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# PROPOSED CABLES FOR THE VLBA RECEIVING STATION

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This memorandum outlines the types of cables and connectors for the principal interconnections required on a VLBA antenna, and between the antenna and the station building. Connections between racks in the same room or in adjacent rooms are not included. A list of the cables included is given in Table 1.

## Semi-rigid Cables

The cables for which the phase stability is most critical are those used for the transmission of IF (500-100 MHz) and LO-reference signals (100 and 500 MHz) between the vertex room and the station building, and for the 330 and 610 MHz signals from the front-end box to the vertex room. Since semi-rigid cables generally offer better stability than flexible ones, and those with foam dielectric have the advantage that they do not need pressurization for protection against moisture, they are the preferred choice. Cables of this type are made by a number of manufacturers such as Andrews and Cablewave. (Prodelein, which was the manufacturer of the baseband-IF cables of the VLA, no longer appears to be in business, and cable that closely resembles their Spir-O-Line design can be found in the Cablewave catalog.) The smallest diameter cable listed by both Andrews and Cablewave is 3/8-inch, which can be used up to approximately 13 GHz. Cable of this size has a low enough attenuation (~4 dB per 100 ft at 1 GHz) to be satisfactory for the signals listed above. The temperature coefficient of phase (Andrews 3/8-inch, LDF series) is +9 to -9 ppM per deg C so, for the approximately 75 ft run from the 330/610 front end to the vertex room, the maximum value of the temperature coefficient of phase at 610 MHz is 0.15 deg per deg C. Temperature effects in the runs from the vertex room to the station building (approximately 310 ft) are less critical since the round-trip phase of one of six cables (four IF, one LO reference, one spare) will be monitored. Thus the important requirement is that all six cables behave similarly, which can most closely be achieved by mounting them as a bundle within an insulating jacket of foam rubber or similar material, and by using 'phase-stabilized' cables. 'Phase-stabilized', a manufacturers' term, indicates that the cable has been subjected to about ten 12-hour temperature cycles up to about 100 deg C. This process has the effect of relieving stresses, so that the subsequent variations in temperature will be smooth and repeatable. The additional cost for this process is about 10% of the cost of the cable.

Note that cables designed for very low temperature coefficient of phase by taking advantage of the opposite signs for the conducting and the dielectric materials are described as 'phase-compensated'. Such cables are not listed in the catalog of either Andrews or Cablewave. Cablewave does, however, make a phase-compensated cable (described in Cablewave Technical Bulletin No. 25A) with temperature coefficient 1.8 to 3.6 ppM per deg C, i.e. 2.5 to 5 times less than that of the Andrews LDF series. This phase-compensated cable is semi-air-spaced and would need pressurizing.

The 3/8-inch Andrews cable (Heliax type LDF 2-50) is used on the VLA for the 330 MHz system. It would be advantageous to use the same cable on the VLBA to simplify spares requirement for the cable and its connectors.

Flexible Sections of the IF/LO Cable Runs

Two sections of flexible cable are required in each of the LO/IF runs on the antenna. These are a length of approximately 10 ft at the elevation axis, and a length of a little over 20 ft at the azimuth cable wrap. The cheapest type of cable to use here would be RG9/U or RG214/U which has solid polyethylene dielectric. The temperature coefficient of phase is of order 100 ppM per deg C, and experience indicates that phase changes that result from flexure vary considerably for individual cables flexed in a common bundle. A number of types of flexible cable have more recently become available that are advertised as having much better phase stability than the older types. Some of these have dielectric that is not solid but of a low-density fiber or spline type. The temperature coefficient of phase is comparable to that of foam dielectric, semi-rigid cables, i.e. about an order of magnitude less than that of solid-polyethylene dielectric cables. In particular, the very rapid change of phase with temperature near 20 deg C is largely avoided. In addition these cables show relatively low change of phase with flexure. Manufacturers include Flexo, Gore-Tex and Huber and Suhner (Succoflex). The disadvantage of these cables is their price: $300 to $514 for a 10 ft length with type N connectors. In all cases connectors are factory installed. Three different 5 ft lengths have been ordered for testing. The part numbers of these are as follows:

| | |
|---|---|
| GNN01N01060.0 | ($307, Gore Tex) |
| F242AA0600AD | ($245, Flexco) |
| 104P/150cm/11N/11N/0.5-2.0 GHz | ($202, Succoflex) |

These cables will be tested and compared with RG214/U and other types before a final decision on which to use is made. The cost of using the high-stability cables (in the flexible parts only) of the IF/LO runs on one antenna would be in the range $5k to $9k per antenna. Use of the high-stability cables is presently considered to be an option.

Equalizers to compensate for the variation of attenuation in the IF band (500-1000 MHz) will be specified and procured after cables have been installed at Pie Town, and the attenuation has been measured.

A few remarks about the azimuth cable wrap should be made here. The initial design by RSi is large: the vertical dimension of the cylindrical cable form is 18 ft (when not twisted) and the diameter is 5 ft. At the maximum rotation of ± 270 deg the bottom end is raised by 4.4 ft. Thus although the cable on the wrap cylinder is only very gently flexed, the length that goes from the bottom end of the cylinder to a fixed point at the side of the pit in which the wrap is located can suffer considerable bending. This problem has been raised with RSi who propose to reduce the diameter to 3 ft. The vertical travel is thus reduced to 1.4 ft, which is much more acceptable. The reason for the large size of the cable wrap is presumably to accommodate the heavy electric power cables required. If the size of the cable wrap were reduced to halve the length of the cables on it, the cost of the high-stability cables would be reduced by $600- $2000 per antenna.

Monitor and Control Bus

Three runs of the monitor and control (M/C) bus cable from the station building to the antenna will be installed: one to the pedestal room, and two to the vertex room. One of the ones to the vertex room will be an unused spare, and will pass through the pedestal room to provide backup to that point also. One run from the vertex room to the prime focus is also required for the focus rotation unit. A possible cable is Belden 9842 which consists of two twisted pairs within a single shield. To minimize interference from the digital signals on the bus, the connectors should have metal housing designed to connect to the cable shield in a manner that maintains full shielding of the conductors. Commonly-used types of circular multipin connectors do not provide for such termination of the shield. The best choice appears to be a 9-pin D connector for which a metal RFI-shielding hood is available (Amp part no. 745171-5). It is assumed at this time that the use of a single cable for both the transmit and receive lines of the bus will be satisfactory. An alternative scheme would be the use of two twinax cables, one for transmission of command signals from the computer, and one for reception of monitor data. Connectors could be the Amp twinax series (Amp 22724-1 and matching units) or the triaxial series (Amp 227110-2 and matching units).

Other Coaxial Cables

Coaxial cables to carry timing signals from the station building to the vertex room are required. The signals include the drive waveform for the reflector of the round-trip-phase measuring system, and switching waveforms for the switched noise sources and possibly also for a phase switch. For the last two signals it may only be necessary to transmit the station timing signal to the vertex room and derive the switching waveforms from it. To accommodate these waveforms, and also to allow for spares and test requirements, five runs of RG223/U (similar to RG 58/U but double shielded) are proposed. Two cables of the same type for noise source drives should run from the vertex room to the 330/610 MHz front end box.

Multiconductor Cable

One eight-conductor cable will be required between the 330/610 MHz front-end box and the vertex room for power and monitor signals.

One 15-pair cable (Belden 9777) will run from the station building to the pedestal room, to be used in part for signals associated with antenna control to be specified by L. Serna. One six-pair cable (Belden 9774) will run from the vertex room to the pedestal room, and is provided for test purposes not yet specified. This cable will link with unused pairs of the 15-conductor cable to give test connections from the building to the vertex room. Both of these cables will be terminated in termination strips in boxes in the station building, pedestal room, and vertex room.

Weather Station Cables

A power cable and a M/C interface cable will run from the station building to the weather station.

Telephone Cables

Telephone cables will be required from the station building to the azimuth and vertex rooms.

Cables Between Front Ends and Racks

For each of approximately 7 front ends in the vertex room there will be a Front-End control module in Rack A. Each front end will be connected to its module by two 25 conductor cables with type D connectors. These cables will be procured complete with connectors: for example ORA Electronics supply standard lengths in the range 3 to 25 ft for prices in the range $12-$24 each. There will be two output cables from each front end to the IF/LO Rack (Rack B) which contains the converter modules for frequency bands up to and including 10.7 GHz. The 3/8 inch Heliax, which is designed for operation to 13 GHz, would be a good choice for these cables. The 1/4 inch size Heliax, usable up to 18 GHz, or RG91/U waveguide, would be suitable at 15 GHz. The superflexible type of 1/4 inch Heliax (type no. FSJ1-50) is used for short sections of the 330 MHz runs on the VLA, and at 15 GHz its attenuation is 0.4 dB per foot. The attenuation of RG91/U at 15 GHz is approximately 0.12 dB per foot. For bands above 15 GHz the first frequency conversion will be made at the front end, and 3/8 inch Heliax will be suitable for the IF signals. Waveguide may be used for the highest local oscillator frequencies.

Focus/Rotation Cables

Cables from the pedestal room to the prime focus for the subreflector mount control will be specified by D. Weber.

Cost Estimate

An estimate of the quantities and costs of cables and connectors is given in Table 2.

Table 1. Principal Cables in VLBA Receiving System

| From/To (Length) | Signal | Type of Cable | No. of Cables | Type of Connector | No. of Connectors |
|---|---|---|---|---|---|
| Prime Focus/Vertex Room (Approx. 75 ft) | 330 and 610 MHz | 3/8" Heliax | 4 | N (fem) (Andrews L42N) | 8 |
| " | Noise Source Drive | RG 223/U | 2 | BNC | 4 |
| " | 15V and monitor | 8-conductor | 1 | Bendix M53106F20-7S | 2 |
| Vertex Room/Station Building (Approx. 210 ft) | L.O. Reference, IF, Spare | 3/8" Heliax plus flexible sections | 6 | N (fem) (Andrews L42N) | 36 |
| | | | | N (male) on flexible sections | 24 |
| " | M/C Bus and Spare | Belden 9842 | 2 | 9-pin D with RFI Hood | 4 |
| " | Timing, Test, Spare | RG 233/U | 5 | BNC | 10 |
| " | Test | Belden 9774 (6-pair) | | Terminal Strip | |
| " | Telephone | 4-conductor | 1 | Not required | |
| Pedestal Room/Station Building (Approx. 140 ft) | M/C Bus | Belden 9842 | 1 | 9-pin D with RFI Hood | 2 |
| " | Telephone | 4-conductor | 1 | Not required | |
| " | Antenna and Test | Belden 9777 (15-pair) | | Terminal Strip | |
| Front Ends to Vertex Room Racks (5 to 20 ft) | Front End Outputs (RF or IF, <13 GHz) | 3/8" Heliax | 14 | N (male) (Andrews L42W) | 28 |
| " | 15 GHz | 1/4" Heliax or RG 91/U | 2 | N (male) (Andrews 41SW) for 1/4" Heliax | 4 |
| " | Monitor and Control of Front Ends | 25-conductor cable | 16 | 25-pin D (factory installed on cable) | |
| Station Building/ Weather Station (200 ft) | M/C Bus | Belden 9842 | 1 | 9-pin D with RFI Hood | 2 |
| | AC Power | | | | |

Table 2. Cable and Connector Types with Approximate Quantities and Costs (Per Antenna)

| Cable Type | Length[1] | Approximate Cost | Connector Type | Number[2] | Approximate Cost |
|---|---|---|---|---|---|
| 3/8" Heliax, phase stabilized Andrews 35422-22 | 1700 ft | 1700x$1.60=$2720 | L42W<br>L42N | 36<br>36 | 36x$24=$864<br>36x$24=$864 |
| 1/4" Heliax, Superflex Andrews FSJ1-50 | 30 ft | $ 30 | 41SW | 2 | 2x$30=$60 |
| RG 223/U | 1200 ft (+300 ft) | 1.5x$1020=$1530 | BNC | 12 (+40) | 52x $2=$104 |
| RG 9/U or RG 214/U | (300 ft) | 3x $200=$ 600 | Type N | (50) | 5 x $4=$200 |
| Belden 9842 | 860 ft (+200 ft) | $ 600 | 9-pin D with RFI Hood | 10 (+20) | $300(?) |
| 8 conductor | 75 ft | $ 150 | Bendix M53106F20-7S | 2 | 2 x $15=$30 |
| Telephone (4 conductor) | 400 ft | $ 40 | Not Required | | |
| 25 conductor | 16 X ~10 ft | $ 320 | Factory fitted (25-pin D) | | |
| Flexible high-stability coaxial cables (optional) | 6 X 25 ft | up to $6000 | Factory fitted (N male) | | |
| " | 6 X 10 ft | up to $3000 | Factory fitted (N male) | | |
| Belden 9774 | 100 ft | $ 150 | Terminal Strip | | |
| Belden 9777 | 140 ft | $ 550 | Terminal Strip | | |
| <u>TOTAL</u> | | | | | $9,112 + $9,000 (optional) |

[1,2] Quantities in parantheses are for general purposes and are additional to items listed in Table 1.