

THEORY OF OPERATION

The following discussion is divided into three parts; the first is a general description of the operation when power is first applied and grain is loaded into the Test Cell. The second part, with the aid of the Overall Block Diagram (Figure 3), describes basic self-checks and measurements performed by the unit. The third part is a more detailed explanation of circuit operation which is useful for technical understanding.

1. BASIC OPERATIONAL OVERVIEW

When power is turned on, the unit automatically begins self-checking to determine status of the (1) load/strike-off function, (2) unload function, (3) empty test cell weight, and (4) conductance and capacitance measurement circuitry. After these self-checks are completed, the operator selects the appropriate grain name, then pours grain into the hopper and depresses the LOAD switch on the keyboard. Just prior to the hopper doors opening and dropping grain into the cell, the temperature of the empty test cell is measured. If any self-checks fail, the display shows an appropriate ERROR code.

After the grain is loaded into the test cell, four measurements are made during a normal cycle. These are for the (1) weight, (2) temperature, (3) capacitance and (4) conductance of the grain in the test cell. Computations, using these measurements and the stored calibration constants for the selected grain, are then performed by the unit and the resulting % moisture is displayed. If a printer is connected, the results shown on the display may be printed out.

2. OVERALL BLOCK DIAGRAM DESCRIPTION

For the following discussion, refer to the Overall Block Diagram (Figure 3). It represents circuitry contained on two circuit boards. The blocks in the upper half of the diagram are generally located on the Main Board and those on the bottom half are on the Cell Board (located in the center of the cell assembly). The GAC2100 operation is explained by describing the capacitance, conductance, weight, and temperature measurements taken.

a. SELF-CHECK ROUTINE

When the operator depresses the LOAD key, the unit goes through a self-check routine to ensure its operating parameters are correct before dropping grain into the test cell. This routine includes checking the position of the load and strike-off mechanisms, the position of the dump mechanisms, empty cell temperature, empty cell weight, and empty cell and test load capacitance and conductance measurements. The first of these self-checks to fail, if any, will cause the corresponding ERROR code to be displayed. The following paragraphs explain each of these self-checks:

(1) LOAD/STRIKE-OFF Self-Check – When power is applied to the unit, the strike-off motor begins to rotate a cam shaft assembly, causing the hopper doors to open and the strike-off arm to sweep across the top of the test cell. At the end of the cam shaft assembly opposite the motor, a crank arm is attached with a magnet mounted on its tip end. A reed switch mounted on the hopper plate assembly remains closed because of the proximity of this magnet. As the strike off motor begins to turn, the crank and magnet swing away from the home position. As the magnet moves away, the magnetic field weakens, allowing the reed switch to open. The cam on the cam shaft assembly permits the hopper doors to drop open. The cycle pauses briefly, then continues until the cam returns to its home position, causing the hopper doors to close and the magnet on the

crank to, once again, close the reed switch. The microprocessor checks for proper switch operation and the time required to complete the cycle. If either is wrong, an ERROR “4” is displayed.

(2) UNLOAD Self-Check – If the load/strike off self-check above was successful and the reed switch functioned properly, then the microprocessor next applies power to the dump motor. Again, the microprocessor checks the period of time required for the test cell to complete the dump cycle and monitors the position of the test cell at the end the dump cycle. The microprocessor is also checking the operation of the two reed switches mounted on brackets located on the center panel inside the unit. A collar containing a magnet on its outer edge is mounted on the cell shaft assembly. As the dump motor rotates the shaft to dump the cell, the magnet on the collar travels between the dump start reed switch (“Home Position”) and the dump end reed switch (180° inverted position). When the dump end reed switch closes (cell inverted), the dump motor reverses direction and the cell returns to its upright position causing the dump start reed switch to close again. If either of the reed switches fails to open or close properly or the time duration of the dump cycle is too long, the microprocessor instructs an ERROR “3” be displayed.

(3) EMPTY TEST CELL WEIGHT Self-Check – When the microprocessor is ready for a weight self-check, an empty cell weight measurement is made. The actual weight of the cell is compared to the stored empty cell weight value. If these are not within acceptable limits, the microprocessor directs an ERROR “2” message be displayed.

(4) TEMPERATURE Self-Check – This check is performed after the LOAD switch is depressed but before the hopper doors drop open. To do this, the microprocessor briefly applies a current through the two exposed temperature sensing diodes in the cell. The voltage drop across the diodes is then quickly measured and stored in RAM. The microprocessor accesses the temperature constants in memory for comparison to the normal temperature range for the empty test cell. If the temperature is out of limits, an ERROR “8” is displayed to indicate the condition.

(5) CAPACITANCE and CONDUCTANCE Self-Check – In performing these checks, two groups of three measurements are made. The first group is with the test cell empty and the second group is with the dummy test load (parallel RC network simulating grain in the cell) connected. The three measurements in each group are with (1) null voltage, (2) 2 MHz signal, and (3) 5 kHz signal connected to the test cell. The first group of measurements is made with the test cell empty and the test load disconnected. The microprocessor issues the command to read the null voltage and an analog switch on the Cell Board closes its contacts via the /NULL command. This removes the signal and applies a ground to the test cell. The microprocessor reads and stores the resulting voltage. (The null voltage is adjusted during factory calibration to ensure it does not go negative.) Next, it applies the 2 MHz signal to the cell, then measures and stores this result. Finally, the 5 kHz signal is connected, measured, and results are stored.

The second group of measurements is made under identical conditions as the previous paragraph except with the test load connected to the test cell. With these six stored values, the ratio between the 5 kHz empty cell and 5 kHz test load readings is calculated. Also, the ratio of the 2 MHz empty cell and 2 MHz test load readings is calculated. If either of these ratios exceeds the programmed limits, an “Error 1” message is issued.

When determining moisture content of a grain sample, a set of six measurements is made similar to those indicated above except, of course, the test load measurements are replaced by those made with the test cell full of grain.

When the unit is ready to make a capacitance measurement of the grain in the test cell, the output of a 2 MHz crystal-controlled sine wave oscillator on the Cell Board (lower, left corner of Figure 3) is gated by the 2 MHz SELECT line (from the PIO on the Main Board) thru an analog switch, buffer stage, and 5200 ohm resistor to the center electrode of the test cell. The electrical impedance of the test cell, determined primarily by the dielectric constant of the grain sample, causes the 2 MHz oscillator signal to be "loaded down" or attenuated (because of the voltage divider formed by the 5200 ohm resistor and the test cell impedance).

This attenuated AC signal is buffered and applied to a "peak-detector" circuit which develops a proportional, positive DC output voltage. TEMP/OSC from the PIO on the Main Board, Gates this DC voltage (which is correlated to the capacitance of the grain in the test cell) thru another analog switch to the input of a voltage-to-frequency (V-F) converter whose output frequency is proportional to its DC input. This frequency (which ranges from 0 Hz at 0 volts to 150 kHz at +5 volts input) is gated on the Main Board thru a "measurement select gate" to the PIO and then, finally, to the MPU for processing at the appropriate time.

c. CONDUCTANCE MEASUREMENT (D1)

The conductance measurement is very similar to the capacitance measurement except the 5 kHz oscillator output is used instead of the 2 MHz oscillator output. The cell capacitance (due to the dielectric constant of the grain) has a negligible attenuating effect on the 5 kHz oscillator output. The conductance of the grain, however, has a major effect. The 5 kHz SELECT line from the PIO gates the 5 kHz oscillator output thru an analog switch, then thru the same buffer and 5200 ohm resistor to the center electrode of the test cell. The 5 kHz (conductance) signal is processed in the same fashion as the 2 MHz (capacitance) signal.

d. WEIGHT MEASUREMENT (D3)

Weight measurements are determined by a frequency generated through the use of a weight transducer mounted on the side of the cell assembly. The weight transducer consists of a ferrite slug mounted to the stationary portion of the flexure assembly with a coil mounted to the cell (movable portion). As the weight of the grain lowers the cell, the fixed slug is driven deeper into the movable coil. The coil, a pair of capacitors and an amplifier create an oscillator with its frequency determined by the position of the slug in the coil. As the slug is driven deeper into the coil, the frequency of the oscillator is decreased. The signal is amplified and applied through the measurement select gate on the main circuit board and applied to the PIO. The frequency is counted for a fixed period of time and then processed by the MPU. The results are transferred to the RAM for storage and displayed.

e. TEMPERATURE MEASUREMENT (D4)

The transducer for measuring temperature consists of two series-connected diodes across an opening in the lower portion of the cell board. The cell board is located in the center partition of the cell assembly. After grain is poured into the hopper and the LOAD switch is depressed, a one-half second pause occurs before the hopper doors open to drop the grain into the cell.



During this pause, the voltage drop across the diodes is quickly measured indicating an empty cell temperature. After the one-half second has elapsed, the hopper doors open and the grain drops into the cell. Once loaded into the cell, the grain comes into contact with two diodes. After a fixed time period, a second voltage reading is taken across the two diodes. The unit waits for another fixed period of time and takes a third voltage reading. Each one of these dc voltage readings is applied through the voltage- to-frequency converter and routed to the PIO on the main board. The three readings are used by the microprocessor to compute (predict) the actual temperature of the grain.