6. Theory of operation

6.1 Receiver

- **Antenna switch and front-end :** Received signal from antenna fed through the N701-AT GSM module antenna port via a coplanar wave guide made of flexible PCB. The signal than fed into IC404 Front End Module("FEM" here after) The signal get routed to proper SAW BPF internal to the FEM module and than fed in to IC401 PMB6271 the transceiver IC. All unwanted signals that are away from GSM850/GSM900/GSM1800/GSM1900 receiving frequencies are attenuated at the SAW BPF filters inside the FEM module for ensure not to have sudden call drop due to out of band interference signals. Appropriate internal SAW filters to be selected by control signals to CTRL1 and CTRL2 ports of the IC404 FEM that are controlled by IC101 PMB7860 GSM main processor.

  Signals fed onto IC401 PMB6271 transceiver IC Rx1~RX4 ports respect to GSM850/GSM900/ GSM1800 and GSM1900 are getting amplified by internal LNAs and get down-converted to DC.

  Outputs on each LNAs are composed of I and Q two ports which has 90 degree phase shifted from one to the other to make down converter possible to perform an image rejection down converting to eliminate-reduce- much of imaginary response of down conversion and all of those circuits are internal to IC401 PMB6271 the transceiver IC.

  All the functionality of the IC401 PMB6271 transceiver IC are controlled by IC101 PMB7860 GSM main processor via a serial interface line CLK, DA and EN.

- **Demodulator and Basband processing :** The amplified RF signal is converted by a quadrature demodulator to the final orthogonal output signals at baseband frequency. The orthogonal LO signals are generated by a divider by 4 for the GSM850/GSM900 bands and by a divider by 2 for the GSM1800/1900 bands. The resulting in-phase and quadrature signals are fed into two bas band low pass filters and the PGC(Power Gain Control) Amplifier chain. The base band filters provide an effective suppression of in-band-blocking signal and adjacent channel interferers. The design of the filter provides reasonable N+1 suppression, the pass band is optimised for low group delay ripple to avoid the degradation of the receivers co-channel performance. After the filtering, the signal fed in to a PGC amplifier chain that offers 78dB of programmable gain with 2dB steps and differential offset voltages are reduced by an internal offset compensation circuit.

6.2 Transmitter.

- **Tx Modulator :** Tx GMSK signals that are generated by IC101 PMB7860 GSM main processor is fed to IC401 PMB6271 transceiver IC's I/Q modulator input ports. The analog I/Q signals are converted to digital using two ADCs to regenerate the digital data stream for the digital modulator.

Following Gaussian filer shapes the digital data stream for the GMSK modulation. Additionally a pre-emphasis filter compensates the attenuation of the PLL transfer function resulting in a very low distortion at the transmit output.

The filtered digital data stream is scaled appropriately and added to the channel world. This sum is fed into the MASH modulator. The output of the MASH modulator is a sequence of integer divider values representing the high resolution fractional input signal. This sequence controls the MMD(multi modulus divider) at a sample rate of 26Mhz. Thus a tightly controlled frequency modulation of the VCO is achieved.

The output signal of the VCO is divided by four for GSM 850/900 or by two for GSM1800/1900 respectively. Finally the divided signal is amplified by a single ended output driver with 50 Ohm output impedance to allow a direct connection to the PA.

The transmitter achieves a very low out-of-band noise, typically –165.5dBc/Hz@20Mhz offset, and a very low rms phase error of 0.7 degree typically in GSM850/900

- **Power amplifier :** Tx signals from IC401 PMB6271 transceiver is fed to IC400 TQM7M4001 quad band Power Module to boost it's power to meet GSM output power requirements-class 4 for GSM850/900 and class 1 for GSM1800/1900. The power module is capable of amplifying either GSM850/900 or GSM1800/1900 signals depending on control signal-BS signal- from IC101 PMB7860 GSM main processor.

  The output power control is to be achieved by controlling VRAMP input port of the power module and is controlled by IC101 PMB7860 GSM main processor.

- **Antenna switch :** Power boosted GSM transmit signal is fed into IC404 FEM(Front End Module) for route Tx signal to the antenna port for it's proper Tx time slot. On the FEM is controlled by IC101 PMB7860 GSM main processor via CTRL1 and CTRL2 ports to route Tx and Rx signals on to proper ports in proper time slot. The FEM also perform as Tx low pass filter to reduce harmonics form over all Tx signal chain.

6.3 RF-synthesizer.

- **RF-Synthesizer :**. The IC401 PMB6271 transceiver contains a fractional-N sigma-delta synthesizer for the frequency synthesis in the RX and TX operation mode. The 26Mhz reference signal is provided by the internal crystal oscillator. This frequency serves a comparison frequency of the phase detector and as clock frequency of all digital circuitry.

  The N-counter of the synthesizer is carried out as a multi-modulus divider(MMD). The loop filter is fully integrated and the loop bandwidth is about 100Khz to allow the transfer of the phase modulation. The fully integrated quad-band VCO is designed for the four GSM bands (850, 900, 1800, 1900Mhz) and operates at the double or four times transmit or receive frequency. To cover the wide frequency range the VCO is automatically aligned by a binary automatic band selection(BABS) before each synthesizer startup.

- **Over all frequency stabilities :** frequency stabilities are insured by a VCTCXO that is composed of U401 26Mhz XTAL, oscillator circuit and frequency trimming circuitry inside IC401 PMB6271 transceiver that is controlled by IC101 PMB7860 GSM main processor.
  In order to maintain accurate 26Mhz of reference frequency, the IC101 PMB7860 GSM main processor is giving controlling signal to the VCTCXO circuit based on a ambient temperature measurement from the IC401 PMB6271 and pre-programmed XTAL compensation table stored on IC204 non volatile memory IC.

6.4 Power supplies.

The power supplies are mainly composed of two part. One is main power supply reside on main board and the other one is one in N701-AT GSM module as follows.

- **TC100G main power supply :**. + 9 ~ 28 Volts of input power to be fed the TC100G via J502 Molex power connector and than go through FUSE1 2A fuse and D501 diode to prevent possible damage caused by reverse power supply connection. The supply power fed in to IC501 MIC4684YM DC-DC converter forms buck step down switching regulator operate at 200KHz.
  The output voltage of the DC-DC converter is 4 Volts DC and is capable of supply 2A continues current to the whole circuitry including the N701-AT GSM module.

- **N701-AT GSM module power supply :**. +4 Volts of DC power supplied by the IC501 main power supply fed in to the N701-AT GSM module as a module system power source.
  On the N701-AT GSM module, all of the required powers are controlled and maintained by IC200 PMB6814 power management IC.
  Upon power on, IC101 PMB7860 GSM main processor is controlling the IC200 power management IC to feed all other circuit with proper voltage. The control of IC200 power management IC is done by controlling EP_SDA, EPSCL from IC101 PMB7860 GSM main processor.

6.5 GSM main processor, MMI and audio circuits.

- **GSM/GPRS protocol processing :**.
  Most of GSM/GPRS protocol is processed with in IC101 PMB7860 GSM main processor in conjunction of IC204 64Mbytes flash memory. An embedded DSP, MCU, A/D and D/A converters work together to perform the task.

- **User interfaces and GPIO, UART controls :**.

All the GPIO, UART ports as well as A/D converters are embedded to IC101 PMB7860 GSM main processor and is directly under control of a MCU embedded to the GSM main processor.

Man machine interfaces such as most common AT commands are also being handled directly by the GSM processor.

- **Acoustics :**.

  All the audio circuitries are embedded to IC101 PMB7860 GSM main processor and are controlled by an embedded MCU on the GSM main processor.

  The audio circuitries are composed of :

  a) Microphone amplifier
  b) Audio band pass filter for the microphone and receiving audio signals.
  c) Tx microphone volume control.
  d) side tone circuit include side tone volume control circuit.
  e) Tx codec.
  f) receiving audio codec.
  g) audio volume control.
  h) audio amplifier to drive an earpiece

6.6 GPS receiver.

An off the shelf GPS receiver module is being used with the TC100G product to obtain current precise location and is connected to the N701-AT GSM module UART1 serial port. Enable and disable of the power to the GPS receiver and read GPS current coordination is being controlled by IC101 PMB7860 GSM main processor.