NATIONAL RADIO ASTRONOMY OBSERVATORY

Green Bank, West Virginia

(additional list attached)

Memo No. 10

Project 2.625

Pulsar Signal Processor

SPECIFICATIONS

UPDATE 1

W. D. Brundage

24 June 1982

SPECIFICATIONS

Update 1

0. INTRODUCTION

These specifications, update 1, are mostly based on a teleconference dis-
cussion made 3 June 1982 which included:

J. Taylor   - Princeton University
W. Brundage - NRAO-GB
J. Coe   -   "
R. Fisher   -   "
R. Lacasse   -   "
R. Mauzy   -   "
C. Moore   -   "
R. Norrod   -   "
D. Schiebel -   "
R. Weimer   -   "

Joe Taylor gave the desirable specifications and some trade-off guides from
the astronomer/user viewpoint. Earlier, Joe had discussion with several
pulsar observers. Later discussions with M. Damashek added some details.

These specifications are not complete and are not cast in concrete. Prac-
tical 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, SELECTABLE (P_i)

a) One polarization (P_1).

b) Sum of 2 orthoginal polarizations (P_ϕ).

c) Two orthoginal polarizations (P_2).

d) Four polarizations which yield 4 Stokes Parameters (P_4) obtained
    by 2 IF inputs and 4 filter/processor banks singly or in combina-
    tion.

2. INSTANTANEOUS BANDWIDTH, MAXIMUM AVAILABLE ($f_{B\ max}$), OF OUTPUT FREQUENCY
    SPECTRA

a) 20 MHz is necessary from each filter/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.

3. FREQUENCY RESOLUTION (Δf) OF OUTPUT FREQUENCY SPECTRA

    a)   30 kHz to 2 MHz in each filter/processor band.

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

    c)   Wider Δf's may be derived by summing adjacent filters.

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

4. FREQUENCY RESPONSE OF INDIVIDUAL FILTERS

    a)   Passband flatness $\pm$ 0.5 dB.

    b) $\geq$ 6 dB isolation center-to-center of adjacent filters.

    c) $\geq$ 12 dB isolation center-to-center of $\pm$ 2 filters.

    d) $\geq$ 6 n dB isolation center-to-center of $\pm$ n filters up to 70 dB.

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

5. TIME RESOLUTION (Δt) OF OUTPUT FREQUENCY SPECTRA

    a)   1 ms is necessary.

    b)   0.1 ms is very desirable.

6. DEDISPERSION IN FREQUENCY SPECTRA

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

    b)   1 μs Δt_D increments.

    c) $\leq$ 0.1 Δt uncertainty in delay across filter bank(s).

    d)   Selectable 2nd order delay distribution across filter banks so that t_D of ith filter = $k \, (f_{sky})^{-2}$.

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

7. AVERAGING OF FREQUENCY SPECTRA IN TIME DOMAIN

    a) 0 to 10 sec selectable averaging period (A).

    b) Δt increments of averaging period.

    c) ≤ 1 μs uncertainty in averaging period.

    d) 2 to 4096 selectable number of periods in average (N_A).

    e) ≥ 128 frequency points (channels) 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) 0 to 10 sec selectable pulsed cal period.

    d) 0 to 5 sec selectable pulsed cal width.

    e) 0.1 ms increments.

    f) ≤ 0.1 Δt uncertainty in pulsed cal period and width.

    g) ≤ 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 ≤ 1 σ of time variation in output spectra.

    c) ≥ 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. RFI EXCISING

   a) Excise wide-band impulse RFI (ignition, lighting, power line) ahead of filter banks.

   b) Excise narrow-band impulse RFI (radar, VORTAC, spread-spectrum communications).

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

   d) All excising algorithims must not excise pulsar pulses.

   e) All excising on/off is user selectable.

12. 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.

13. USER INPUTS

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

   b) Polarizations P_i.

   c) Frequency resolution Δf.

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

   e) Averaging period A and number N_A.

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

   g) IF frequencies.

   h) RFI excising on/off's.

   i) Start/end scan.

14. DIGITAL OUTPUTS TO ON-LINE COMPUTER

    a) On-line computer is either Modcomp II or LSI-11 system.

    b) Processor set-up (control) parameters.

    c) Frequency spectra from 4 filter banks 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.

15. PROCESSOR SET-UP PARAMETERS FOR OBSERVATIONAL OBJECTIVES

    a) See Table 1.

16. PROCESSOR FUNCTION DIAGRAM

    a) See Figure 1.

| PROCESSOR PARAMETER	OBSERVATIONAL OBJECTIVE			
	Search	Timing and Dispersion	Polarization and Scintillation	Single Pulse Profiles
Instantaneous Bandwidth, $f_{B\ max}$ Max Available	≤ 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	Yes	Yes
Time Averaging	None	Yes or	Yes or none	None

TABLE 1

Processor Set-Up Parameters for Observational Objectives
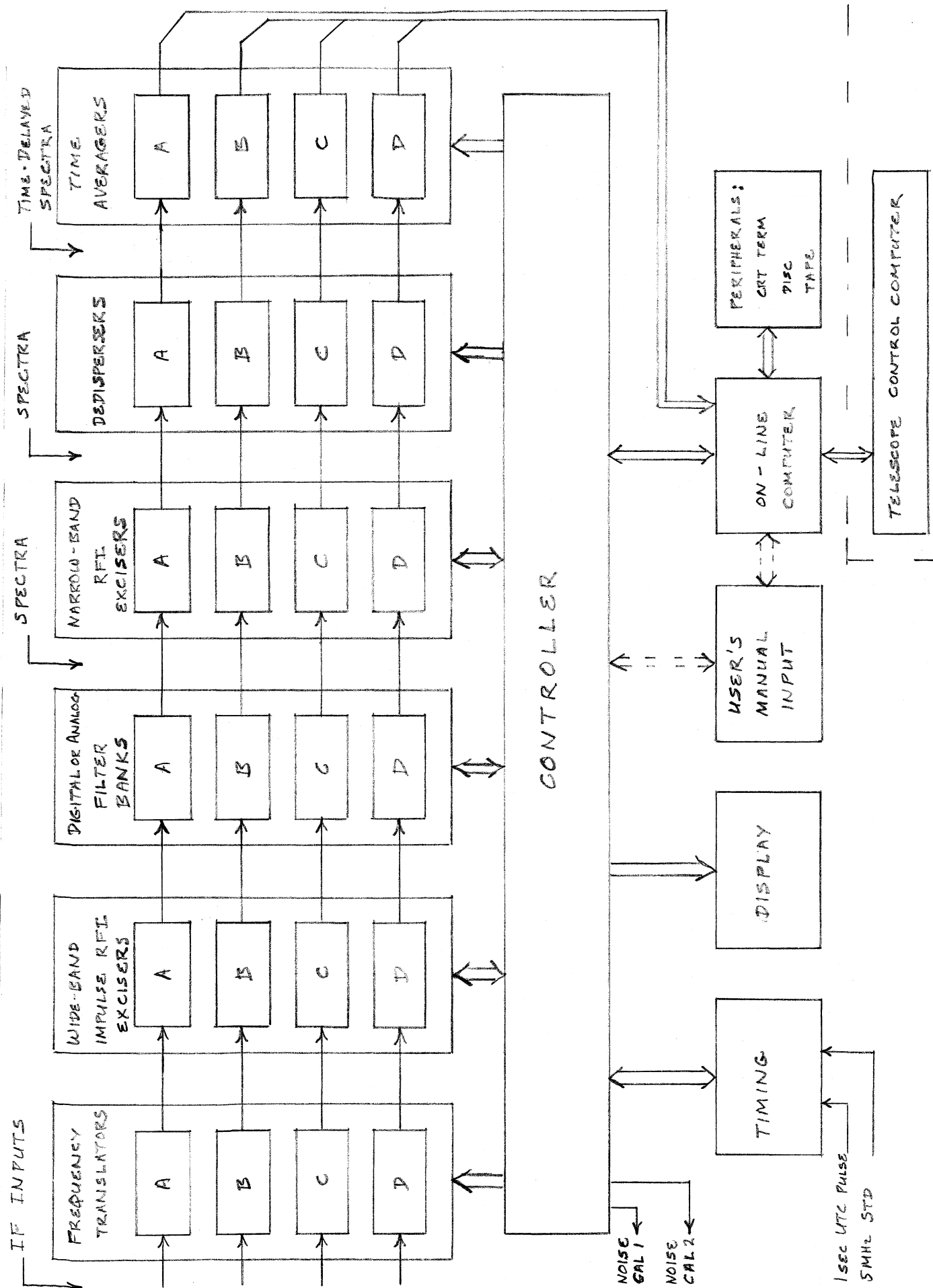
FIGURE 1: PROCESSOR FUNCTION DIAGRAM