WESTERN DIGITAL
C O R P O R A T I O N

WD-51 IRRIGATION CONTROLLER

FEATURES

- CONTROLS UP TO 6 IRRIGATION STATIONS
- PUMP CONTROL/MASTER VALVE OUTPUT
- USER PROGRAMMABLE FOR UP TO 3 WATERING CYCLES DURING A 24 HOUR DAY
- USER PROGRAMMABLE RUN TIMES OF 1 TO 99 MINUTES FOR EACH STATION
- USER SELECTION OF WATERING DAYS OF 0 TO 7 DAYS PER WEEK
- TIME OF DAY AND DAY OF WEEK CONTINUOUSLY DISPLAYED
- RAIN INHIBIT MODE
- EASY TO DESIGN IN

GENERAL DESCRIPTION

Preprogrammed Controller for Irrigation Applications. The WD-51 is a single-chip controller preprogrammed to operate a 6 station irrigation system. It is implemented using P-channel silicon gate MOS/LSI technology and requires minimal support circuitry. All program and data storage are on-chip, as well as input switch matrix scan, 7 segment display decode and drive, and output control logic.

FUNCTIONAL DESCRIPTION

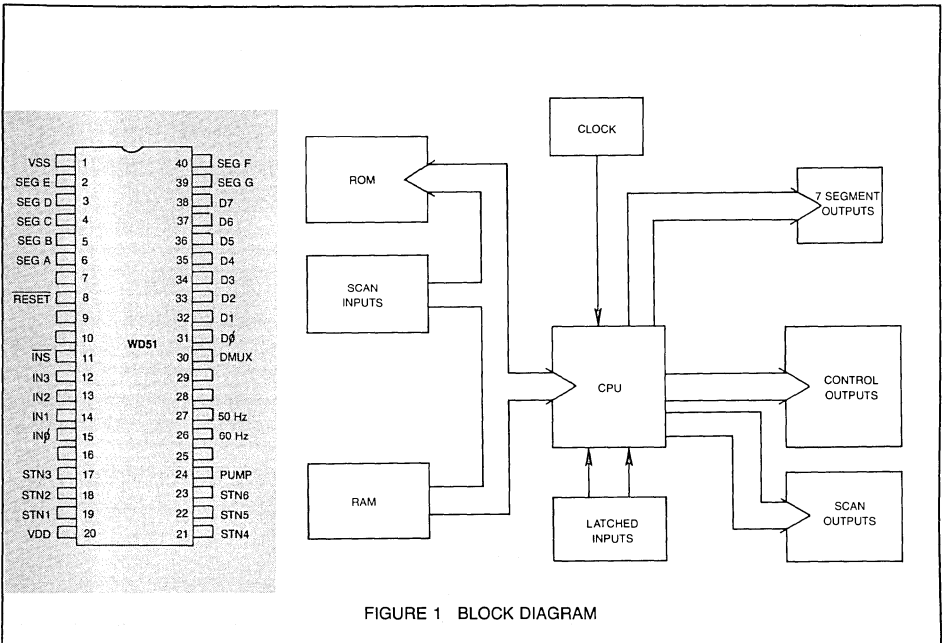The logic symbol and block diagram of the WD-51 is shown in Figure 1.

FIGURE 1 BLOCK DIAGRAM

SECTION 4

PIN DESCRIPTION

SYMBOL	PIN NO.	FUNCTION
V_{SS}	1	Positive Supply voltage
V_{DD}	20	Negative Supply voltage
Seg A,B,C, D,E,F,G	2-6, 39-40	Decoded 7-Segment Multiplexed outputs, 15 mA source.
$\overline{RESET}$	8	A low-level input voltage resets internal logic and initializes RAM data.
IN0, 1N1, 1N2, 1N3	12-15	Scanned inputs, 1N3 is MSB
STN 1,2,3, 4,5,6	17-19 , 21-23	Station Output control for solenoid drivers.
PUMP	24	Pump control output- a high-level output indicates a manual or automatic cycle is in progress.
60HZ	26	60 HZ time base input
50HZ	27	50 HZ time base input
DMUX	30	4-digit display control output
D0-D7	31-38	Digit scan outputs, (D7=MS_D, D0=LS_D)
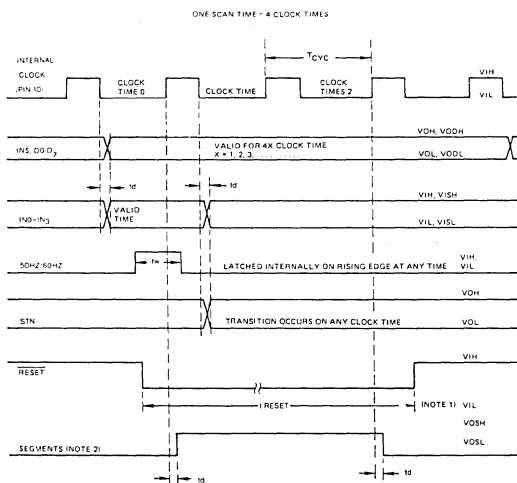
NOTE 1 RISING EDGE OF RESET GENERATES SCAN TIME 0 WITHIN 4 CLOCK TIMES

NOTE 2 SEGMENT OUTPUTS ARE VALID DURING CLOCK TIMES 1 TO 3 ONLY THEY ARE LOW AT TIME 0

FIGURE 2

TIMING DIAGRAM

INPUT SWITCH MATRIX—The WD-51 may be used with any switch configuration which is matrix compatible, such as a keyboard, rotary switch, slide switch, or combinations of both. All multiplexing and decoding is performed on-chip, thus requiring no external components, other than the switch matrix.

SETTING DAY OF WEEK—If SET DAY is depressed in conjunction with ADVANCE, the Day digit (D4) will increment, with rollover from 7 to 1. Note that since the day is numerically displayed (as opposed to alphanumeric), the numbering is arbitary, i.e., if Sunday is considered to be "1", then Wednesday is "4", Friday is "6", etc.

DIGIT SCAN TIME OUTPUTS

		D7 (38)	D6 (37)	D5 (36)	D4 (35)	D3 (34)	D2 (33)	D1 (32)	D0 (31)
	IN0 (15)	ADVANCE	3-STATION STRAP	SET MINUTES	ACTIVE DAY 4	ACTIVE DAY 1	START TIME #1	RUN TIME #4	RUN TIME #1
SCANNED INPUTS	IN1 (14)			SET HOURS	ACTIVE DAY 5	ACTIVE DAY 3	START TIME #1	RUN TIME #5	RUN TIME #2
	IN2 (13)			SET DAY	ACTIVE DAY 6	ACTIVE DAY 3	START TIME #3	RUN TIME #6	RUN TIME #3
	IN3 (12)			SKIP -A-DAY	ACTIVE DAY 7		MANUAL OFF	MANUAL ON	RUN

FIGURE 3   INPUT SWITCH MATRIX

The basic functions of the Irrigation Controller are selected by one or more switches as defined in Figure 2. Inputs IN0-IN3 form a 4 bit wide input port which is scanned by the Digit Scan Outputs D0-D7, forming an 8 × 4 matrix which connects to the user-supplied keyboard/switches.

SWITCH FUNCTIONS—The switch functions shown in Figure 3 are defined as follows:

ADVANCE—For all setting operations, a common key is used to increment the selected data (time, day, start-time, or run-time). Immediately after the detection of the advance switch, the data increments by 1, waits 1½ seconds, then begins incrementing at the rate of 3 per second. This allows the operator to move rapidly to the desired value without "overshooting" and then "tapping" the advance key when close to the find value.

SETTING TIME OF DAY—Two separate switch inputs for setting hours and minutes in conjunction with the ADVANCE key. If SET MINUTES is selected while ADVANCE is depressed, the minutes digits (D0 & D1) will increment. Minutes rollover is from 59 to 00 with no carry into the hours. If SET HOURS is selected while ADVANCE is depressed, the hours digits (D2 & D3) will advance. Hours rollover is from 24 to 01, with midnight equal to 2400.

SETTING START TIMES—There are up to 3 automatic watering cycle times available in a 24 hour period. To examine them, START TIME 1, 2, or 3 is selected and displayed in hours on digits D7 and D6. If it is desired to change the data, the ADVANCE key is depressed. The rollover is from 24 to 00, with 00 being a start-time "skip" value. Thus 1, 2, or 3 cycles per day may be selected.

SETTING RUN-TIMES—Each one of 6 stations may be set to a run time of 0 to 99 minutes, with 00 being a "skip station" value. To examine the stored data, the desired station RUN TIME key (1–6) is selected with the time in minutes being displayed on digits D7 and D6. To change the data, the ADVANCE key is depressed. The selected run time will then increment with rollover from 99 to 00 minutes.

SETTING ACTIVE DAYS—The WD51 reads active day information from the switch matrix, with typically slide, toggle, or "DIP" switches being used. An automatic watering cycle may be set for 0 to 7 days a week simply by closing the switch for the respective day. An ALTERNATE DAY switch position is provided, which, when activated, causes the controller to ignore the 7 active-day switches and to run an automatic cycle every other day.

MANUAL ON—This switch position immediately activates a timed watering cycle beginning with station No. 1, regardless of the setting of the start-times or active days. The run times programmed for stations 1–6 are automatically run.

The cycle may be terminated anytime with the MANUAL OFF key. If it is desired to start with a specific station other than station No. 1, that station ONE-TIME-key should be depressed *first*, then the manual key. The cycle will then begin at the selected station and continue through station No. 6.

RUN MODE—This is the normal automatic operating mode of the Irrigation Timer. When in this mode, the START and RUN-TIME data cannot be displayed or modified, preventing accidental erroneous entry of data.

RAIN INHIBIT (MANUAL OFF)—This switch is used to cancel or prevent a watering cycle, either manual or automatic. When activated during a current cycle, it immediately turns off all station outputs and returns to a time-keeping mode only. With external signal conditioning circuitry, this input could be used to interface with a moisture or rain sensor. This function is normally implemented by paralleling a toggle switch ("rain") with a momentary key ("manual off").

3 STATION OPTION—By connecting IN3 to D5 through a diode, run times for Stations 4, 5 and 6 will be continuously set to zero, thus they will always be skipped. Also, if switch positions for Run Times 4, 5 and 6 are not provided to the user, these stations cannot be examined.

RESET—This is the reset input of the micro-controller. An external capacitor of approximately 2 μf is recommended between 8 and VDD to generate a reset signal when power is first applied.

OUTPUTS

DISPLAY SEGMENT OUTPUTS (SEG A-SEG F)—The WD-51 is designed to directly drive vacuum flourescent (V-F) displays or common-cathode LED displays up to 0.3

The selected station (1–6) is shown in digit D5. The station number is displayed when a RUN-TIME key is depressed or the controller is active during a manual or automatic watering cycle; otherwise a zero is displayed.

The start time and run times are displayed in digits D6 and D7. When any of the start-time switches are selected, the D6 and D7 digits display the hour of the day the watering cycle is to start. If a run-time switch is activated, the selected station run-time is displayed in a minutes format. During a manual or automatic watering cycle, the time remaining for the currently active station is displayed in minutes. Otherwise, 00 is displayed.

STN1-STN6—The station outputs are latched logic outputs designed to control the solenoid drives in an irrigation system. These outputs are normally a low-level voltage (solenoid drive is off). When a manual or automatic watering cycle occurs, the appropriate station output goes to a logic "high" voltage for the selected run-time interval. Station-to-station switching is essentially instantaneous. It is recommended that these outputs be buffered by a current driver to supply sufficient current for triacs, relays, or other high-power switching devices.

PUMP CONTROL OUTPUT—This output is a latched logic output which is normally a logic "low" voltage for the pump off condition. It goes to a logic "high" voltage at the beginning of a watering cycle, either manual or automatic, and remains high until the last station goes off. With suitable buffering, this output may be used to turn a pump motor on and off when needed or simply to drive a "cycle on" LED status indicator, or to act as a "master valve" output.

DMUX OUTPUT—This output, in conjunction with minimal external logic, provides a means of using a 4 digit display with the WD51. It is a logic high when a RUN-TIME, START-

DIGIT SCAN TIME

D7	D6	D5	D4	D3	D2	D1	D0
				T	I	M	E
START/RUN TIME (MSD)	START/RUN TIME (LSD)	STATION NUMBER	DAY OF WEEK	10's HOURS	HOURS	10's MINUTES	MINUTES

FIGURE 4   DISPLAY REGISTER

inches. The seven segment outputs are high current outputs and are multiplexed in synchronization with D0 - D7 with sufficient interdigit blanking to prevent "ghosting". The display register is shown in Figure 4.

The time of day is displayed as a four digit number in 24 hour format (9AM = 0900, 5PM = 1700, MIDNIGHT = 2400, etc.) and the day of the week is displayed as a number between 1 and 7. The time and day are continuously displayed regardless of the mode selection. Zero blanking is not provided for any of the digits.

TIME, or SET-DAY key is depressed and a logic low voltage at all other times, hence it may be used to externally select digit times D4–D7 when high and D0–D4 when low.

DEFAULT INITIALIZATION—Upon the occurrence of a RESET the micro-controller defaults to the following: Time of day to 12:00; day to 1; start time 1 to 0200 hours; start times 2 and 3 to 00; and run time 1–6 to 10 minutes each. Thus if power is lost to the microcomputer, a default program will be executed without user intervention.

SPECIFICATIONS

Absolute maximum ratings indicate limits beyond which damage to the device may occur. DC and AC electrical specifications are not ensured when operating the device at absolute maximum ratings.

ABSOLUTE MAXIMUM RATINGS

Operating Free-Air Temperature
T_A Range .... 0°C to 70°C
Lead Temperature (Soldering, 10 sec.) .... 300°C

Storage Temperature...... −65°C to +150°C (Ceramic)
                                  −55°C to +125°C (Plastic)

Power Dissipation 2.5 Watt at 25°C
Positive Voltage on any Pin with Respect to V_{SS}: +0.3V
Negative Voltage on any Pin with Respect to V_{SS}: −20.0V

ELECTRICAL CHARACTERISTICS

TA = 25°C, $V_{SS}-V_{DD}$ = 13.2V unless noted otherwise

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Operating Voltage ($V_{SS}-V_{DD}$)	All inputs and outputs open	11.5	13.2	14.5	V
Operating Current		6		15	mA
Input Voltage Levels All Inputs Except IN0−IN3					
Logic High (V_{IH})	Note 1	$V_{SS}-1.0$		V_{SS}	V
Logic Low (V_{IL})		V_{DD}		$V_{SS}-4.2$	V
Inputs IN0−IN3	Note 2				
Logic High (V_{ISH})		$V_{SS}-3.75$		V_{SS}	V
Logic Low (V_{ISL})		V_{DD}		$V_{SS}-9.0$	V
Output Voltage Levels All Outputs Except D0-D7 and SEG A-SEG G					
Logic High (V_{OH})	I_{OH} = +100 μA Min.	$V_{SS}-1.0$		V_{SS}	V
Logic Low (V_{OL})	I_{OL} = −1.6 mA Min.	V_{DD}		$V_{SS}-4.6$	V
D0-D7 Outputs Logic High (V_{ODH})	I_{ODH} = 1.5 mA+1 Input (IN0-IN3)	$V_{SS}-1.5$ $V_{SS}-3.0$		V_{SS} V_{SS}	V V
V_{ODL}	I_{ODH} = 5.0 mA+1 Input Note 3	$V_{SS}-3.5$		V_{SS}	V
Seg Outputs Seg A-G	I_{OSH} = 16 mA			$V_{SS}-6.0$	V
Segment Output Current Seg A-G I_{OSH}	Note 3	10	15	40	mA
AC Electrical T_{CYC} Instruction Cycle Time			10		μsec
td/tw		5.0			μsec
t RESET		15			msec
TBase		0	60	500	HZ

Note 1: Internal Pullup Resistors of Approximately 6K to V_{SS} Across Each Input.

Note 2: Internal Pulldown Resistors of Approximately 12K to V_{DD} Across Each Input.
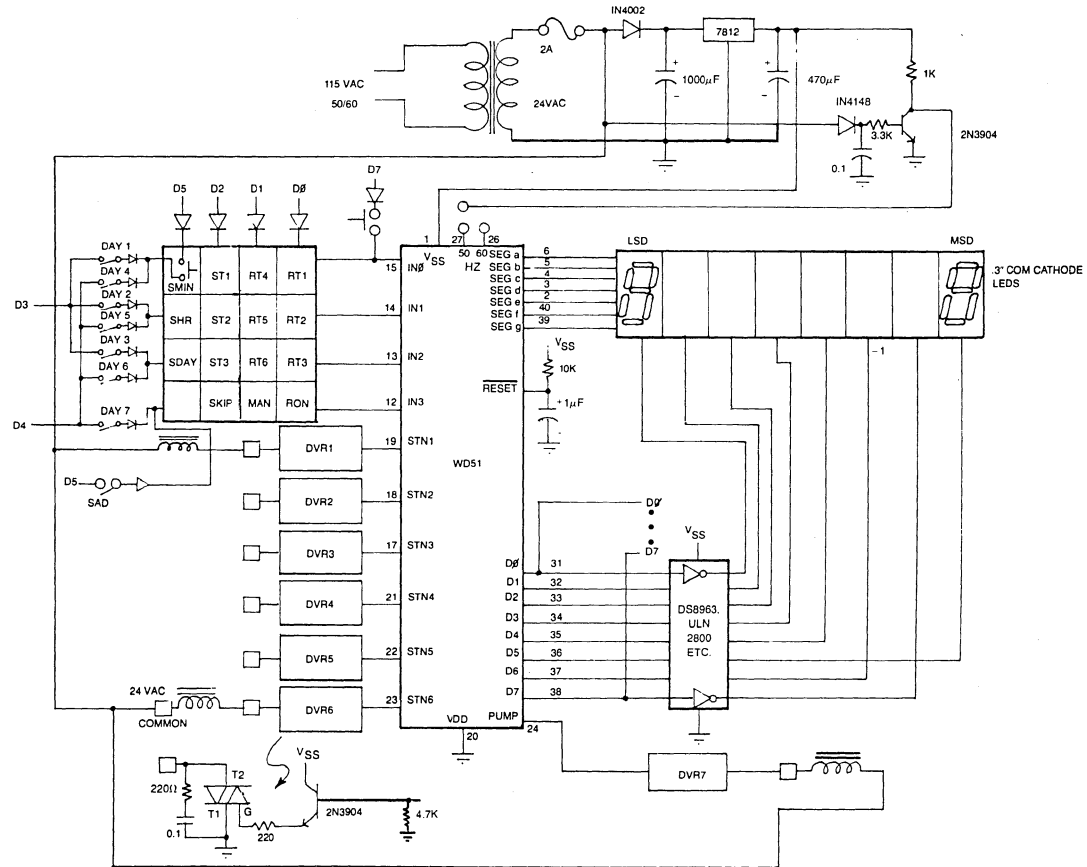
Note 3: Single Transistor to V_{SS} Output Only.

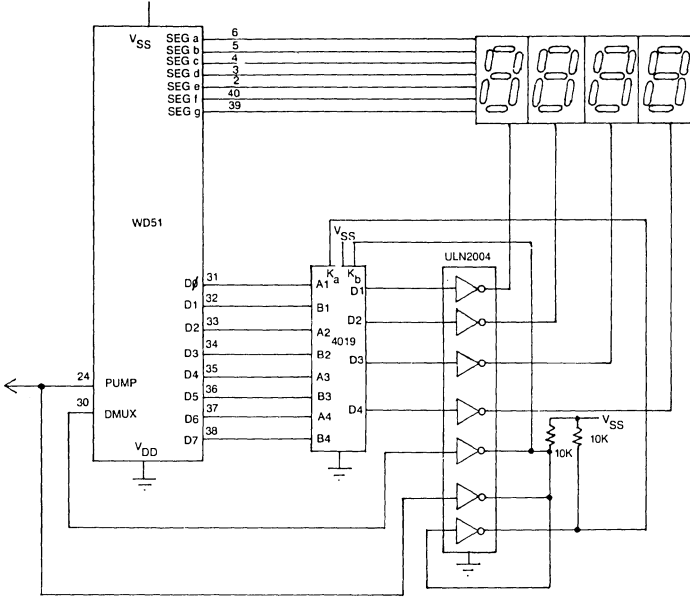FIGURE 5   COMPLETE 6-STATION IRRIGATION CONTROLLER

468

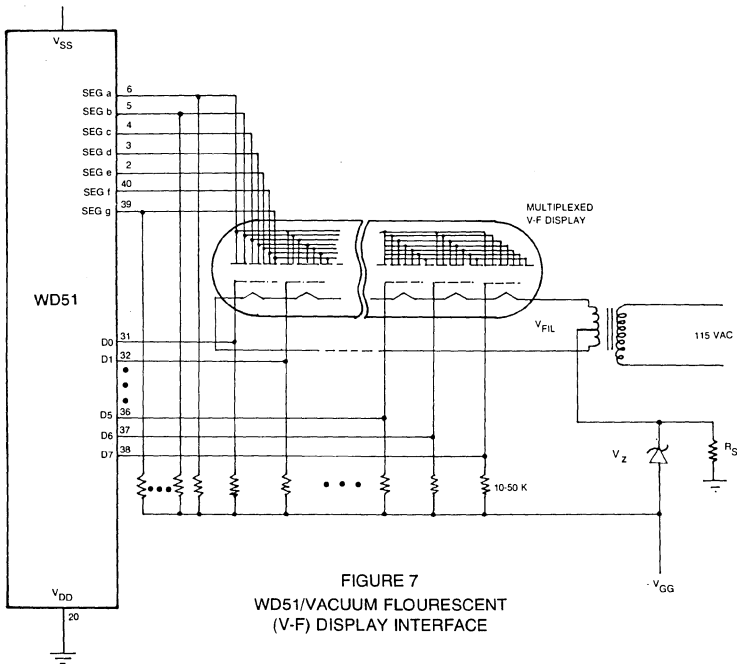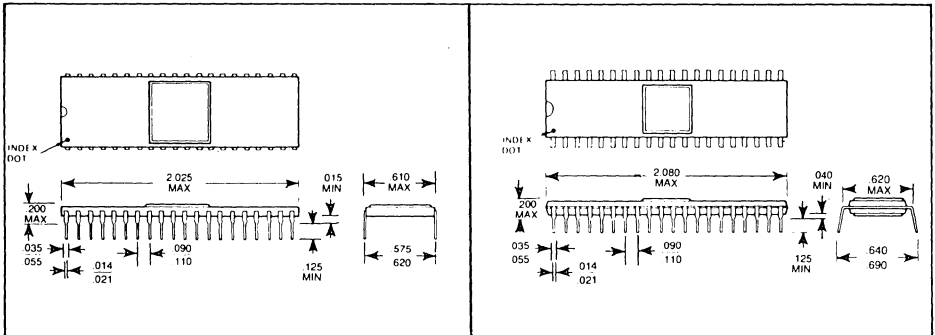FIGURE 6   WD51 WITH 4-DIGIT DISPLAY OPTION

FIGURE 7
WD51/VACUUM FLOURESCENT
(V-F) DISPLAY INTERFACE

MECHANICAL

40 Pin DIP Package available in plastic or ceramic packages.

WD51A CERAMIC PACKAGE   **WD51B PLASTIC PACKAGE**

SUPPORT:

Application and Design support is available from Western Digital.

ORDERING INFORMATION:

Specify upon ordering

WD51A for 40 pin ceramic package
WD51B for 40 pin plastic package

WESTERN DIGITAL | 3128 REDHILL AVENUE, BOX 2180
C O R P O R A T I O N | NEWPORT BEACH, CA 92663 (714) 557-3550,TWX 910-595-1139