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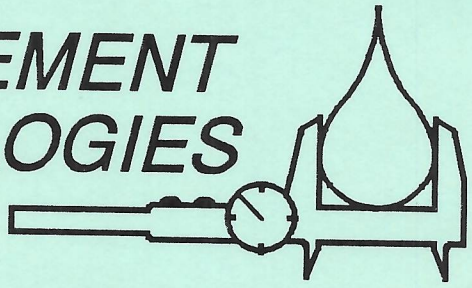
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FORWARD SCATTERING SPECTROMETER PROBE (FSSP) PARTICLE SIMULATOR

Model FPS100-01 OPERATIONS MANUAL

DROPLET MEASUREMENT TECHNOLOGIES



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Disclaimer

The electronic instruments manufactured by Particle Measuring Systems (PMS) are highly sophisticated and easily damaged. Improper care in the use of these instruments in conjunction with test equipment manufactured by Droplet Measurement Technologies (DMT) can result in damage to either or both of the instruments. DMT does not take responsibility for such damage resulting from misuse or improper care of the equipment. Damage to a PMS probe can occur if any instrument, device or printed circuit card is attached to or plugged into, or removed from, the probe with *POWER ON* the probe. The user is also urged to take great care in plugging and unplugging any connectors or circuit boards. Severe damage can occur if the proper orientation of circuit boards or connectors is not adhered to.

All instruments manufactured by DMT come with a 30-day (from receipt) money back, satisfaction guarantee, and a 6-month parts and labor warranty.

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SECTION 1: INTRODUCTION

Droplet Measurement Technologies' (DMT) forward scattering spectrometer probe (FSSP) particle simulator was designed as an aid in measuring important electronic characteristics of Particle Measuring Systems' (PMS) FSSP and as a tool for locating problems in the electronic circuitry of this instrument. Section 2 of this manual describes the function of each control on the simulator and Section 3 discusses some applications of this diagnostic instrument.

This manual is not intended as an extensive troubleshooting guide for the FSSP. The manual that comes with the FSSP supplies circuit diagrams, describes the operating principles and gives some tips on troubleshooting the probe. There have been many modifications made to the FSSP electronics over the years and, as such, it is not possible in this manual to refer to particular circuit module signal lines by letter or number when discussing the tracing of electronic signals. Over the years, even circuit modules that perform the same function have been given different identification codes.

In this manual, the FSSP circuit modules will be referenced by name only, as will the points on the circuit boards where particular voltage signals are found. For example, when describing a particular measurement procedure the manual might say "connect channel 1 of the oscilloscope to the point on the Pulse Height Analyzer (PHA) module labeled *SIGNAL IN*". If the PHA module was the PMS402A, then *SIGNAL IN* would be labeled 2/B on the circuit diagram.

The particle simulator uses red LEDs (635 nm wavelength) to produce light pulses of frequency, length, and amplitude similar to the pulses of scattered light produced by droplets passing through the FSSP's laser beam. The simulator circumvents the optical path of the FSSP and attaches directly to the signal and annulus photodetectors. Thus, the entire chain of electronics is exercised with this device. *Although the amplitude of the light pulses are within the acceptable size range of the probe, the simulator should not be used as a calibrator since the light levels have not been adjusted to correspond to any particular size category.*

SECTION 2: PARTICLE SIMULATOR FUNCTIONS

The particle simulator controls the pulsing of two LEDs that are mounted in an assembly (plastic cube) that is similar to the photodetector mounting block of the FSSP. The first step in the use of the simulator is to remove the mounting block carefully from the FSSP. *Power should be removed from the probe at all times when attaching the simulator to the FSSP!* Gently extract both photodetectors from this block and insert them in the plastic cube attached to the simulator. Make sure that the annulus detector is inserted in the receptacle marked with an A. Position the photodetector module to insure that it will not accidentally make

electrical contact between any components or printed circuit board traces and the rest of the probe.

After applying power to the probe and turning on the power switch of the simulator, the simulator will control the relative magnitude, frequency, and duration of the light pulses using the following control functions (Figure 1).

PULSE LEVEL SIGNAL: Turning this dial adjusts the amplitude of the light at the signal photodetector. If the FSSP is attached to a data system while being tested, counts will fall in increasingly higher size channels as the signal amplitude control is rotated clockwise (this happens only if the annulus pulse level is turned off or lower or is lower than the signal pulse level).

PULSE LEVEL ANNULUS: The light at the annulus detector is varied with this control in the same fashion as the signal pulse level control. The annulus and signal amplitudes are independent of one another.

PULSE FREQUENCY: Different droplet concentrations can be simulated with three fixed repetition rates selectable in the Low, Medium, and High position of the pulse frequency control. These three positions give frequencies of 33.3, 38.5, and 45.4 Khz, respectively[1]. Note: The measured counts from the FSSP will be substantially less than these frequencies because of the velocity rejection circuitry. If velocity rejection is disabled, the number of counts out of the probe should be nearly equal to the number that are input.

PULSE WIDTH: Different airspeeds are simulated by selecting one of six pulse durations with the pulse width control knob.

Although the annulus and signal amplitudes can be controlled independently, the pulse frequency and duration controls produce the same pulse frequency and duration at both the annulus and signal detector.

SECTION 3: PARTICLE SIMULATOR APPLICATIONS

3.1 Measurement of Electronic Characteristics

There are many important electronic parameters of the FSSP that should be measured with the particle simulator. These parameters are used in the appropriate correction algorithms such as discussed by Baumgardner et al (1985)

[1] These three frequencies can be changed to a different set of frequencies by selecting a different position of jumpers that are located on the printed circuit board. Please refer to the circuit diagram located at the back of this manual for further instructions.

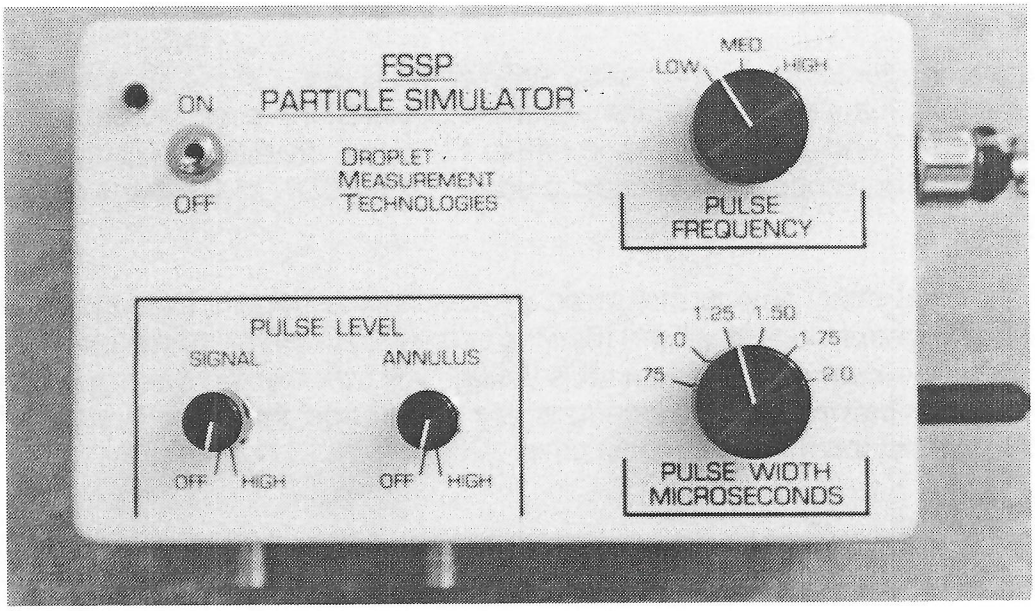


Figure 1 FSSP Particle Simulator Control Panel

and Baumgardner (1987). Corrections for coincidence and dead time require a measurement of the reset delay times. Proper matching of the Mie scattering function to the PHA threshold voltages requires an accurate measurement of these thresholds. Size corrections for airspeed effects require a measurement of the rise time of the signal voltage at the PHAs.

3.1.1 Delay Time Measurements

A preset delay time is generated by the FSSP after each droplet passes through its beam. The length of this delay period will sometimes depend on where the droplet passed through the beam. Most FSSPs have both a "slow reset" and a "fast reset" delay time depending on whether the droplet passed within the depth-of-field (DOF) or outside the DOF, respectively. Some earlier model probes have the same delay period regardless of where the droplet passed through the beam.

The trailing edge of either the signal or annulus transit gate starts the reset delay process by triggering the first one-shot in the strobe and reset circuit. The length of time between the delay initiation and reset pulse depends on the state of the *STROBE ENABLE* line, i.e., whether or not the annulus exceeded the signal voltage. The signal voltage will be higher than the annulus voltage if the particle passes through the DOF and the annulus will be higher than the signal otherwise. Both conditions must be simulated to measure the fast and slow reset delay times.

The slow reset delay time is measured by rotating the simulator annulus pulse level control completely counter-clockwise and adjusting the signal pulse level to approximately mid-position. Set the pulse width to 2.0 µs, and the pulse repetition rate to low. Connect the first channel of an oscilloscope to the pin labeled *SIGNAL TRANSIT TIME GATE* on the PHA module closest to the front of the probe and

adjust the trigger to fire on the trailing edge of this pulse. On the strobe and reset module, attach the probe from the second channel of the oscilloscope to the pin labeled *RESET* and adjust the sweep rate to 1.0 μs per division. The time between triggering of the scope and the leading edge of the *RESET* pulse is the slow reset delay time.

The fast reset delay time is measured by rotating the particle simulator annulus pulse level control clockwise, until the time to the *RESET* pulse on the oscilloscope is observed to decrease. The annulus voltage will now exceed the signal voltage and the time between the triggering of the scope and the leading edge of the *RESET* pulse is the fast reset delay time.

3.1.2 Electronic Response Time Measurement

An important parameter that is needed for measurement corrections for the effect of airspeed on sizing is the amount of electronic roll-off at higher frequencies (referred to as bandwidth). Each probe has a different bandwidth determined by its particular electronics. If the bandwidth of a probe is high, it will respond quickly when a particle passes through it. This response time should be measured periodically, at least once a year, and always after any electronic component changes have been made to the amplification circuitry.

To measure the response time, connect the first channel of an oscilloscope to the output of the simulator (BNC connector on side) and the second channel to the pin labeled *SIGNAL* on any one of the PHA modules. Set the pulse width on the simulator to 2.0 μs and pulse frequency to low. On the oscilloscope, set the gain of the second channel high enough to obtain an accurate measurement of the maximum amplitude of the *SIGNAL* pulse (this will be a negative-going pulse). Set the sweep rate to 0.1 μs / division and adjust the positioning of the signal pulse on the oscilloscope screen so that an accurate measurement can be made of the time that passes before the signal reaches 63% (1/e) of its maximum value from its baseline value. This time is the response time of the probe.

3.1.3 PHA Threshold Voltage Measurements

There are fifteen size channels in the FSSP and sixteen voltage thresholds that require measuring for each size range. One method of measuring these threshold levels is to select each individual PHA module and measure the threshold voltage at each of the four LM311 comparator inputs. A much simpler and quicker method is to attach the probe to a data system where the counts in each size channel can be monitored. Attach an oscilloscope to the pin labeled *SIGNAL* on any one of the PHA modules and set the range of the probe to the largest size range (range 0). Set the simulator at the lowest pulse frequency with the longest pulse duration.

The voltage threshold for any particular size channel is the *SIGNAL* pulse amplitude where counts begin to accumulate in the selected channel. Begin with the first level by setting the signal pulse level as low as possible and increase it slowly until counts begin to accumulate in the display of the data system for channel 1. Set the oscilloscope to trigger on the leading edge of the pulse and adjust the gain for best resolution. The voltage threshold is the absolute value of the amplitude of this pulse. Repeat this process for all the size channels. The sixteenth size threshold is found by increasing the pulse amplitude until the measured size is just beyond the last size channel (all counts in the fifteenth channel should disappear). This procedure should be repeated for all ranges at which the probe will be operated.

NOTE: On some probes, the particle simulator lacks sufficient light power to make "particles" appear in all size channels on all ranges, i.e., maximum signal power may be reached before the particles appear in the larger numbered channels.

3.2 Troubleshooting of FSSP Electronics

The number of possible problems that could arise in the FSSP electronics are too numerous to cover with this manual. However, simple troubleshooting procedures can be performed with the simulator to check the DOF and the sizing circuitry.

To check that the DOF circuitry is working in at least a rudimentary fashion, connect the probe to a data system or monitor the *GATED STROBE* output on the strobe and reset module. Turn off the annulus pulse level and set the signal pulse level midway. Counts should begin accumulating in one of the size channels on the data system and there should be fairly regular *GATED STROBE* pulses. Turn on the annulus pulse and slowly increase the amplitude. If the DOF enable circuitry is working correctly, the counts on the data system should go away and there will be no more *GATED STROBE* pulses, at some point before midway.

The size encoding circuitry can be checked by turning off the annulus pulse and turning the signal level down to minimum. While monitoring all fifteen size channels on a data system, slowly increase the amplitude of the signal. If the size encoding is working properly, counts will fall in progressively larger size channels until the size is too large and all counts go away.

SECTION 4: SUGGESTED READING

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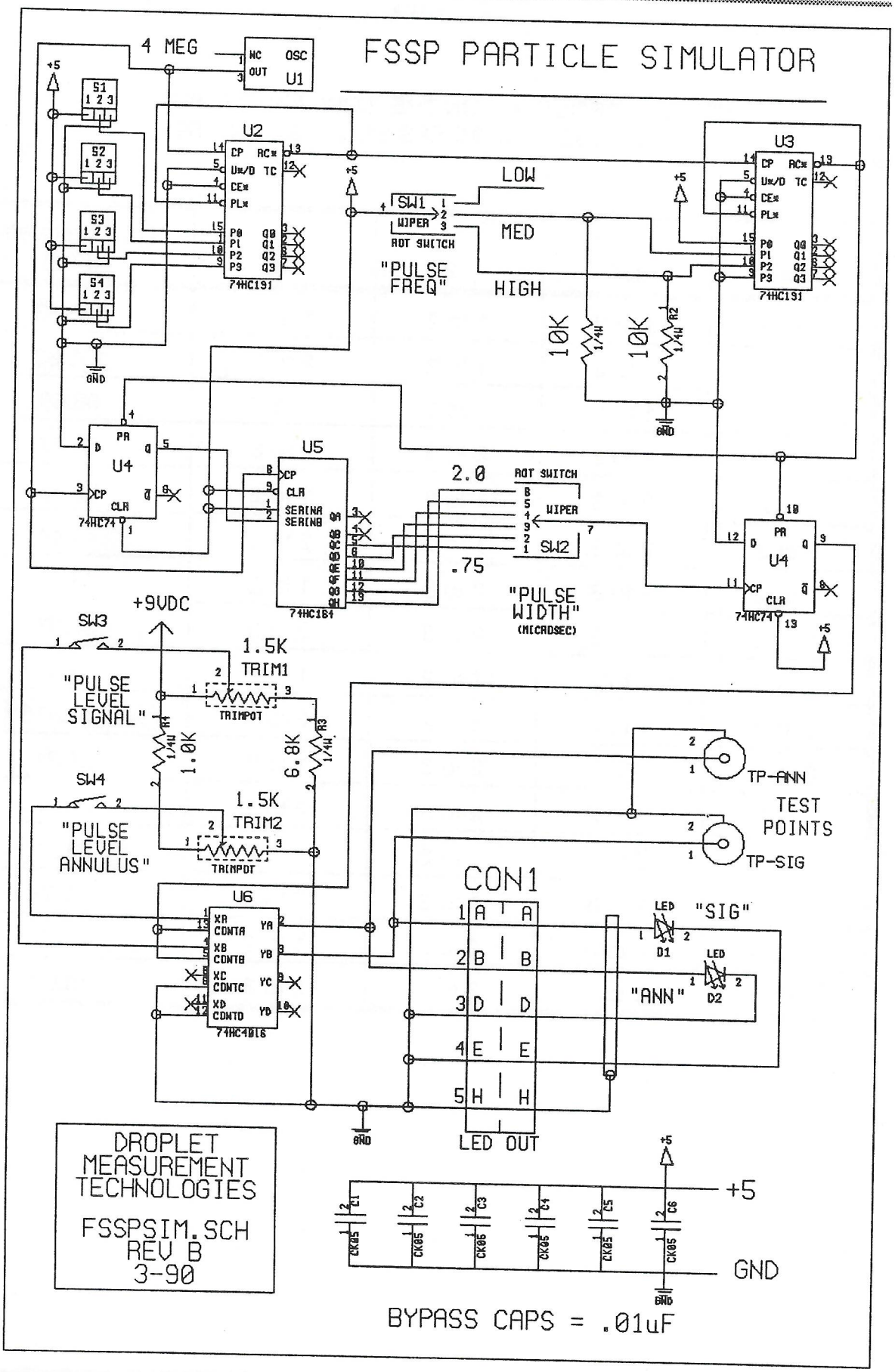
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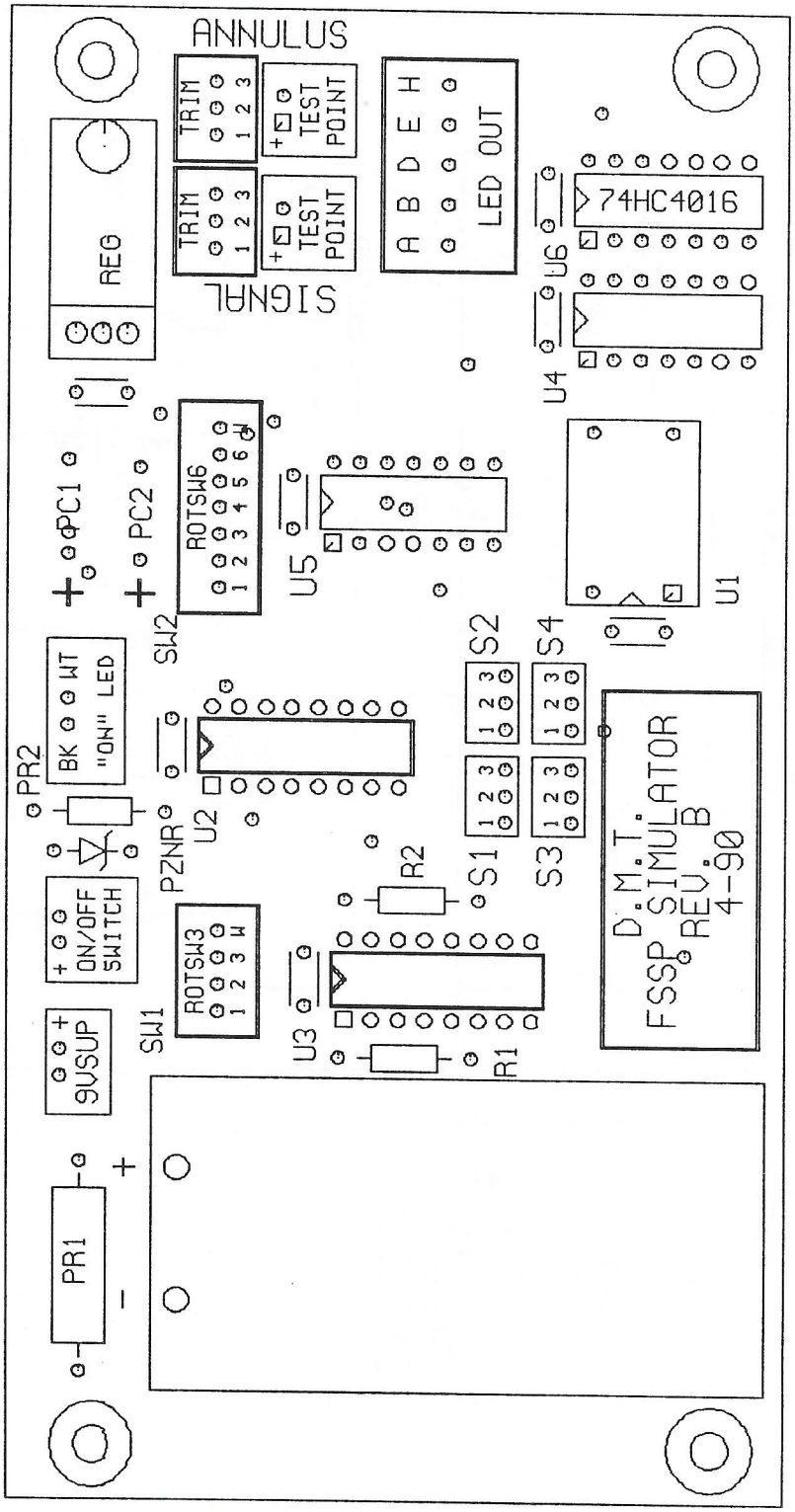
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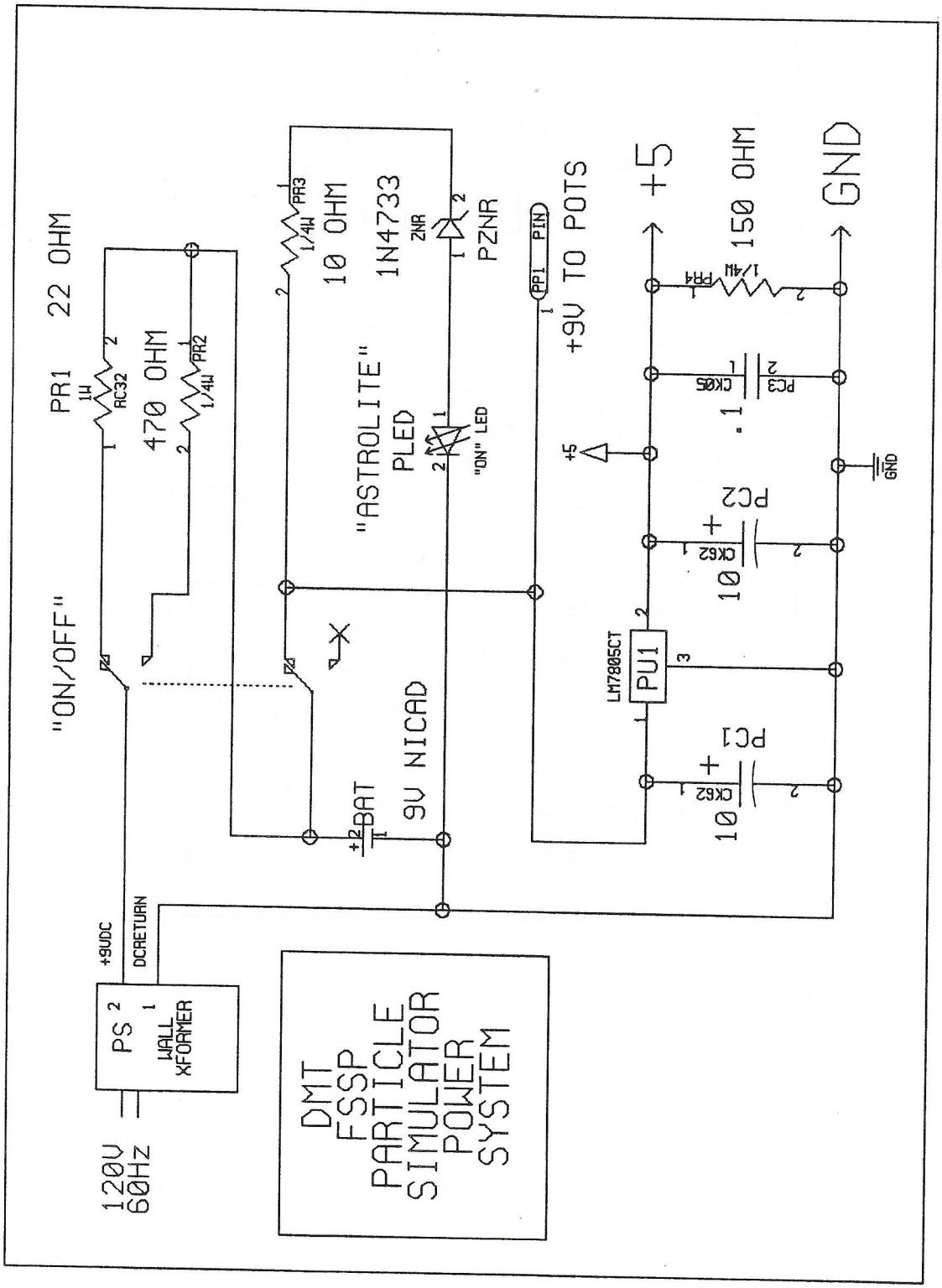
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ACTUAL FREQUENCY ON THE "LOW" FREQUENCY SETTING DUE TO JUMPERS S1, S2, S3, AND S4

S4	S3	S2	S1	"Low" Frequency (Khz)
1 to 2	1 to 2	1 to 2	1 to 2	266.67
1 to 2	1 to 2	1 to 2	2 to 3	133.33
1 to 2	1 to 2	2 to 3	1 to 2	88.88
1 to 2	1 to 2	2 to 3	2 to 3	66.67
1 to 2	2 to 3	1 to 2	1 to 2	53.33
1 to 2	2 to 3	1 to 2	2 to 3	44.44
1 to 2	2 to 3	2 to 3	1 to 2	38.09
1 to 2	2 to 3	2 to 3	2 to 3	33.33
2 to 3	1 to 2	1 to 2	1 to 2	29.62
2 to 3	1 to 2	1 to 2	2 to 3	26.67
2 to 3	1 to 2	2 to 3	1 to 2	24.24
2 to 3	1 to 2	2 to 3	2 to 3	22.22
2 to 3	2 to 3	1 to 2	1 to 2	20.51
2 to 3	2 to 3	1 to 2	2 to 3	19.05
2 to 3	2 to 3	2 to 3	1 to 2	17.77
2 to 3	2 to 3	2 to 3	2 to 3	16.67


FSSP PARTICLE SIMULATOR
4 MEG
HC OSC
OUT U1
+5
S1
S2
S3
S4
U2
74HC191
GND
SW1
WIPER
ROT SWITCH
LOW
MED
HIGH
"PULSE FREQ"
10K 1/4W R1
10K 1/4W R2
U3
74HC191
U4
74HC74
U5
74HC184
2.0
ROT SWITCH
WIPER
SW2
.75
"PULSE WIDTH"
(MICROSEC)
+9VDC
SW3
"PULSE LEVEL SIGNAL"
1.5K TRIM1
TRIMPOT
1.0K 1/4W R4
6.8K 1/4W R3
SW4
"PULSE LEVEL ANNULUS"
1.5K TRIM2
TRIMPOT
TP-ANN
TP-SIG
TEST POINTS
U6
74HC4816
CON1
LED "SIG"
D1
LED
"ANN"
D2
LED OUT
DROPLET MEASUREMENT TECHNOLOGIES
FSSPSIM.SCH
REV B
3-90
C1 C2 C3 C4 C5 C6
CK05
+5
GND
BYPASS CAPS = .01uF


ANNULUS
SIGNAL
TRIM
TEST POINT
A B D E H
LED OUT
74HC4016
U6
U4
REG
PC1
PC2
ROTSW6
SW2
U5
U1
S2
S4
PR2
BK WT
"ON" LED
U2
PZNR
R2
S1
S3
ON/OFF SWITCH
ROTSW3
SW1
U3
R1
9VSUP
PR1
D.M.T.
FSSP SIMULATOR
REV. B
4-90


"ON/OFF"
PR1 22 OHM
1W RC32
470 OHM 1/4W PR2
10 OHM 1/4W PR3
"ASTROLITE" PLED
"ON" LED
1N4733 ZNR
PZNR
PP1 PIN
+9V TO POTS
+5
150 OHM 1/4W PR4
.1 PC3 CK05
PC2 10 CK62
PC1 10 CK62
LM7805CT PU1
GND
BAT 9V NICAD
+9VDC
DCRETURN
PS 2 1 WALL XFORMER
120V 60Hz
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