Section 2 - 2.983 Application for type acceptance - Applicant Information

2.1 - (a) Applicant

The full name and address of the applicant is stated below:

Linear Modulation Technology Inc.
Intek Global House
Westfield Industrial Estate
Midsomer Norton
Bath
Avon
BA3 4BS
The United Kingdom

Note: Linear Modulation Technology (LMT) is a trade mark of **Intek Global Corp.**

2.2 - (c) Production quantity

Production of more than one unit is planned.

Section 3 - 2.983 Application for type acceptance - Technical Information

3.1 - Overview of equipment tested

The LMP4213 is a handportable transceiver designed for operation on 7.5 kHz and 5kHz channel assignments. A modulation scheme called Transparent Tone In Band (TTIB) is used, which is spectrally efficient and provides a medium particularly suited to varying propagation effects (e.g. multi-path and Doppler) encountered in a typical handportable environment.

The transceiver operates in two frequency simplex mode in the VHF Highband frequency band (150-162 MHz transmit and receive).

The transceiver employs digital signalling and trunked operation using the Advanced Digital Network Trunking (ADNT) system, based on UK specification MPT1327 (typical digital trunking control signals would be 1200 BPS FFSK). The unit provides features such as Status Calls, Call Stacking, Emergency Calling, Group Calls, Individual Calls and Telephone Connection.

The transceiver is workshop programmable, allowing it to be customised both for the system it is to be used on , and for a particular user.

The transceiver has been designed to be hand-portable and can withstand vibration, shock and range of temperatures typically encountered in this environment.

3.2 - Circuit descriptions and block diagrams

The LMP4213 handportable transceiver contains three main circuits:

- **Signal Processing Unit (SPU)** - Implements the baseband processing for modulation and demodulation. It also manages the Man Machine Interface (MMI) and trunking data functions
- **Radio Frequency Unit (RFU)** - Implements conversion to and from radio frequency
- **Power Amplifier (PA)** - Generates the necessary power for transmission. The PA circuit forms part of the RFU PCB.

The circuits are constructed on multi-layer printed circuit boards and are connected together via a single 50 way connector with the SPU circuit on one PCB and the RFU and PA on the second.

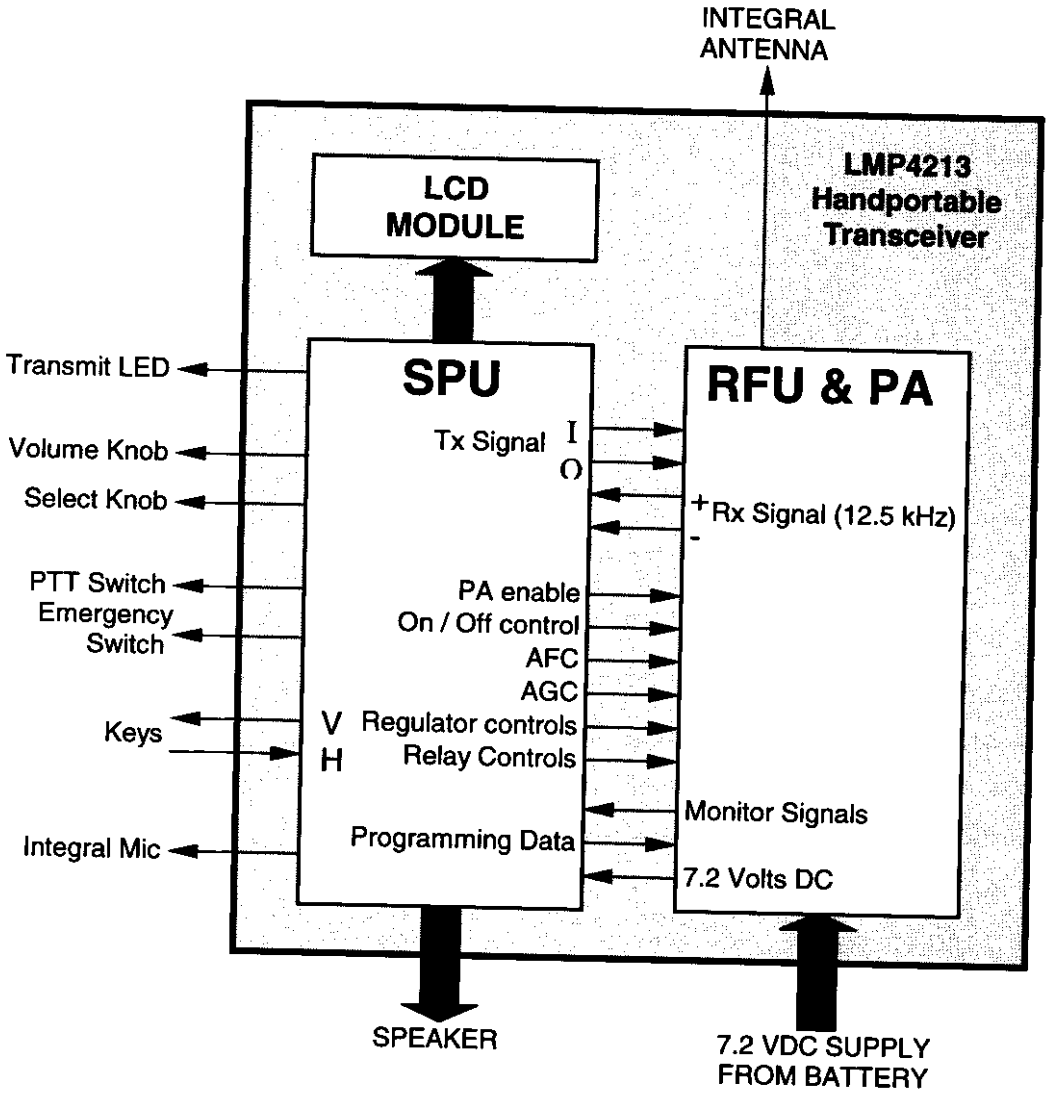
The user controls, display, speaker and microphone are housed in the case mouldings. They are connected to the circuit boards via a flexible printed circuit cable loom and two twisted pair cables.

Power at a nominal 7.2 volts, is provided by a rechargeable battery pack. Linear regulators are used to provide +5 volts for the analogue and some digital circuits, while a switch-mode regulator provides 3.3 volts for most digital devices.

The following block diagram illustrates the signalling that occurs between the main circuits.

Block Diagram

The following block diagram illustrating the main interconnections between modules :



Signal Processing Unit (SPU)

The SPU implements the baseband digital signal processing functions required for Transparent Tone In Band (TTIB) modulation and demodulation and Feed Forward Signal Regeneration (FFSR) channel equalisation. It also performs all control functions for the transceiver including the user interface functions (channel selection, on/off switching etc.), trunking protocol management and RFU programming.

DSP Subsystem

This comprises a TMS320C53 masked digital signal processor (DSP) (U15), its associated memory, some glue logic and A to D and D to A converters. The single channel ADC (U5) is used to sample either the received signal or the microphone input. A 16 bit stereo DAC (U7) is used to produce either the transmitted signal or the received audio whilst in a call, but is shut down during standby mode to reduce power consumption. A 12 bit quad DAC (U9) is used to produce AGC, AFC, and confidence tones. The selection of

inputs is performed by an analogue multiplexer (U37). The DSP memory consists of two 32k x 8 SRAMs (U20, U21) and a 128k x 8 flash PROM (U22). A PAL (U16) provides address decode and an FPGA (U19) is used for ADC and DAC interfacing and general purpose logic.

Man Machine Interface (MMI)

The Man Machine Interface functions are controlled by the H8 processor on the SPU. A brief description of these functions has been included below.

Keypad

A keypad is situated on the front of the radio beneath the display. Keypad scanning allows sensing of a 5 x 5 array of keys. Two general purpose ports of the H8 are used for scanning the key pad. Combination key presses can be detected for special functions. The H8 performs software key debounce.

Menu Select and Volume Control Operation

The menu scroll / select (right hand knob) and power on-off / volume (left hand knob) control are sensed by the H8 on its external interrupt lines. Each control has a rotary action switch plus a momentary action push function.

LCD Display

The back-lit display has a row of 8 custom icons below which there are two rows of 16 dot matrix characters. The display system consists of a display controlled by a dot matrix driver IC. The LCD system has its own character generation ROM and on board RAM and is controlled by a simple synchronous serial hardware port. Descriptions of what the icons represent can be found in the operating instructions.

Radio Frequency Unit (RFU) and Power Amplifier (PA)

The RFU upconverts baseband audio signals from the SPU to RF and amplifies to 5 watts PEP for transmission via the antenna, and downconverts received radio signals to a baseband IF for reception and demodulation by the SPU.

The unit possesses two programmable frequency synthesisers, these being the IF and RF synthesisers. Both synthesisers are found on a dual PLL synthesiser IC (IC3). The RF synthesiser, together with an UHF VCO (VCO1), provides the local oscillator (LO) for the first mixer stage of the receiver (780 MHz to 828 MHz). This is subsequently frequency divided by 4 to achieve improved phase noise. In transmit, the IF synthesiser with the VCO (TR5), produces a stable 180 MHz reference which is frequency mixed with the RF synthesiser (780 MHz to 828 MHz) to provide the transmit LO (600 MHz to 648 MHz). This signal is then bandpass filtered for rejection of spurious signals and amplified by IC16 to -7dBm, providing the LO for the upconversion process in the Cartesian Loop ASIC transmitter.
Within the Cartesian Loop ASIC the signal is subsequently divided by 4 in the quadrature LO generation process. The RF synthesiser is programmable in 2.5 kHz steps.

A 10 MHz synthesiser reference is provided by TCXO1. The TCXO has Automatic Frequency Control (AFC) which the SPU uses to lock the handportable unit to a high accuracy reference received from the repeater station.

In the transmit LO generation circuit, the RF LO is amplified by TR7 and the 180 MHz LO is amplified by TR6. Both are then frequency mixed by MX1 to produce the transmit frequency as explained above.
The ASIC (IC23) implements the baseband and RF upconverter and downconverter functions required for the Cartesian loop transmitter. An instability detector is provided to prevent transmission in the unlikely event of the loop instability. The Cartesian Loop up-converts the baseband audio on TXI+/TXI- and TXQ+/TXQ- to the channel frequency and down-converts a sample of the transmitted RF. This provides compensation at baseband for non-linearities in the power efficient Power amplifier. The up-converted signal is amplified by TR20 before passing to the Power Amplifier Module (PAM).

The LMP1603 Power Amplifier module (IC11) amplifies the up-converted RF signal to 5 watts PEP. The amplified signal passes through a Tx/Rx relay (PL1-A) which switches between transmit and receive modes, a 5 pole low-pass filter which suppresses unwanted harmonics, a 30 dB directional coupler (CPLR1) and an antenna relay (RL2-A) which switches between the radios integral antenna and an optional external antenna.

The signal from the FWD port of the coupler is split equally between the forward power detector and the RF feedback for the Cartesian loop. The forward power detector (D5) is biased for linear detection and has temperature compensation (D6 and IC13). The signal from the REV port of the coupler is detected (D4) to prevent transmission into high VSWR loads, e.g. in the event of antenna removal. The thermistor TH1 senses the PA temperature for radio shut-down in the event of a radio fault. The signals required by the SPU to calibrate the Cartesian Loop and sense fault conditions are supplied via an analogue multiplexer (IC24).

The received RF signal is amplified by a LNA (TR12) and image filtering is provided by filters F1,F2. It is then frequency mixed down to the IF of 45.0125 MHz by mixer MX1. The local oscillator as described above is divided by 4 in the prescaler (1C5) and amplified by the RxLO buffer(TR9). The IF signal is amplified by AGC amplifier TR3, and filtered by crystal filters F1, F2, F3 and F4. The IF signal is then frequency mixed down to a second IF of 12.5 kHz by IC1 with the fixed 180 MHz LO divided by four (IC7). The balanced second IF signal is then buffered by an operational amplifier(IC8) .

Power Supply

Battery power is supplied to the radio through an EMC filter F6, 3 Ampere fuses FS1 and FS2 and a MOSFET supply switch (IC12) which allows operation off battery or +8V charger supplies. The PA is supplied by the raw battery voltage, whilst power for the rest of the RFU is smoothed by noise filter TR19 and supplied by 5 Volt linear regulators (IC6, IC10, IC17 and IC25)

Operation during charging is provided for by the +8V supply from the charger unit. The presence of this voltage actuates switches TR8 and TR18 which turn off supply switch IC12. This blocks the battery voltage and forces the radio unit to operate from the +8V supply.

Over voltage and reverse voltage protection is provided in the form of diodes D8, D9 for the Battery supply and +8V charger supply respectively.

In order to save battery power 3.3 Volt devices are used where possible. These include the DSP, memory devices and gate array. The H8 is a 5 Volt device, necessitating the use of 16 bit wide level shifter, U31.

SPU supply voltages are generated as follows: the switched battery voltage FBATT+ (from the RFU), nominal 7.2 V is linearly regulated by U33 and U34 to produce the +5 VA (analogue 5 volt supply) and +5 VL (logic 5 volt supply) rails. Switch mode regulator U35, with associated inductors and capacitor produces the 3V3L 3.3 Volt logic supply.
Full circuit diagrams are contained in Section 3.9

3.4 - (d)(1) Emission types PARAGRAPH 2.983 (d) - TECHNICAL DESCRIPTION

Emission type (voice modulation) : 4K00J3E
Emission type (trunking control) : 4K00J2D

3.5 - (d)(2) Frequency Range

Frequency range (Transmit and Receive) : 150.0000 to 162.0000 MHz

3.6 - (d)(3) Operating Power Range

Operating power : 5.0 Watts PEP

3.7 - (d)(4) Maximum Power Rating

Maximum power rating : 5.0 Watts PEP

3.7 -(d)(5) DC Voltage and Current Into Final Amplifying Devices

Method of Measurement

Fully modulate the transmitter with 800 Hz and 2100 Hz tones to 5 W PEP nominal.

Measure Peak Envelope Power (PEP) in a 10 kHz bandwidth. The spectrum analyser is set to maximum hold (span 200 kHz, RBW 10 kHz, VBW 10 kHz, positive peak detector). Measurements are made on the lowest, centre and highest channel frequencies.

Power is calculated according to the equation :

$$P = 10^{(\frac{A+L}{10})-3}$$

Where : A is the attenuation in dB between the transmitter and the spectrum analyser.
L is the maximum level measured on the spectrum analyser in dBm.
P is the peak envelope power in watts.

Results

DC Current into pin 12 of IC11.

Power level : 5 W PEP nominal
Modulation : Full modulation with 800 Hz and 2100 Hz tones

Frequency	Voltage	Current	Measured Level (L)	Attenuation (A)	Power (P)
(MHz)	(V)	(A)	(dBm)	(dB)	(W)
150.0000	7.2	0.95	6.32	30.6	4.92
156.0000	7.2	0.95	6.32	30.6	4.92
162.0000	7.2	0.95	6.11	30.7	4.80

3.8(d)(6) Function of semiconductors and active devices

Signal Processing Unit (SPU)

REFERENCE	DESCRIPTION	FUNCTION
D1	CR40LG	Green LED (Keyboard backlight)
D2	CR40LG	Green LED (Keyboard backlight)
D3	CR40LG	Green LED (Keyboard backlight)
D11	CR40LG	Green LED (Keyboard backlight)
D12	CR40LG	Green LED (Keyboard backlight)
D13	CR40LG	Green LED (Keyboard backlight)
D21	CR152RG	Green / Red LED (Tx/Rx LED)
D22	Vref	4.096V Voltage Reference
D23	Vref	2V5 Voltage Reference
D25	BAV74JA	Dual Diode (clamp)
D26	1N5817M	Schottky Diode (Switching Reg)
Q1, 2, 6	NDS356P	P-FET
Q3, 7	BSS138	N-FET
Q4	NDS356P	P-FET (audio PA switch)
Q5	BSS138	N-FET (audio PA switch)
Q8	NDS356P	P-FET (mic pre-amp switch)
Q9	BC846A	NPN Tran. mic pre-amp switch)
Q10	BSS138	N-FET (mic pre-amp switch)
Q11	BC849C	NPN Transistor (mic pre-amp)
Q12, 13	BSS138	N-FET
Q16	NDS356P	P-FET
Q17	BSS138	N-FET (Int / Ext audio select)
Q18	BSS138	N-FET (mic. disable)
U1, 6	TLC2264	Op amp
U3	TLC2262	Op amp
U4	SI9956	Dual N-FET (speaker disable)
U5	MAX189	A to D conv. (monitor)
U7	CS4331	A to D conv. (audio, TxI, TXQ)
U9	MAX525	D to A conv. (AFC, tuning Volts)
U10	74LV14	Hex Inverter
U12	TDA7052AT	Audio PA
U15	TMS320C53	DSP
U16	PAL16V8	Address decode PAL
U19	QL8x12BL	FPGA (system glue logic)
U20, 21	IDT71V256SA15	SRAM
U22	SST29LE010	128K x 8 Flash memory
U23	MAX706	Power on reset circuit
U24	74HCT74	Clock divider
U25	29.4912 MHz	Main system clock
U27	74HCT14	Various functions
U29	H8 / 330	Microcontroller - MMI
U30, 39	24C65	E^2PROM - personality and setup
U31	IDT74FCT164245	Bi-Dir. Level shifter / buffer
U32	LTC1384	RS232 I/F circuit
U33	MAX603	5V voltage reg. (analogue rail)
U34	MAX603	5V voltage reg. (digital rail)

REFERENCE	DESCRIPTION	FUNCTION
U35	MAX763	Sw voltage reg. 3.3v
U37	MAX399	Analogue mulitplexer

Radio Frequency Unit (RFU)

REFERENCE	DESCRIPTION	FUNCTION
D1,D2	BB535	IF LO Varactor
D3	BAS28	Protection for IC9
D4, 5, 6	HSMS2800	Power detector
D7	ZRA125	Voltage reference
D8	VC060318A400	Battery protection
D9	VCO60309A200	PSU Protection
D10	BAV74JA	Supply switch pull-up
D11	SK32B	PSU protection
D12	BAS28	Protection for IC2
IC1	SA612A	2nd Rx mixer
IC2	IMH10A	Tx/Rx Relay control
IC3	LMX2332	PLL synthesiser
IC4	NC7SU04	Reference frequency buffer
IC5	UPB1510GV	Rx LO1divider
IC6	TK11250	Rx regulator
IC7	UPB1509GV	Rx LO2 divider
IC8	TLC271ID	Rx baseband amplifier
IC9	IMH10A	Antenna relay control
IC10	TK11250	PLL regulator
IC11	LMP1603	PA module
IC12	SI6965DQ	Battery supply switch
IC13	LMC7101BIM5X	Power detector amplifier
IC16	UPC2713	TxLO amplifier
IC17	TK11250	VCO regulator
IC23	TH1088	Cartesian loop ASIC
IC24	MAX349EAP	Multiplexor
IC25	MAX603ESA	Tx regulator
MX1	TUF-2SM	Tx LO mixer
TCX1	GTXO566V	Crystal oscillator reference
TR1	BSS138	Control line buffer
TR2	BF998	1st Rx mixer amplifier
TR3	BF998	Rx IF AGC amplifier
TR4	BC846A	Rx AGC source bias amplifier
TR5	BFS17A	Rx VCO2 oscillator
TR6	BFR92A	Rx VCO2 buffer
TR7	NE85619	Rx VCO1 buffer
TR8, 18	BC846A	Battery supply switch
TR9	NE85619	Rx LO1 buffer
TR10	BC846A	VCO supply regulator
TR11,14, 15, 16	BSS138	Control line buffer
TR12	NE85619	Rx RF Amplifier
TR19	FMMT618	PSU noise filter
TR20	NE85619	ASIC Tx buffer

REFERENCE	DESCRIPTION	FUNCTION
VC01	LVCO2722	VCO module

3.9 - (d)(7) Circuit schematic diagrams

The following pages contain schematic diagrams for all circuits

Radio Frequency Unit (RFU) and PA circuits.

Signal Processing Unit (SPU).

3.10 - (d)(9) Tune up procedure

The LMP4213 handportable radio has no adjustable components inside and therefore does not need to be tuned up prior to testing or operation.

3.11- (d)(10) Frequency stabilisation circuitry

The temperature compensated crystal oscillator (TXCO) generates a 10 MHz signal. The frequency of this signal can be adjusted over a limited range by the Automatic Frequency Control (AFC) signal from the SPU. When the mobile transceiver is in receive mode, the SPU locks to a transmitted reference tone from the base station. The reference tone frequency is accurate to within 0.1 ppm (defined by the base station oven controlled crystal oscillator).

When the handportable transceiver is in transmit mode, the SPU holds the AFC level as it was during the last occurrence of receive. The trunking system prevents the transceiver from transmitting unless it has previously obtained a suitable reference from the base station. Thus the frequency of the transmission is always locked to the base reference within the limit of any frequency drift due to temperature variation in the transceiver unit. Frequency variation with time during transmission has been measured and the results are presented in Section 5.9.

The combined effect of locking to the base frequency reference and allowing some drift with temperature means that the mobile transceiver frequency accuracy is always much better than 2.0 ppm.

All Local Oscillators within the transceiver are phase locked to the TCXO.

3.12 - (d)(11) Limiting of spurious radiation

Modulation and RF power limiting
Modulation limiting is implemented within the signal processing sub-system. This monitors the output drive to the Cartesian amplifier and reduces the level of the modulating signal if necessary. Detection is achieved using a peak detector in the DSP so that control is based on the output PEP rather than the average power.

The Cartesian amplifier applies power limiting to the RF PA by implementing a feedback loop which generates an error signal based on the difference between the transmitted signal and the amplifier drive signal. The Cartesian loop is a high gain negative feedback system which acts to maintain the output as a good amplified version of the input.

Bandwidth limiting
Within the DSP, the drive signal to the Cartesian amplifier is filtered prior to output. This filter is specified to be tighter than the FCC mask. The Cartesian amplifier then acts to limit the bandwidth of the transmitted signal by reducing power amplifier intermodulation.

Spurious and harmonic limiting
Power supply, control and signal lines are filtered to ensure that unwanted signals do not appear on the transmitter output.

The RF power amplifier is designed for low harmonic distortion. The output of the amplifier is then passed through a seventh order lowpass filter to reduce all harmonics to below the permissible level.