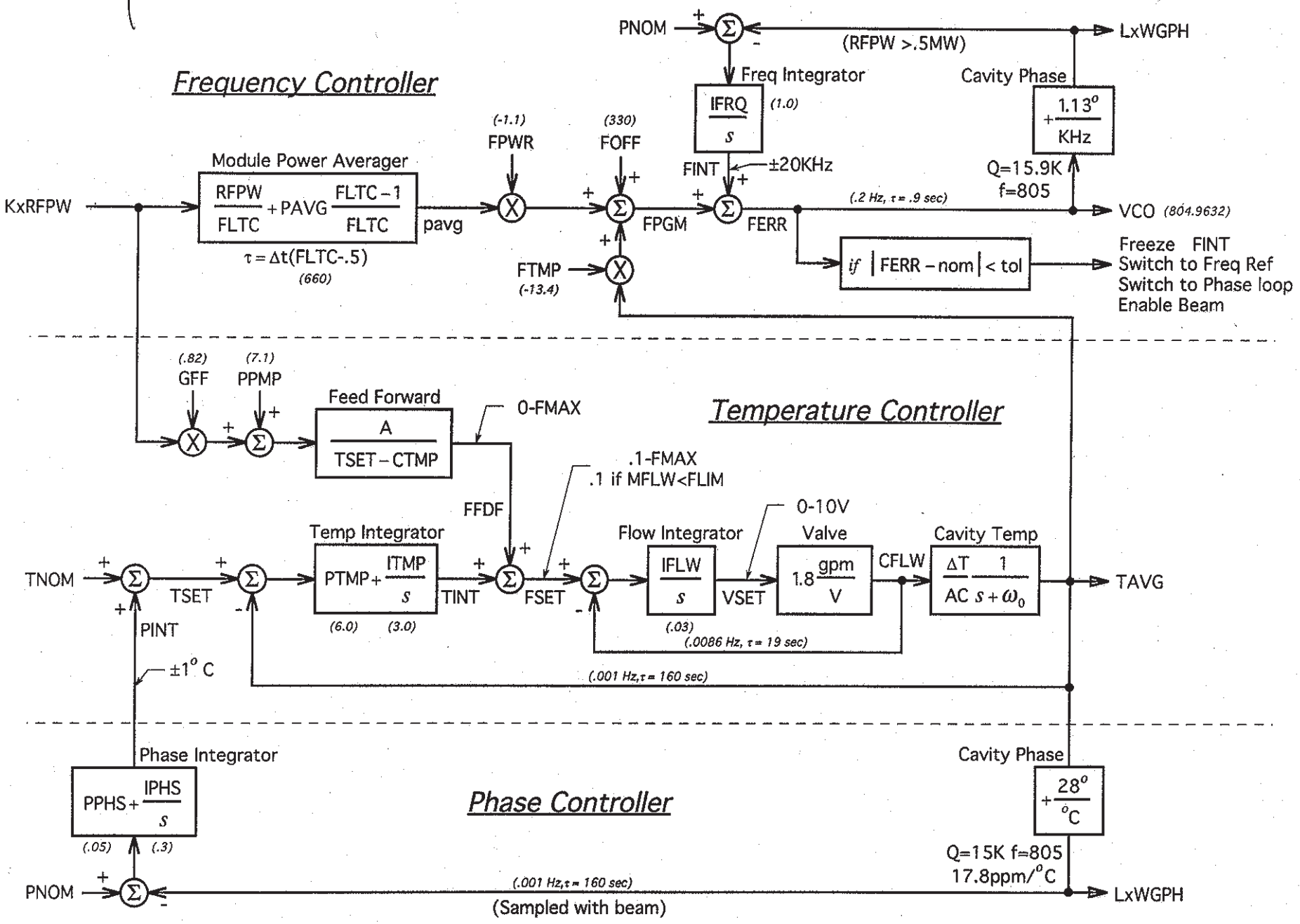
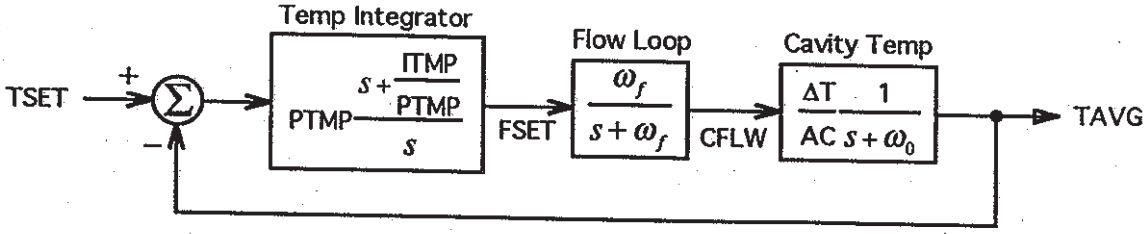
A9

# Temperature, Phase, and Frequency Control Diagram




Crisp 1/8/93

# *Simplified Temperature Loop*



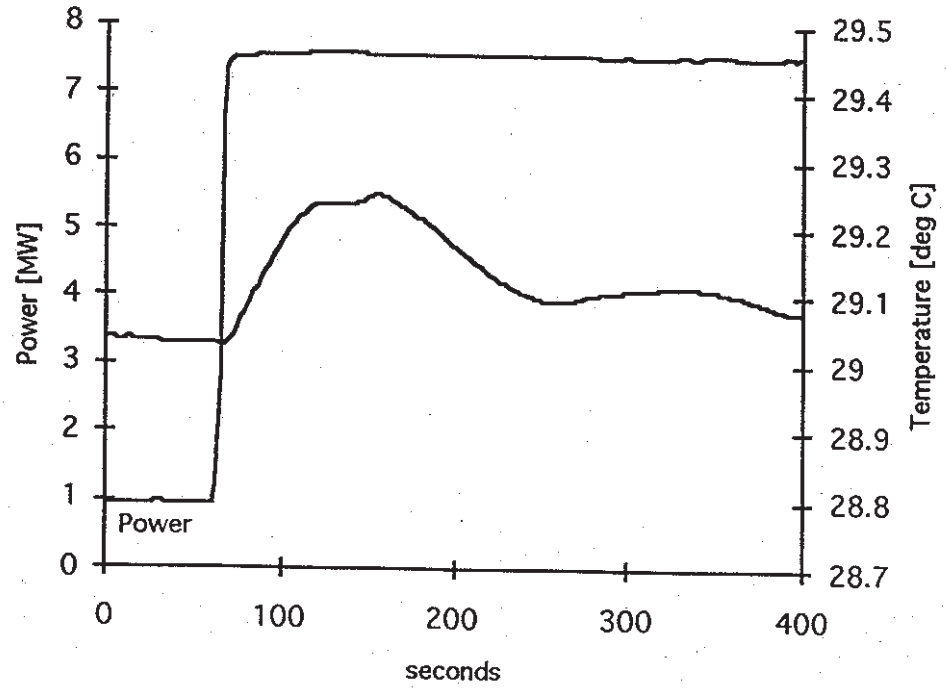

$$\text{let} \quad \omega_f = \text{IFLW} \cdot G_V \quad \text{and} \quad \omega_o = \frac{P}{\Delta TC}$$

$$\text{choose} \quad \frac{\text{ITMP}}{\text{PTMP}} = \omega_o$$

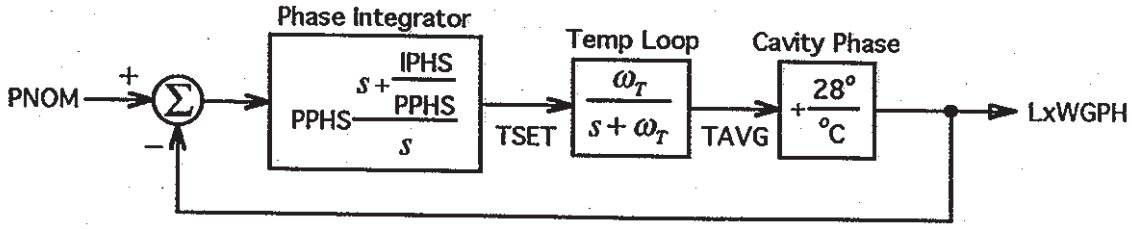
$$\text{for } \omega_f >> \omega_T = \text{PTMP}\frac{\Delta T}{AC}$$

$$\boxed{\frac{\text{TAVG}}{\text{TSET}} = \frac{\omega_T}{s + \omega_T}}$$

## 6.5 MW Step Change in Power



# *Simplified Phase Loop*

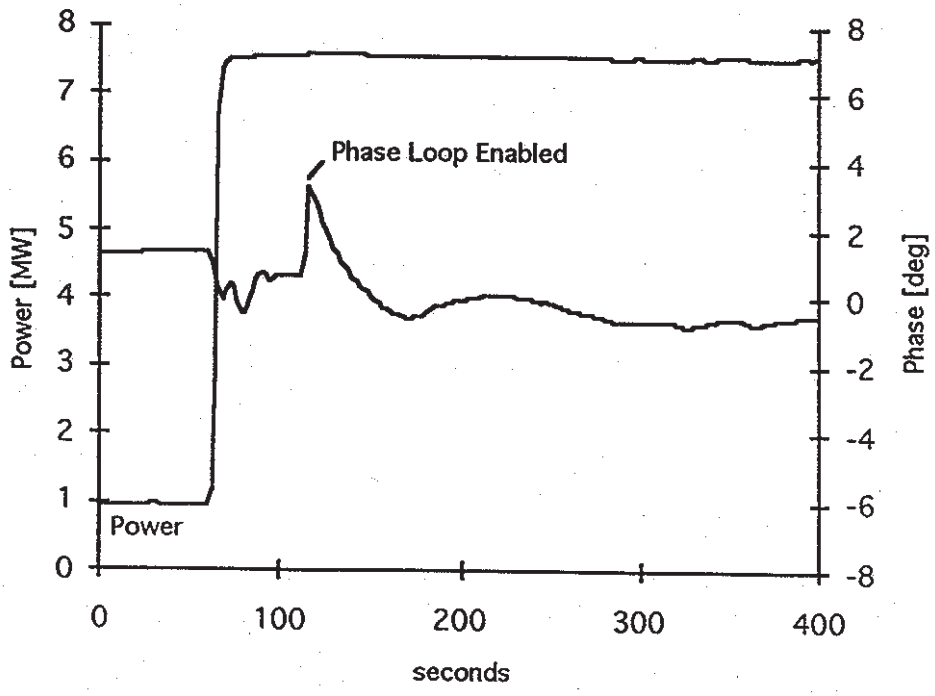



$$\text{let } \omega_P = \text{PPHS} \cdot \omega_T \cdot G_P$$

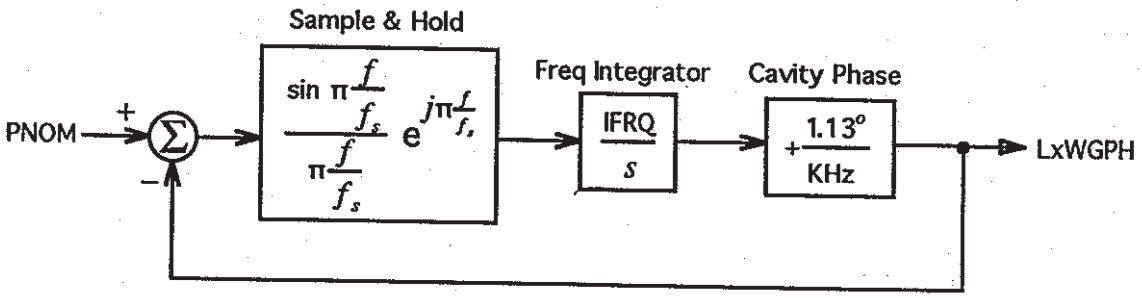
$$\text{choose } \frac{\text{IPHS}}{\text{PPHS}} = \omega_T \text{ and } \omega_P = \omega_T$$

$$\boxed{\frac{\text{WGPH}}{\text{PNOM}} = \frac{\omega_P}{s + \omega_P}}$$

## 6.5 MW Step Change in Power



# *Simplified Frequency Loop*




$$\omega_f = 2.84\,\text{IFRQ}\,\frac{\sin \pi \frac{f}{f_s}}{\pi \frac{f}{f_s}}$$

$$\phi_f = 90° + 180° \frac{f}{f_s}$$

For 45° phase margin, $f_s$ = 15 Hz, sinx/x = .9003, IFRQ = 23, w$f$ = 2π 3.75 Hz

## Temperature/Phase Loop

Temperature loop runs every 16/15 seconds.

Monitor rf power at 15 Hz and apply $\tau$=1sec LPF.

Use average temperature of 4 sections.

Don't use temperature measurement if <5° or >45°.

If all sections have bad temperature assume T=TSET.

If CTMP is <5° or >45° assume 17°.

If MFLW < FLIM then freeze TINT and set FSET = .1 gpm.

Feed forward uses TSET-CTMP rather than module temperature.

Feed forward limited between 0 and FMAX

VSET can be controlled manually with temperature loop off.

Set ITMP to 0 to reset TINT.

Set IFLW to 0 to reset VSET.

Set IPHS to 0 to reset PINT

Add error to TINT only if result is .1<FSET<FMAX gpm.

Add error to VSET only if result is 0<VSET<10 volts.

Add error to PINT only if result is |PINT| < 1°C.

Phase loop runs only if |FERR-nom| < tol.

GTF allows the temperature of the copper and water to be held constant.

Probe tip .1°C from module surface and .33° from nose at 105 W/cell.

## Frequency Loop

Frequency loop runs 15 times per second.

Apply $\tau$=44 second LPF to rf power reading. Same as module time constant.

Use average temperature of 4 sections.

Don't use temperature measurement if <5° or >45°.

If all sections have bad temperature assume 25°C.

Set IFRQ to 0 to reset FINT

Freeze FINT if |FERR-nom| < tol.

Add error to FINT only if result is |FINT| < 20 KHz.

Add error to FINT only if rf power > .5 MW.

VCO can be controlled manually with freq loop off.

Turns off phase loop enable bit when freq loop is turned off.

Phase loop enable bit can be controlled manually with freq loop off.

## Known Problems

CLCW valve too big. Allows up to 60 gpm, only need 10 gpm.

CLCW valve hysterisis causes .2 gpm, .05 °C variation in module temperature.

CLCW valve cannot control flow below 1.5 gpm. Causes flow loop to oscillate.

CLCW valve requires about 40 seconds to open or close. Limits flow bandwidth.

CLCW turbine too big, has 75 to .75 gpm range. Only need 10 gpm.

RF sum signal from low level does not have sufficient resolution.

Use dir cplr 2 and "april" detector to measure forward power.

Module power depends on freq. April detector changes with room temp.

CLCW valve, turbine, and power errors limit accuracy of feedforward.

Increasis time required to stabalize after power change.

WG to Module phase detector very noisy.

Requires reducing freq loop BW from 3.8 Hz to .2 Hz.

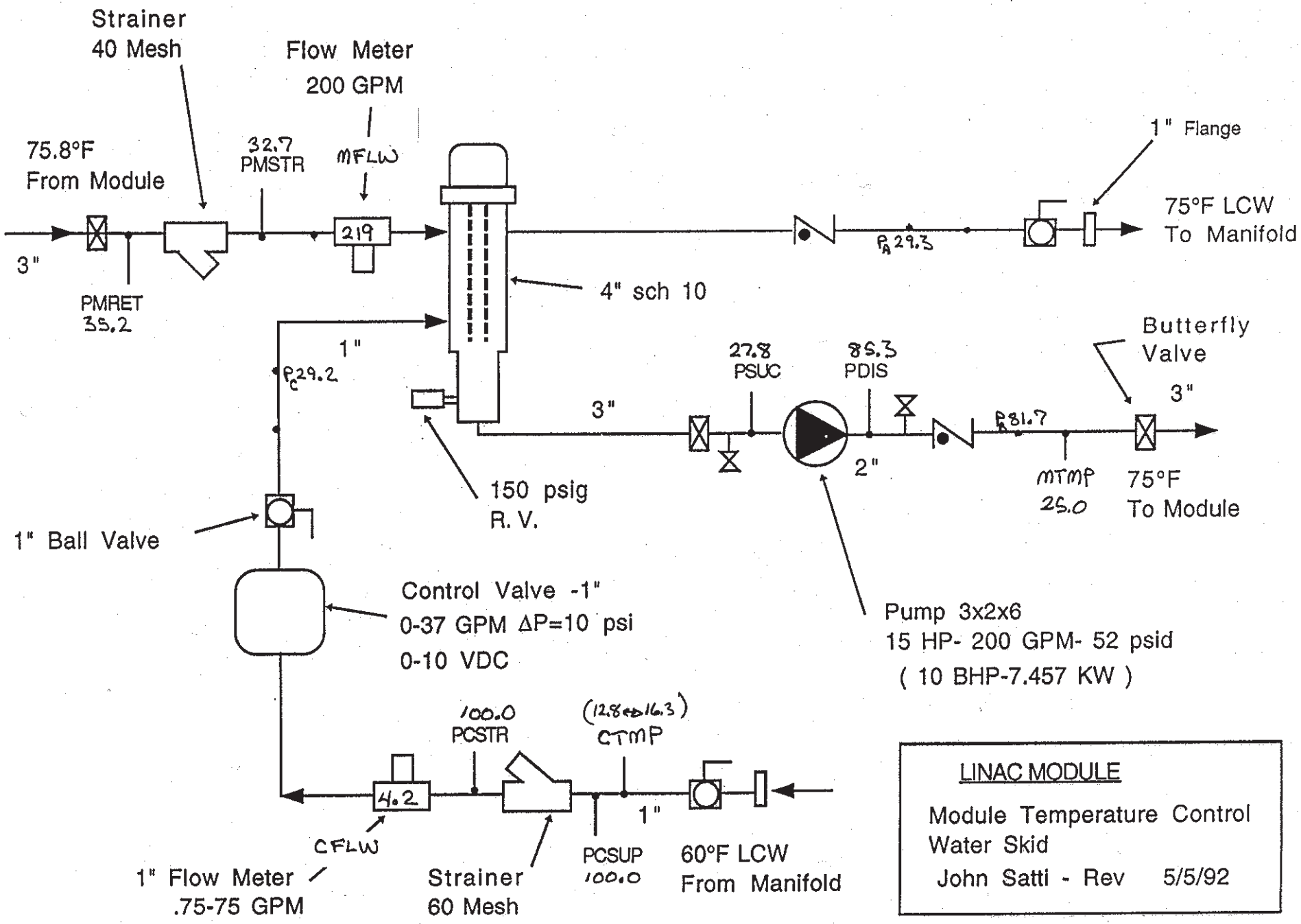
WG to Module phase detector depends on power.

Requires step change in frequency when power changes.

With closed loop wg to module phase depends on power.

VCO is turned off when not in use.

When turned on frequency drifts by 1.2 KHz during 1000 sec warm up.


Strainer
40 Mesh
Flow Meter
200 GPM
75.8°F
From Module
32.7
PMSTR
MFLW
219
1" Flange
75°F LCW
To Manifold
3"
PMRET
35.2
4" sch 10
PA 29.3
1"
PC 29.2
Butterfly
Valve
27.8
PSUC
85.3
PDIS
3"
3"
PB 81.7
150 psig
R. V.
2"
MTMP
25.0
75°F
To Module
1" Ball Valve
Control Valve -1"
0-37 GPM ΔP=10 psi
0-10 VDC
Pump 3x2x6
15 HP- 200 GPM- 52 psid
( 10 BHP-7.457 KW )
100.0
PCSTR
(12.8↔16.3)
CTMP
4.2
1"
CFLW
PCSUP
100.0
60°F LCW
From Manifold
1" Flow Meter
.75-75 GPM
Strainer
60 Mesh
LINAC MODULE
Module Temperature Control
Water Skid
John Satti - Rev 5/5/92