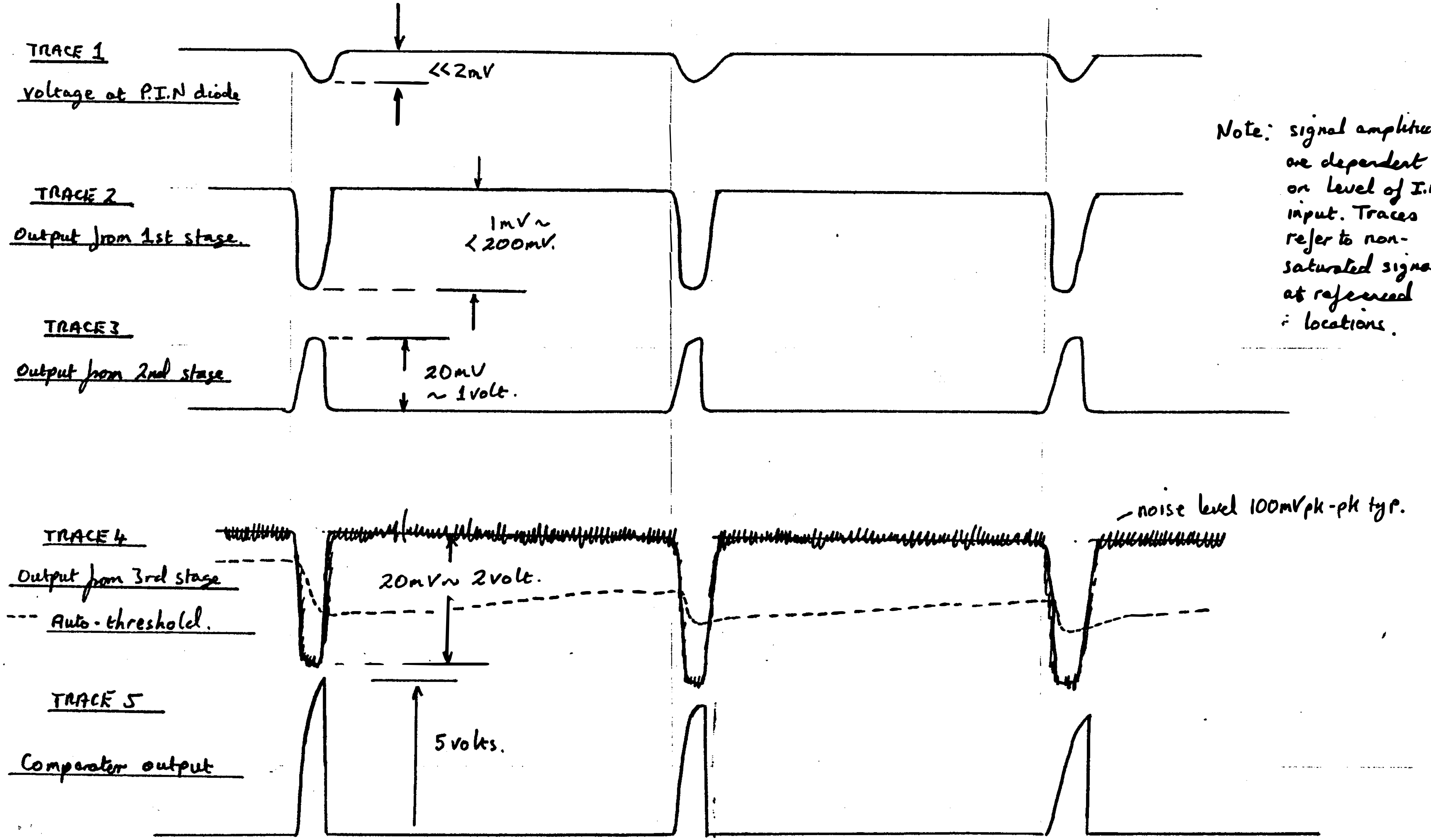


FIGURE 3: Infra-Red Receiver/Amplifier Block Diagram.



GURE 4: I.R. Amplifier Signal Di. gram.