Another source of distortion is due to the phase modulation produced by the ac components in the LPF output. The second harmonic distortion is approximately proportional to the level of the fundamental component, and the third harmonic distortion proportional to the level of the second harmonic component; higher harmonics are generally negligible. In order to keep the ac components low, additional filtering may be necessary, or a sampler-type phase detector rather than the flip-flop type should be considered.

E. Channel Crosstalk

For multichannel applications, such as phase measurement, the sampling pulses are generated from a common source in order to achieve coherence. The pulses are then fed to each sampler through a pair of transmission lines. Thus, a signal from one channel can be coupled to another channel through the pulse generator. This is significant when the phase difference between signals of a large-level difference are to be measured, since the accuracy of phase measurement is limited by the channel crosstalk. Because of the resonance of the transmission lines, channel crosstalk is also frequency sensitive. Variation of about 20 dB was observed as a function of the input frequency. In an experimental circuit designed by J. Alonzo, channel crosstalk of less than -90 dB was achieved [7].

Applications

With the basic sampling phase-lock loop, measurements of RF signals can now be made with a constant low-frequency readout circuit. Typical measurements which can be made are:

1) Phase difference.
2) Level.
3) Harmonics and distortion.
4) Amplitude modulation.

When properly adjusted, phase difference of less than a degree at 1000 Mc/s can be measured. For level measurement, if the input level is larger than 1 mV, either one or two channels can be used. But for input level less than 1 mV, both channels are necessary. Channel 1 is used to synchronize the system to a high-level signal, and channel 2 is used to probe the low-level signal. With a narrow band-pass filter at the output, levels as low as 1 μV can be measured.

The most outstanding features common to the phase-locked sampling instruments are:

1) Fully automatic.
2) Wide frequency coverage.
3) High input impedance (typically 100 kΩ shunted by 2 pF).
4) Constant low-frequency readout circuit.

However, the phase-locked sampling instruments are not without certain limitations. In addition to those discussed before, the following should be emphasized:

1) Signal level should be such that the effect of random noise on the output phase is negligible. Typically, 1 mV is required to assure synchronization.
2) Signal source should have very low-phase jitter.
3) Signal source should be able to tolerate the small sampling pulse which can not be completely balanced out.

An experimental system using only semiconductor devices has been constructed. For input frequencies from 1 Mc/s to 1000 Mc/s, synchronization is readily obtained. The signal sources used are the Hewlett-Packard 606, 608, and 612 Signal Generators. Synchronization was achieved for harmonic frequencies of a crystal oscillator as high as 2200 Mc/s. However, the amplitude response was poor, since the sampler used had a bandwidth of about 1000 Mc/s.

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