# DERIVATION OF SUBCARRIER AND TWICE LINE FREQUENCY

## INTRODUCTION

Colour television coding requires subcarrier and line frequencies that are precisely related. In addition the sync pulse generator requires a feed of twice line frequency (2H). The only sure way to guarantee the relationship is if the 2H and subcarrier signals are derived from the same oscillator. This information sheet looks at two different ways in which this can be done.

## 1. USING A 'STANDARD' OSCILLATOR

As well as the subcarrier to line relationship there is often the requirement for a very high stability subcarrier signal. Using a subcarrier with a good long term stability eases many of the problems of video tape recording and editing. The BBC has desgined a sync pulse generator round a 5MHz oscillator. This is normally a small, high stability unit with a short term stability of about 2 parts in $10^{10}$.

### 1.1 Stability Figures

A short term stability of 2 in $10^{10}$ sounds very impressive, but what does it mean? (1 cycle of subcarrier has a period of 226 nS, i.e., 226 x $19^{-9}$ s.) The stability quoted at 2 in $10^{10}$ means 2 seconds drift in $10^{10}$ seconds relative to an absolute frequency standard.

Therefore in one second the drift will be 2 x $10^{-10}$ seconds. This corresponds to approximately 0.3° subcarrier per second or once round the vectorscope in 20 minutes, assuming the vectorscope is locked to our absolute standard.

This is the short term stability, i.e. that maintained over a few hours. Over a long period the drift is given by the ageing rate, which for the oscillator used is about 2 parts in $10^8$ per month. In other words the drift of 0.3° per second at the beginning of the month is about 35° a second at the end. The solution to this is to check the oscillator against a known standard regularly.

For higher stabilities a rubidum vapour oscillator is used. This has a stability of 5 in $10^{11}$, i.e. 50ps per second, and a drift rate of 0.08° subcarrier per second, or one cycle in just over an hour.

1.2 Twice Line From 5MHz

If it's only twice line from 5MHz that's needed the solution is easy - divide by 160. Unfortunately when the unit was designed there was also a requirement for the 2H to be changed in very small increments. The smallest change in ÷ 160 (±1) resulted in changes in 2H which were far too big. As a result the ÷160 was realised by a divider-modulator system. Figure 1.1 shows this.

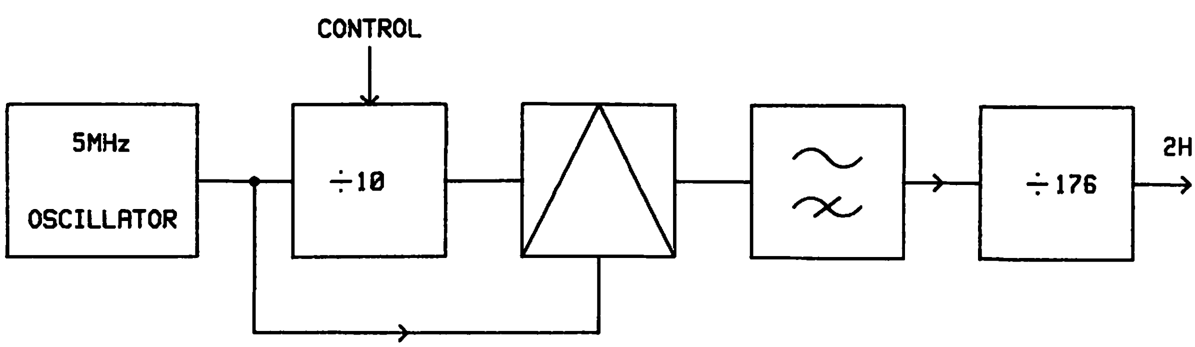


Figure 1.1: Derivation of 2H from 5MHz

Applying normal "product over sum" rules the division ratio is normally:

$$\frac{10}{11} \times 176 = 160.$$

Changing the ÷10 stage changes the overall division ratio and hence timing offsets can be introduced. If you calculate the new overall division ratios you will find that the overall change is <u>greater</u> than ±1. However the ÷10 stage cycles almost 20 times faster than the overall ÷160 stage would do. A division ratio change can therefore be applied <u>occasionally</u>, leaving the stage dividing by 10 most of the time. In this way very small overall division ratio changes can be achieved.

1.3 <u>Subcarrier by Synthesis</u>

Although there is a simple and direct relationship between 5MHz and 2H, subcarrier and 5MHz are nothing like as conveniently matched (5 ÷ 4.433.. = 1.1277..!) Subcarrier is derived in this case by frequency synthesis. Several frequencies, all multiples of a common base frequency, are added together to produce the resultant subcarrier.

The base frequency obviously has to be an integer sub-multiple of both subcarrier and 5MHz. Consider the subcarrier to line relationship:

$$CSC = \left(\frac{567}{2} + \frac{1}{4} + \frac{1}{625}\right) \times H$$

H is an integer sub-multiple of 5MHz but not of sub-carrier. Try field frequency:

$$CSC = \left(\frac{567}{2} + \frac{1}{4} + \frac{1}{625}\right) \times \frac{625}{2} \times f_{FIELD}$$

$$= \frac{709379}{8} \times f_{FIELD}$$

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Again $f_{FIELD}$ is an integral sub-multiple of 5MHz but not of subcarrier. The expression does, however, reveal a suitable frequency - 6.25 Hz, or an eighth field frequency.

i.e. CSC = 709379 x 6.25 Hz

5MHz = 800,000 x 6.25 Hz

All we have to do is synthesise the difference (90,621 x 6.25 Hz) and subtract it from 5MHz. Figure 1.2 shows how.

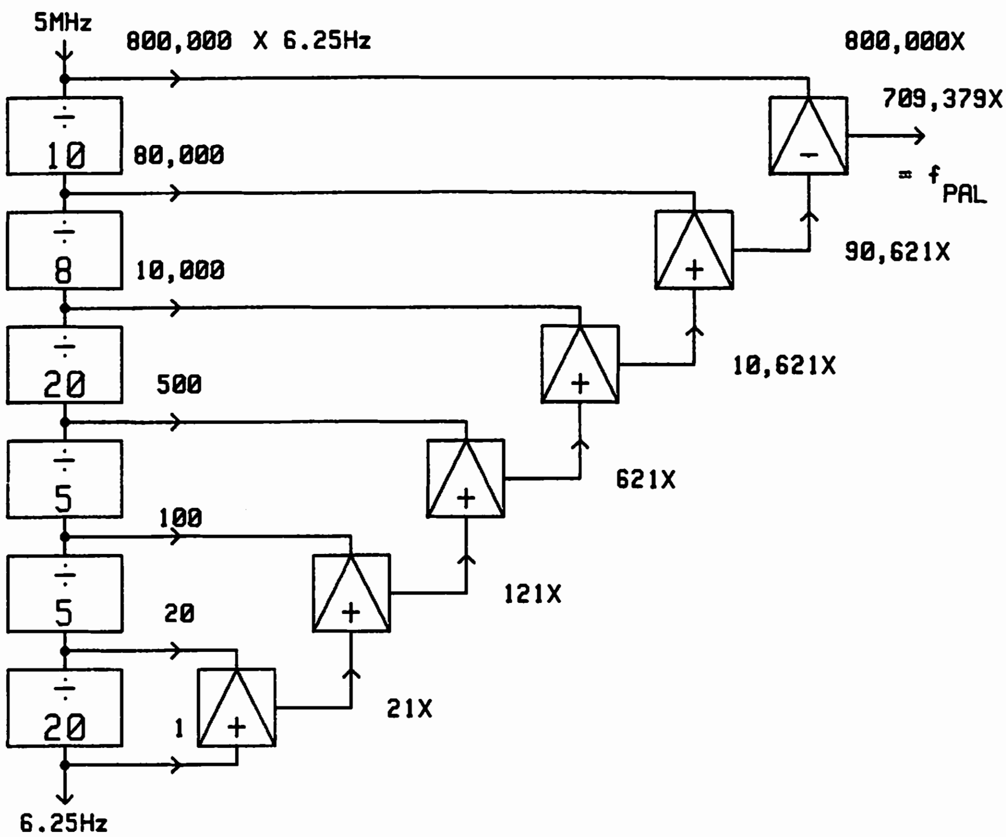


Figure 1.2: Derivation of Subcarrier from 5MHz

Figure 1.2 is fine in theory but gets a bit impracticable. The filter to select 131.25Hz (6.25Hz x 21) from the unwanted 118.75Hz (6.25Hz x 19) defies the imagination! Consequently the arrangement of figure 1.3 is used which achieves the same result with much more practicable filters.

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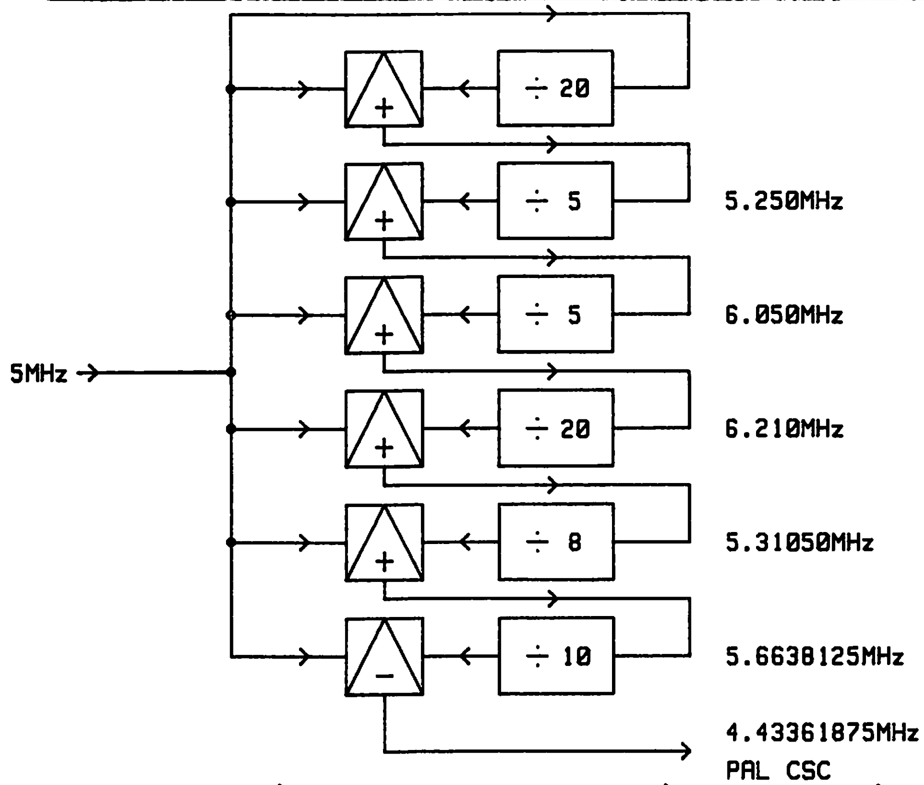



Figure 1.3: Practical 5MHz to Subcarrier Synthesiser

2. USING A TAILOR-MADE OSCILLATOR

Most commercial manufacturers prefer to use an oscillator which relates sensibly to at least one of the outputs. A good example is the Seltech 110 spg which utilises an oscillator at four times subcarrier frequency.

2.1 Subcarrier from 4 x subcarrier

Subcarrier from 4 x csc? - Simple! Yes, but let's just look ahead. This spg may well be genlocked, and you might just need to change the phase of its subcarrier output. If we're careful we can simplify the problem at this stage. Figure 2.1 shows how the division is achieved.

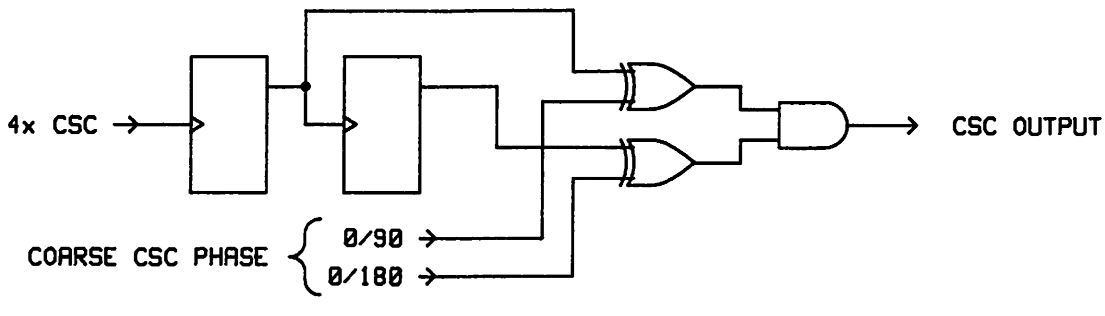



Figure 2.1: Subcarrier Divider Network

## DERIVATION OF SUBCARRIER AND TWICE LINE FREQUENCY

The two exclusive-OR gates enable the timing of the subcarrier produced at the output to be altered by steps of ±90° and ±180°. This enables a coarse phase adjustment to be made in steps of 90°.

The gate output is a 3:1 rectangular wave at logic levels. A simple monostable arrangement can be used to provide the remainder of the 90° phase shift required. A mono with a 60nS range (not 0 - 60nS, why not?) will do the trick. The output of this mono is converted to conventional sine wave by a 113nS monostable (half a cycle of subcarrier) followed by a low pass filter. Figure 2.2 shows this.

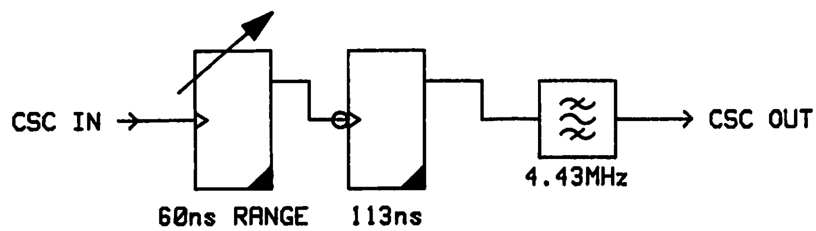



Figure 2.2: Subcarrier Fine Phasing Adjustment

### 2.2 2H As Well

The oscillator from which 2H is to be derived runs at 4 times subcarrier frequency. Remember subcarrier to line relationship:

$$CSC = \left(\frac{567}{2} + \frac{1}{4} + \frac{1}{625}\right) H$$

$$\text{or} \quad 283\tfrac{3}{4}\ H + 25Hz$$

with 4 x CSC this becomes

$$4 \times CSC = 1135H + 100Hz$$

So the problem of the quarter line has gone away, all we're left with is the 100Hz offset.

## DERIVATION OF SUBCARRIER AND TWICE LINE FREQUENCY

Seltech use an elegant solution based on one of those trigonometric identities long since forgotten. Figure 2.3 shows how.

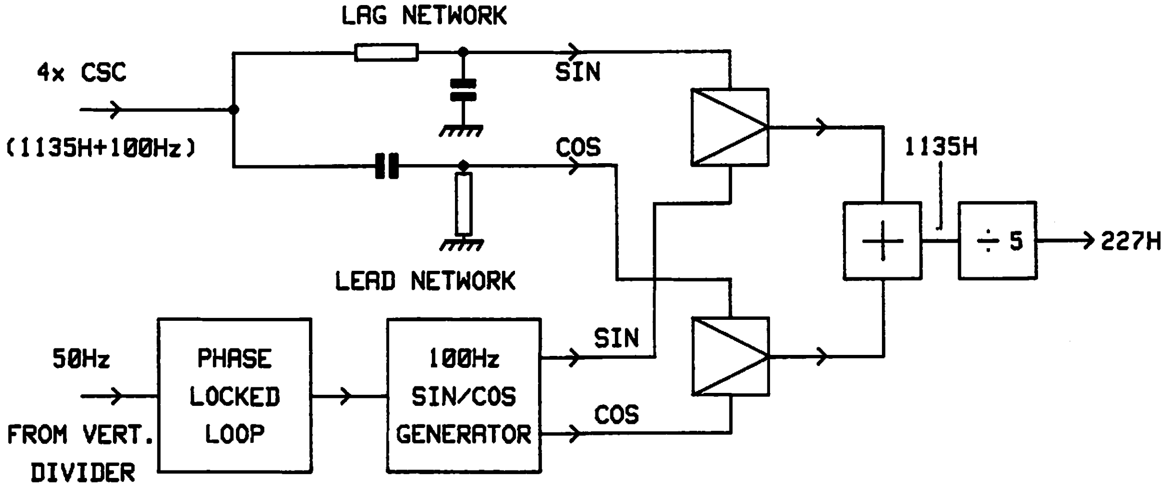



Figure 2.3:: Derivation of 2H from 4 x Subcarrier

2 Feeds of 4 x subcarrier having a sin/cos relationship are modulated with two 100Hz signals, also having a sin/cos relationship. The modulators are basically multipliers, and produce outputs which are the product of their two inputs. If the two input frequencies are called A and B then the relationship if the two modulator outputs are summed is

$$O/P = (\cos A \times \cos B) + (\sin A \times \sin B) = \cos (A - B)$$

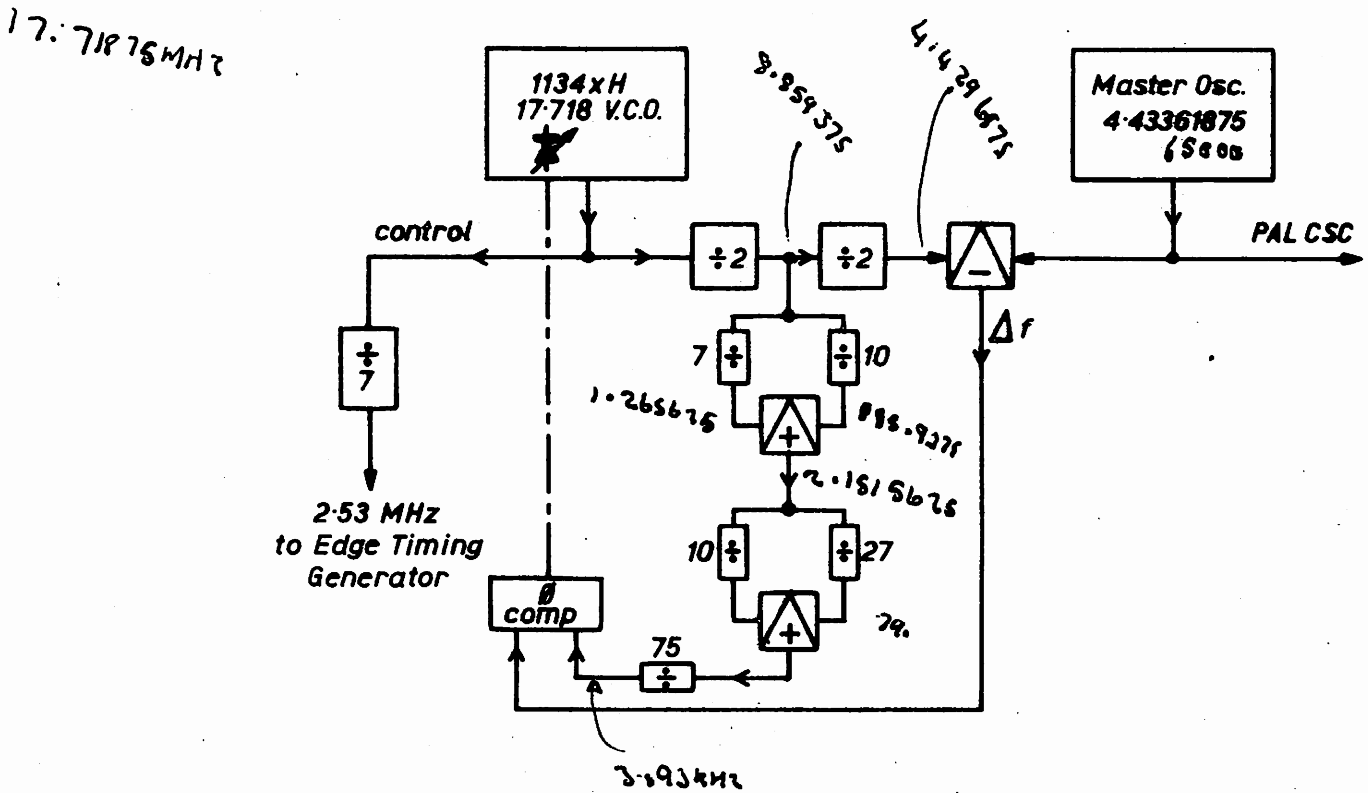
If A represents the 4 x subcarrier, and B the 100Hz, then this becomes:

$$O/P = 4 \times CSC - 100Hz = 1135H$$

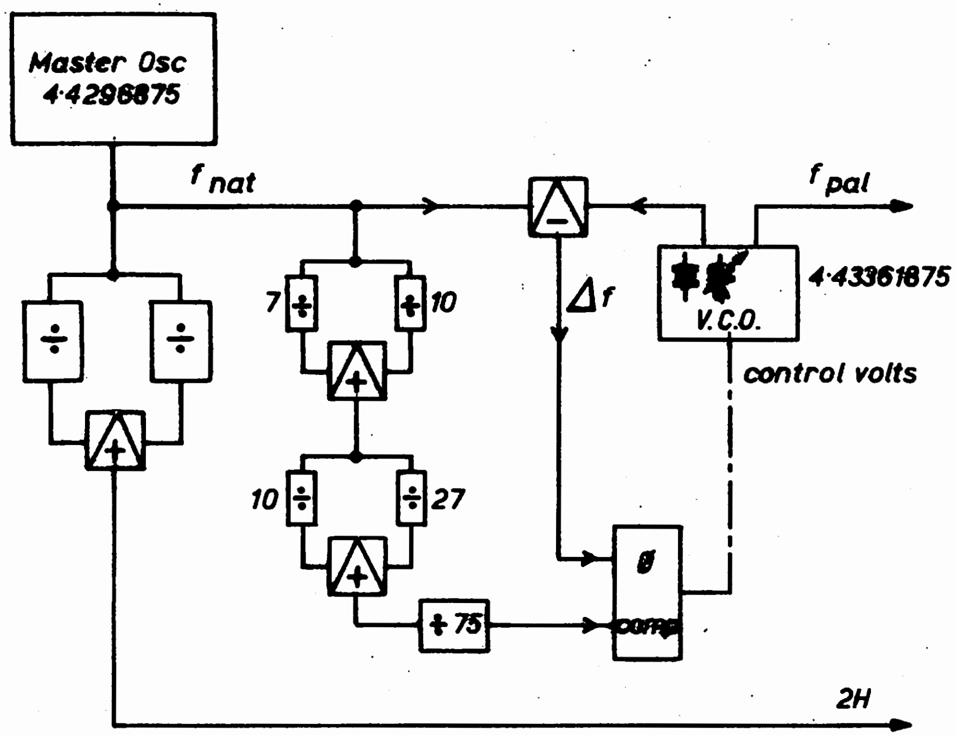
The resultant output is then divided by 5 which results in a signal at 227H. This has to be reduced to 2H, a division ratio of ÷ 113.5. You will recall from your lectures on sync pulse generation how this is achieved.

4·43361875
4·429

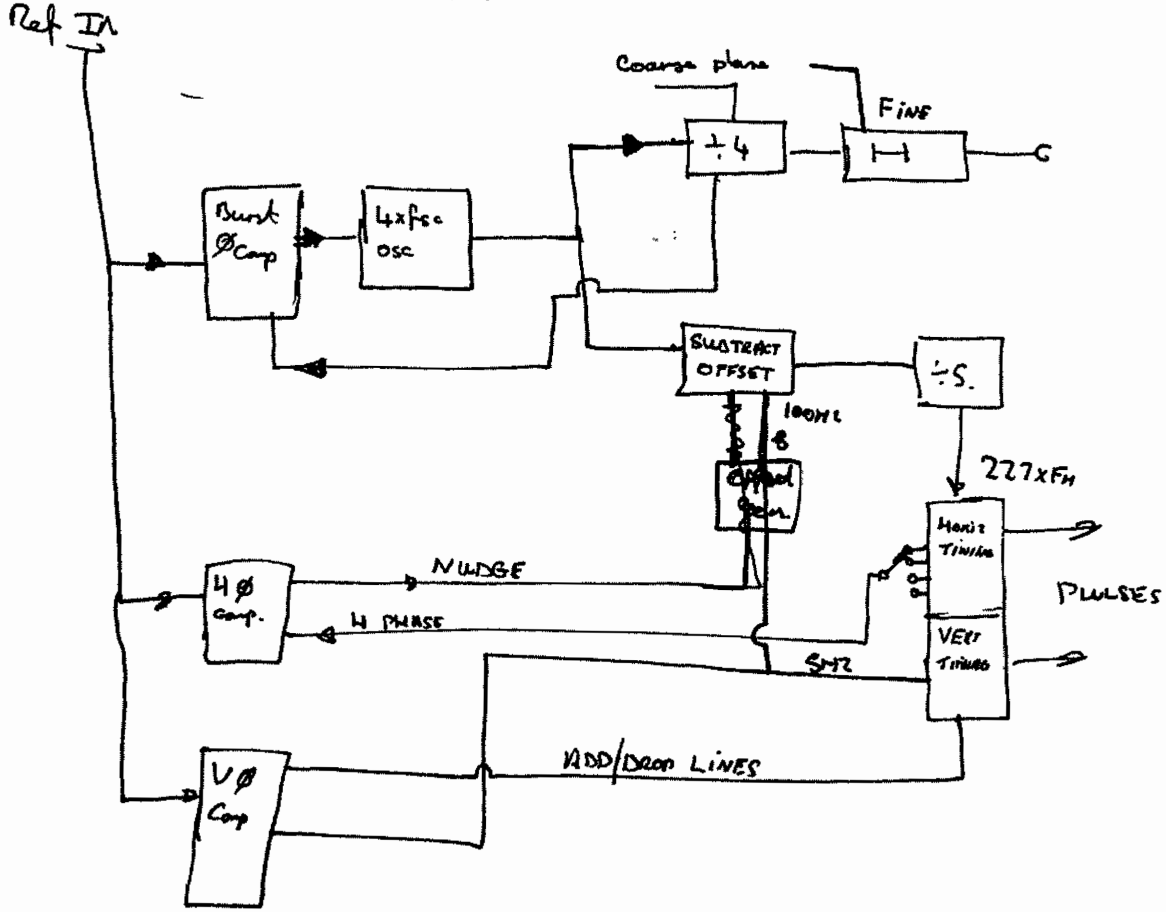
# LINK 250 SPG



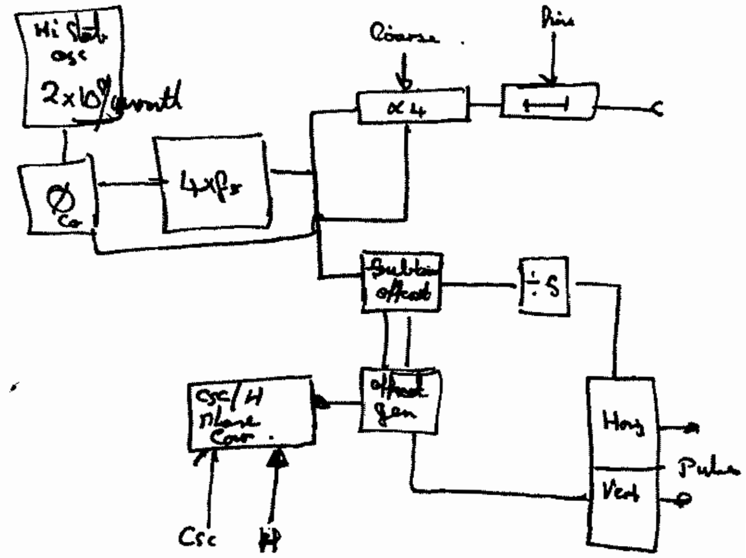
## OLD NATLOCK CSC SYNC LOCK



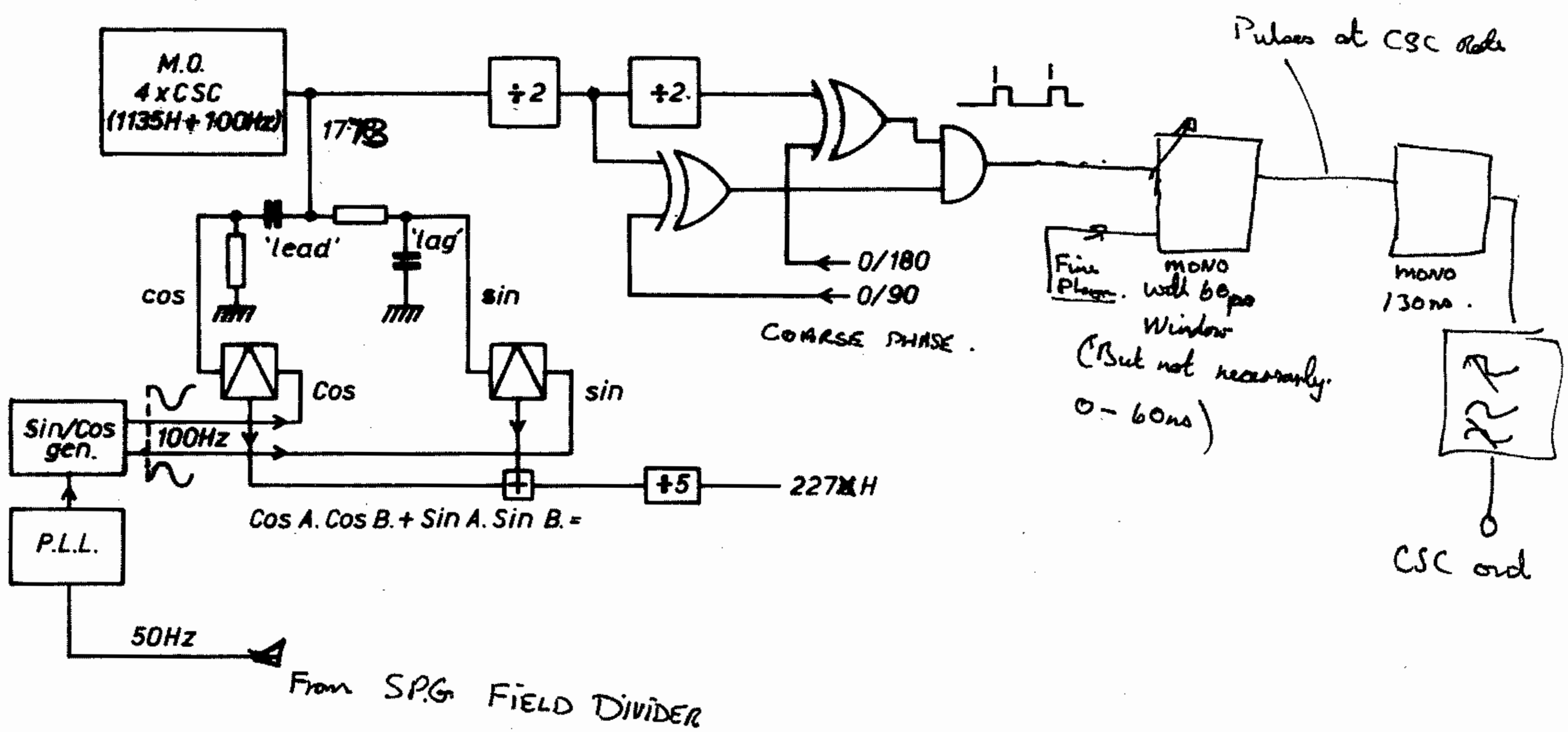
SELTECH 110 GENLOCK



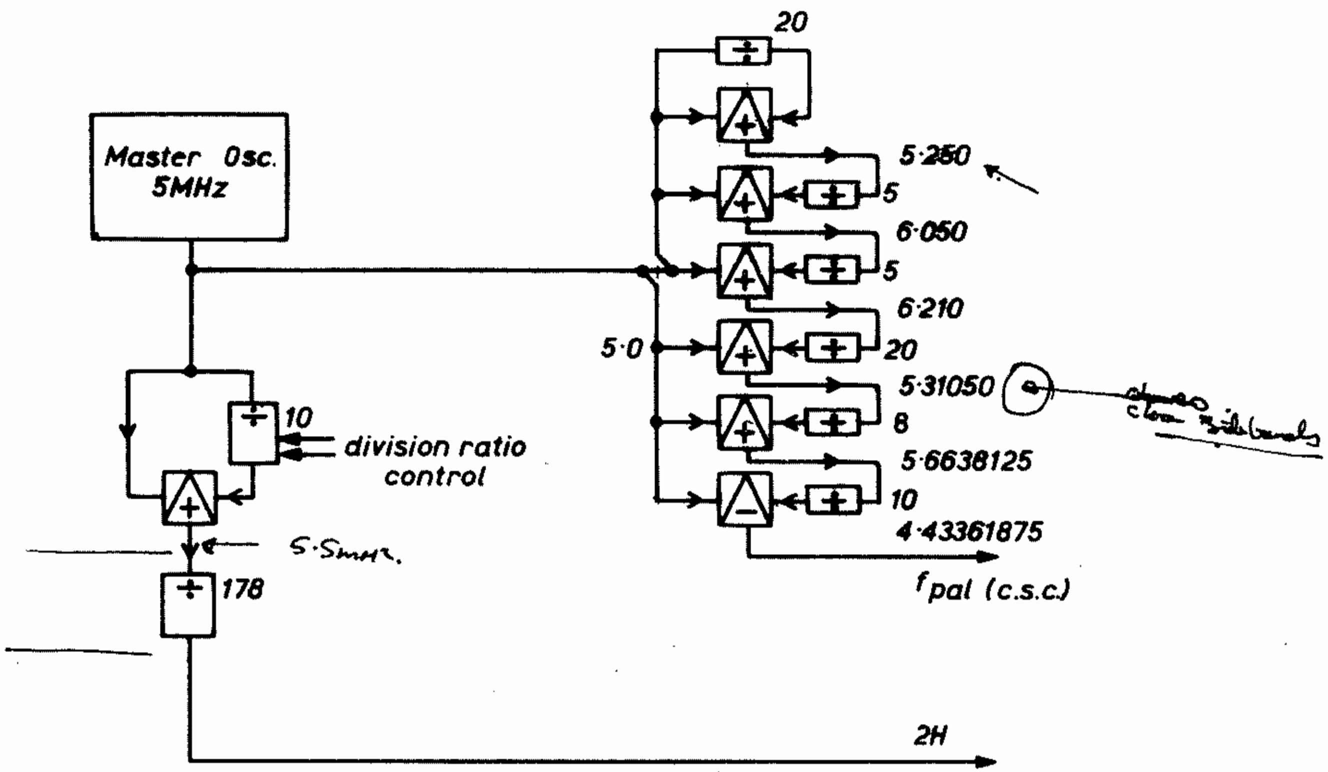

MASTER



## SELTECH 110 S.P.G.

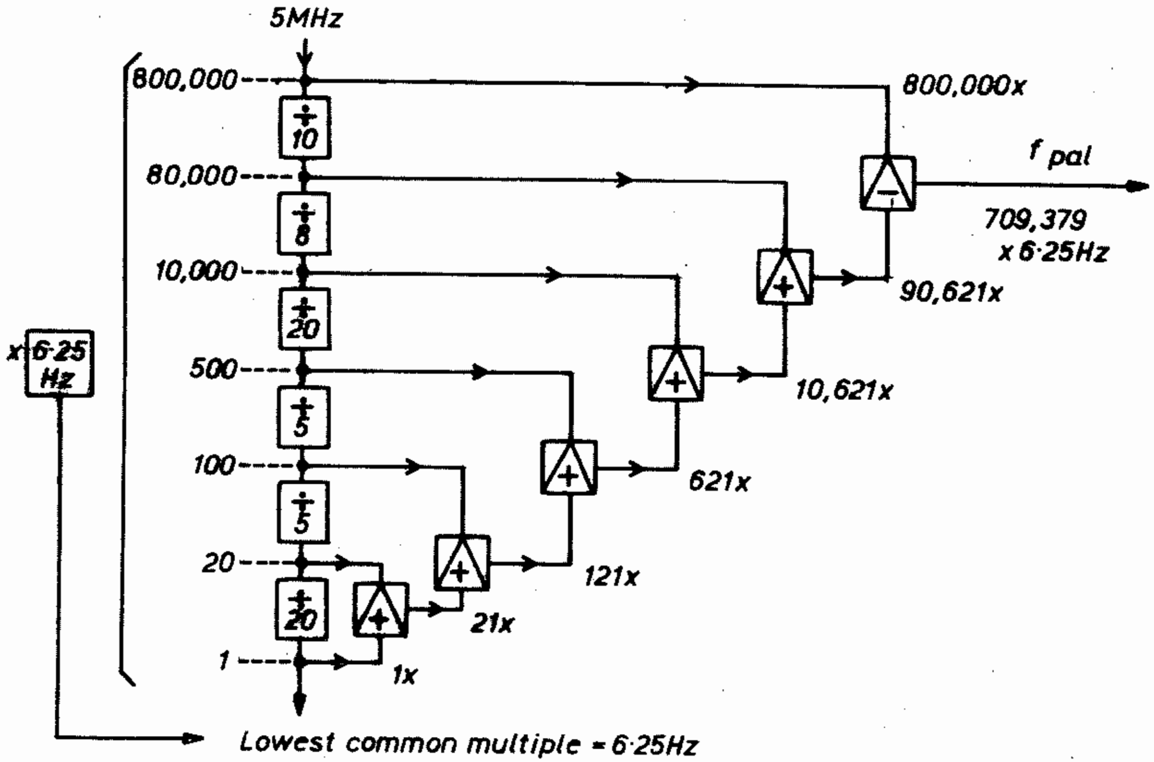


# NEW BBC NATLOCK – 5MHz M.O.




Division ratio of 160 required but 178 used because finer control available on the early mod. 10/11.

## 5MHz M.O. to C.S.C.




DELAY LINE for CSC
0 – 240 ns.
at 5ns steps

line Delay
50ns. steps.