phasor diagram of narrowband FM.

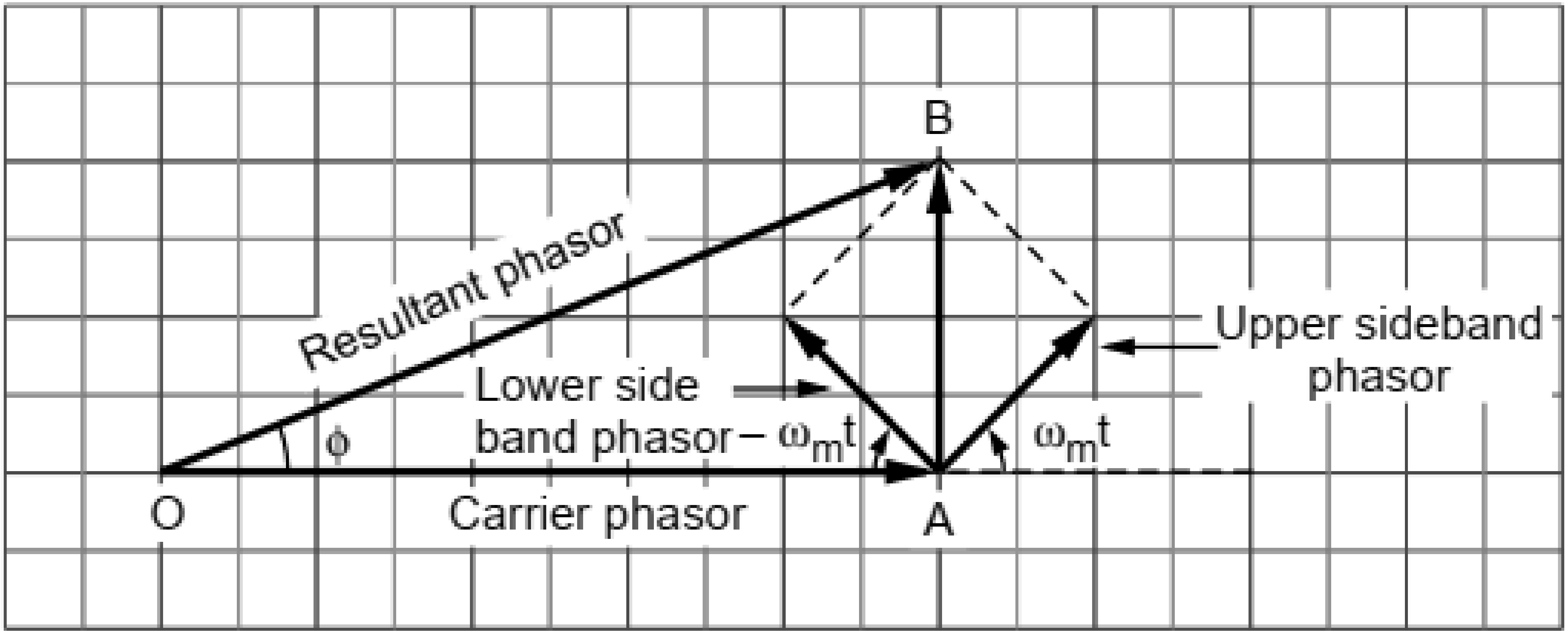

Fig. 2.3.7 shows the block diagram of WBFM modulator used to transmit audio signals containing frequencies in the range 100 Hz to 15 kHz. The desired FM signal at the transmitter output is to have a carrier frequency of 100 MHz and a minimum frequency deviation of 75 kHz. Assume the modulation index $\beta = 0.2$ *radians for NBFM. Find the frequency multiplier values* N_1, N_2 *and values of carrier frequency and frequency deviation at the various points in WBFM modulator.*

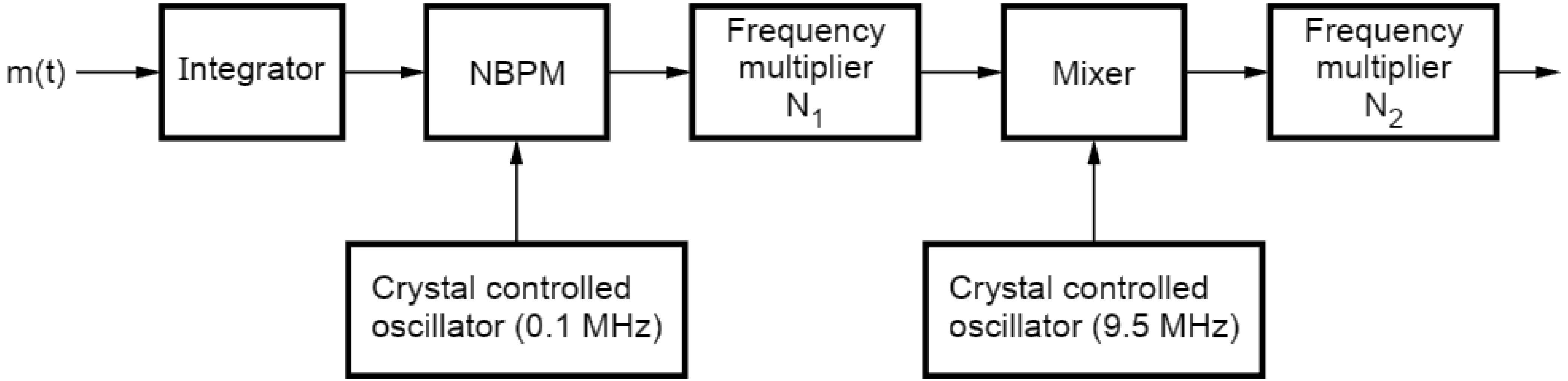

Fig. 2.3.7 Block diagram of WBFM modulator

Output frequency and deviation

$$f_c = 100 \text{ MHz} \quad \text{and} \quad \delta = 75 \text{ kHz}$$

Given data

$$f_{c_1} = 0.1 \text{ MHz} \quad f_{c_2} = 9.5 \text{ MHz}, \ m = \beta = 0.2 \text{ radians.}$$

Baseband signal frequency range = 100 Hz to 15 kHz.

Modulation index $m = \dfrac{\delta_i}{f_m}$

Here δ_i is frequency deviation before multiplication and f_m should be taken as lowest signal frequency for obtaining multiplication factor, N_1 and N_2.

Hence taking $f_m = 100$ Hz and putting for $m = \beta = 0.2$ in above equation,

$$0.2 = \frac{\delta_i}{100} \Rightarrow \delta_i = 20 \text{ Hz}$$

To obtain N_1 and N_2

Step 1 : Obtain multiplication factor for deviation.

The output frequency deviation is $\delta = 75$ kHz

The input frequency deviation is $\delta_i = 20$ Hz

$\therefore$ Multiplication factor for one shot frequency deviation is,

$$\frac{\delta}{\delta_i} = \frac{75 \text{ kHz}}{20 \text{ Hz}} = 3750$$

Hence $N_1 \cdot N_2 = 3750$

Step 2 : Oscillator and carrier frequency relationships.

- Frequency at the output of first multiplier = $N_1\left(f_{c_1}+\delta_i\right)$
- Frequency at the output of mixer = $N_1\left(f_{c_1}+\delta_i\right)-f_{c_2}$
- Frequency at the output of second multiplier

$$= N_2 \times \text{Frequency at the output of mixer}$$

$$= N_2\left\{N_1\left(f_{c_1}+\delta_i\right)-f_{c_2}\right\}$$

$$= N_1N_2f_{c_1}+N_1N_2\delta_i-N_2f_{c_2}$$

$$= \underbrace{N_1 N_2 f_{c_1}-N_2 f_{c_2}}_{\substack{\text{output carrier}\\ \text{frequency}, f_c}} + \underbrace{N_1 N_2 d_i}_{\substack{\text{output frequency}\\ \text{deviation}, \delta}}$$

Step 3 : Values of N_1 and N_2

Thus $$f_c = N_1 N_2 f_{c_1} - N_2 f_{c_2}$$

Putting values in above equation,

$$100 \text{ MHz} = 3750 \times 0.1 \text{ MHz} - N_2 \times 9.5 \text{ MHz}$$

$$\therefore \quad N_2 = 28.94$$

and from equation (2.3.8), $N_1 = \dfrac{3750}{N_2} = \dfrac{3750}{28.94} = 129.58$

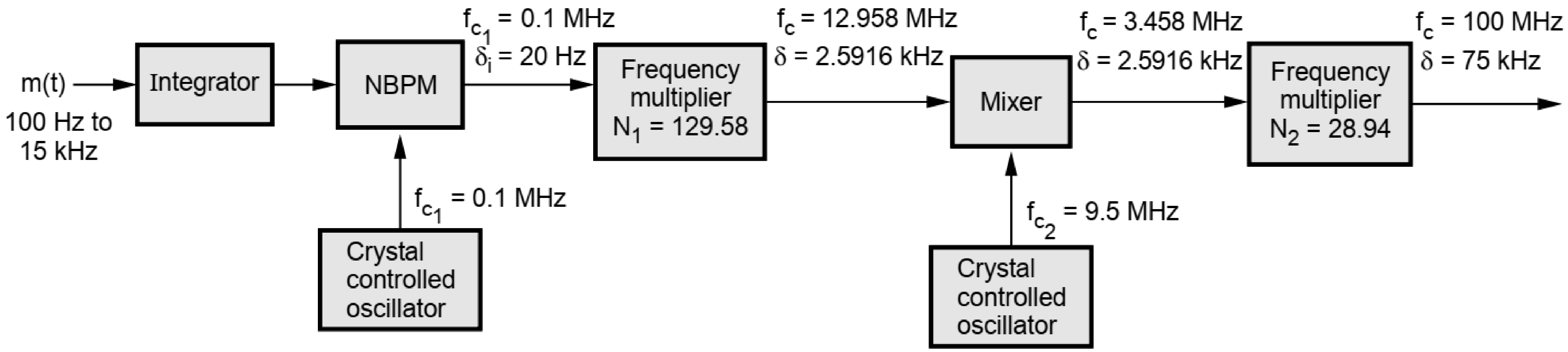

Fig. 2.3.8 : WBFM modulator with stage wise values of f_c and δ