



US005940450A

United States Patent [19]

Koslov et al.

[11] Patent Number: **5,940,450**

[45] Date of Patent: **Aug. 17, 1999**

- [54] **CARRIER RECOVERY METHOD AND APPARATUS**
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- [73] Assignee: **Hitachi America, Ltd.**, Tarrytown, N.Y.
- [21] Appl. No.: **08/807,565**
- [22] Filed: **Feb. 28, 1997**
- [51] Int. Cl.⁶ **H04L 27/06**
- [52] U.S. Cl. **375/344; 375/326; 375/329; 375/331**
- [58] Field of Search **375/326, 327, 375/340, 329, 324, 334, 325, 371, 375, 344, 260**

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Assistant Examiner—Bayard Emmanuel
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[57] ABSTRACT

Improved carrier recovery methods and apparatus suitable for use with QAM, QPSK and a wide variety of other modulation formats is described. In accordance with the invention, the phase error between received symbols, representing a frequency error, is determined using one of a plurality of techniques. The estimated frequency error is used to adjust the phase and/or frequency of a received carrier signal to achieve a frequency lock. The methods and apparatus of the present invention can be easily integrated into existing carrier recovery designs to supplement known frequency In accordance with a first embodiment of the present invention, the receipt of pairs of consecutive outer symbols is detected, a frequency error associated with each pair of consecutive symbols is generated, and the frequency error is compared to a selected threshold value to determine if it is a non-ambiguous estimate of the frequency error. If the frequency error is non-ambiguous and from a pair of consecutive outer symbols, it is used to adjust the frequency and/or phase of a received carrier signal. In the second embodiment, the receipt of pairs of consecutive outer symbols are detected. An estimate of the frequency error, determined as the phase error between received symbols, is made in the second embodiment by doing a symbol to symbol, as opposed to a symbol to target comparison.

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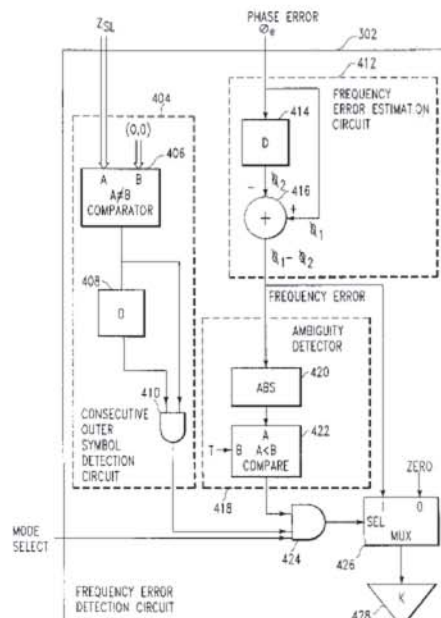
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26 Claims, 7 Drawing Sheets



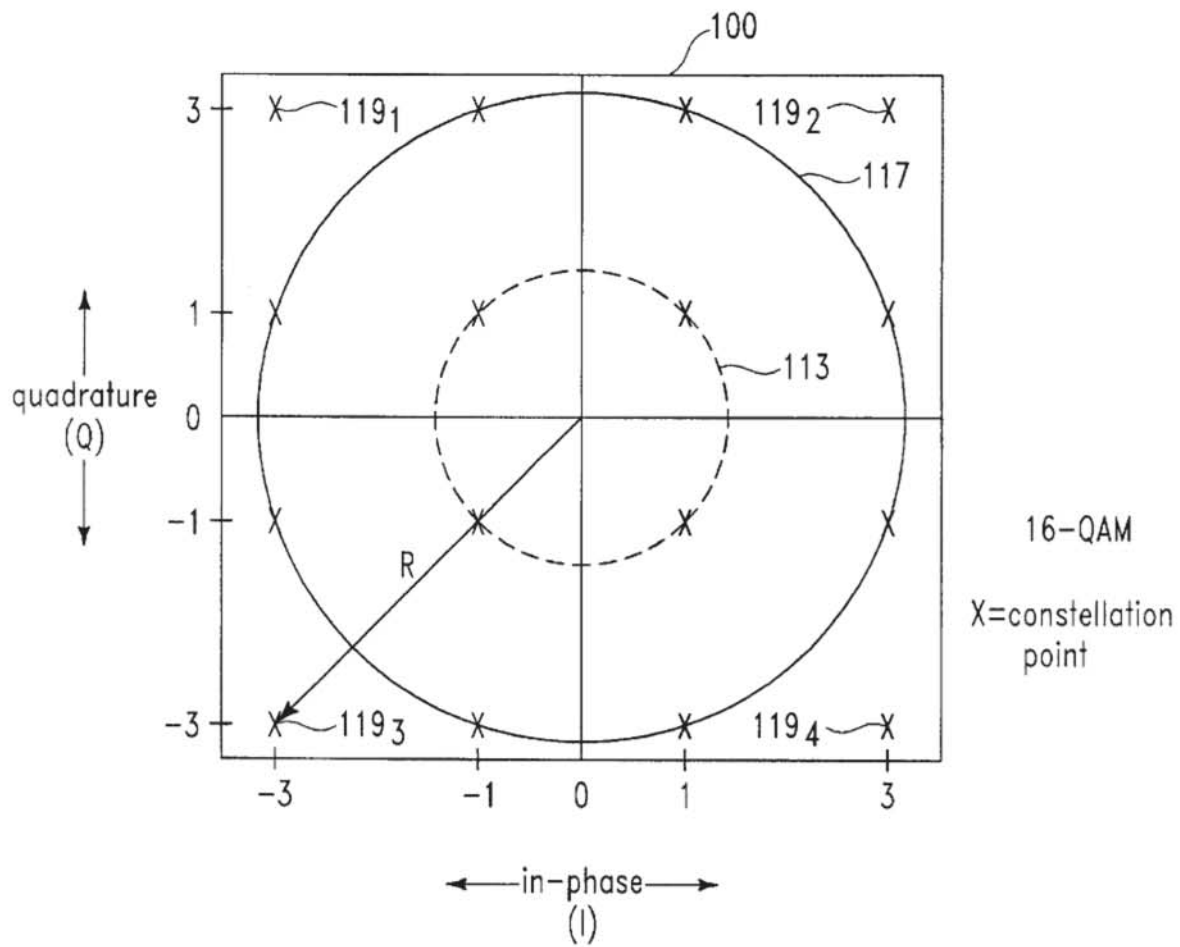
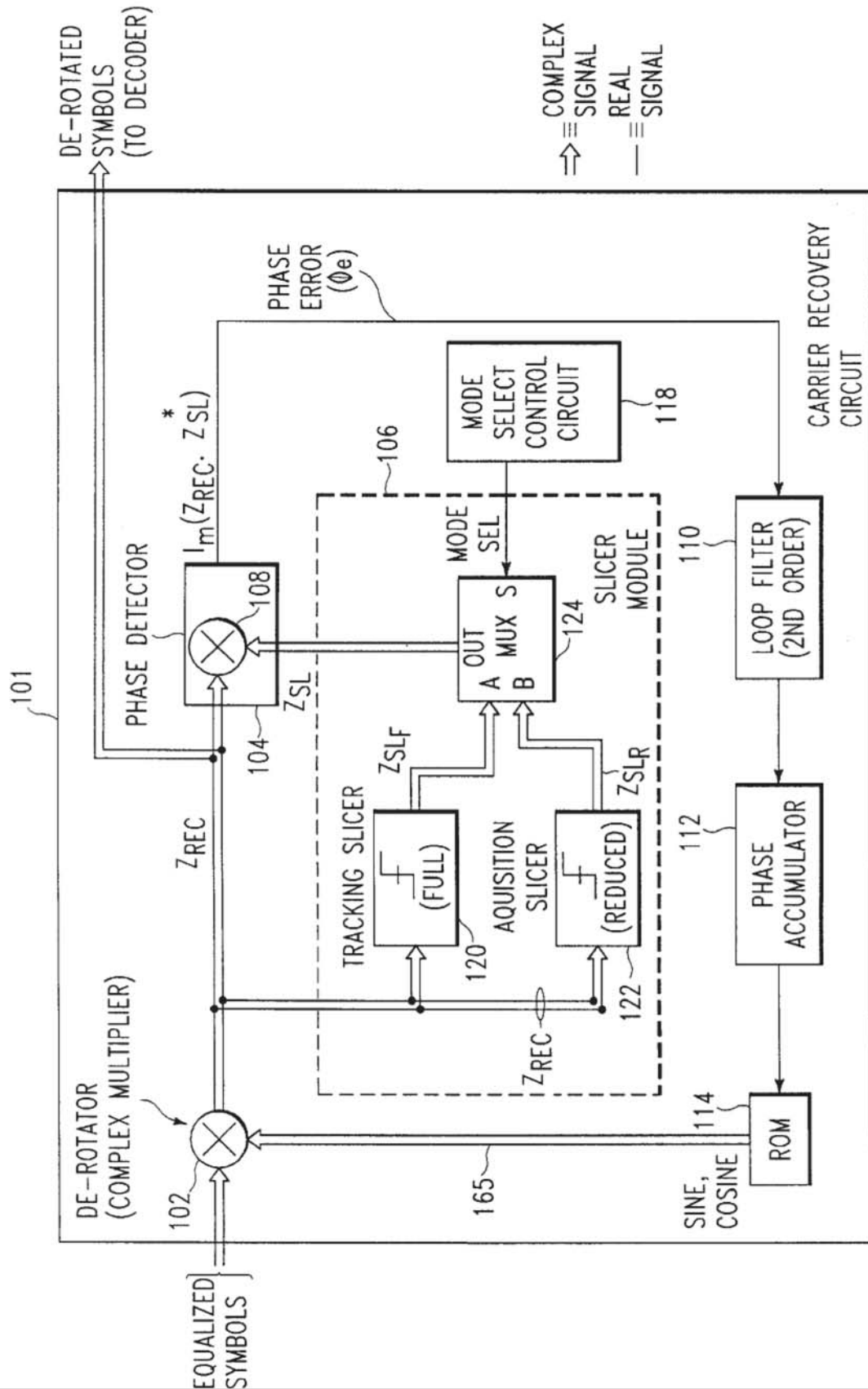


FIG. 1 PRIOR ART



\Rightarrow COMPLEX SIGNAL
 \rightarrow REAL SIGNAL

FIG. 2 PRIOR ART

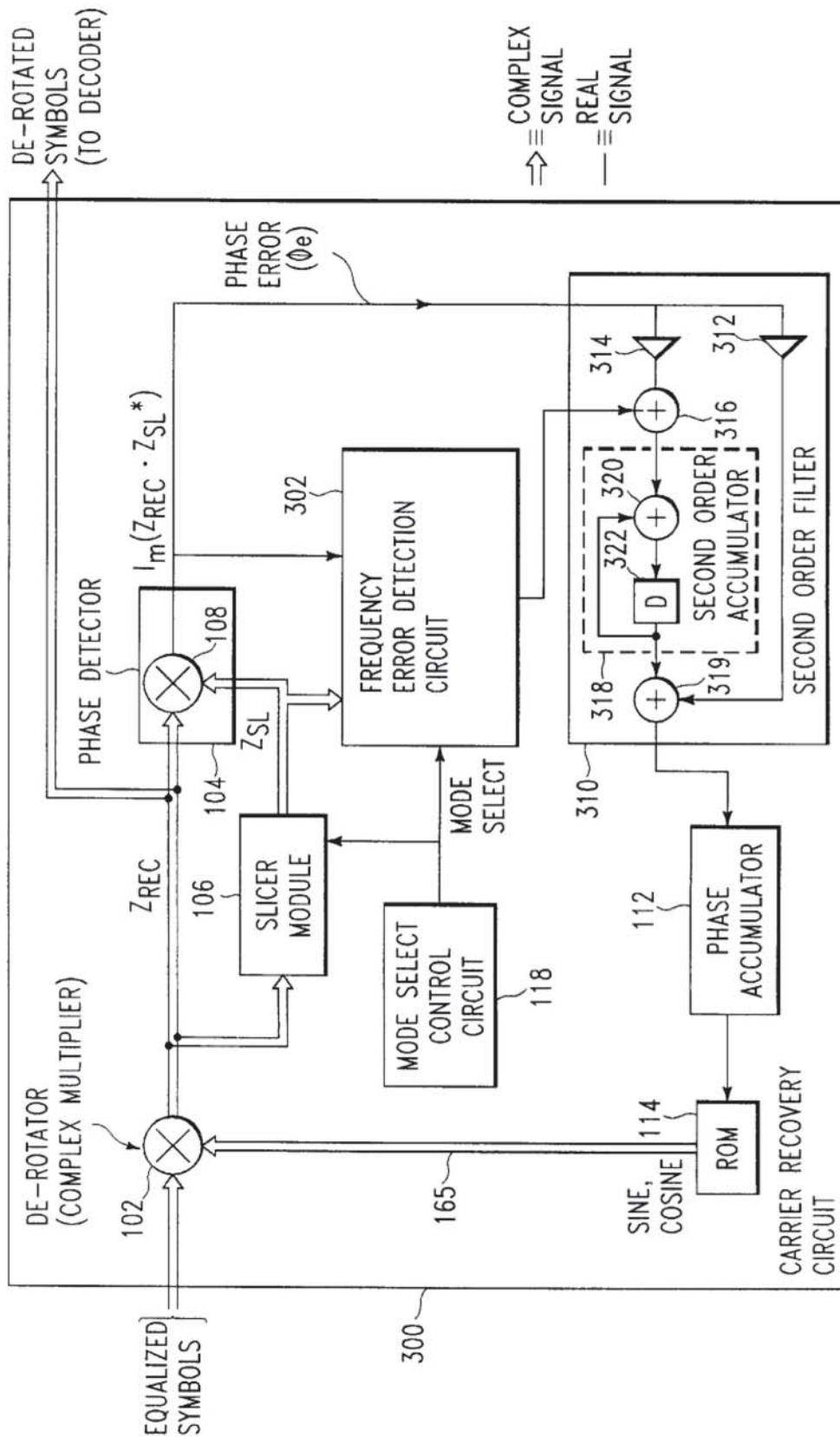


FIG. 3

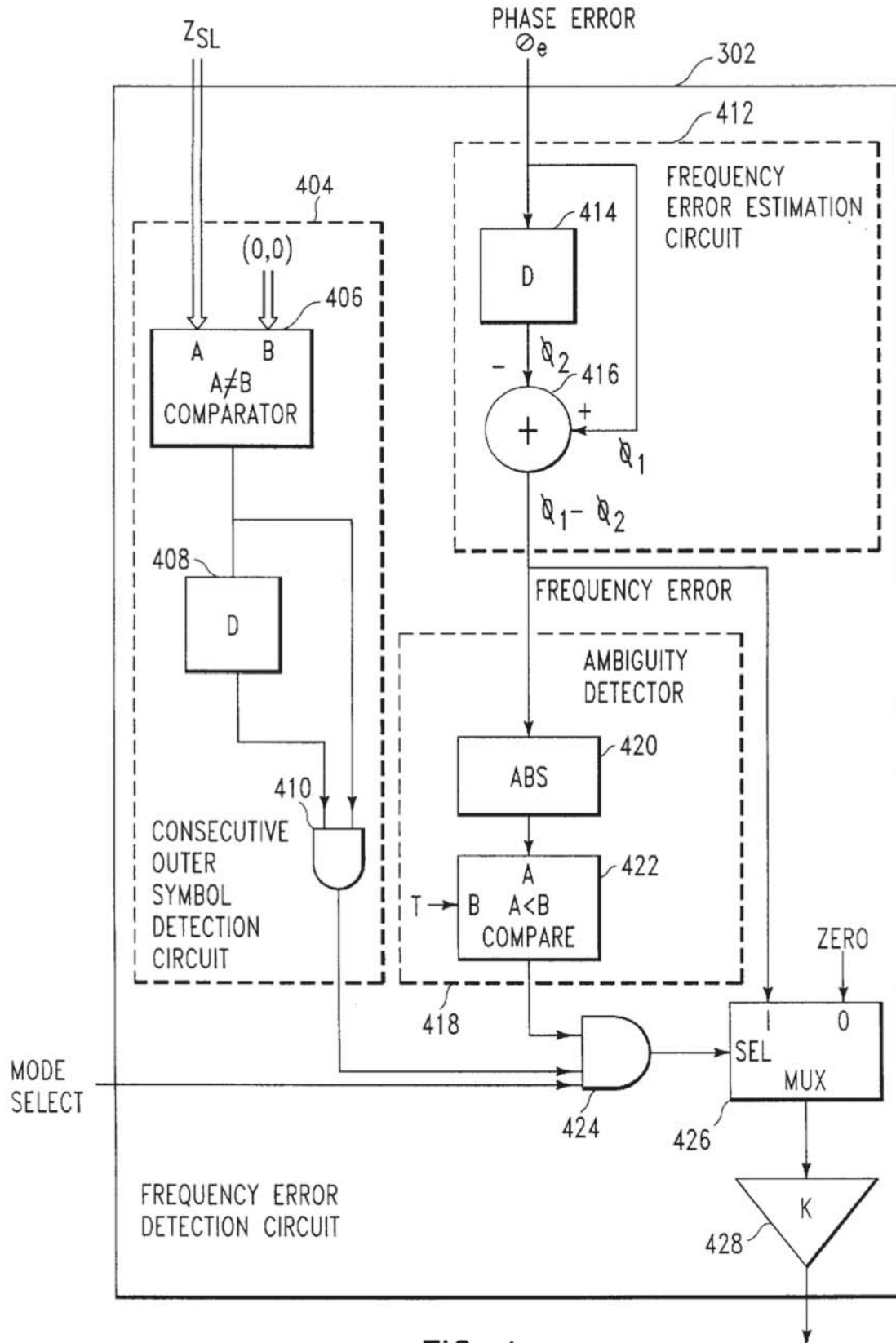


FIG. 4

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