shifters

A barrel shifter performs a right rotate operation. It handles left rotations using the complementary shift amount. Barrel shifters can also perform shifts when suitable masking hardware is included. Barrel shifters come in array and logarithmic forms. The logarithmic barrel shifters are most useful because they are better suited for large shifts. Fig.4.2 (a) shows a simple 4-bit barrel shifter that performs right rotations. Unlike funnel shifters, barrel shifters contain long wrap-around wires.

In a large shifter, it is necessary to upsize or buffer the drivers for these wires. Fig.4.2 (b) shows an enhanced version that can rotate left by prerotating right by 1, then rotating right by k. Performing logical or arithmetic shifts on a barrel shifter requires a way to mask out the bits that are rotated off the end of the shifter, as shown in fig 4.2.
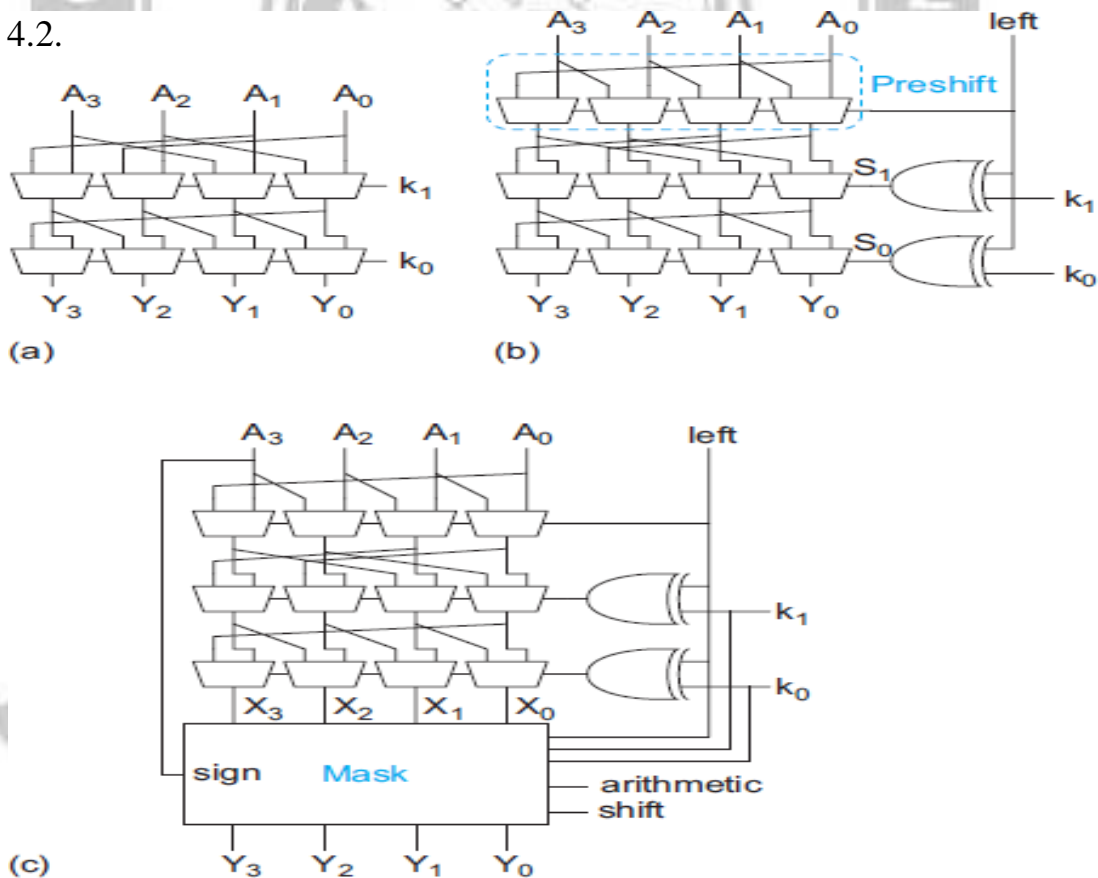
Fig.4.3.1 shifters: (a) rotate right, (b) rotate left or right, (c) rotates and shifts

Source: Jan M. Rabaey ,Anantha Chandrakasan, Borivoje. Nikolic, ‖Digital Integrated Circuits:A Design perspective]

Fig.4.3.1 shows a 32-bit barrel shifter using a 5:1 multiplexer and an 8:1 multiplexer. The first stage rotates right by 0, 1, 2, 3, or 4 bits to handle a pre-rotate of 1 bit and a fine rotate of up to 3 bits combined into one stage. The second stage rotates right by 0, 4, 8, 12, 16, 20, 24, or 28 bits. The critical path starts with decoding the shift amount for the first stage. If the shift amount is available early, the delay from A to Y improves substantially.
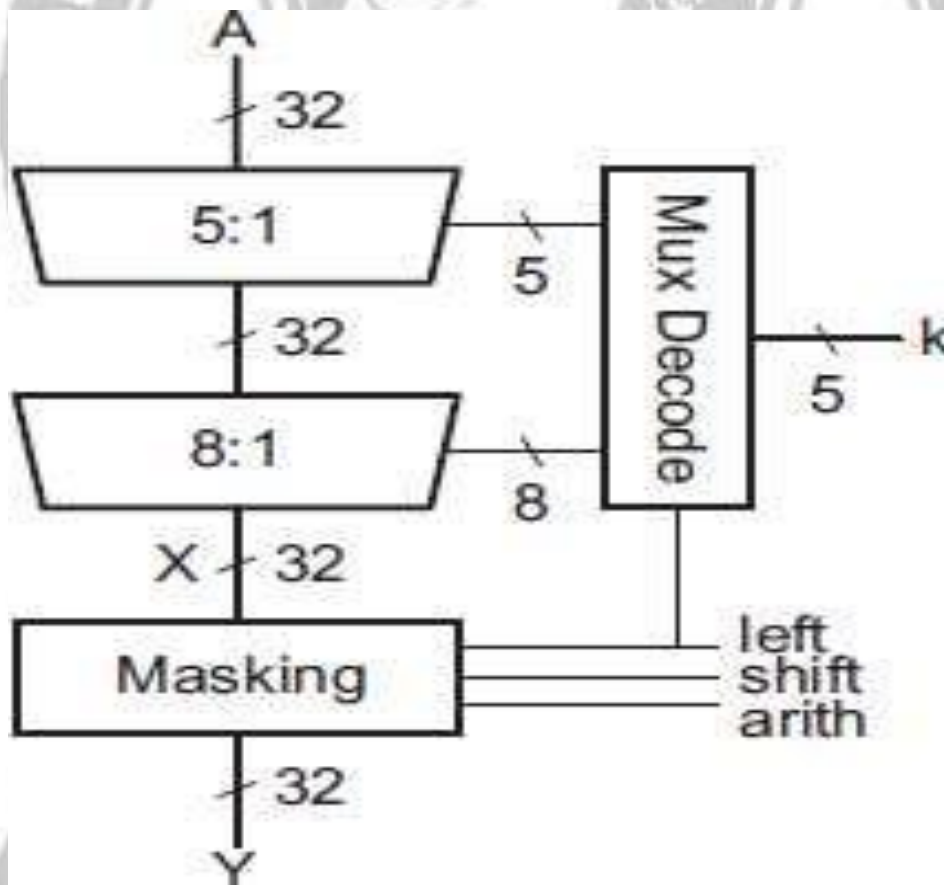

Fig.4.3.2: 32-bit logarithmic barrel shifter

[Source: Wayne Wolf, ―Modern VLSI Design: System On Chip]

While the rotation is taking place, the masking unit generates an N-bit mask with ones where the kill value should be inserted for right shifts. For a right shift by m, the m most significant bits are ones. This is called a thermometer code. When the rotation result X is complete, the masking unit replaces the masked bits with the kill value. For left shifts, the mask is reversed.
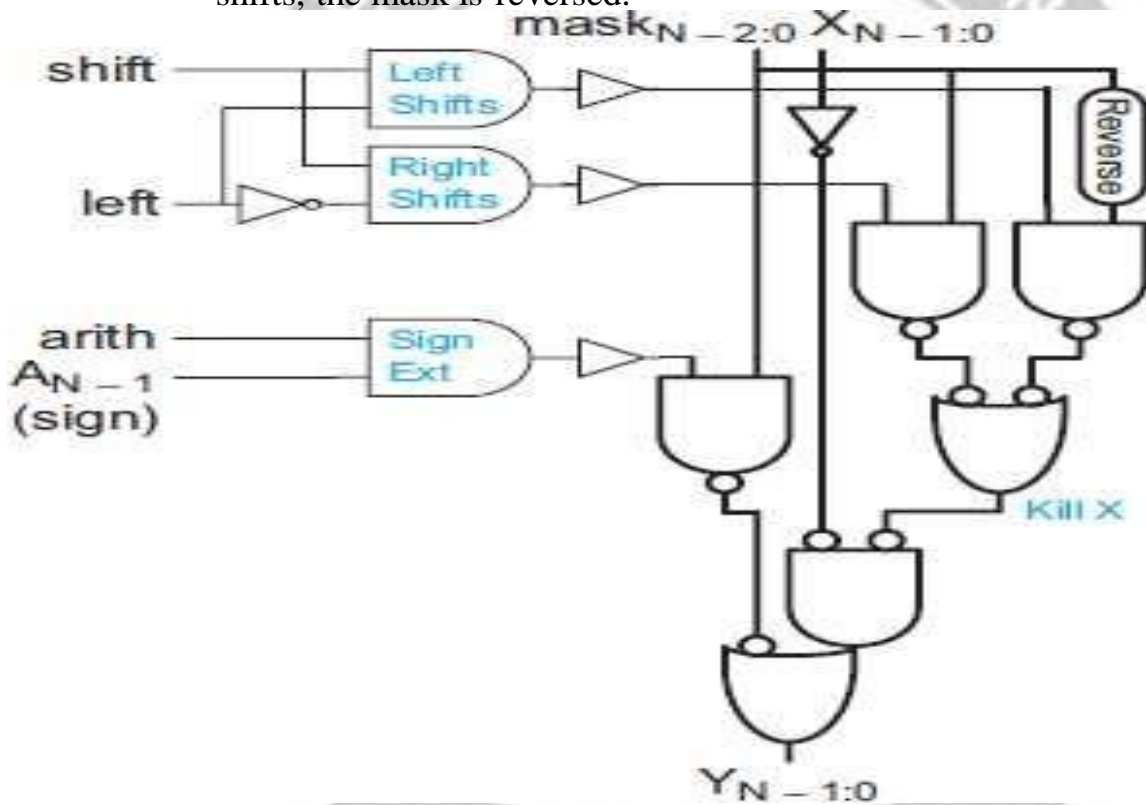
Fig.4.3.3: Barrel shifter masking logic

[Source: Wayne Wolf, ―Modern VLSI Design: System On Chip]