2 CIRCUIT DESCRIPTION

2.1 General information

The HM435 is basically divided into 2 printed circuit boards: **Main board** and **Head**. Circuitry and signals can be divided in the following sections:

Microprocessor/control
Front panel (head) circuitry
VCO / Synthesizer (PLL)
Transmitter
Receiver
ON/OFF switch, rear connector and internal connectors

Refer to the Block Diagram and the Schematics.

2.2 Microprocessor/control

The microprocessor **DD5** is constantly operating when the radio is turned ON. It is continuously monitoring the keyboard, the PTT line and other internal inputs such as the squelch detect, etc. When a change occurs, the microprocessor makes the appropriate response according to its program in order to control the all radio functions. On channel change, the Radio emits a beep and the synthesizer is loaded with the correct frequency information. The microprocessor runs off a 8 MHz oscillator which is composed of **X3**, **C353**, **C354** and **R319**.
When the radio is first turned on, the microprocessor reads the radio status from the EEPROM **DD3** which contains all the radio's parameters.
The microprocessor determinates the receive frequency codes, then loads the synthesizer via its pins **42** (line **PLL_LE**), **43** (line **PLL_DATA**) and **46** (line **PPL_CLK**).
Pin **40** outputs a PWM signal which is converted by **DA18:B** into a CC voltage at its output (line **RF_PWR_CTRL**) which controls the RF output power.
Pins **37** and pin **39** outputs a PWM signal which are used, respectively, to generate the Selcall signal (line **MCU_SELCALL_PWM**) and CTCSS/DCS signal (line **MCU_CTCSS_DCS_PWM**) as further explained. The digital signals coming from the ADC converters which drive the microprocessor in order to decode the Selcall and CXTCSS/DCS signals are applied, respectively, to pin **59** (line **ADC_HI_SPEED_DATA_RX**) and pin **60** (**ADC_lo_SPEED_DATA_RX**).
The firmware program interface is made by means of the connector **XP3**
The microprocessor is fitted with an internal program flash memory as well, therefore functions can be customized, if necessary, upon specific request from the customer.

2.2.a PTT circuit

The PTT switching is totally controlled by the two microprocessors (**DD5** in the main board and **DD800** in the front board in the front panel): when the PTT is pressed, the line **AUX_PTT** goes low, so the transistor **VT806** changes the status of the pin **20** of microprocessor **DD800** which is "informed" that the radio is in TX mode (i.e. PTT is pressed), so it changes its output at pin **22** putting the low level at pin **8** of the connector **XT802** which is connected to the main PCB with the connector **XT2**. This means that pin **8** of **XT2** (line **HANDSET_PTT_TO_MPU**) goes low. This line is connected to the **VT56** which changes the status of pin **26** of the microprocessor **DD5** from hi to low. Now the microprocessor **DD5** is also "informed" that the radio is in TX mode, so it can control the +8V voltage which is alternatively fed to the TX or RX stages according to the radio's status. Pins **29** (line **TX_FROM_MCU**) and **30** (line **RX_FROM_MCU**) control the +8V power switches which alternatively outputs this voltage to the RX section (line **+8V_RX**) with **VT42** or to the TX one (line **+8V_TX**) with **VT41**.
The transistor **VT805** is controlled by the pin **19** of the microprocessor **DD800** and it is used to eventually disable all the over stated PTT chain according to the radio's status (e.g. busy lock out, timeout timer etc).

2.3 Front panel (head) circuitry

The microprocessor **DD800** runs off a 8 MHz oscillator which is composed of **X800**, and **R829**. **DD800** is basically used to control the LCD unit **XT80**, to decode the commands coming from the front keypad **S801** to **S808**) as well as to switch the front LEDs **DA800**. It is also used to light up the LCD backlight (**VD800** to **VD805**) as well as for the PTT circuit as over stated.
The negative voltage necessary for the LCD is created by a charge pump which consists of **VT815**, **VT813**, **VT812**, **VD809** and **VD808**. The output (line **–8V**) is fed to the regulator **DA804:A** which outputs the line **VD** in order to supply the LCD unit.
The hang-up functions work this way: the line **AUX_HOOK** is connected to the microphone's hook and it's normally grounded (microphone hooked). When the mike is removed from its hook, the line **AUX_HOOK** changes its state driving the transistor **VT809**. This changes the status of the pin **21** of the microprocessor **DD800** which opens the monitor through a command sent to the main microprocessor **DD5** through a serial command.

2.4 VCO / Synthesizer (PLL)

This section basically consists of the Temperature-Compensated Crystal Oscillator (TCXO), Voltage Controlled

Oscillators (VCOs), Synthesizer and the Loop Filter.

2.4.a Temperature-Compensated Crystal Oscillator (TCXO)

The reference oscillator is composed by the temperature compensated Oscillator G1 and related circuitry (DA1:A), **RP2** is used to adjust the oscillator on frequency (14.4 MHz) at room temperature.

The reference oscillator is held within the specifications ±5 ppm from -30 to +60°C.

2.4.b Voltage-Controlled Oscillators

The receive VCO consists of **VT511**, **CV1**, **VD1006, 1006a, 1009** and **VD1009a**. This VCO oscillates at 45.1 MHz above the programmed1
receive frequency. The VCO's oscillating frequency is tuned by the varactors **VD1006 thru VD1009a**.

The transmitter VCO consists of **VT512**, **CV2**, **VD1111**-**VD1112** and **VD1113**-**VD1114** and oscillates directly to the TX carrier frequency range. The TX VCO is directly frequency-modulated by means of the varactor **VD15** which is driven by the modulating signal (line **A**) regulated by the trimmer **RP4**. This is part of the double-point modulation and works mainly in high AF modulating frequencies), the other part of the double point-modulation is explained in the par. "Transmitter Audio Circuits".

The tuning voltage for the VCOs is supplied from the output of the Loop Filter made with **R118**, **R281 R337**, **C112**, **C113** and **C114**.

Only one of the VCOs runs at a time. In RX the line **RXC** (which is obtained from the **+8V_RX** line coming from the voltage switch **VT41**) is high enabling the RX VCO via the transistor **VT16**. During this time the line **TXC** (which is obtained from the **+8VTX** line coming from the voltage switch **VT42**) is low, so the TX VCO is disabled.

When the PTT is pressed, the **RXC** line becomes low switching the RX VCO off. At the same time the line **TXC** goes high activating the TX VCO via the transistor **VT18**.

The output of the VCOs are AC coupled (**C1091** and **C1109**) and sent to the synthesizer buffer **VT19**, then sent to **DA5** for an additional buffering. The output of **DA5** is connected to the low-pass filter (**L1027**, **L1028**, **L1029** and related capacitors), then directly sent to the TX stages (line **HET_TX** which is sent to the pre-driver amplifier **VT24**) or RX stages (line **HET_RX** which is sent to the RX mixer **A1**) due to the RF switching action provided by **VD16** and **VD17** which are controlled by the lines **+8VRX** and **8V_TX_F** respectively (this last line is obtained from the line +8VTX passed through the filter created with **L52**, **L53** and related capacitors). The output from the VCO necessary to feedback the PLL IC **DA3** (i.e. line **PLL_RF** send to pin **8**) is directly output from **VT19** and fed through **R106**, **C362** and **C134**. , while the other part of the signal is fed to **DA5**, then passed through the lowpass filter (**L1027**, **L1028**, **L1029**, **C1130**, **C1132**, **C1133** and **C1131**). Diodes **VD16** and **VD17** act as signal switches in order to feed the signal to RX or TX stages at the appropriate time according to the switching voltages which are, respectively, the lines **+8VRX** and **8V_TX_F**.

The PLL IC **DA3** receives the reference signal from the TCXO (pin **1**) and the feedback from the VCO (pin **8**). The synthesizer is tuned in 5.00 KHz or 6.25 KHz steps. The output from the PLL IC (pin **15** and **16**) is used to drive the PLL charge pump which consists of **VT20**, **VT14** and **VT21**, then the charge pumps sent the output to the PLL filter in order to close the loop.

2.4.c Synthesizer

The PLL IC frequency synthesizer is a large scale monolithic synthesizer integrated circuit **DA3**.

The synthesizer IC contains a dual modular prescaler, programmable divide-by-N counter, prescaler control (swallow) counter, reference divider, phase detector and unlock detector.

RF output from the active VCO is AC coupled to the synthesizer **DA3** prescaler input at Pin **8**. The divide-by-N counter chain in **DA3**, consisting of the dual-modulus prescaler, swallow counter and programmable counter, divides the VCO signal down to a frequency very close to 5.00 KHz or 6.25 KHz which is applied to the phase detector. The phase comparator compares the edges of this of this signal with that of the 5.00 KHz or 6.25 KHz reference signal from the reference divider and drives the external charge pump (**VT20**, **VT14** and **VT21**).

The synthesizer unlock detector circuit prevents the operation of the transmitter when the phase lock loop (PLL) is unlocked. The following discussion assumes the unit has been placed in the transmit mode. **DA3** lock detector Pin **7** goes high when the PLL is properly locked. This high level is applied to pin **21** of the microprocessor **DD5**. A software timing routing brings the pin 28 of the microprocessor **DD5** low making the line **PA** (connected via **R323** and **C361**) low as well. With the PA line low, **VT28** is cut off and **VT27** biases the RF driver (VT23) and RF power amplifier (**VT22**) which enables transmission.

When the PLL become unlocked, the lock detector at **DA3** pin **7** will begin pulsing low. A RC circuit (**R311** and **C347**) converts pulsing low to a low level for the microprocessor (pin **21**). The microprocessor then changes the PA line to a high switching the transistor **VT28** on. This cuts off the transistor **VT27** which is not able to supply the bias to the RF driver and RF power amplifier disabling the transmission. Therefore, the transmitter remains disabled while the phase locked loop remains unlocked.

2.5 Transmitter

2.5.a RF Power Amplifier

The TX RF amplifier is made with 3 stages: **VT24** is the pre-driver, **VT23** is the driver and **VT22** is the Power Amplifier (PA). Output from the last PLL buffer **DA5** (line **HET_TX**) feeds the pre-driver amplifier **VT24**. The output signal from **VT24** feeds the driver amplifier **VT23**, whose output from the driver stage feeds the final RF power

amplifier **VT22** to produce the rated output power of 25 watts. The output of the power amplifier is applied to the RX/TX switch made with **VD21**, **VD22** and related circuitry, then to the low-pass filter (consisting of **L1146** to **L1149** and connected capacitors) and then to the SWR coupling line **TA1** which is directly connected to the antenna connector.
The **8V_TX_F** line supplies the total bias current to the bias regulators. Pre-driver is biased by **VT25** and both the driver and power amplifier are biased by the same transistor **VT27**. Obviously, the output of **VT27** biases these two stages via 2 different trimmers, which are **RP5** for the driver (about 200 mA) and **RP6** for the power amplifier (about 300mA).

2.5.b Antenna Switching

Switching of the antenna between the transmitter and the receiver is accomplished by the antenna transmit/receive switch consisting of diodes **VD21** and **VD22** in conjunction with **C1089**, **C1190** and **L1144**. In reception mode both the diodes are unbiased, so the RX signal coming from the **ANTENNA** line passes through the coupling line **TA1**, the low pass filter (**L1149**, **L1148**, **L1146**, **C194** etc.), going to the receiver's front-end input (line **RF_RX**) via **L1144**. In the transmit mode, switched **+8VTX** is applied to the base of **VT26** through **R142** and **R143** hard forward biasing the two diodes on. **VD21** thus permits the RF power from output of the power amplifier to flow to the input of the low-pass filter. At the same time, **VD22** avoids that the residual RF coming from the transmitter is accidentally sent to the receiver by removing it with the 3 capacitors **C183**, **C1184** and **C1185**.

2.5.c Power control

Output power is picked up from the output coupling line **TA1** and sent to the diodes **VD24** and **VD26**. The first one detects the forward power and the second one the reflected power which drops, respectively, across **R146** and **R152**. These two signals (respectively the lines **FWD_PWR** and **REFL_PWR**) are fed separately to an operational amplifier (**DA6:A** and **DA6:B**) and combined into a third one (**DA6:C**) which regulated the output power according to the input signal. The calibration of the output power is provided by the trimmer **RP7** which controls **DA6:C**. Its output is connected to the transistor **VT27** which provides the bias for the driver and power amplifier closing the power control loop. In case of excessive S.W.R., the output power is automatically reduced in order to protect the final stage.

2.5.d Transmitter Audio Circuits

The speech audio coming from the MIC connector (line **AUX_MIC**) is applied to the FET **VT804** which acts as sensitivity switch (function high/low MIC sensitivity) in 2 levels and is directly controlled by the microprocessor (pin **27**) via the transistor **VT807**. The signal is then fed to the amplifier made by **DA801:A** (**DA801:B** is used to supply the reference voltage at its positive input) providing a stronger speech signal (line **MIC_INPUT**) which is fed to the 6dB per octave pre-emphasis circuit provided by the capacitor **C277** and the resistor **R213** and applied to pin **6** of **DA11:B**.

*NOTE: Between the **C277** and the **MIC_INPUT** line, the transistor **VT48** acts as a mute switch which disable the speech audio when a Selcall is sent.*

Selcall audio PWM signaling coming from the pin **37** of the microprocessor (line **MCU_SELCALL_PWM**) is fed to the 3 KHz low pass filter which consists of **DA9:B** and related circuitry. Its output is then fed to the input of the **DA11:B**, so routed the same way of the speech audio.
The speech/Selcall signal is applied to the input of **DA11:B** which limits the peak-to-peak output, then is fed to the pin **3** of IC **DA10** which is a double digital audio regulator. After the level regulation, the speech/Selcall is output at pin **11** and sent to the first input (pin **9**) of **DA9:C** in order to be summed with the CTCSS/DCS signal.

*NOTE: The level regulation of **DA10** comes in form of digital data from the pins **6, 7** and **8** (lines **POT_DATA, POT_CLK** and **DAC_CS** respectively) which are directly controlled by the microprocessor **DD5** (pins **43**, **46** and **36** respectively) via related logical inverters.*

CTCSS/DCS sub-audio tone PWM signaling coming from the pin **39** of the microprocessor (line **MCU_CTCSS_DCS_PWM**) is fed to the CTCSS/DCS 300 Hz low pass filter which consists of **DA9:A** and related circuitry, then fed in the pin **2** of the IC **DA10** which regulates the level and outputs the regulated CTCSS/DCS at its pin 12. This signal is then applied to the second input of **DA9:C** in order to be summed with the speech/Selcall signal.
DA9:C sums the two signals (speech/Selcall coming from pin **11** of **DA10** and CTCSS/DCS coming from pin **12**) feeding its combined output to **DA9:D** which is a 3 KHz low pass filter. The output of **DA9:D** is then applied to pins **4** and **5** of the **DA10**.

2.5.e Double-point modulation

The outputs (lines **REF_MOD** and **VCO_MOD**) coming, respectively, from pins **10** and **9** of **DA10** are fed to the PLL area. The line **REF_MOD** is directly applied to the trimmer **RP3** which provides the Ref. Modulation control (low audio frequencies) directly applied to the TCXO. The line **VCO_MOD** is applied via the resistors **R116** to the trimmer **RP4** which provides the VCO modulation control (high audio frequencies) directly sent to the TX VCO.

2.6 Receiver

2.6.a Receiver's Front-End

The RX signal coming from the antenna connector is fed in sequence through the coupling line **TA1**, the low pass filter (consisting of **L1146** to **L1149** and connected capacitors) and the antenna switching (**VD21** and **VD22)**. The output of the antenna switching (line **RF_RX**) is sent to input of the receiver and coupled to the input band-pass

filter. The IC DA-22 is the front-end amplifier and its output is applied to the second band-pass filter (**L1041**, **L1044**, and related capacitors). The output from the band-pass filter is applied to the pin **4** of the RF mixer **A1**.
The diode **VD1** is used for the function local/distance. Normally the line **LOCAL_DIST** issued by the pin **25** of the microprocessor (properly adapted by **R317** and **C352**) goes to high so **VT1** is switched on forward biasing the diode **VD1**. This provides a bypass of the resistor **R5** for the RF, so the RF signal fed to the mixer is higher (distance mode). On the other side, if the line **LOCAL_DIST** drops to low, the diode **VD1** is not forward biased and the RF is attenuated of 10dB approx. due to the **R5** (local mode).

2.6.b Local Oscillator (LO)

As already explained in the PLL section, the output coming from the RX VCO (working at 45,1 MHz above the RX frequency) is sent to the synthesizer buffer **VT19**, then sent to **DA5** for an additional buffering. The output of **DA5** is connected to the low-pass filter (**L1027**, **L1028**, **L1029** and related capacitors), then sent to the RX stages (line **HET_RX**) which is sent to the RX mixer **A1** via an attenuator which consists of **R13**, **R14** and **R15**.

2.6.c Mixer

The mixer LO frequency is 45.1 MHz above the desired receiver frequency. When the receiver frequency is present, the mixer output will be a 45.1 MHz signal. The mixer output is peaked for 45.1 MHz by means of the diplexer filter (**L12**, **L15**, **C56**, **C46**, **C47**, **R31**, **R35** and **R36**) and the RF amplifier **VT7**, then signal is filtered by crystal filters **XF1A** and **XF1B** and amplified by **VT5** and **VT4** before being applied to the input (pin **16**) of the IF IC **DA2**.
Inside **DA2**, the 45.1 MHz IF signal is sent to the input of the second mixer with a LO frequency of 44.645 MHz (the frequency of the crystal **X1** is 44.545 MHz, but it is 100 KHz shifted by means of the connected components **C68**, **C69** and **C70**, **L17**, **R54** and **R51**). The output of the second mixer is sent from pin **3** of **DA2** to the 455 KHz ceramic filters **CF2** (for 12,5 KHz bandwidth) or **CF1** (for 25 KHz bandwidth) which filter the second mixer's output, then fed to the second IF signal input of **DA2** (pin **5**). The mixer's output is then fed to the internal limiting amplifier and then on to the FM decoder.

*Note: the switching of the two filters **CF2** or **CF1** is accomplished by means of the line **12.5_25** coming from the pin **24** of the microprocessor **DD5** which drives, in sequence, the transistor **VT10** and the switches **DD1** and **DD2**.*

2.6.d FM Detector and Squelch

The FM detector output (pin **9** of **DA2**) is used for squelch, decoding tones and audio output. The setting of the squelch adjustment **RP1** sets the input to the squelch amplifier.
The squelch amplifier is internal to **DA2** and its output is fed to an internal rectifier and squelch detector.
The output on **DA2** (pin **14**) signals the microprocessor **DD5** with a low level to unmute the radio. The audio is unmuted by using the line **RX_MUTE** sent from the pin **50** of the microprocessor **DD5** to the mute switch **VT54** controlled by the transistor **VT55**.

2.6.e Audio routing

The detector's audio output (line **DETECTOR_AUDIO**) is fed to **DA13:A** and **DA13:B** (3 KHz low-pass filter deeply described in the next paragraph), then routed to the 300 Hz audio high-pass filter which consists of **DA12:A** and **DA12:B**. The output of the audio high-pass filter feeds the AF de-emphasis (**DA15:A**) and AF preamplifier (**DA15:B**), then the volume control provided by the IC **DA16**. The audio is then routed to Pin **1** and **9** of the audio amplifier **DA14**.
VT61 is used to enable/disable the internal speaker and is controlled by **VT52** by means of the signal **INT_SPEAKER_OFF** sent by the pin **48** of the microprocessor **DD5**.
If the radio is in alert mode, the microprocessor **DD5** generates an alert signal at its pin **38**, this signal (line **ALERT**) is injected in the low-pass filter (**DA15:C**) and routed at the input of the AF pre-amplifier **DA15:B** by means of the resistor **R269**.

2.6.f CTCSS/DCS signal routing

Similarly to the audio routing the detector's audio output (line **DETECTOR_AUDIO**) is fed to **DA13:A** and **DA13:B** which make the tone (CTCSS and DCS) 3 KHz low-pass filter, however the output of the low-pass filter (line **TO_CTCSS_DATA_FILTER**) is directly routed to the second stage tone filter which consists of **DA17:A**, **DA17:B** and **DA17:C**. The output of this filter (line **ADC_LO_SPEED_DATA_RX** is then sent to the microprocessor **DD5** (pin **60**) in order to be decoded.

2.6.g Selcall signal routing

The Selcall signal follows the same routing of the audio one, but it's picked up at the output (pin **1**) of **DA15:A** (line **TO_CCIR_DATA_FILTER**), then fed to **DA17:D** and sent (line **ADC_HI_SPEED_DATA_RX**) to the microprocessor (pin **59**) in order to be decoded.

2.7 Signaling

2.7.a General

The microprocessor is fitted with a ADC/DAC converter built-in, so it provides generating and decoding the tones for selective calls, CTCSS and DCS. It can do that without using any other external I.C.s, but only by means of some external circuitry. The deviation of the selective call can be adjusted by the trimmer IRV1.

The microprocessor manages the analogue switches for the scrambler as well, which is base-band-inversion type.

2.7.b CTCSS (Continuous Tone Coded Squelch System)/DCS (Digital Coded Squelch)

CTCSS signals and DCS signals are synthesized by the microprocessor **DD5** (pin **39** - line **MCU_CTCSS_DCS_PWM**) and appear as PWM, then smoothed by the CTCSS/DCS 300 Hz low pass filter which consists of **DA9:A** and related circuitry to produce an acceptable sine wave output. The output of the filter is fed in the pin **2** of the IC **DA10** which adjusts the level and outputs the regulated CTCSS/DCS at its pin **12**. This signal is then applied to the second input of **DA9:C** in order to be summed with the speech/Selcall signal.

The CTCSS/CTS decoding is provided by the microprocessor **DD5** (pin **60**) which gets the proper signal from the detector as explained in par. "CTCSS/DCS signal routing".

2.7.c Selective call (Selcall) encoder

Similarly to CTCSS/DCS, Selcall signals are also generated and decoded by the microprocessor **DD5**. Selcall encoding audio PWM signaling coming from the pin **37** of the microprocessor (line **MCU_SELCALL_PWM**) is fed to the 3 KHz low pass filter which consists of **DA9:B** and related circuitry. Its output is then fed to the input of the **DA11:B**, so routed the same way of the speech audio.

The speech/Selcall signal is applied to the input of **DA11:B** which limits the peak-to-peak output, then is fed to the pin **3** of IC **DA10** which is a double digital audio regulator. After the level regulation, the speech/Selcall is output at pin **11** and sent to the first input (pin 9) of **DA9:C** in order to be summed with the CTCSS/DCS signal.

The Selcall decoding is provided by the microprocessor **DD5** (pin **59**) which gets the proper signal from the detector as explained in par. "Selcall signal routing".

2.8 ON/OFF switch, rear connector and internal connectors

2.8.a ON/OFF switch

The line ON/OFF_SWITCH is normally pulled up by the resistor R182. When the front ON/OFF switch is switched on, this line becomes low, so the zener VD32 can bias the transistor VT35 which activates the main electronic power ON/OFF switch **VT33** which feeds the main voltage to the regulators **DA7** (+8V) and **DA8** (+5V). The diode **VD37** acts as a typical protection against polarity inversion.

2.8.b Rear connector

The rear connector **XT3** accomplishes a variety of connections and functions allowing to connect the radio to many kinds of devices. For example:

Pins **3** and **16** (lines **EXT_SPEAKER-** and **EXT_SPEAKER+)** can be connected to an appropriate external speaker

The line **AUX_OUT_FROM_MPU** coming from the pin **16** of the main microprocessor **DD5** drives the transistor **VT33** which can switch ON/OFF by software a 5,6 V voltage at pin **1** (line **AUX_OUT**) of **XT3** is an auxiliary output programmable by firmware.

The pin **13** of **XT3** duplicates the hang up function normally provided by the microphone hang up: grounding or not the line **HUNG_UP** reflect a status change in the line **HANG_UP_TO_MPU** via the zener **VD27** and the transistor **VT29**

Pin **9** duplicates the PTT connection normally provided by the microphone connector in the front panel. Its line **EXTERNAL_PTT** drives the zener **VD30** and the transistor **VT32** which reflect a status change in the line **PTT_TO_MPU**

2.8.c Internal connectors (accessory board)

The internal connectors **XP1** and **XP2** are used to internally fit a variety of option boards, such as scrambler modules, audio processing modules etc. For this reason there are many contacts in parallel with **XT3**, e.g. **XP1** has **AUX_OUT** at pin **13** and **EXTERNAL_PTT** at pin **1**. Moreover, the two connectors have other specific lines in order to handle a large number of internal signals, e.g. flat unsquelched RX audio at pin **14** pf **XP1** and microphone input/output at pins **1** and **2** of **XP2**.