Claims

1. An integrated oscillator circuit comprising:

an oscillator configured to be switched between a first frequency and a second frequency; and

switching means configured to receive an input representative of a target frequency and to switch the oscillator between the first and second frequencies at intervals determined by the input so as to cause the average output frequency of the oscillator to approximate the target frequency.

2. An integrated oscillator circuit as claimed in claim 1 wherein a higher one of the first and second frequencies is less than double a lower one of the two frequencies.

3. An integrated oscillator circuit as claimed in claim 2 wherein the higher of the first and second frequencies is less than 10 percent higher than the lower of the two frequencies.

4. An integrated oscillator circuit as claimed in any preceding claim wherein one of the first and second frequencies is incrementally adjustable, and wherein the difference between the first and second frequencies is wider than a smallest increment by which said frequency can be adjusted.

5. An integrated oscillator circuit as claimed in any preceding claim wherein the switching means is configured to receive an input comprising or encoding a value indicating a switching ratio between the first and second frequencies.

6. An integrated oscillator circuit as claimed in any preceding claim comprising a calibration controller configured to provide the input representative of the target frequency to the switching means and further configured to calibrate the oscillator at intervals in order to provide an updated input to the switching means.

7. An integrated oscillator circuit as claimed in claim 6 wherein the calibration controller is configured to count oscillator output cycles over a reference time period

for each of the first and second frequencies, and to derive an input to the switching means from these counts.

8. An integrated oscillator circuit as claimed in any preceding claim comprising means for calibrating the oscillator against a reference clock.

9. An integrated oscillator circuit as claimed in claim 8, configured to output a clock signal derived from a crystal oscillator while the oscillator is being calibrated, and to output a clock signal derived from the oscillator configured to be switched between a first frequency and a second frequency when the circuit is not being calibrated.

10. An integrated oscillator circuit as claimed in any preceding claim comprising charge-storing means whose capacitance can be varied between a first value and a second value; and a current source connected to the charge-storing means, to form an oscillator configured to oscillate at the first frequency when said capacitance is equal to the first value, and at the second frequency when the capacitance is equal to the second value, wherein the switching means is configured to switch the charge-storing means between the first and second capacitance values at intervals determined by the input.

11. An integrated oscillator circuit as claimed in claim 10 wherein the charge-storing means comprises a first capacitor that is permanently connected into the oscillator circuit, and a second capacitor that is selectively connectable into the circuit.

12. An integrated oscillator circuit as claimed in claim 10 wherein the charge-storing means comprises first and second capacitors having respective first and second capacitances, and a switch arranged to connect one or other of the first capacitor and the second capacitor into the oscillator circuit at a time.

13. An integrated oscillator circuit as claimed in any preceding claim wherein the switching means is configured to distribute first-frequency cycles among second-frequency cycles according to a predetermined pattern or dispersion characteristic.

14. An integrated oscillator circuit as claimed in any preceding claim wherein the switching means comprises a sigma-delta modulator, arranged to distribute frequency cycles at the first frequency as uniformly as possible among frequency cycles at the second frequency, over a finite time period.

15. An integrated oscillator circuit as claimed in any preceding claim comprising a programmable current source, wherein the oscillator is arranged so that the value of one or both of the first and second frequencies depends on the level of a variable current within the oscillator circuit.

16. A method of operating an integrated-circuit oscillator, wherein the oscillator is configured to be switched between a first frequency and a second frequency, the method comprising:

receiving an input representative of a target frequency; and

switching the oscillator between the first and second frequencies at intervals determined by the target frequency so as to cause the average output frequency of the oscillator to approximate the target frequency.

17. A method as claimed in claim 16 wherein a higher one of the first and second frequencies is less than double a lower one of the two frequencies.

18. A method as claimed in claim 17 wherein the higher of the first and second frequencies is less than 10 percent higher than the lower of the two frequencies.

19. A method as claimed in any of claims 16 to 18 wherein the target frequency has a value between the first and second frequencies.

20. A method as claimed in any of claims 16 to 19 wherein the input comprises or encodes a value indicating a switching ratio between the first and second frequencies.

21. A method as claimed in any of claims 16 to 20 further comprising calibrating the oscillator at intervals to generate an updated input representative of the target frequency.

22. A method as claimed in any of claims 16 to 21 comprising counting oscillator output cycles over a reference time period for each of the first and second frequencies, and deriving an input representative of the target frequency from these counts.

23. A method as claimed in any of claims 16 to 22 comprising calibrating the oscillator against a reference clock.

24. A method as claimed in any of claims 16 to 23 comprising switching the oscillator so as to distribute first-frequency cycles among second-frequency cycles according to a predetermined pattern or dispersion characteristic.

25. A method as claimed in any of claims 16 to 24 comprising coarsely calibrating the oscillator by adjusting the values of the first or second frequencies so that they span the target frequency.

26. A method as claimed in claim 25 wherein said adjusting of the values comprises adjusting a current source.

27. A method as claimed in claim 25 or 26 comprising performing said coarse calibration when the integrated-circuit oscillator is powered up.

28. An integrated circuit comprising an integrated oscillator circuit according to any of claims 1 to 15 and further comprising a microprocessor.

29. An integrated circuit as claimed in claim 28 comprising a further clock source, wherein the circuit is configured to provide an output which can be switched between an output of the oscillator circuit and an output of the further clock source.

30. An integrated circuit as claimed in claim 28 or 29 configured to calibrate the oscillator in response to the microprocessor waking up.

31. An integrated circuit comprising an integrated oscillator circuit, a crystal oscillator, a power-management component and a calibration component, wherein the power-management component is configured to turn the crystal oscillator on

when one or more criteria are met, wherein the calibration controller is configured to calibrate the integrated oscillator against the crystal oscillator when the crystal oscillator is turned on.

32. An integrated circuit as claimed in claim 31, comprising an integrated oscillator circuit according to any of claims 1 to 15.

33. An integrated circuit as claimed in claim 31 or 32, further comprising a microprocessor arranged to receive a clock signal from the crystal oscillator, wherein the circuit is arranged to turn on the microprocessor at or around the same time as the crystal oscillator is turned on.

34. An integrated circuit comprising an integrated oscillator circuit, a crystal oscillator, a timer, and a calibration component arranged to calibrate the integrated oscillator against the crystal oscillator at intervals, wherein the integrated circuit is configured so that the timer receives a clock signal derived from the integrated oscillator except when the integrated oscillator is being calibrated, during which time the timer receives a clock signal derived from the crystal oscillator.

35. An integrated circuit as claimed in claim 34 configured so that the timer receives clock signals of substantially the same frequency when being calibrated as when not being calibrated.

36. An integrated circuit as claimed in any of claims 28 to 35, comprising circuitry forming all or part of a radio transmitter or receiver configured to transmit or receive radio packets according to a schedule implemented using the integrated oscillator as a clock source.

Claims

1. An integrated oscillator circuit comprising:

an oscillator configured to be switched between a first frequency and a second frequency;

switching means configured to receive an input representative of a target frequency and to switch the oscillator between the first and second frequencies at intervals determined by the input so as to cause the average output frequency of the oscillator to approximate the target frequency; and

means for calibrating the oscillator against a reference clock,

wherein the circuit is configured to output a clock signal derived from a crystal oscillator while said oscillator is being calibrated, and to output a clock signal derived from said oscillator when the circuit is not being calibrated.

2. An integrated oscillator circuit as claimed in claim 1 wherein the reference clock is the crystal oscillator.

3. An integrated oscillator circuit as claimed in claim 1 or 2 wherein said output derived from a crystal oscillator is of substantially the same frequency as the output derived from said oscillator.

4. An integrated oscillator circuit as claimed in any preceding claim, configured to change from one of said outputs to the other of said outputs within one clock cycle.

5. An integrated oscillator circuit as claimed in any preceding claim wherein a higher one of the first and second frequencies is less than double a lower one of the two frequencies.

6. An integrated oscillator circuit as claimed in claim 5 wherein the higher of the first and second frequencies is less than 10 percent higher than the lower of the two frequencies.

7. An integrated oscillator circuit as claimed in any preceding claim wherein one of the first and second frequencies is incrementally adjustable, and wherein the difference between the first and second frequencies is wider than a smallest increment by which said frequency can be adjusted.

8. An integrated oscillator circuit as claimed in any preceding claim wherein the switching means is configured to receive an input comprising or encoding a value indicating a switching ratio between the first and second frequencies.

9. An integrated oscillator circuit as claimed in any preceding claim comprising a calibration controller configured to provide the input representative of the target frequency to the switching means and further configured to calibrate the oscillator at intervals in order to provide an updated input to the switching means.

10. An integrated oscillator circuit as claimed in claim 9 wherein the calibration controller is configured to count oscillator output cycles over a reference time period for each of the first and second frequencies, and to derive an input to the switching means from these counts.

11. An integrated oscillator circuit as claimed in any preceding claim comprising charge-storing means whose capacitance can be varied between a first value and a second value; and a current source connected to the charge-storing means, to form an oscillator configured to oscillate at the first frequency when said capacitance is equal to the first value, and at the second frequency when the capacitance is equal to the second value, wherein the switching means is configured to switch the charge-storing means between the first and second capacitance values at intervals determined by the input.

12. An integrated oscillator circuit as claimed in claim 11 wherein the charge-storing means comprises a first capacitor that is permanently connected into the oscillator circuit, and a second capacitor that is selectively connectable into the circuit.

13. An integrated oscillator circuit as claimed in claim 11 wherein the charge-storing means comprises first and second capacitors having respective first and

second capacitances, and a switch arranged to connect one or other of the first capacitor and the second capacitor into the oscillator circuit at a time.

14. An integrated oscillator circuit as claimed in any preceding claim wherein the switching means is configured to distribute first-frequency cycles among second-frequency cycles according to a predetermined pattern or dispersion characteristic.

15. An integrated oscillator circuit as claimed in any preceding claim wherein the switching means comprises a sigma-delta modulator, arranged to distribute frequency cycles at the first frequency as uniformly as possible among frequency cycles at the second frequency, over a finite time period.

16. An integrated oscillator circuit as claimed in any preceding claim comprising a programmable current source, wherein the oscillator is arranged so that the value of one or both of the first and second frequencies depends on the level of a variable current within the oscillator circuit.

17. A method of operating an integrated oscillator circuit, wherein the circuit comprises an oscillator configured to be switched between a first frequency and a second frequency, the method comprising:

receiving an input representative of a target frequency;

switching the oscillator between the first and second frequencies at intervals determined by the target frequency so as to cause the average output frequency of the oscillator to approximate the target frequency;

calibrating the oscillator against a reference clock;

outputting a clock signal derived from a crystal oscillator during said calibration; and

outputting a clock signal derived from said oscillator when the circuit is not being calibrated.

18. A method as claimed in claim 17 comprising calibrating the oscillator against the crystal oscillator.

19. A method as claimed in claim 17 or 18, wherein the output derived from the crystal oscillator is substantially the same frequency as the output derived from the oscillator.

20. A method as claimed in any of claims 17 to 19, comprising changing from one of said outputs to the other within one clock cycle.

21. A method as claimed in any of claims 17 to 20 wherein a higher one of the first and second frequencies is less than double a lower one of the two frequencies.

22. A method as claimed in any of claims 17 to 21 wherein the higher of the first and second frequencies is less than 10 percent higher than the lower of the two frequencies.

23. A method as claimed in any of claims 17 to 22 wherein the input comprises or encodes a value indicating a switching ratio between the first and second frequencies.

24. A method as claimed in any of claims 17 to 23 further comprising calibrating the oscillator at intervals to generate an updated input representative of the target frequency.

25. A method as claimed in any of claims 17 to 24 comprising counting oscillator output cycles over a reference time period for each of the first and second frequencies, and deriving an input representative of the target frequency from these counts.

26. A method as claimed in any of claims 17 to 25 comprising switching the oscillator so as to distribute first-frequency cycles among second-frequency cycles according to a predetermined pattern or dispersion characteristic.

27. A method as claimed in any of claims 17 to 26 comprising coarsely calibrating the oscillator by adjusting the values of at least one of the first and second frequencies so that they span the target frequency.

28. A method as claimed in claim 27 wherein said adjusting of the values comprises adjusting a current source.

29. A method as claimed in claim 27 or 28 comprising performing said coarse calibration when the integrated-circuit oscillator is powered up.

30. An integrated circuit comprising an integrated oscillator circuit according to any of claims 1 to 16 and further comprising a microprocessor.

31. An integrated circuit as claimed in claim 30 configured to calibrate the oscillator in response to the microprocessor waking up.

32. An integrated circuit as claimed in claim 30 or 31 configured to use said crystal oscillator as a system clock for the microprocessor.

33. An integrated circuit as claimed in any of claims 30 to 32, comprising circuitry forming all or part of a radio transmitter or receiver configured to transmit or receive radio packets according to a schedule implemented using the integrated oscillator as a clock source.