THE NEW AZIMUTH CABLE WRAP ARRANGEMENT FOR VLBA ANTENNAS

D. S. Bagri and J. Ruff

Introduction.

In the VLBA the local oscillator (LO) and IF signals between the station building and the vertex room are carried using rigid 3/8 inch diameter Heliax cables for the most parts of the cable runs. Small lengths of (about 29.5 feet around the azimuth axis and 17 feet around the elevation axis) RG214 flexible cables were used in each cable run to facilitate the antenna rotation around its axes. Heliax cable is used for most of the length of each cable run because it is relatively inexpensive cable which has low attenuation and very low ($\pm 10 ppm/^{\circ}C$) coefficient of length changes with temperature. The RG214 is a double shielded cable and has an outer diameter of 0.425 inches. It uses polythelene dielectric and has an attenutation of 4.6 dB/100 ft. at 400 MHz and 9 dB/100 ft. at 1000 MHz. The path length changes of the 500 MHz LO cable, between the station building and the vertex room, are measured using the round trip phase measurement technique. It was planned to assume the same variation for all other local oscillator and IF cables.

Original azimuth cable wrap arrangement and its performance.

In the initially planned azimuth cable wrap arrangement, all the coaxial cables were bunched together, and passed through holes in rings, located around the azimuth shaft to guide the wrapping of the cables around the azimuth axis, when the antenna is rotated. These 5 rings are located along the height of the azimuth shaft. As the antenna is rotated, these rings move up or down, and also rotate. This causes twisting of the cables which distorts field lines in the cable. This results in changes in the transfer function of the cable. The amount of twisting, and the resulting change in the transfer function for different cables may not be the same. Tests made on the azimuth cable wrap for the Pie Town antenna showed (Table 1) a differential variation of 10 to 70 psec for different cables as the antenna was rotated by ±260° of the allowed azimuth rotation. Also these variations showed hysteresis.

For the elevation wrap all the cables are bunched together and form a loop. The loop moves around the elevation shaft as the antenna is rotated in the elevation. Differential length changes between various cables due to the antenna elevation movement are less than about 10 psec for the antenna elevation changes from 2° to 120°.

For several experiments, especially astrometry and crustal dynamics projects, it is desirable that the overall delay variations for each signal path are kept to less than a few psec or are measured to this accuracy. Therefore we decided to investigate better cable wrap arrangement, especially for azimuth cable wrap, to reduce the cable length changes as the antenna is rotated, even though we realized that to achieve a few psec type accuracy, it was necessary have active pulse calibration system.

Discussions of the original cable wrap measurements.

From the data in Table 1 we notice that the amount of differential cable length changes for elevation wrap is much smaller than the azimuth cable wrap. With the original cable wrap arrangement the coaxial cable is twisted when the antenna is rotated in the azimuth, whereas when the antenna is rotated in the elevation axis, the elevation wrap cable is wound like a watch spring. The elevation cable wrap distortion is only due to the compression of the inner radius side of the cable and stretching of the cable on the outer radius side. On the other hand in the azimuth cable wrap arrengement apart from this compression and stretching of the cable, there was also additional twisting of the cable. The twisting of the cable was suspected to cause more distortion of the cables, resulting in larger differential variations amongst different cables. Therefore we decided to try out a watch spring type arrangement for the azimuth wrap as well. Also, after some bench tests for phase variations when the cables are wound in watch spring form, we decided to use RG142B cable for the azimuth cable wrap instead of the the RG214 used earlier, as this had less phase variations when wound in spring form. We decided to use RG142B cable (outer diameter 0.195 inch), even though it has slightly higher attenuation (8dB/100ft. at 400 MHz) compared with the RG214, because it employs PTFE dielectric which has lower temperature coefficient of expansion (about 80ppm/° C) compared with polyethelene (about 190ppm/° C) used in the RG214 cables. Also it has better construction for holding the outer conductor in place when wound.

New azimuth cable wrap arrangement.

The watch spring arrangement consists of a ribbon made of eight RG142B cables. The ribbon is formed using 32 gauge aluminum strips of 3 inches by 17 inches as backing. Cables are attached to the aluminum strips using metal clamps with grooves in them. To allow for changes in the cable lengths due to changing diameter of the spring and finite cable diameter, we provided slots at both ends in the aluminum strips where they attach to each other. This allows the aluminum strips to slide with respect to each other. This prevents stress on the cables or buckling of the aluminum strips. The ribbon is held edge wise to form a spring around the azimuth shaft. It is supported in a tray located just below the azimuth encoder. The inner and outer radii of the spring arrangement are 12 inches and 24 inches and the total length of the cable spring arrangement is 214 inches. The new cable wrap arrangement requires only about 20 ft. of RG142B cable for the wrap around the azimuth axis instead of about 29 ft of RG214 used in the earlier cable wrap arrangement.

Performance of the new azimuth cable wrap arrangement.

The new cable wrap arrangement was bench tested in the laboratory for the differential cable length changes with the cable winding in the (watch) spring form. A differential cable length change of less than 5 psec was measured for ±260° winding of the cable. The new azimuth cable wrap arrangement was installed (Fig.1) on Pie Town antenna in Dec 1988. Test results for cable length changes with antenna rotation in azimuth are shown in Table 2. These results show differential cable length changes of 2 to 9 psec for ±260° of antenna rotation in azimuth. This is about 7 times lower than what was measured with the earlier cable wrap arrangement. The variations are a factor of two smaller for only ±180° of antenna azimuth rotation.

Conclusion.

The new cable wrap arrangement is based on allowing only winding of the cables (in a watch spring form) around the azimuth axis instead of both winding and twisting of the cables which used to take place in the original azimuth cable wrap. In addition we have used RG142B cable for the wrap which is thinner than RG214 cable, and seem to have somewhat better construction to resist deformation of outer conductor when wound in a spring form. These modifications have improved the differential cable changes to less than a few psec for the antenna azimuth rotation, which is almost an order of magnitude improvement.

TABLE 1. Cable length changes in psec for original cable wrap.

CABLES USED	FOR ANTENNA AZIMUTH ROTATION (+/-260 DEG) AT			FOR ANTENNA ELEVATION ROTATION (2 TO 120 DEG)
	500MHz	750MHz	999MHz	500MHz
Cable A - Cable C	55	52	59	12
Cable B - Cable C	69			
Cable D - Cable C	62			6
Cable D - Cable A	12		14	8
Cable B - Cable A			25	
SPARE - Cable A	40			
SPARE - Cable C	35			
SPARE + Cable A			77	
SPARE + Cable B			85	
SPARE + Cable D			77	

TABLE 2. Cable length changes in psec for the new cable wrap arrangement.

CABLES USED	FOR ANTENNA AZIMUTH ROTATION (+/-260 DEG) AT 500MHz	FOR ANTENNA AZIMUTH ROTATION (+/-180 DEG) AT 500MHz
Cable A - 500MHZ Cable	9.4	4.5
Cable A - Cable B	4.8, 5.2	
Cable A - Cable C	4.8	
Cable A - Cable D	4.0	
Cable D - Cable B	6.3	
Cable C - Cable B	8.7	
Cable C - Cable D	5.2	
100MHz + Cable C	39.0	

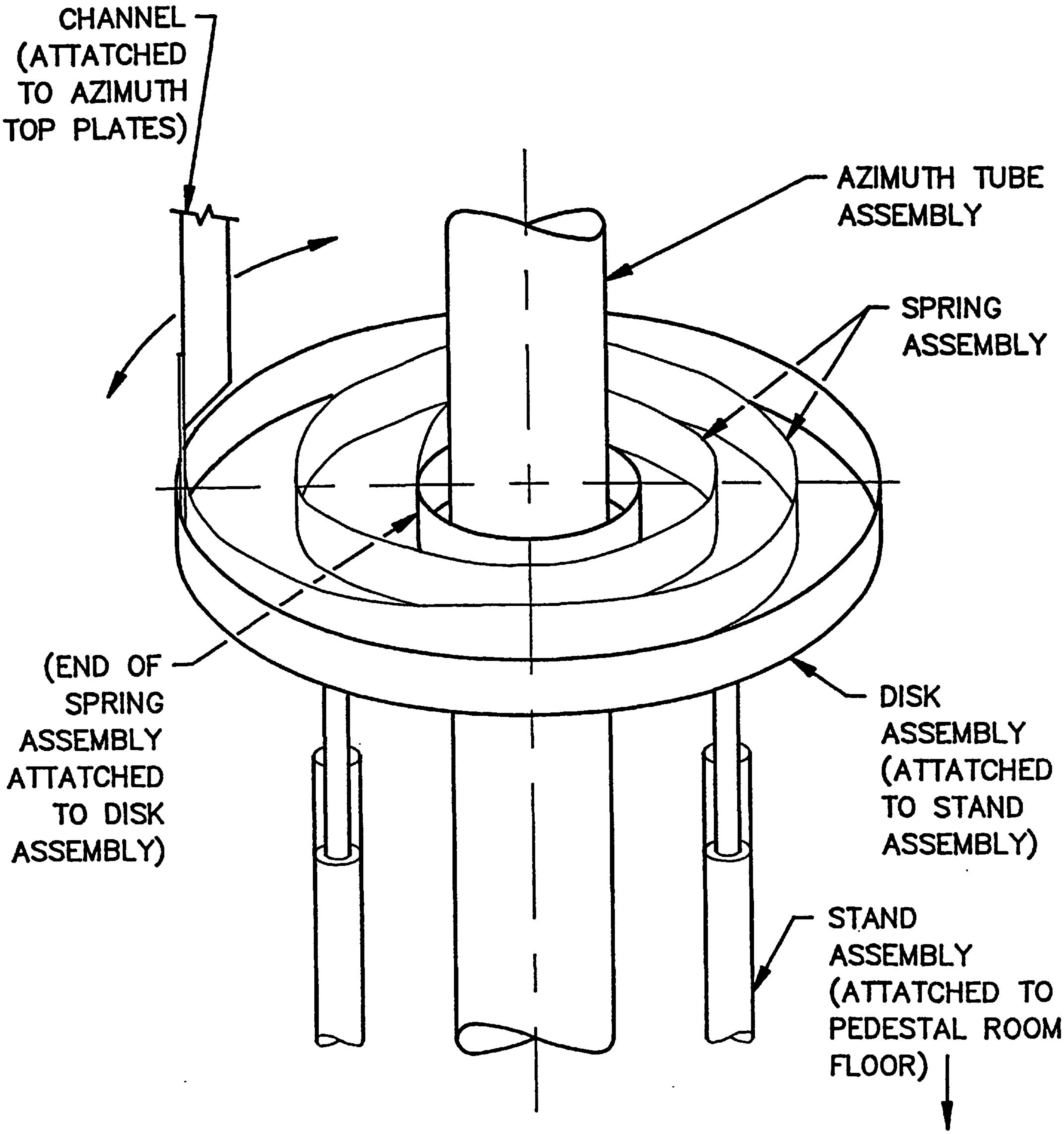

FIGURE 1. NEW AZIMUTH CABLE WRAP ARRANGEMENT.