ROUND TRIP PHASE CORRECTION FOR GMRT LO & IF SYSTEM

Goutam Chattopadhyay. Sept. 19,1991

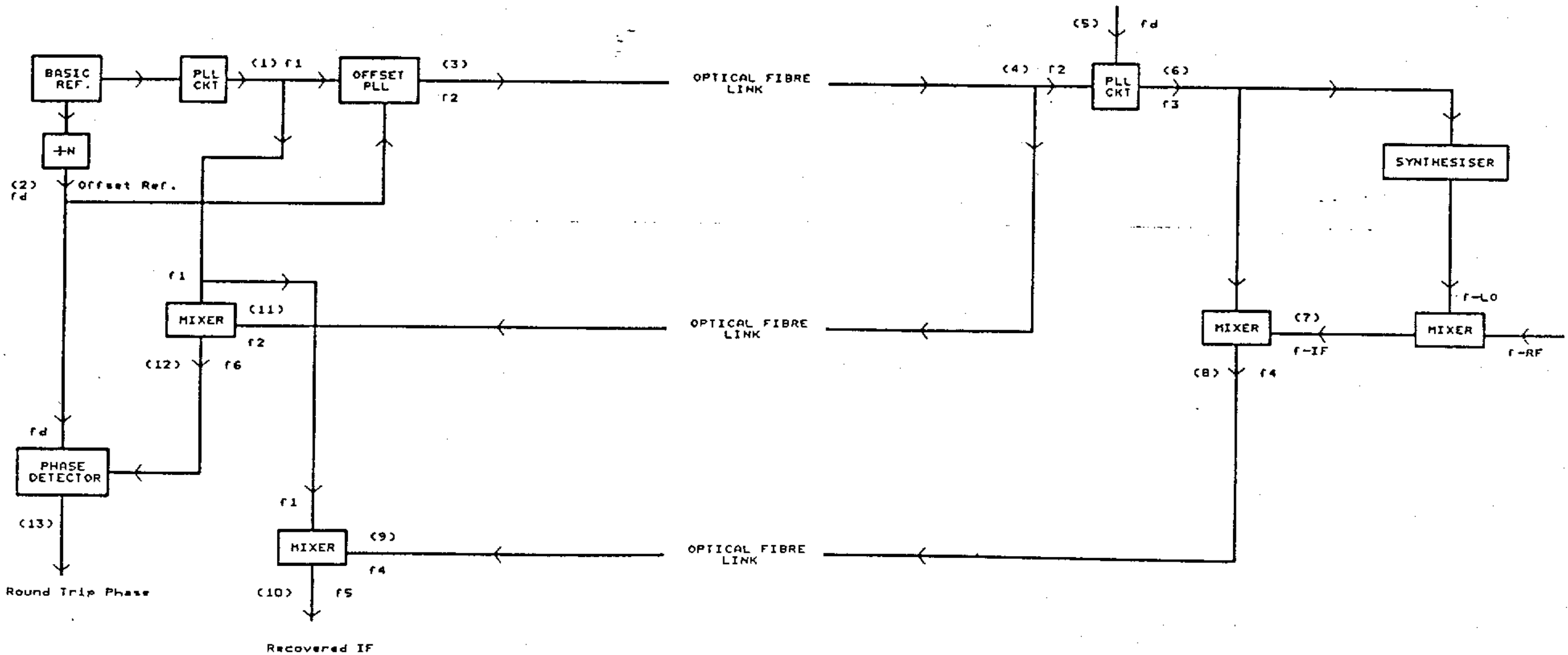
In GMRT Local Oscillator System round trip Phase will be esta blished to correct the phase delays of Local Oscillators sitting at different spatially seperated antennas and also the phase delay of the IF signals brought to the Central Electronics Build ing through Optical fibre cable.

It was previously proposed that the Fringe correction will be done at Local Oscillator at the Central Electronics Building and for that necessary hardware (Fringe Rotator, fringe correct ed LO etc.) will be built. Now it is proposed that Fringe correction will be done at the correlator. So, the Fringe Rotator circuit and the generation of the Fringe corrected LO is no longer required. Under this circumstances GMRT Receiver Block diagram at the Central Electronics Building needs to be changed and as a result of that we won't be needing as many as 120 modules. In this report we shall look at the scenerio from the phase correction point of view under the new circumstances and suggest some alternations.

Fig.1 shows the simplified block with no. marked for phases at different locations of LO, IF and RF blocks. the phases at different locations and the corresponding phase equations are shown on pages 3 and 4. We can see clearly that round trip phase information which is stored for offline correction is $2(\frac{\omega_1 L}{c}+\frac{\omega_d L}{c})$ whereas we need the information of $\frac{\omega_1 L}{c}$ for IF phase correction. So, we will have to calculate the phases of ω_d for different antenna path lengths as we dont have any measured value for this. The question is can we fit a linear curve and find out the phase at ω_d if we know the phase at $(\omega_1+\omega_d)$? The answer obviously is yes, one can find out if the system is linear. It was experimentally measured the linearity of the optical fibre here and it was found quite satisfactory. But the point is if there is some non-linearity , however small it is, the error will be quite high as the factor n/m in the equation is quite high at the high frequency end. Since the ionosphcheric phase fluctuation is not high at 1420 MHz, any error due to this approximation will be quite appreciable. Now we shall ask ourselves whether we have any other option with us to get rid of this situation without changing much of the exisung hardware ? I feel it is poosible with the following scheme. Instead of bringing offset frequency (105.01 MHz or 200.01 MHz) back to the Central Electronics Building from the different antennas, if we bring integer frequencies (105 MHz or 200 MHz) the error term due the offset term will nolonger be present, which will be clear from the equations below. The phases at different locations for this new block is shown in Fig.2. The corresponding phase equations are shown in the pages 6 and 7. It is clear that in the above equations no term of offset frequency is involved in the round trip phase correction, everything is measured in terms of ω_1 only. It is also very clear that the necessary hardware changes are minimal.

One question is still unanswered. We are using two separate fibres for up and down link and it is found that they track each other very wellas long as the frequencies are same. Now we will have to see whether they track as well when different frequencies are involved. It will be ex perimented shortly. If it is so, (I feel personally it will be) the new scheme will have less error limit in round trip phase corection than the previous one.

FIG. 1. BLOCK DIAGRAM SHOWING PHASES AT DIFFERENT LOCATIONS.



PHASE EQUATIONS FOR FIG 1.

The following equations show the frequency and phase at different locations for the fig - 1.

(1) $\omega_1 \angle \phi_1$ (2) $\omega_d \angle \phi_d$ (3) $\omega_2 \angle \phi_2$ $\omega_2 \approx \omega_1 + \omega_d \angle \phi_2 \approx \angle \phi_1 + \phi_d$

(4) $\omega_2 \angle \phi_2 - \omega_1 \cdot \frac{L}{c}$ $\left[\omega_1 + \omega_d\right] \angle \phi_1 + \phi_d - \omega_1 \cdot \frac{L}{c} - \omega_d \cdot \frac{L}{c}$

(5) $\omega_d \angle \phi_d - \omega_d \cdot \frac{L}{c}$

(6) $\omega_3 \angle \phi_1 + \phi_d - \omega_1 \cdot \frac{L}{c} - \omega_d \cdot \frac{L}{c} - \phi_d + \omega_d \cdot \frac{L}{c}$

$\omega_3 \approx \omega_1 + \omega_d - \omega_d \approx \omega_1 \angle \phi_1 - \omega_1 \cdot \frac{L}{c}$

(7) $\omega_{IF} \angle \phi_{IF}$ (8) $\omega_4 \angle \phi_1 - \omega_1 \cdot \frac{L}{c} + \phi_{IF}$ $\omega_4 \approx \omega_1 + \omega_{IF}$

(9) $\left[\omega_1 + \omega_{IF}\right] \angle \phi_1 - \omega_1 \cdot \frac{L}{c} + \phi_{IF} - \left[\omega_1 + \omega_{IF}\right] \cdot \frac{L}{c}$

That is $\angle \phi_1 - 2 \cdot \omega_1 \cdot \frac{L}{c} - \omega_{IF} \cdot \frac{L}{c} + \phi_{IF}$

(10) $\omega_5 \angle \phi_1 + \phi_{IF} - 2 \cdot \omega_1 \cdot \frac{L}{c} - \omega_{IF} \cdot \frac{L}{c} - \phi_1$

$\left[\omega_1 + \omega_{IF} - \omega_1\right] \angle \phi_{IF} - \omega_1 \cdot \frac{L}{c} - \left[\omega_1 + \omega_{IF}\right] \cdot \frac{L}{c}$

$\omega_{IF} \angle \phi_{IF} - \omega_1 \cdot \frac{L}{c} - \left[\omega_1 + \omega_{IF}\right] \cdot \frac{L}{c}$

The Phase Correction needed at IF

$$\angle\left(\omega_1\cdot\frac{L}{c}+\left[\omega_1+\omega_{IF}\right]\cdot\frac{L}{c}\right)$$

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(11) $$\left[\omega_1+\omega_d\right]\angle\left(\phi_1+\phi_d-2\cdot\omega_1\cdot\frac{L}{c}-2\cdot\omega_d\cdot\frac{L}{c}\right)$$

(12) $$\omega_6\angle\left(\phi_1+\phi_d-2\cdot\omega_1\cdot\frac{L}{c}-2\cdot\omega_d\cdot\frac{L}{c}-\phi_1\right)$$

$$\omega_6\approx\omega_1+\omega_d-\omega_1$$

That is $\omega_d\angle\left(\phi_d-2\cdot\omega_1\cdot\frac{L}{c}-2\cdot\omega_d\cdot\frac{L}{c}\right)$

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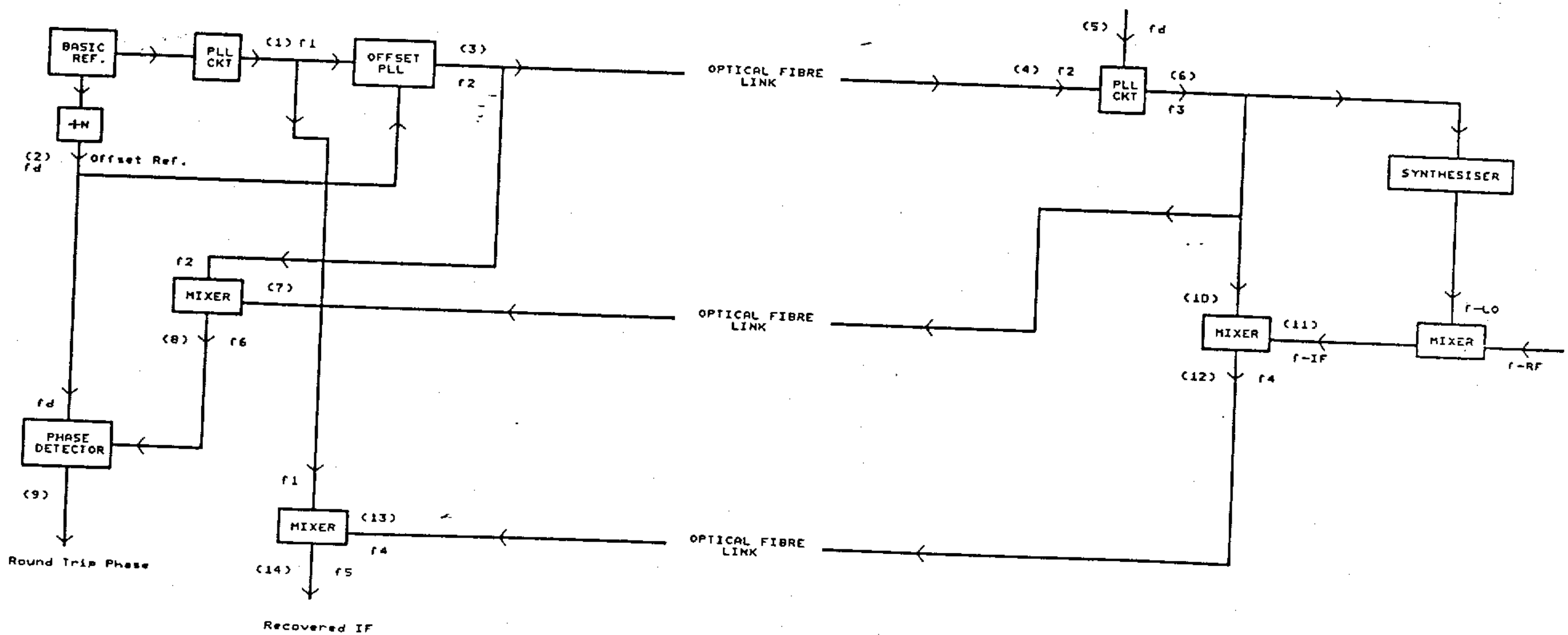
(13) Round Trip Phase $\angle\phi\approx\angle\left(2\cdot\omega_1\cdot\frac{L}{c}+2\cdot\omega_d\cdot\frac{L}{c}\right)$

Now at (10) we have $\omega_{IF}\angle\left(\phi_{IF}-2\cdot\omega_1\cdot\frac{L}{c}-\omega_{IF}\cdot\frac{L}{c}\right)$

$$\omega_{IF}\approx\left[\frac{n}{m}\cdot\omega_1-\omega_{RF}\right]$$

So, $$\left[\frac{n}{m}\cdot\omega_1-\omega_{RF}\right]\angle\left(\frac{n}{m}\cdot\left[\phi_1-\omega_1\cdot\frac{L}{c}\right]-\phi_{RF}-2\cdot\omega_1\cdot\frac{L}{c}-\left[\frac{n}{m}\cdot\omega_1-\omega_{RF}\right]\cdot\frac{L}{c}\right)$$

FIG. 2. BLOCK DIAGRAM SHOWING PHASES AT DIFFERENT LOCATIONS.



PHASE EQUATIONS FOR FIG 2.

The following equations show the frequency and phase at different locations for fig - 2.

(1) $\omega_1 \angle \phi_1$ (2) $\omega_d \angle \phi_d$ (3) $\omega_2 \angle \phi_2$ $\quad \omega_2 \approx \omega_1 + \omega_d \angle \phi_2 \approx \angle \phi_1 + \phi_d$

(4) $\omega_2 \angle \phi_2 - \omega_1 \cdot \frac{L}{c}$ $\quad \left[\omega_1 + \omega_d\right] \angle \phi_1 + \phi_d - \omega_1 \cdot \frac{L}{c} - \omega_d \cdot \frac{L}{c}$

(5) $\omega_d \angle \phi_d - \omega_d \cdot \frac{L}{c}$

(6) $\omega_3 \angle \phi_1 + \phi_d - \omega_1 \cdot \frac{L}{c} - \omega_d \cdot \frac{L}{c} - \phi_d + \omega_d \cdot \frac{L}{c}$

$\omega_3 \approx \omega_1 + \omega_d - \omega_d \approx \omega_1 \angle \phi_1 - \omega_1 \cdot \frac{L}{c}$

(7) $\omega_1 \angle \phi_1 - \omega_1 \cdot \frac{L}{c} - \omega_1 \cdot \frac{L}{c}$

(8) $\omega_1 + \omega_d - \omega_1 \angle \phi_1 + \phi_d - \phi_1 + 2 \cdot \omega_1 \cdot \frac{L}{c}$

$\omega_d \angle \phi_d + 2 \cdot \omega_1 \cdot \frac{L}{c}$

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(9) Round Trip Phase $\angle \phi \approx \angle 2 \cdot \omega_1 \cdot \frac{L}{c}$

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(10) $\omega_1 \angle \phi_1 - \omega_1 \cdot \frac{L}{c}$ (11) $\omega_{IF} \angle \phi_{IF}$

(12) $\omega_1 + \omega_{IF} \angle \phi_1 - \omega_1 \cdot \frac{L}{c} + \phi_{IF}$

(13) $\omega_1 + \omega_{IF} \angle \phi_1 - \omega_1 \cdot \frac{L}{c} + \phi_{IF} - \left[\omega_1 + \omega_{IF}\right] \cdot \frac{L}{c}$

(14) $\omega_1 + \omega_{IF} - \omega_1 \angle \phi_{IF} - \omega_1 \cdot \frac{L}{c} - \left[\omega_1 + \omega_{IF}\right] \cdot \frac{L}{c}$

$$\omega_{IF} \angle \phi_{IF} - \omega_1 \cdot \frac{L}{c} - \left[\omega_1 + \omega_{IF}\right] \cdot \frac{L}{c}$$

Phase Correction needed at IF $\angle \omega_1 \cdot \frac{L}{c} + \left[\omega_1 + \omega_{IF}\right] \cdot \frac{L}{c}$

Now at (14) we have $\omega_{IF} \angle \phi_{IF} - 2 \cdot \omega_1 \cdot \frac{L}{c} - \omega_{IF} \cdot \frac{L}{c}$

$$\omega_{IF} \approx \left[\frac{n}{m} \cdot \omega_1 - \omega_{RF}\right]$$

So, $\left[\frac{n}{m} \cdot \omega_1 - \omega_{RF}\right] \angle \frac{n}{m} \cdot \left[\phi_1 - \omega_1 \cdot \frac{L}{c}\right] - \phi_{RF} - 2 \cdot \omega_1 \cdot \frac{L}{c} - \left[\frac{n}{m} \cdot \omega_1 - \omega_{RF}\right]$