NATIONAL RADIO ASTRONOMY OBSERVATORY
Green Bank, West Virginia

Memo No. 12

Pulsar Signal Processor

Project 2.625

SPECIFICATIONS

UPDATE 2

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SPECIFICATIONS
UPDATE 2

0. INTRODUCTION

These updated specifications are mostly based on a Green Bank staff discussion and a letter from J. Taylor dated July 13, 1982.

These specifications are not complete and are not cast in concrete. Practical cost, hardware and manpower limitations, trade-offs and additions encountered in the design and prototyping processes will require revisions. After consideration among the group, specification updates will be issued in this memo series.

1. POLARIZATIONS

User selects:

a) One polarization (P_1).

b) Sum of 2 orthogonal polarizations (P_ϕ).

c) Two orthogonal polarizations (P_2).

d) Four polarizations which yield 4 Stokes Parameters (P_4) obtained by 2 IF inputs and 4 spectrometer/processors singly or in combination.

2. INSTANTANEOUS TOTAL BANDWIDTH f_B OF OUTPUT FREQUENCY SPECTRA

a) 20 MHz total available bandwidth is necessary from each spectrometer/processor bank;

b) 40 MHz is desirable;

c) Up to 100 MHz is useful if RFI excising is effective and if receiver system does not overload or produce intermodulation products.

d) Narrower total bandwidths are required to achieve high frequency resolution and to avoid extremely strong RFI.

3. FREQUENCY RESOLUTION (Δf) AND MERGING IN FREQUENCY OF OUTPUT SPECTRA

a) Require 30 kHz to 2 MHz Δf in each spectrometer/processor.

b) User selects in steps of 1, 3, 10 ... or 1, 2, 4, 8, 16 ...

c) Wider Δf's may be derived by summing adjacent filters (merging in frequency).

d) Δf is center-to-center frequency spacing between filters or combinations as well as nominal bandwidth of each filter or combinations of filters.

4. FREQUENCY RESPONSE OF INDIVIDUAL FILTERS

a) Adjacent filters cross over at -1 dB to -3 dB.

b) $\geq$ 12 dB is necessary, 20 dB desirable, isolation center-to-center of adjacent filters.

c) $\geq$ 24 dB is necessary, 35 dB desirable, isolation center-to-center of $\pm$ 2 filters.

d) $\geq$ 12 n dB isolation center-to-center of $\pm$ n filters up to 70 dB.

e) $\leq$ 0.1 Δt dispersion across -6 dB passband of filter.

5. TIME RESOLUTION (Δt) AND MERGING IN TIME OF OUTPUT FREQUENCY SPECTRA

a) 0.1 ms Δt is necessary.

b) Get longer Δt time resolutions by averaging each filter over n Δt (merging in time).

6. DEDISPERSING FREQUENCY SPECTRA, SHIFTING IN TIME VS. FREQUENCY

a) User selects 0 μs to 10 ms filter-to-filter time delay Δt_D.

b) Δt_D increment = 1 μs and multiples.

c) $\leq$ 0.1 Δt uncertainty in delay of a single filter with respect to nominal delay.

d) User selects 2nd order delay distribution across filter banks so that t_D of i^{th} filter = k $(f_{sky})^{-2}$.

e) User sets sign for sky frequency increasing or decreasing with filter number (IF spectrum non-inverted or inverted relative to sky spectrum).

f) User sets Δt_D independently in channela A, B, C, D to permit offset sky frequencies f_A, f_B, f_C, f_D for dispersion measurements.

7. PERIODIC TIME AVERAGING OF FREQUENCY SPECTRA, PERIODIC MERGING IN TIME

a) User selects 0 to 10 sec pulsar period (A).

b) Period increment = Δt.

c) $\leq$ 1 μs uncertainty in period.

d) User selects number of periods in average (N_A) up to 4096.

e) $\geq$ 128 frequency points (filters) in an average.

8. AMPLITUDE CALIBRATION

   a) Two independently controlled pulsed noise cals in front-end.

   b) One noise cal in each feed polarization.

   c) User selects 0 to 10 sec pulsed cal period.

   d) User selects 0 to 5 sec pulsed cal width.

   e) 0.1 ms increments.

   f) $\leq$ 0.1 Δt uncertainty in pulsed cal period and width.

   g) $\leq$ 0.1 Δt front-end delay in turn-on and turn-off.

9. AMPLITUDE DYNAMIC RANGE

   a) Up to 10 T_{sys} pulsar data range.

   b) 1 bit quantization $\leq$ 1 σ of time variation in output spectra.

   c) $\geq$ 30 dB above rms noise in each filter, internally, prior to RFI excising.

10. TIMING

   a) 5 MHz maser standard is reference input.

   b) 1 second UTC pulse is reference input.

   c) UTC clock referenced to VLBI clock.

   d) Phase-coherent clock, delay and period generation.

   e) Phase-coherent LO's for frequency translators might be useful.

11. TOTAL SYSTEM DELAY

   a) Must be measurable and put into on-line computer.

12. EXCISING RFI

   a) Excise wide-band impulse RFI (ignition, lightning, power line) by blanking total spectrum for Δt.

12. (CONTINUED):

b) Excise narrow-band RFI which has durations ranging from 0.1 to ∞ seconds.

c) All excising algorithims must not excise pulsar pulses.

d) User selects on/off for any or all excising.

13. DISPLAY

a) Continuous or manually selected display of all user input parameters.

b) Status of 5 MHz, 1 sec UTC, UTC clock inputs and noise cal outputs.

c) Activity indicators for RFI excising, de-dispersion, averaging and digital output spectra in each filter bank may be useful.

d) Real-time digital output spectra displayed in some limited form.

14. USER INPUTS

a) All inputs via manual means and via on-line computer.

b) Polarizations P_i.

c) Total bandwidth f_B.

d) Frequency resolution Δf.

e) Dispersion delays Δt_D, t_D and K, also sign.

f) Pulsar period A and number of periods in average, N_A.

g) Noise cal period and duration, delay of cal 2 relative to cal 1.

h) IF frequency

i) RFI excising on/off's.

j) Start/end scan.

15. DIGITAL OUTPUTS TO ON-LINE COMPUTER

a) On-line computer is LSI-11 system.

b) Processor controller (set-up) parameters.

15. (CONTINUED):

c) Frequency spectra from 4 spectrometer/processors or combinations put out at time intervals of Δt.

d) UTC time.

e) Status of pulsed noise cals.

f) RFI excising activity in some limited form.

16. PROCESSOR SET-UP PARAMETERS FOR OBSERVATIONAL OBJECTIVES

a) See Table 1.

17. PROCESSOR FUNCTION DIAGRAM

a) See Figures 1 and 2.

PROCESSOR PARAMETER	OBSERVATIONAL OBJECTIVE			
	Search	Timing and Dispersion	Polarization and Scintillation	Single Pulse Profiles
Instantaneous Bandwidth, f_B	≤ 20 MHz 40 MHz useful	≤ 20 MHz 40 MHz useful	≤ 20 MHz	≤ 20 MHz
Frequency Resolution ... Δf	≤ 2 MHz	30 kHz to 2 MHz	30 kHz to 2 MHz	30 kHz to 2 MHz
Time Resolution ..... Δt	0.1 to 1 ms	0.1 to 1 ms	0.1 to 1 ms	0.1 ms
Polarizations ..... P_i	Sum of 2 orthogonal	Two orthogonal	Four	Two orthogonal or 4
Dedispersion	None	Yes or none	Yes	Yes
Periodic Time Averaging	None	Yes	Yes or none	None

TABLE 1

Processor Set-Up Parameters for Observational Objectives

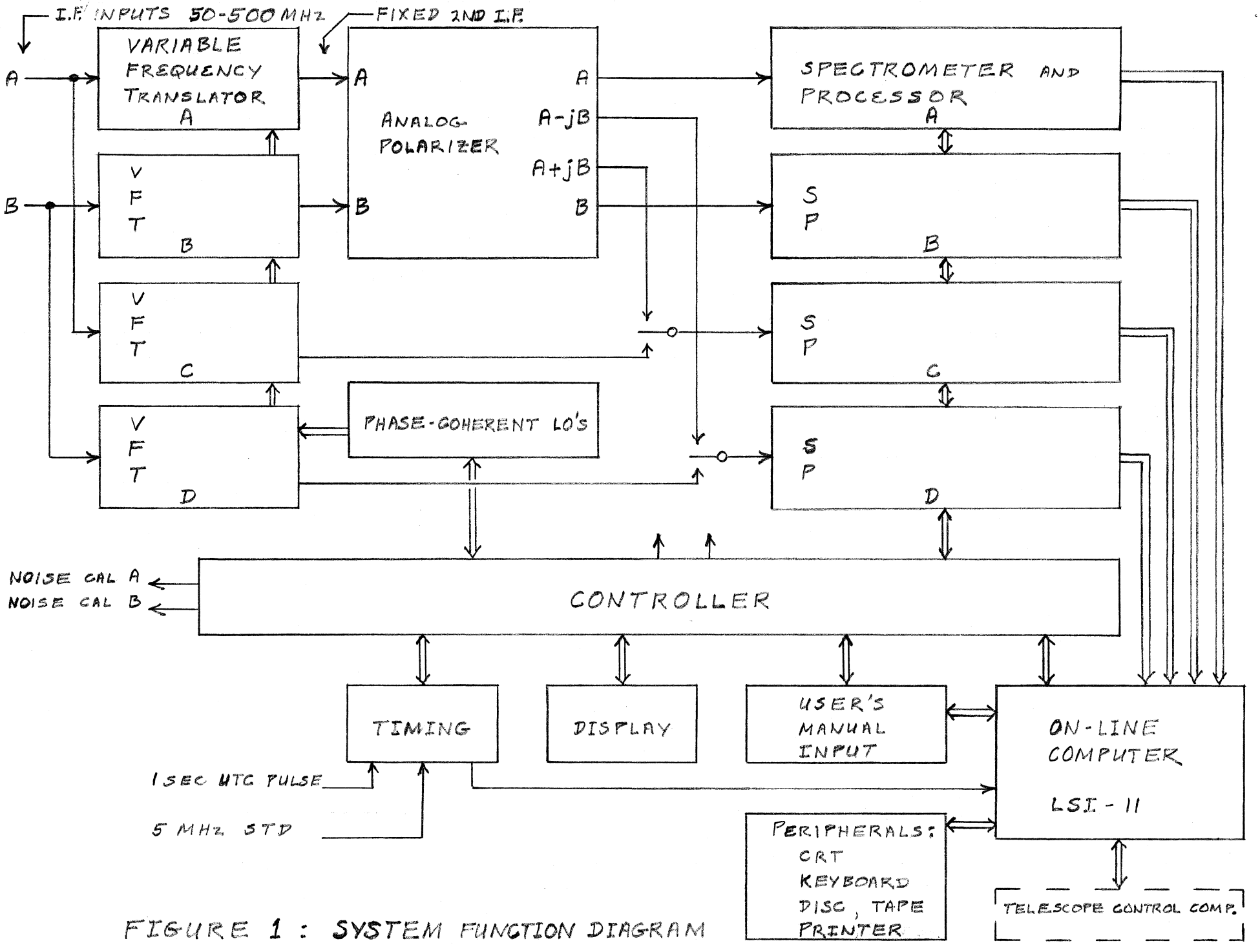

FIGURE 1 : SYSTEM FUNCTION DIAGRAM

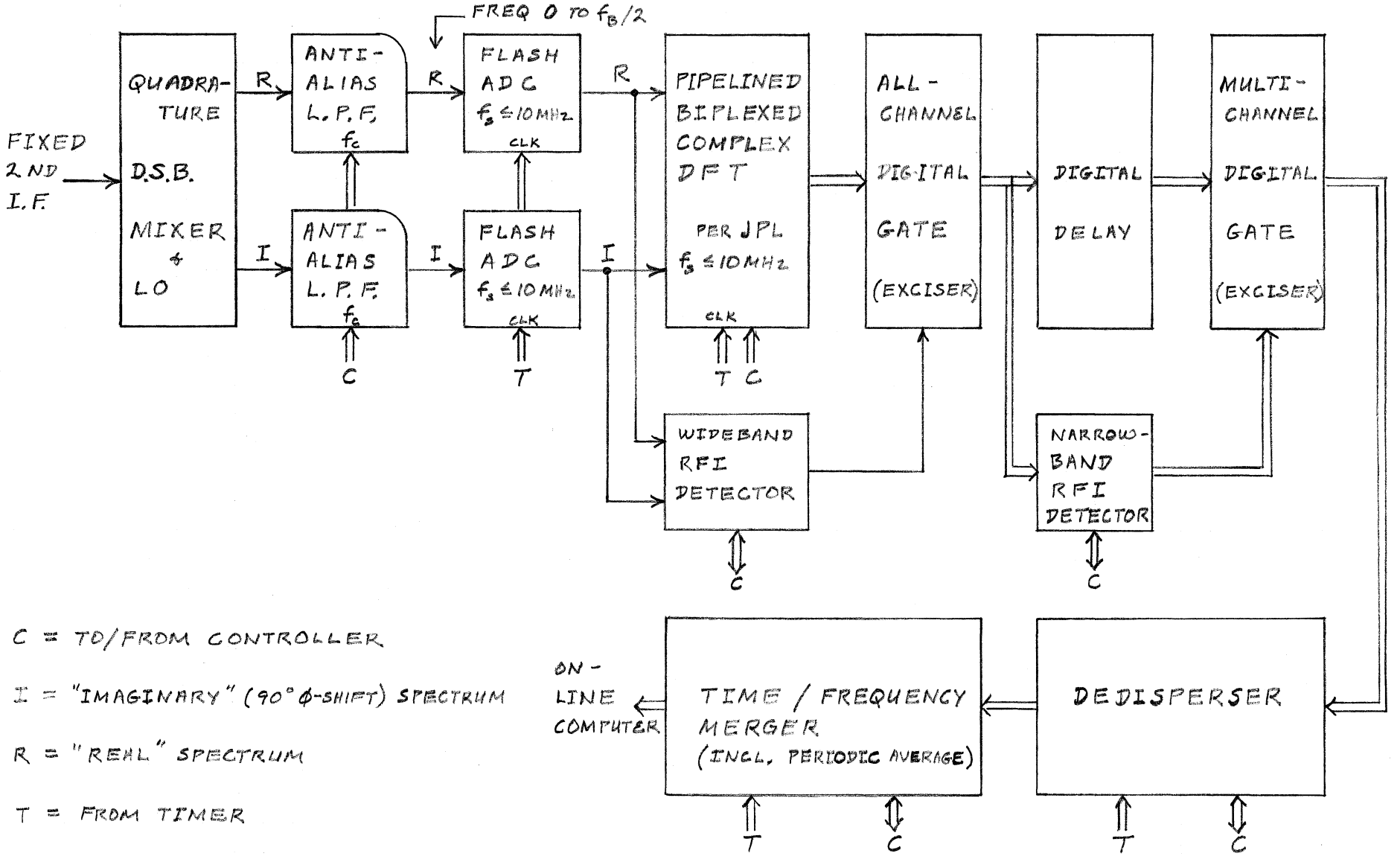

FIGURE 2 : SPECTROMETER AND PROCESSOR FUNCTION DIAGRAM