CLAIMS

1. An ultrasound treatment system comprising:

an ultrasonic probe comprising an ultrasound therapy transducer adapted to apply ultrasonic therapy to tissue; and

an electrical power system configured to provide electrical power to the ultrasound therapy transducer, the electrical power system comprising a power amplifier device and a circuit;

in which the power amplifier device comprises at least one semiconductor transistor,

in which the at least one semiconductor transistor is a field effect transistor,

in which the field effect transistor is configured to operate with an efficiency of at least 75% at a radio frequency (RF) in a range between 200 kHz and 20 MHz.

2. A system according to Claim 1, in which semiconductor transistor comprises a III-V compound.

3. A system according to Claim 1, in which semiconductor transistor comprises Gallium Nitride (GaN).

4. A system according to Claim 1,

in which the power amplifier device comprises:

a switch-mode amplifier design comprising the field effect transistor; and

a circuit configured to generate digital waveforms to drive a plurality of gates of the field effect transistor to drive a piezoelectric ultrasound transducer;

in which the circuit comprises four transistors configured in an H-bridge configuration.

5. A system according to Claim 1,

in which the power amplifier device comprises:

a switch-mode amplifier design comprising at least one field effect transistor; and

a circuit configured to generate digital waveforms to drive a plurality of gates of the field effect transistor to drive a piezoelectric ultrasound transducer;

in which a signal driving the field effect transistor is generated by comparing an output of a sinusoidal direct digital synthesis circuit to a DC voltage;

in which an output power is in the range from 0.1 W to 200 W;

in which the circuit comprises four transistors configured in an H-bridge configuration.

6. A system according to Claim 1,

in which the semiconductor is gallium nitride,

in which power amplifier device comprises:

a switch-mode amplifier design comprising at least one gallium nitride field effect transistor, in which each gallium nitride field effect transistor comprises a plurality of gates; and

a circuit configured to generate digital waveforms to drive the plurality of gates of the gallium nitride field effect transistors to drive a piezoelectric ultrasound transducer;

in which a signal driving the field effect transistor is generated by comparing an output of a sinusoidal direct digital synthesis circuit to a DC voltage;

in which an output power is in the range from 0.1 W to 200 W;

in which the circuit comprises four gallium nitride transistors configured in an H-bridge configuration;

in which a gate drive signal has a variable duty cycle that is used to control a harmonic content and a power in the output signal;

in which a power amplifier converter supplies power to a radio frequency output signal power with an efficiency greater than 75%;

in which a supply voltage to the power amplifier is modulated using a switch-mode DC-DC converter that reduces a fixed high voltage input to a lower supply voltage;

comprising two or more power amplifiers, in which a single power amplifier is configured to drive at a single piezoelectric transduction element of a high-intensity focused ultrasound transducer;

in which the power amplifier is configured to drive output at two or more different amplitudes;

in which the power amplifier is configured to drive output at two or more different phases;

in which a phase and a frequency are controlled by a direct digital synthesizer;

in which the system is configured to drive transducers with an impedance in the range from 20 ohms to 120 ohms and a phase angle from +45 degrees to -45 degrees.

7. A system according to Claim 1, in which power amplifier device comprises:

a switch-mode amplifier design comprising at least one semiconductor; and

a circuit configured to generate digital waveforms to drive the semiconductor to drive the ultrasound therapy transducer.

8. A system according to Claim 1, in which a signal driving the field effect transistor is generated by comparing an output of a sinusoidal direct digital synthesis circuit to a DC voltage.

9. A system according to Claim 1, in which an output power is in the range from 0.1 W to 200 W.

10. A system according to Claim 1, in which an output power is in the range from 5 W to 50 W.

11. A system according to Claim 1, in which the circuit comprises four transistors configured in an H-bridge configuration.

12. A system according to any of Claims 1 to 3 and 7 to 11, in which the circuit comprises two transistors configured in a half bridge configuration.

13. A system according to any of Claims 1 to 3 and 7 to 11, in which a gate drive signal has a variable duty cycle that is used to control a harmonic content and a power in an output signal.

14. A system according to any of Claims 1 to 3 and 7 to 11, in which a power amplifier converter supplies power to a radio frequency output signal power with an efficiency greater than 75%.

15. A system according to any of Claims 1 to 3 and 7 to 11, in which a supply voltage to the power amplifier is modulated using a switch-mode DC-DC converter that reduces a fixed high voltage input to a lower supply voltage.

16. A system according to any of Claims 1 to 3 and 7 to 11, comprising two or more power amplifiers, in which a single power amplifier is configured to drive at a single piezoelectric transduction element of a high-intensity focused ultrasound transducer.

17. A system according to any of Claims 1 to 3 and 7 to 11, in which the high-intensity focused ultrasound transducer is configured for driving by a separate power amplifier.

18. A system according to any of Claims 1 to 3 and 7 to 11, in which the power amplifier is configured to drive output at two or more different amplitudes.

19. A system according to any of Claims 1 to 3 and 7 to 11, in which the power amplifier is configured to drive output at two or more different phases.

20. A system according to any of Claims 1 to 3 and 7 to 11, in which the amplifier is configured to drive output at two or more different frequencies.

21. A system according to any of Claims 1 to 3 and 7 to 11, in which a phase and a frequency are controlled by a direct digital synthesizer.

22. A system according to any of Claims 1 to 3 and 7 to 11, configured to drive transducers with an impedance in the range from 20 ohms to 120 ohms and a phase angle from +45 degrees to -45 degrees.

23. A power amplifier device for driving high intensity ultrasound transducers comprising:

a switch-mode amplifier design comprising at least one field effect transistor; and

a circuit configured to generate digital waveforms to drive the at least one field effect transistor.

24. A power amplifier device for driving a high intensity ultrasound transducer comprising:

a switch-mode amplifier design comprising at least one gallium nitride field effect transistor, in which each gallium nitride field effect transistor comprises a plurality of gates; and

a circuit configured to generate digital waveforms to drive the plurality of gates of the gallium nitride field effect transistors to drive a piezoelectric ultrasound transducer.

25. A power amplifier device according to Claim 24, comprising one or more of the following features:

in which the power amplifier is configured to drive output at two or more different amplitudes,

in which the power amplifier is configured to drive output at two or more different phases.

26. A method of controlling electrical power in an ultrasound system for delivering a desired amount of focused acoustic power by an ultrasound transducer, the method comprising:

providing an electrical power control system comprising a circuit comprising a control system microprocessor, and a control system look-up table (LUT);

providing an ultrasound transducer comprising a transducer controller, a transducer microprocessor, and a transducer LUT;

determining with the transducer microprocessor, from the transducer LUT, an amount of electrical power delivered to a load equivalent to a desired amount of acoustic power delivered to a tissue by the ultrasound transducer;

determining with the control system microprocessor, from the control system LUT, an amplitude of an electrical signal output from a power amplifier of the electrical power system that would deliver the equivalent amount of electrical power delivered to the load; and

setting at least one parameter of the electrical power system output the determined amplitude of the electrical signal output.

27. A method of configuring an electrical power system according to Claim 26, in which the load is 50 ohms.

28. An ultrasound treatment system comprising:

an ultrasonic probe comprising a housing containing a piezoelectrically active ultrasound therapy transducer adapted to focus acoustic ultrasonic waves a depth from the housing in a focal zone in a tissue;

an electrical power system configured to provide electrical power to the ultrasound therapy transducer, the electrical power system comprising a power amplifier; and

an electrical power measurement system configured to monitor electrical output power from an output signal from the power amplifier,

in which the electrical power measurement system comprises:

a resistive current sensing circuit configured to monitor an electrical current output from the power amplifier; and

a resistive voltage sensing circuit configured to monitor an electrical voltage output from the power amplifier, and

in which the electrical power measurement system is configured to monitor electrical output power from the power amplifier in a frequency range spanning at least two octaves for the ultrasound therapy transducer.

29. A system for measuring a radio frequency (RF) electrical current and voltage of a drive circuit in a high-intensity focused ultrasound system, comprising:

a current sense resistor in series with a load;

a shunt voltage sense resistor network in parallel with the load; and

an electrical power output voltage and current monitoring circuit (IQ demodulator circuit) with a local oscillator clock synchronized in a phase and a frequency to a signal driving a power amplifier and configured to demodulate an output signal to a carrier frequency lower than an ultrasound drive frequency.

30. A system according to Claim 28 or 29, in which the measurement system is configured to take multiple measurements at different relative phase shifts between the local oscillator and the power amplifier.

31. A system according to Claim 28 or 29, in which the local oscillator clock is generated from an independently controlled direct digital synthesizer.

32. A system according to Claim 28 or 29, in which the number of phase measurements is six.

33. A system according to Claim 28 or 29, in which the measurement system is configured to take multiple measurements at local oscillator frequencies.

34. A system that uses a measurement system according to Claim 28 or 29 to modify a gate drive signal so as to achieve a desired harmonic content in the output signal.

35. A method for determining the number of measurements of the type described in Claim 30 adequately measure the harmonics by assessing a number of harmonics of the lowest frequency in the passband that exceed the system noise floor.

36. A method to calculate the complex harmonic components of the voltage and current waveforms by forming linear combination of the multiple measurements described in Claim 27.

37. A method for calibrating a high intensity ultrasound transducer, comprising:

calibrating an acoustic output power delivered by a transducer for a driver configuration corresponding to an electrical power delivered by a driver into one or more reference loads for the driver configuration where a calibration information is stored with the transducer;

calibrating the electrical driver configuration against the electrical power delivered into one or more reference loads where the calibration information is stored with the driver; and

calculating with a processor of a driver configuration to achieve a desired acoustic output power that uses the transducer calibration information to determine a power level into one or more reference loads for a desired acoustic power setting and that uses the driver calibration information to determine a driver configuration for the desired acoustic output power level into the reference load.

38. A method according to Claim 37, in which the transducer calibration information also includes the electrical power delivered to the transducer at each acoustic power level, in which the stored power information includes a complex power component or a real power component.

39. A method according to Claim 38, in which dynamic measurements of electrical power delivered from the driver are made during tissue insonification and verified against electrical power stored in the transducer calibration for the desired acoustic power level.

40. A method according to Claim 37,

in which the transducer calibration information also includes the electrical power delivered to the transducer at each acoustic power level, in which the stored power information includes a complex power component or a real power component;

in which dynamic measurements of electrical power delivered from the driver are made during tissue insonification and verified against electrical power stored in the transducer calibration for the desired acoustic power level.

41. A method according to Claim 37,

in which the transducer calibration information also includes the electrical power delivered to the transducer at each acoustic power level, in which the stored power information includes a complex power component or a real power component;

in which dynamic measurements of electrical power delivered from the driver are made during tissue insonification and verified against electrical power stored in the transducer calibration for the desired acoustic power level;

in which the acoustic output power is generated by performing measurements using a force balance;

in which the transducer calibration is stored as a lookup table in a non-volatile memory chip inside the transducer;

in which at least one of the voltage or current measured at the driver is adjusted using a transfer matrix describing the two-port network between the therapy driving circuit output and the transducer;

in which the calibration information is stored in a look-up table (LUT);

in which a target electrical voltage is calculated from the calibration information and a desired acoustic power set in the clinic by interpolating the values in one or more look-up tables.

42. A method according to Claim 37, in which the acoustic output power is generated by performing measurements using a force balance.

43. A method according to Claim 37 or 38, in which the transducer calibration is stored as a lookup table in a non-volatile memory chip inside the transducer.

44. A method according to Claim 37, 38 or 39, in which at least one of the voltage or current measured at the driver is adjusted using a transfer matrix describing the two-port network between the therapy driving circuit output and the transducer.

45. A method according to Claim 37 or 38, in which the calibration information is stored in a look-up table (LUT).

46. A method according to Claim 45, in which a target electrical voltage is calculated from the calibration information and a desired acoustic power set in the clinic by interpolating the values in one or more look-up tables.

47. The storage within the transducer calibration information of electrical power thresholds at each acoustic power level defining an acceptable range of electrical drive power to achieve an acceptable range of acoustic output power of Claim 37.

48. A system for confirming that dynamically measured electrical power is within the range specified in Claim 46 comprising dynamically measuring the power delivered by the driver and comparing that power against the threshold values stored in the transducer.

49. A method according to Claim 44, where the transfer matrix of a handpiece and cable assembly that can be interchanged between transducers and drivers is stored on a non-volatile memory chip inside the handpiece and cable assembly.

50. A method for dynamically adjusting power, comprising:

measuring the electrical power delivered from the driver;

comparing the measured electrical power to the desired electrical power as determined from the calibration information of Claim 37 and

adjusting the driver configuration to reduce the error between the desired and measured electrical power.

51. A method for dynamically adjusting power, comprising:

measuring an electrical impedance of a load and calculating a transducer impedance based on known impedances of other system components;

calculating a required electrical power from the driver to maintain a same amount of dissipated power across a real transducer impedance; and

adjusting a driver configuration satisfy the required electrical power to reduce an error between a desired and measured electrical power.

52. A method according to Claim 49, 50 or 51, in which the power is dynamically adjusted whenever therapy is delivered.

53. A method for tuning high intensity focused ultrasound transducers by sweeping the frequency while measuring the voltage standing wave ratio at the driver and selecting for operating frequency that frequency which minimizes the voltage standing wave ratio.

54. A method for calibrating high intensity focused ultrasound transducers comprising

modelling a driver as a Thevenin-equivalent source with frequency-dependent source voltage and source impedance and storing calibration information comprising the source voltage and source impedance with the driver,

measuring and storing the transducer impedance in calibration information on the transducer, and

calculating the electrical power that will be delivered to transducer by the driver using the source voltage and source impedance stored in the driver calibration into the load impedance stored in the transducer calibration and treating the combined system as a voltage divider network.

55. A method to measure the transducer impedance:

calibrating a driver using one or more known reference impedances;

measuring a transducer impedance at one or more frequencies and one or more amplitudes;

fitting a measured transducer to a resonance circuit in order to calculate transducer parameters such as clamped capacitance, coupling coefficient, and radiation resistance;

using the characterization to determine a transducer age, operating acceptability and required amplitude and phase.

56. A method according to Claim 55, where a fixed distance is between the transducer and intended treatment region.

57. A method according to Claim 56, where the therapy beam is temporarily moved to an untreated region to determine the amount of backscatter from the treatment region using a difference method.

58. A method according to Claim 55, where the transducer impedance is measured by using shorter duration excitation pulses to eliminate backscatter or reflections from tissue or the transducer interface.

59. An ultrasound treatment system comprising:

an ultrasonic probe comprising an ultrasound therapy transducer adapted to apply ultrasonic therapy to tissue; and

an electrical power system configured to provide electrical power to the ultrasound therapy transducer, the electrical power system comprising a power amplifier device and a circuit;

in which the power amplifier device comprises at least one III-V semiconductor power transistor configured to operate with an efficiency of at least 75% at a radio frequency (RF) in a range between 200 kHz and 20 MHz.

60. A system according to Claim 59, in which the at least one III-V semiconductor power transistor is selected from the group consisting of: GaN, GaAs, GaSb, InP, InAs, InSb, InGaAs, AlSb, AlGaAs, and AlGaN.

61. A system according to Claim 59, in which the at least one III-V semiconductor power transistor is Gallium Nitride.

62. A system according to Claim 59, in which the at least one III-V semiconductor power transistor is not one of GaN, GaAs, GaSb, InP, InAs, InSb, InGaAs, AlSb, AlGaAs, and AlGaN.

63. A system according to Claim 59, in which power amplifier device comprises:

a switch-mode amplifier design comprising a plurality of III-V semiconductor power transistors; and

a circuit configured to generate digital waveforms to drive the plurality of III-V semiconductor power transistors to drive a piezoelectric ultrasound transducer.

64. A system according to Claim 59, in which a signal driving the power transistor is generated by comparing the output of a sinusoidal direct digital synthesis circuit to a DC voltage.

65. A system according to Claim 59, in which an output power is in the range from 0.1 W to 200 W.

66. A system according to Claim 59, in which an output power is in the range from 5 W to 50 W.

67. A system according to any of Claims 59 to 66, in which the circuit comprises four power transistors configured in an H-bridge configuration.

68. A system according to any of Claims 59 to 66, in which a gate drive signal has a variable duty cycle that is used to control a harmonic content and a power in the output signal.

69. A system according to any of Claims 59 to 66, in which a power amplifier converter supplies power to a radio frequency output signal power with an efficiency greater than 75%.

70. A system according to any of Claims 59 to 66, in which a supply voltage to the power amplifier is modulated using a switch-mode DC-DC converter that reduces a fixed high voltage input to a lower supply voltage.

71. A system according to any of Claims 59 to 66, comprising two or more power amplifiers, in which a single power amplifier is configured to drive a single piezoelectric transduction element of a high-intensity focused ultrasound transducer.

72. A system according to any of Claims 59 to 66, in which the power amplifier is configured to drive output at two or more different amplitudes.

73. A system according to any of Claims 59 to 66, in which the power amplifier is configured to drive output at two or more different phases.

74. A system according to any of Claims 59 to 66, in which a phase and a frequency are controlled by a direct digital synthesizer.

75. A system according to any of Claims 59 to 66, configured to drive transducers with an impedance in the range from 20 ohms to 120 ohms and a phase angle from +45 degrees to -45 degrees.

76. A power amplifier device for driving high intensity ultrasound transducers comprising:

a switch-mode amplifier design comprising at least one III-V semiconductor power transistor; and

a circuit configured to generate digital waveforms to drive the at least one III-V semiconductor power transistor.

77. A device with a plurality of power amplifiers for driving high intensity ultrasound transducers comprising:

a switch-mode amplifier design comprising a plurality of III-V semiconductor power transistors; and

a circuit configured to generate digital waveforms to drive the plurality of III-V semiconductor power transistors to drive a piezoelectric ultrasound transducer.

78. A device according to Claim 77 in which the III-V semiconductor power transistors are gallium nitride field effect transistors.

79. A device according to Claim 77 or 78, comprising one or more of the following features:

in which the power amplifier is configured to drive output at two or more different amplitudes,

in which the power amplifier is configured to drive output at two or more different phases.

80. A method of controlling electrical power in an ultrasound system for delivering a desired amount of focused acoustic power by an ultrasound transducer, the method comprising:

providing an electrical power control system comprising a circuit comprising a control system microprocessor, and a control system look-up table (LUT);

providing an ultrasound transducer comprising a transducer controller, a transducer microprocessor, and a transducer LUT;

determining with the transducer microprocessor, from the transducer LUT, an amount of electrical power delivered to a load equivalent to a desired amount of acoustic power delivered to a tissue by the ultrasound transducer;

determining with the control system microprocessor, from the control system LUT, an amplitude of an electrical signal output from a power amplifier of the electrical power system that would deliver the equivalent amount of electrical power delivered to the load; and

setting at least one parameter of the electrical power system output the determined amplitude of the electrical signal output,

in which the load is in a range of 20 to 120 ohms.

81. An ultrasound treatment system comprising:

an ultrasonic probe comprising a housing containing a piezoelectrically active ultrasound therapy transducer adapted to focus acoustic ultrasonic waves a depth from the housing in a focal zone in a tissue;

an electrical power system configured to provide electrical power to the ultrasound therapy transducer, the electrical power system comprising a power amplifier; and

an electrical power measurement system configured to monitor electrical output power from an output signal from the power amplifier,

in which the electrical power measurement system comprises:

a resistive current sensing circuit configured to monitor an electrical current output from the power amplifier; and

a resistive voltage sensing circuit configured to monitor an electrical voltage output from the power amplifier, and

in which the electrical power measurement system is configured to monitor electrical output power from the power amplifier in a frequency range spanning at least two octaves for the ultrasound therapy transducer;

in which the electrical power measurement system is configured to measure the harmonics by assessing a number of harmonics of the lowest frequency in the passband that exceed the system noise floor.

82. A system for measuring a radio frequency (RF) electrical current and voltage of a drive circuit in a high-intensity focused ultrasound system, comprising:

a current sense resistor in series with a load;

a shunt voltage sense resistor network in parallel with the load; and

an electrical power output voltage and current monitoring circuit (IQ demodulator circuit) with a local oscillator clock synchronized in a phase and a frequency to a signal driving a power amplifier and configured to demodulate an output signal to a carrier frequency lower than an ultrasound drive frequency;

in which the electrical power output voltage and current monitoring circuit is configured to calculate the complex harmonic components of the voltage and current waveforms by forming linear combination of the multiple measurements.

83. A system according to Claim 81 or 82, in which the measurement system is configured to take multiple measurements at different relative phase shifts between the local oscillator and the power amplifier.

84. A system according to Claim 81 or 82, in which the local oscillator clock is generated from an independently controlled direct digital synthesizer.

85. A system according to Claim 81 or 82, in which the number of phase measurements is six.

86. A system that uses the measurement system according to Claim 81 or 82 to modify a gate drive signal so as to achieve a desired harmonic content in the output signal.

87. A method to calculate the complex harmonic components of the voltage and current waveforms by forming linear combination of the multiple measurements described in Claim 81.

CLAIMS

1. An ultrasound treatment system comprising:

an ultrasonic probe comprising an ultrasound therapy transducer adapted to non-invasively apply ultrasonic therapy to tissue;

a switch-mode amplifier design comprising at least one switch-mode amplifier semiconductor;

a switch-mode amplifier circuit configured to generate digital waveforms to drive the switch-mode amplifier semiconductor to drive the ultrasound therapy transducer; and

an electrical power system configured to provide electrical power to the ultrasound therapy transducer, the electrical power system comprising a power amplifier device and a circuit;

in which the power amplifier device comprises at least one semiconductor transistor,

in which the at least one semiconductor transistor is a field effect transistor,

in which the field effect transistor is configured to operate with an efficiency of at least 75% at a radio frequency (RF) in a range between 200 kHz and 20 MHz.

2. A system according to Claim 1, in which semiconductor transistor comprises a III-V compound.

3. A system according to Claim 1, in which semiconductor transistor comprises Gallium Nitride (GaN).

4. A system according to Claim 1,

in which the power amplifier device comprises:

a switch-mode amplifier design comprising the field effect transistor; and

a circuit configured to generate digital waveforms to drive a plurality of gates of the field effect transistor to drive a piezoelectric ultrasound transducer;

in which the circuit comprises four transistors configured in an H-bridge configuration.

5. A system according to Claim 1,

in which the power amplifier device comprises:

a switch-mode amplifier design comprising at least one field effect transistor; and

a circuit configured to generate digital waveforms to drive a plurality of gates of the field effect transistor to drive a piezoelectric ultrasound transducer;

in which a signal driving the field effect transistor is configured to compare an output of a sinusoidal direct digital synthesis circuit to a DC voltage;

in which an output power is in the range from 0.1 W to 200 W;

in which the circuit comprises four transistors configured in an H-bridge configuration.

6. A system according to Claim 1,

in which the semiconductor is gallium nitride,

in which power amplifier device comprises:

a switch-mode amplifier design comprising at least one gallium nitride field effect transistor, in which each gallium nitride field effect transistor comprises a plurality of gates; and

a circuit configured to generate digital waveforms to drive the plurality of gates of the gallium nitride field effect transistors to drive the ultrasound therapy transducer, in which the ultrasound therapy transducer is a piezoelectric ultrasound transducer;

in which a signal driving the field effect transistor is configured to compare an output of a sinusoidal direct digital synthesis circuit to a DC voltage;

in which an output power is in the range from 0.1 W to 200 W;

in which the circuit comprises four gallium nitride transistors configured in an H-bridge configuration;

in which a gate drive signal has a variable duty cycle that is used to control a harmonic content and a power in the output signal;

further comprising a power amplifier converter which supplies power to a radio frequency output signal power with an efficiency greater than 75%;

in which a supply voltage to the power amplifier is modulated using a switch-mode DC-DC converter that reduces a fixed high voltage input to a lower supply voltage;

comprising two or more power amplifiers, in which a single power amplifier is configured to drive at a single piezoelectric transduction element of the ultrasound therapy transducer, in which the ultrasound therapy transducer is a high-intensity focused ultrasound transducer;

in which the power amplifier is configured to drive output at two or more different amplitudes;

in which the power amplifier is configured to drive output at two or more different phases;

in which a phase and a frequency are controlled by a direct digital synthesizer;

in which the system is configured to drive transducers with an impedance in the range from 20 ohms to 120 ohms and a phase angle from +45 degrees to -45 degrees.

7. A system according to Claim 1, in which power amplifier device comprises:

a switch-mode amplifier design comprising at least one switch-mode amplifier semiconductor; and

a switch-mode amplifier circuit configured to generate digital waveforms to drive the switch-mode amplifier semiconductor to drive the ultrasound therapy transducer.

8. A system according to Claim 1, in which a signal driving the field effect transistor is configured to compare an output of a sinusoidal direct digital synthesis circuit to a DC voltage.

9. A system according to Claim 1, in which an output power is in the range from 0.1 W to 200 W.

10. A system according to Claim 1, in which an output power is in the range from 5 W to 50 W.

11. A system according to Claim 1, in which the circuit comprises four transistors configured in an H-bridge configuration.

12. A system according to any of Claims 1 to 3 and 7 to 11, in which the circuit comprises two transistors configured in a half bridge configuration.

13. A system according to any of Claims 1 to 3 and 7 to 11, in which a gate drive signal has a variable duty cycle that is used to control a harmonic content and a power in an output signal.

14. A system according to any of Claims 1 to 3 and 7 to 11, in which a power amplifier converter supplies power to a radio frequency output signal power with an efficiency greater than 75%.

15. A system according to any of Claims 1 to 3 and 7 to 11, in which a supply voltage to the power amplifier is modulated using a switch-mode DC-DC converter that reduces a fixed high voltage input to a lower supply voltage.

16. A system according to any of Claims 1 to 3 and 7 to 11, comprising two or more power amplifiers, in which a single power amplifier is configured to drive the ultrasound therapy transducer, in which the ultrasound therapy transducer comprises a single piezoelectric transduction element, in which the ultrasound therapy transducer is a high-intensity focused ultrasound transducer.

17. A system according to any of Claims 1 to 3 and 7 to 11, in which the ultrasound therapy transducer is a high-intensity focused ultrasound transducer that is configured for driving by a second power amplifier.

18. A system according to any of Claims 1 to 3 and 7 to 11, in which the power amplifier is configured to drive output at two or more different amplitudes.

19. A system according to any of Claims 1 to 3 and 7 to 11, in which the power amplifier is configured to drive output at two or more different phases.

20. A system according to any of Claims 1 to 3 and 7 to 11, in which the power amplifier is configured to drive output at two or more different frequencies.

21. A system according to any of Claims 1 to 3 and 7 to 11, in which a phase and a frequency are controlled by a direct digital synthesizer.

22. A system according to any of Claims 1 to 3 and 7 to 11, configured to drive transducers with an impedance in the range from 20 ohms to 120 ohms and a phase angle from +45 degrees to -45 degrees.

23. An ultrasound treatment system comprising:

an ultrasonic probe comprising an ultrasound therapy transducer adapted to non-invasively apply ultrasonic therapy to tissue;

a switch-mode amplifier design comprising at least one switch-mode amplifier semiconductor;

a switch-mode amplifier circuit configured to generate digital waveforms to drive the switch-mode amplifier semiconductor to drive the ultrasound therapy transducer; and

an electrical power system configured to provide electrical power to the ultrasound therapy transducer, the electrical power system comprising a power amplifier device and a circuit;

in which the power amplifier device comprises at least one III-V semiconductor power transistor configured to operate with an efficiency of at least 75% at a radio frequency (RF) in a range between 200 kHz and 20 MHz.

24. A system according to Claim 23, in which the at least one III-V semiconductor power transistor is selected from the group consisting of: GaN, GaAs, GaSb, InP, InAs, InSb, InGaAs, AlSb, AlGaAs, and AlGaN.

25. A system according to Claim 23, in which the at least one III-V semiconductor power transistor is Gallium Nitride.

26. A system according to Claim 23, in which the at least one III-V semiconductor power transistor is not one of GaN, GaAs, GaSb, InP, InAs, InSb, InGaAs, AlSb, AlGaAs, and AlGaN.

27. A system according to Claim 23, in which power amplifier device comprises:

a switch-mode amplifier design comprising a plurality of III-V semiconductor power transistors; and

a switch-mode amplifier circuit configured to generate digital waveforms to drive the plurality of III-V semiconductor power transistors to drive a piezoelectric ultrasound transducer.

28. A system according to Claim 23, in which a signal driving the power transistor is configured to compare the output of a sinusoidal direct digital synthesis circuit to a DC voltage.

29. A system according to Claim 23, in which an output power is in the range from 0.1 W to 200 W.

30. A system according to Claim 23, in which an output power is in the range from 5 W to 50 W.

31. A system according to any of Claims 23 to 30, in which the circuit comprises four power transistors configured in an H-bridge configuration.

32. A system according to any of Claims 23 to 30, in which a gate drive signal has a variable duty cycle that is used to control a harmonic content and a power in the output signal.

33. A system according to any of Claims 23 to 30, further comprising a power amplifier converter which supplies power to a radio frequency output signal power with an efficiency greater than 75%.

34. A system according to any of Claims 23 to 30, in which a supply voltage to the power amplifier is modulated using a switch-mode DC-DC converter that reduces a fixed high voltage input to a lower supply voltage.

35. A system according to any of Claims 23 to 30, comprising two or more power amplifiers, in which a single power amplifier is configured to drive the ultrasound therapy transducer, in which the ultrasound therapy transducer is a single piezoelectric transduction element of a high-intensity focused ultrasound transducer.

36. A system according to any of Claims 23 to 30, in which the power amplifier is configured to drive output at two or more different amplitudes.

37. A system according to any of Claims 23 to 30, in which the power amplifier is configured to drive output at two or more different phases.

38. A system according to any of Claims 23 to 30, in which a phase and a frequency are controlled by a direct digital synthesizer.

39. A system according to any of Claims 23 to 30, configured to drive transducers with an impedance in the range from 20 ohms to 120 ohms and a phase angle from +45 degrees to -45 degrees.