DESIGN, IMPLEMENTATION AND OPTIMISATION OF CDMA NETWORKS (RF PLANNING)

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CDMA stands for "Code Division Multiple Access." It is a form of spread-spectrum, an advanced digital wireless transmission technique. Instead of using frequencies or time slots, as do traditional technologies, it uses mathematical codes to transmit and distinguish between multiple wireless conversations. Its bandwidth is much wider than that required for simple point-to-point communications at the same data rate because it uses noise-like carrier waves to spread the information contained in a signal of interest over a much greater bandwidth. However, because the conversations taking place are distinguished by digital codes, many users can share the same bandwidth simultaneously.

RF PLANNING deals with the air interface between the BASE TRANSCEIVER STATION & the MOBILE UNIT. It also involves designing and optimizing the network in order to provide a high quality service to customers.

The objective of the project is to plan, design & optimize a cell site at **BANGARPET.** The main purpose of the planning is fewer base stations per network, greater system efficiency and capacity, improved voice quality and a reduction or elimination of drop outs and multi path problems. All of which result in improved services and greatly reduced network cost.

THE VARIOUS STAGES INVOLVED IN CDMA RF PLANNING & OPTIMISATION

1. **MARKET SURVEY:** Depending on the marketing feedback, a thorough survey is conducted to define the area of coverage & potential candidate sites are listed out. The market survey also gives the area morphology-terrain and clutter information. The purpose of the market analysis is to collect all the information from the market that affects the design of the RF Network. The following information is gathered:

a) Classification of various types of morphologies in the area

b) Major points of interest

The exact locations of the important places of the town were recorded using a GLOBAL POSITIONING SYSTEM KIT as shown below.

Latitude	Longitude	Location
12.98606	78.16865	Railway Crossing I
12.9864	78.17067	Gas Agency
12.98814	78.17475	Railway Crossing II

2. CONTINUOUS WAVE TEST: Initially, the signal propagation is studied in the proposed area transmitting a CW signal. The signal propagation is done using an omni directional antenna placed at the center of the proposed clutter

3. PRE-ANALYSIS: All the data collected by the CW test is analyzed using a special pre-analysis software tool. TTL uses a tool called PLANET EV provided by MARCONI. It is used to design & evaluate network problems. It provides with a comprehensive set of coverage and interference analyses of different cell sites.

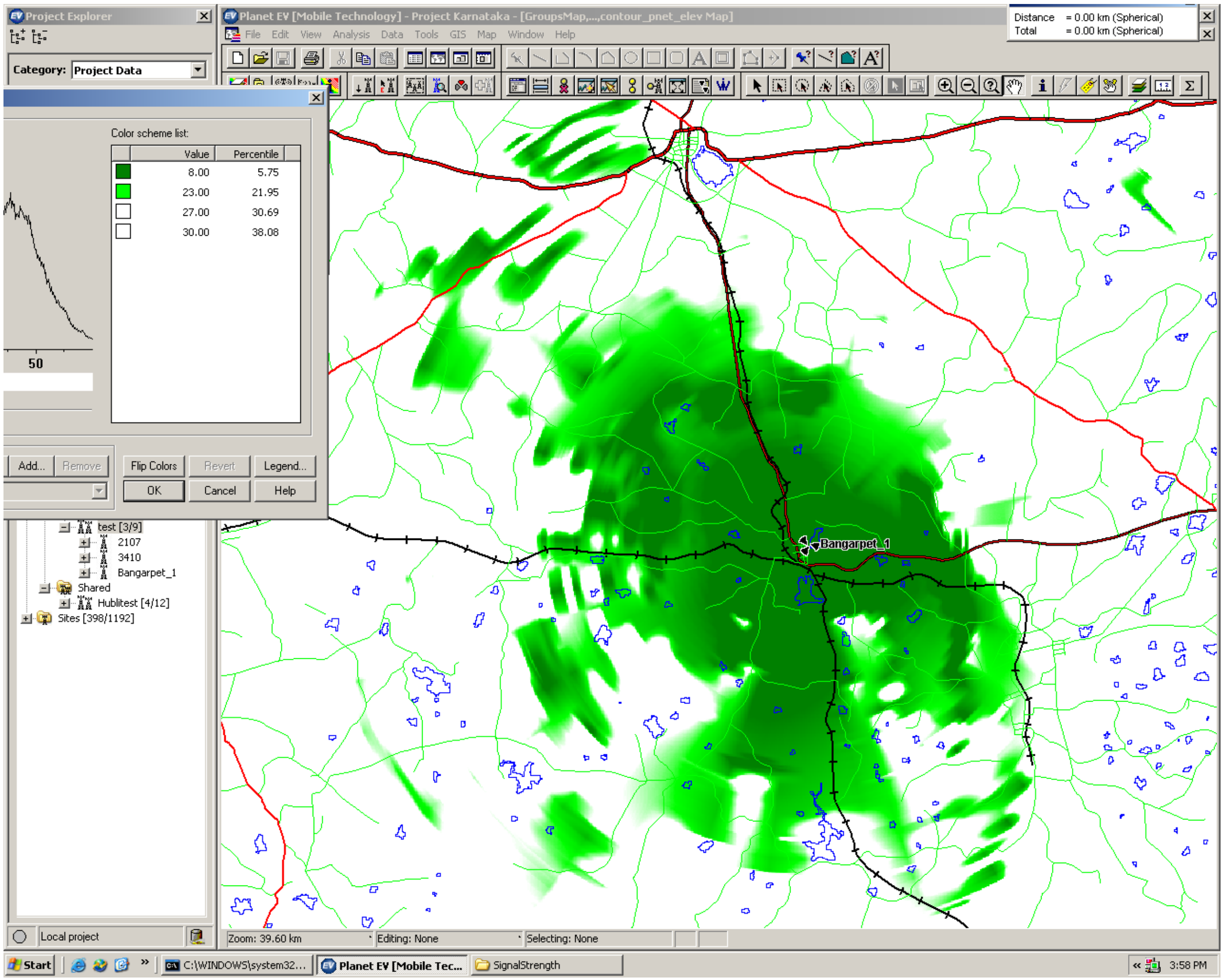

FIGURE 1. BANGARPET PROPOSED SITE COVERAGE CALCULATION USING PLANET EV

After Clutter classification is done, the location of the cell site is derived based on the information gathered. Based on the information collected, design process is carried out as shown:

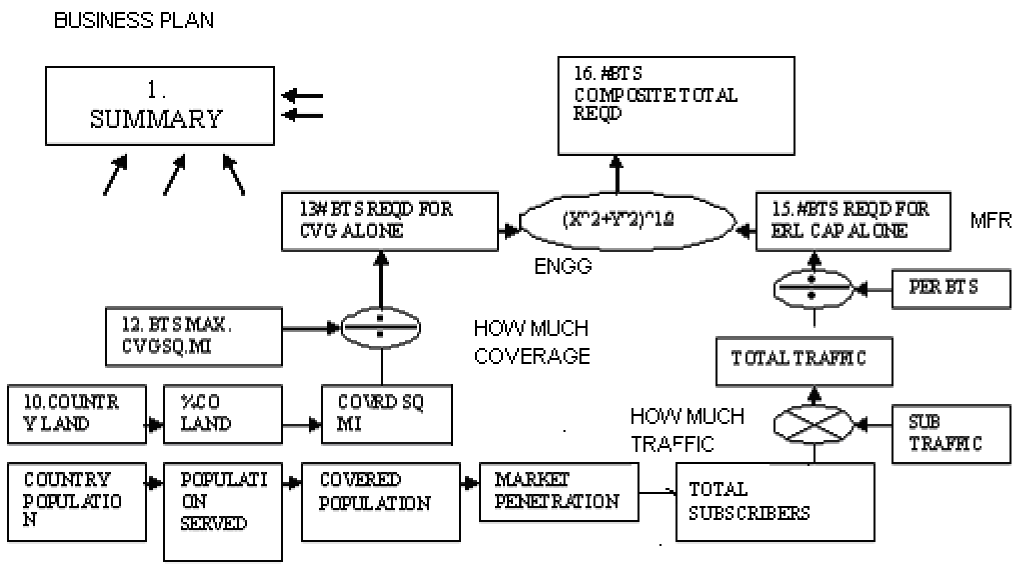

FIGURE 2. DESIGN PROCESS (PRE ANALYSIS)

The penetration median losses, standard deviations, and fade margins calculated on this basis below are taken directly to the link budgets to be used in later cell planning.

COMPOSITE PROBABILITY OF SERVICE
CALCULATING REQUIRED FADE MARGIN

ENVIRONMENT TYPE ("MORPHOLOGY")	BUILDING PENETRATION		OUTDOOR	COMPOSITE TOTAL	
	MEDIAN LOSS,DB	STD. DEV. σ, DB	STD. DEV. σ, DB	AREA AVAILIBILITY TARGET,%	FADE MARGIN (DB)
DENSE URBAN BLDG.	20	8	8	90%/75%@EDGE	7.6
URBAN BLDG.	15	8	8	90%/75%@EDGE	7.6
SUBURBAN BLDG	10	8	8	90%/75%@EDGE	7.6
RURAL BLDG.	10	8	8	90%/75%@EDGE	7.6
TYPICAL VEHICLE	8	4	8	90%/75%@EDGE	7.6

Link Engineering (LINK BUDGET)

(Values are not shown)

1X Reverse Link Budget		Voice	
Parameter	**Units**	**U**	**SU**
RBS Receiver Sensitivity	dBm		
Subscriber Maximum Transmit Power	Watts		
Subscriber Maximum Transmit Power	dBm		
% MS Power used for RL Pilot	%		
Reverse Pilot Overhead Penalty	dB		
MS Antenna Gain	dBi		
MS Total EiRP	dBm		
MS TCH EiRP	dBm		
Building Penetration Loss	dB		
Body Loss	dB		
Probability of cell edge coverage	%		
Slow Fading Std. Deviation	dB		
Fade Margin	dB		
RBS Antenna Gain	dBi		
RBS Rx/Tx Cable and Connector Loss	dB		
Soft-Handoff Gain	dB		
Ant Diversity Gain	dB		
CDMA Traffic Loading Effect	%		
CDMA Traffic Loading Effect	dB		
Maximum Allowable Path Loss	dB		

CDMA Planner's MAPL
(ant gain calculated in ant pattern file)

MS total EIRP	dBm		
MS Antenna Gain	dBi		
Fade Margin	dB		
Building Penetration Loss	dB		
Required MS EIRP (MEIRP Plot)			

NOTE: Body loss & SHO factor is calculated in simulation (MEIRP)

The antenna selection is done from the data base provided by various vendor companies. The antenna is a cross polar antenna with H-beam of XX degrees & V-beam of XX degrees along with a gain of XX.XX dBd operating at the XXX Mhz range. The antenna plots are as follows:

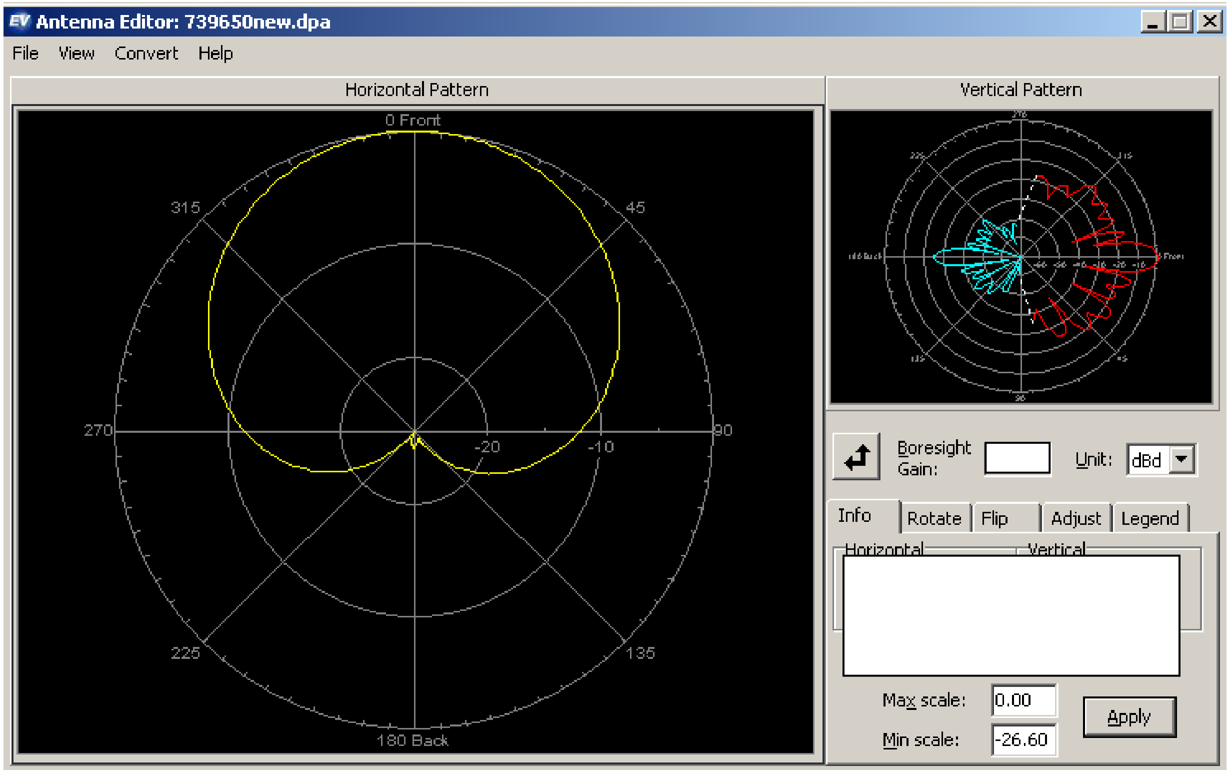

FIGURE 3. HORIZONTAL PLOT

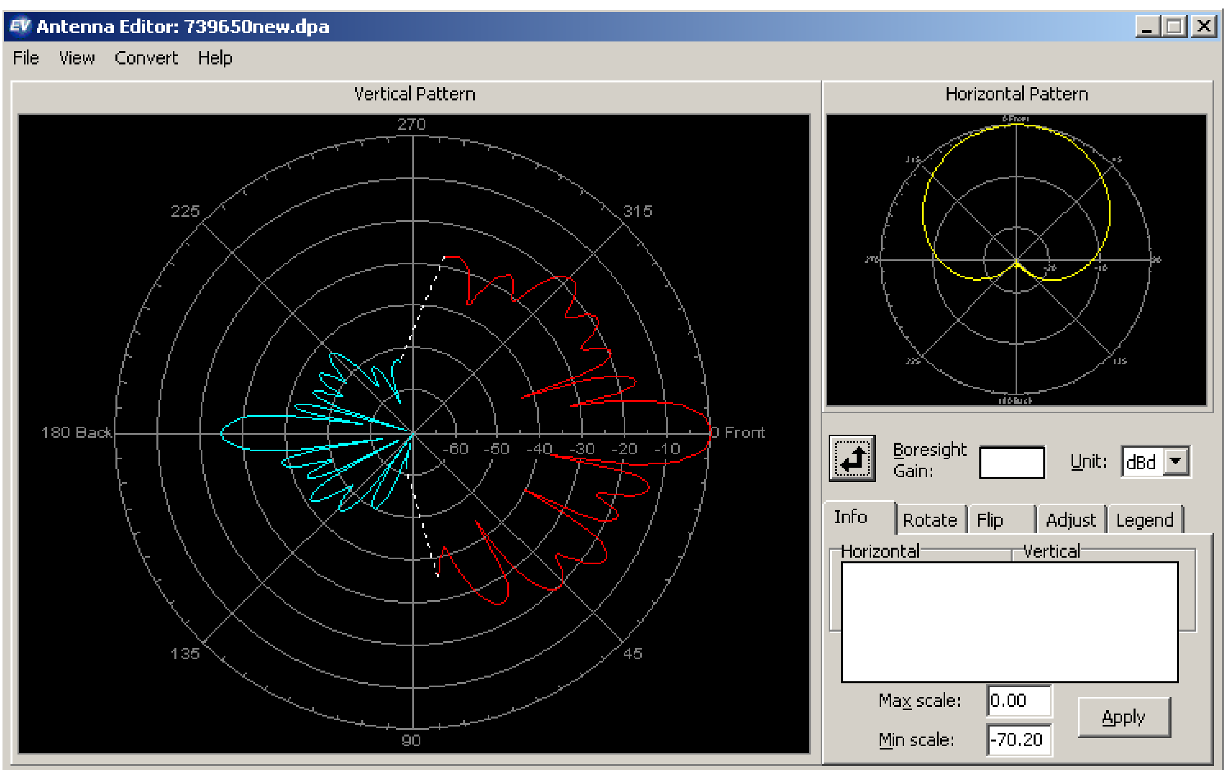

FIGURE 4. VERTICAL PLOT

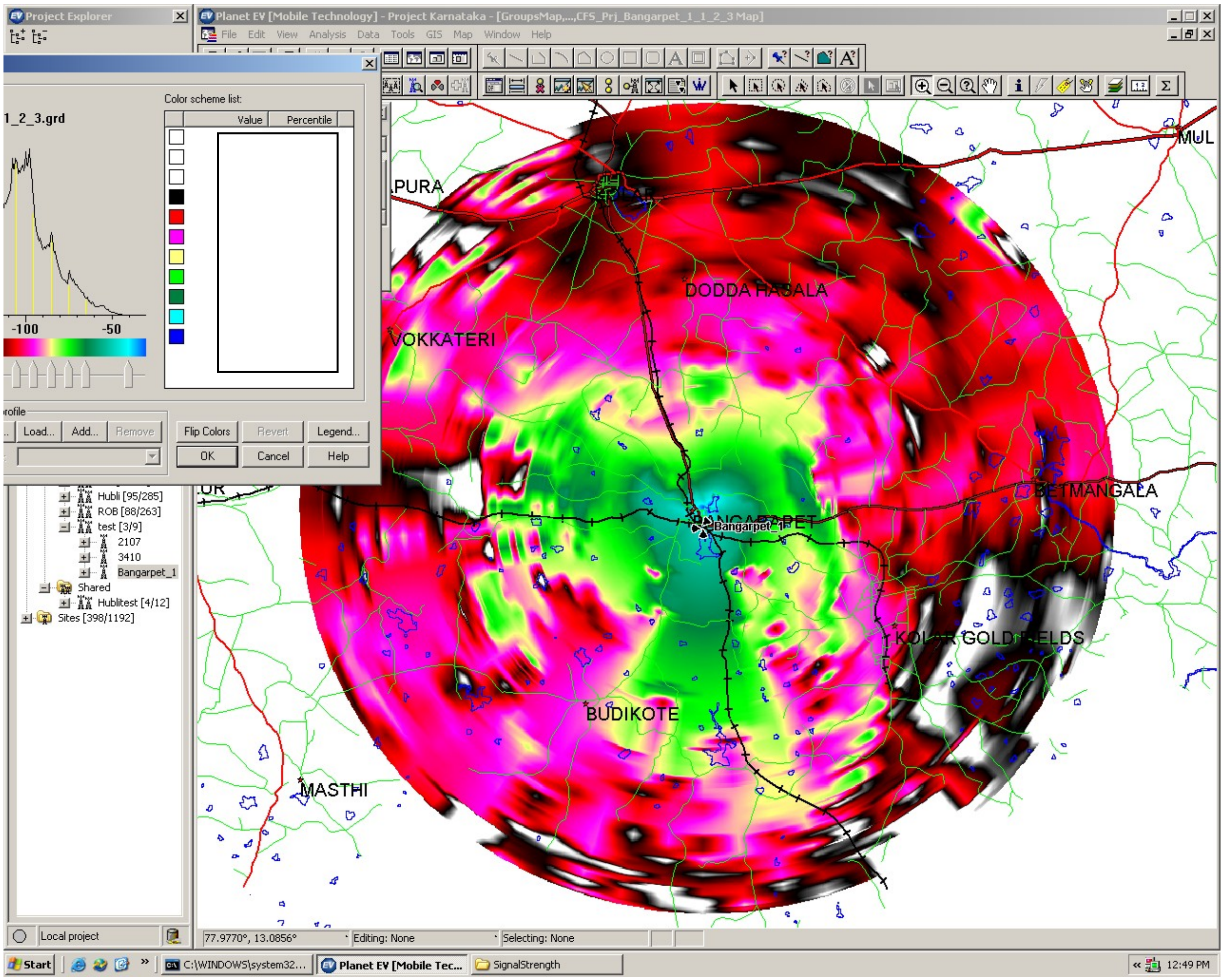

FIGURE 5: BANGARPET ANALOG PREDICTION (TRIAL)

CDMA reverse link analysis: The EV reverse link analysis computes the probability that a mobile user , with the ability to transmit at the max ERP specified by you, is able to close the reverse link. Reverse link closure is computed as the probability of receiving a mobile unit's signal at the serving site(s)

With sufficient mobile unit traffic channel(reverse link target) Eb/Nt for acceptable call quality. The reverse link analysis incorporates the statistical nature of the processes and computes the probability of closing the link for each handoff type.

Closing the reverse link in no handoff is predicted in terms of a single probability. While the various "soft" handoff configurations are computed in terms of joint probabilities that at least one of the contributing entities will receive adequate signal.

CDMA Forward link analysis: This analysis verifies that the specified threshold (T_ADD or T_DROP specified for each cell/sector) for pilot channel coverage has been met or exceeded before a cell/sector is considered to be a valid contributor. The hand-off contributors are based on the strongest pilot signals at each bin.

4. RF IMPLEMENTATION: Once the proposed cell site has been finalized, RF implementation team swings into action wherein the proposed cell site is physically implemented.

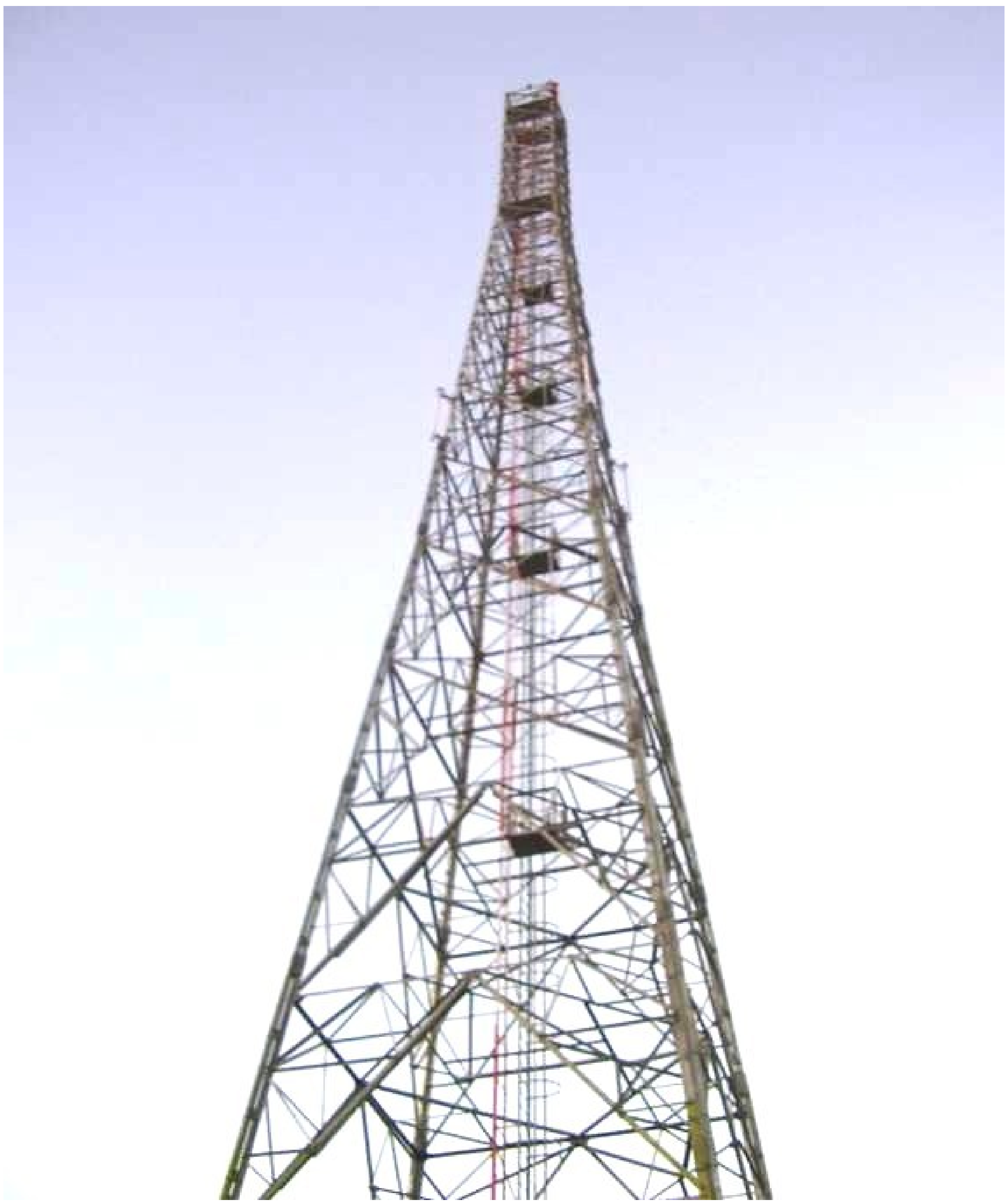

FIGURE 6. TOWER CONSTRUCTED AT BANGARPET

5. NETWORK PERFORMANCE MONITORING: Once the base station is set up, its performance is continuously monitored. This process is called drive testing. The tool is called TEMS INVESTIGATOR from ERICSSON. The drive test system is placed in a vehicle & driven throughout the coverage area of potential site. It actually gives a subscriber's point of view of the network. It can evaluate call - processing operations, perform call processing functions and signal quality of received base station signal.

Drive test for model calibration: A significant number of typical sites are evaluated using the test transmitter & receiver to determine signal decay rates and to get a fairly accurate understanding of the effects of typical clutter in the area. Tests are also conducted to evaluate the additional attenuation which the signal suffers during penetration of typical buildings and vehicles. The focus is on developing models generally applicable to the area, not on performance of specific individual sites.

Drive test for site evaluation: Although propagation models for an area already have been refined coverage of a particular site is so critical, or its environment so variable due to urban clutter that it is essential to actually measure the coverage and interference it will produce. The focus is on this specific site.

CDMA Performance Indicators:

Indicator #1: FER (FRAME ERASURE RATE)

- ON forward channel (realized at handset)
- ON reverse channel(realized at base station)
- FER is excellent call quality "summary" statistic

FER is the end –result of the whole transmission link.

- If FER is good then any other problems aren't having much effect
- If FER is bad that's not the problem-- it is the end result of the problem
- We must investigate other indicators to get a clue what is going on.

INDICATOR #2: Ec/Io –What does it mean?

Why can't we just use the handset's received power level to guide handoffs?

- Because it is a simple total RF power measurement, the total of all sectors reaching the mobile. We need a way to measure the signal strength of each sector individually, & we must be able to measure it quickly & simply. The solution is to use each sector's pilot (Walsh 0) as a test signal to guide handoffs.

- At the mobile, if the pilot of a certain sector is very strong & clean, that means we also should be able to hear a traffic channel on that sector, so handoff would be a good idea.
- If the pilot of a certain sector is weak, then we probably won't be able to get much benefit from using a traffic channel on that sector.

6. POST ANALYSIS: The drive test data is loaded into a post analysis tool. It assesses the end-to-end performance of the network infrastructure. It can be used to analyze the benchmark drive data to compare the performance of their own network with those of competitors. TTL uses TEMS DESKCAT as the post analysis tool. We get the following parameters: Ec/Io, Tx power, Rx power and FER.

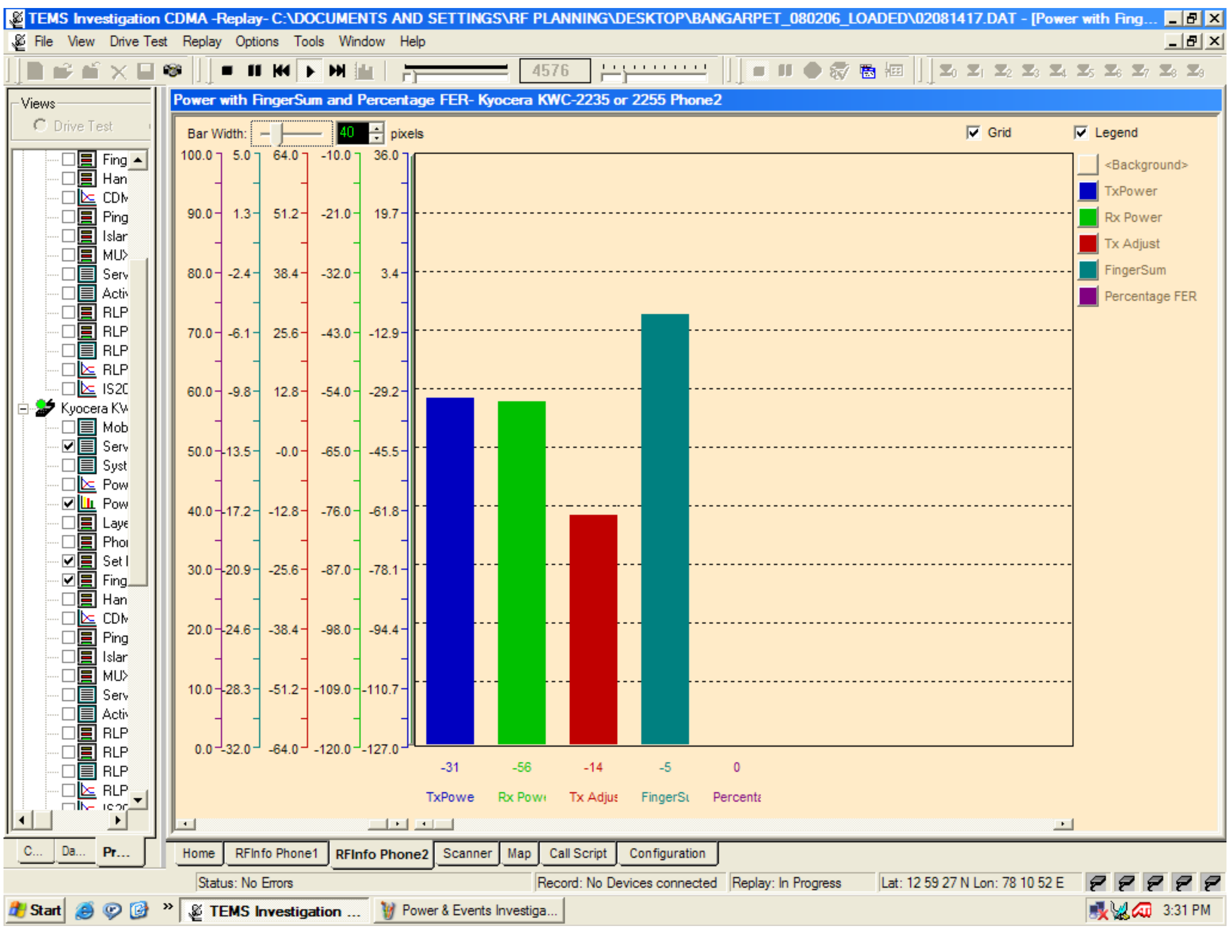

FIGURE 7: CDMA PARAMETERS FROM TEMS INVESTIGATOR

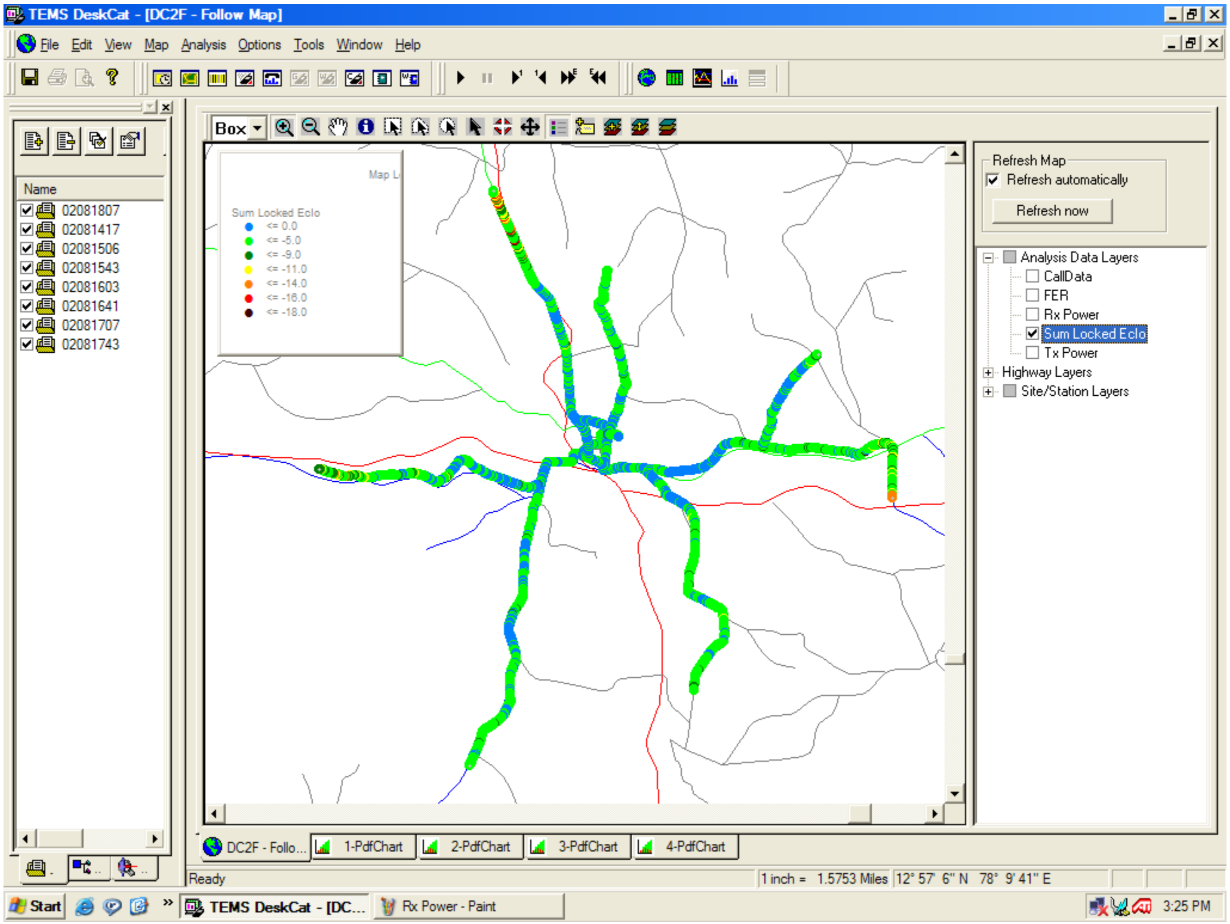

FIGURE 8: EC/IO PLOT

Starting optimization on a new system

RF coverage control

- Try to contain each sectors coverage, avoiding gross spillover into other sectors.
- **Tools** : PN plots, Handoff state plots, mobile Tx plots.

Neighbor list tuning

- Try to groom each sector's neighbor to only those necessary but be alert to special needs due to topography & traffic.
- Tools: PSMM data from mobiles; propagation prediction.

Search window settings

- Find best settings for SRCH_WIN_A,_N,_R

- Especially optimize SRCH_WIN_A per sector using collected finger separation data; has major impact on pilot search speed.

ACCESS failures, dropped call analysis

- Finally, iterative corrections until within numeric goals.

1) Performance monitoring/growth management
2) Benchmark existing performance
3) Identify problem cells & clusters
4) Look for signs of overload
5) Traffic trending & projection

These steps must be continuously applied to guide needed growth.

CONCLUSION

The construction of the cell site at Bangarpet was completed. The site became fully operational in the first week of **APRIL, 2006.** The project work is carried out for TATA Telecom.

PARTIAL DISCHARGE MEASUREMENT FOR HIGH VOLTAGE CABLE TERMINATIONS

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Due to recent advances in cable manufacturing technology it has been generally recognized that the PD in cable insulation itself is no longer a major threat. Consequently, attention has been paid to the cable accessories such as cable joints/terminations where the complex structure and the construction can cause potential hazard to the whole system. When cable joints are subjected to HV testing, it is observed that the weak points in the insulation like void, crack and other imperfections lead to partial discharges in the insulation. Partial discharge is defined as localized discharge process in which the distance between two electrodes is only partially bridged that is the insulation between the electrodes is partially punctured. Partial discharge (PD) measurements are universally accepted as a technique giving some indication of the state of the insulation in high-voltage apparatus. Cable end users are keen to adopt PD monitoring during assembly and commissioning of systems.

This project is aimed in setting up the partial discharge tester with the sensitivity in the order of pico coloumbs, studying the problems in partial discharge measurement, charting out calibration procedure and the study of PD testing for the HV cable industry.

Partial discharge in HV cable termination

When HV cable terminations are subjected to High voltages in surveys ,it is observed that the weak points in the insulation such as void, cracks & other material imperfection leads to partial discharge in the insulation which is catastrophic in nature.

As per the standard (IEC 60270), the partial discharge in cable terminations are measured in broad band frequency range & required sensitivity level of whole measuring system should be less than or equal to 5 Pico coulombs.

Partial discharges are, in general, a consequence of local electrical stress concentrations in the insulation or on the surface of the insulation. Generally, such discharges appears as pulses having a duration of much less than 1 micro sec[IEC60270].[1]

Partial discharge measurement in HV cable terminations is an important step for demonstrating the quality of electrical insulators. Until the PD measurement of cable terminations are less than Pico coulomb, they can not put into service.

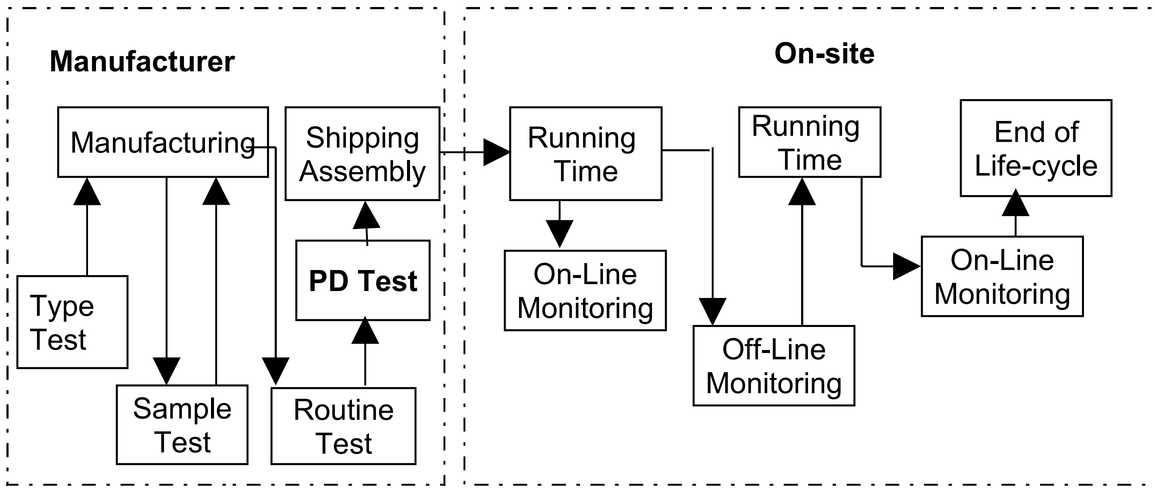


FIGURE 1. TEST CYCLE OF AN ELECTRICAL H.V. EQUIPMENT

PD Measurement Set-up

The ability to measure low levels of partial discharge is referred to as sensitivity.

Block-Diagram

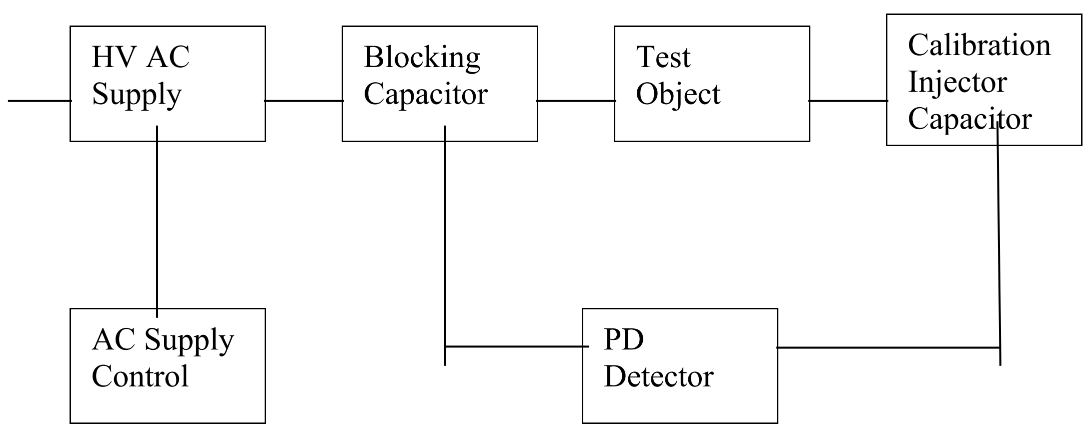


FIGURE 2. BLOCK DIAGRAM OF PD TESTER SETUP

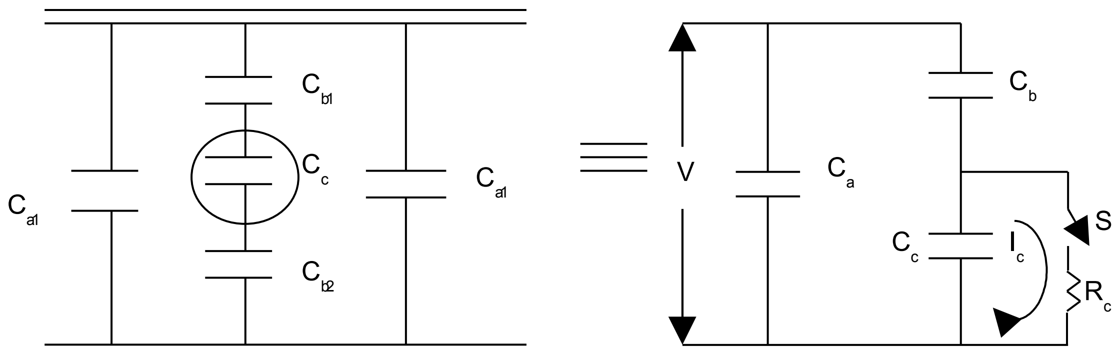


FIGURE 3: EQUIVALENT CIRCUIT FOR PD MEASUREMENT

The above figure shows a simple arrangement in which a gas filled void is present. The partial discharge in the void will take place due to difference in electrical stress. Due to geometry of the material the various capacitances are formed. Flux lines starting from electrode A and terminating at the void will form one capacitance C_{b1} and similarly C_{b2} between electrode B and the cavity. C_c is the capacitance of the void. Similarly C_{a1} and C_{a2} are the capacitance of the healthy portions of the dielectric on the two sides of the void. In the above figure

$$C_a = C_{a1} + C_{a2} \qquad \text{…….. (eq.1)}$$

$$C_b = \frac{Cb1 * Cb2}{Cb1 + Cb2} \qquad \text{…….. (eq.2)}$$

Closing of the switch S is equivalent to simulating partial discharge in the void as the voltage V_c across the void reaches breakdown voltage resulting into a current $I_c(t)$ to flow. Resistor R_c simulates the finite value of current $I_c(t)$.

TEST SET-UP

It is used for measuring the magnitude of partial discharge

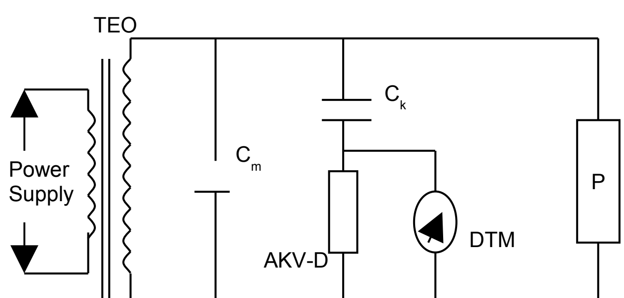


FIGURE 4: TEST SET UP

[TEO - Test Transformer, C_m - Measuring Capacitor, C_k - Coupling Capacitor, P - Test Object,AKV-D - Measuring Impedance, DTM - PD Meter]

Measurement Procedure

Figure 3 depicts physical model and equivalent circuit of a dielectric with internal void as a source of partial discharges. The model comprises of the following elements:

C_c – Capacitance of defect

C_b – Capacitance of healthy dielectric in series with the defect

C_a – Capacitance of the specimen

R – Resistance of the discharge path

If the alternating voltage u(t) is applied to the specimen and the gap does not break down, the voltage u_{10}(t) appears across the gap

$$u_{10}(t) = \frac{C_b}{C_c + C_b} u(t) \qquad \ldots\ldots\ldots$$

(eq.3)

if the gap breaks down at constant, polarity independent voltage u_z (discharge inception voltage) and the discharge extinction voltage is zero, a pulse like voltage u_1(t) appears across the defect. At the same time, a pulse-like current is developed in the circuit as a result of discharging capacitance C_c through the gap resistance R. the amount of charge developed at the void is

$$\Delta q_i = (C_c + C_b) u_z \qquad \ldots\ldots\ldots(\text{eq.4})$$

and the apparent charge, i.e. the charge measurable at the sample terminal is

$$\Delta q = C_b u_z \qquad \ldots\ldots\ldots (\text{eq.5})$$

which leads to

$$\Delta q_i = \Delta q \frac{C_c + C_b}{C_b} = \Delta q \left(1 + \frac{C_c}{C_b}\right) \qquad \ldots\ldots$$

(eq.6)

Since the ratio C_c / C_b is unknown (the defect has unknown location and geometry) there is always the uncertainty about the conclusions drawn from the discharge magnitude and pattern measured at the specimen terminals. Nonetheless, the simple equivalent circuit allows the following observation:

(a) PD current pulses appear as pulse train of alternating polarity

(b) The number of discharges increases with increasing test voltage whereas their amplitude remains nearly the same

(c) The amount of charge released in a void is not identical with that measurable at the specimen terminals as apparent charge

Although the equivalent circuit is well suited to the explanation of principles of partial discharge development it proves inadequate for modeling practical PD phenomena. There are a number of difficulties which arise

- The discharge inception voltage, U_z, may not be identical for positive and negative polarities of the excitation voltage; it may not be also identical from one pulse to the next
- The discharge extinction voltage may not be zero, not identical for positive and negative polarities of the excitation voltage or even from pulse to pulse
- Physics of discharge phenomena at the interface dielectric/defect are not well understood to mention a few more general ones. As the result, identification of partial discharges in power apparatus is based on empirical methods.

Power supply is given to LV side of test transformer and the HV side is connected to the test object with the help of coupling capacitor and measuring capacitor as shown above.

The partial discharge meter is connected across the measuring impedance.

There are several variations of a commonly adopted PD measuring circuit. One of them is shown in the figure below. The specimen C_x is in series with input unit. The input unit contains a current transformer whose primary side is connected to terminals A and E and the secondary sides to terminals Amp and B of the unit. The current transformer provides means for electrical isolation of the test circuit, exposed to high voltage, from the electronic circuitry of the measurement set. The input unit also contains an RLC filter.

The current transformer together with the RLC filter form the detection impedance which shapes the signal sent to the detector amplifier. The amplifier can have a bandwidth of 10 KHz – 500 KHz. This bandwidth is designed for good rejection of 50Hz signal as well as external high frequency interference.

Calibration of Partial Discharge Measurement

Accuracy of measurement depends on the accuracy of calibrators and we have to carry out operational test. These tests have to be carried out because of determination and keeping of characteristics of calibrators.

It is of the following types:

- PD meter calibration
- Charge injection calibration
- Window setting
- Standard specimen calibration

Load on Power supply to PD Tester	Before Calibration	After Calibration
Without light	11.7 pc	11.0 pc
With light	6.2 pc	5.5 pc

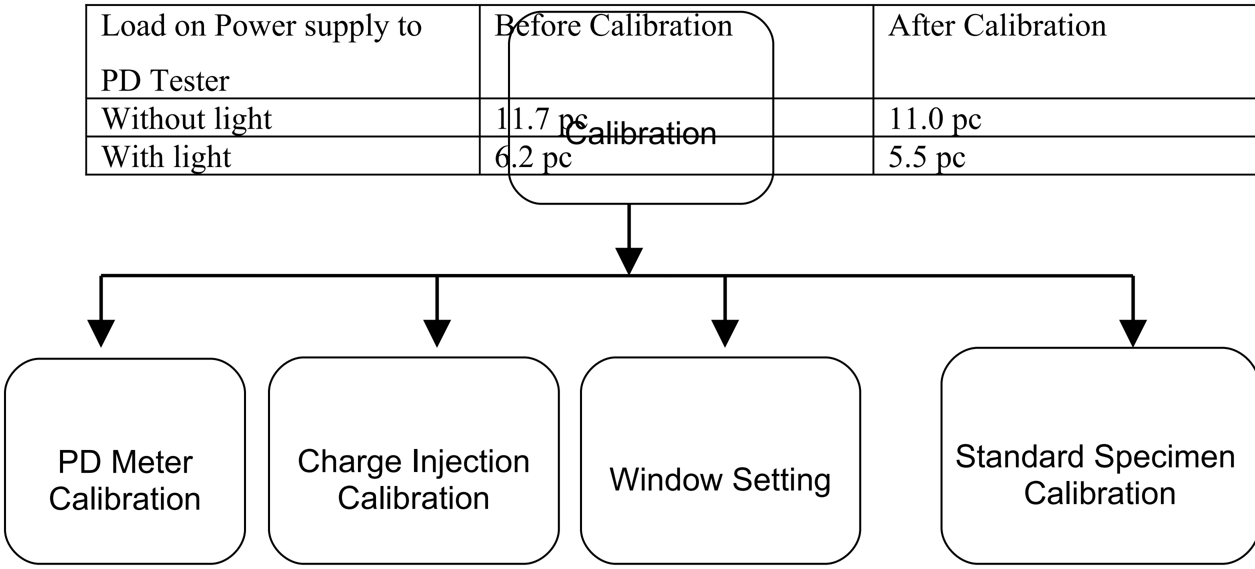


TABLE 1. MEASURED DATA

Noise in PD Data

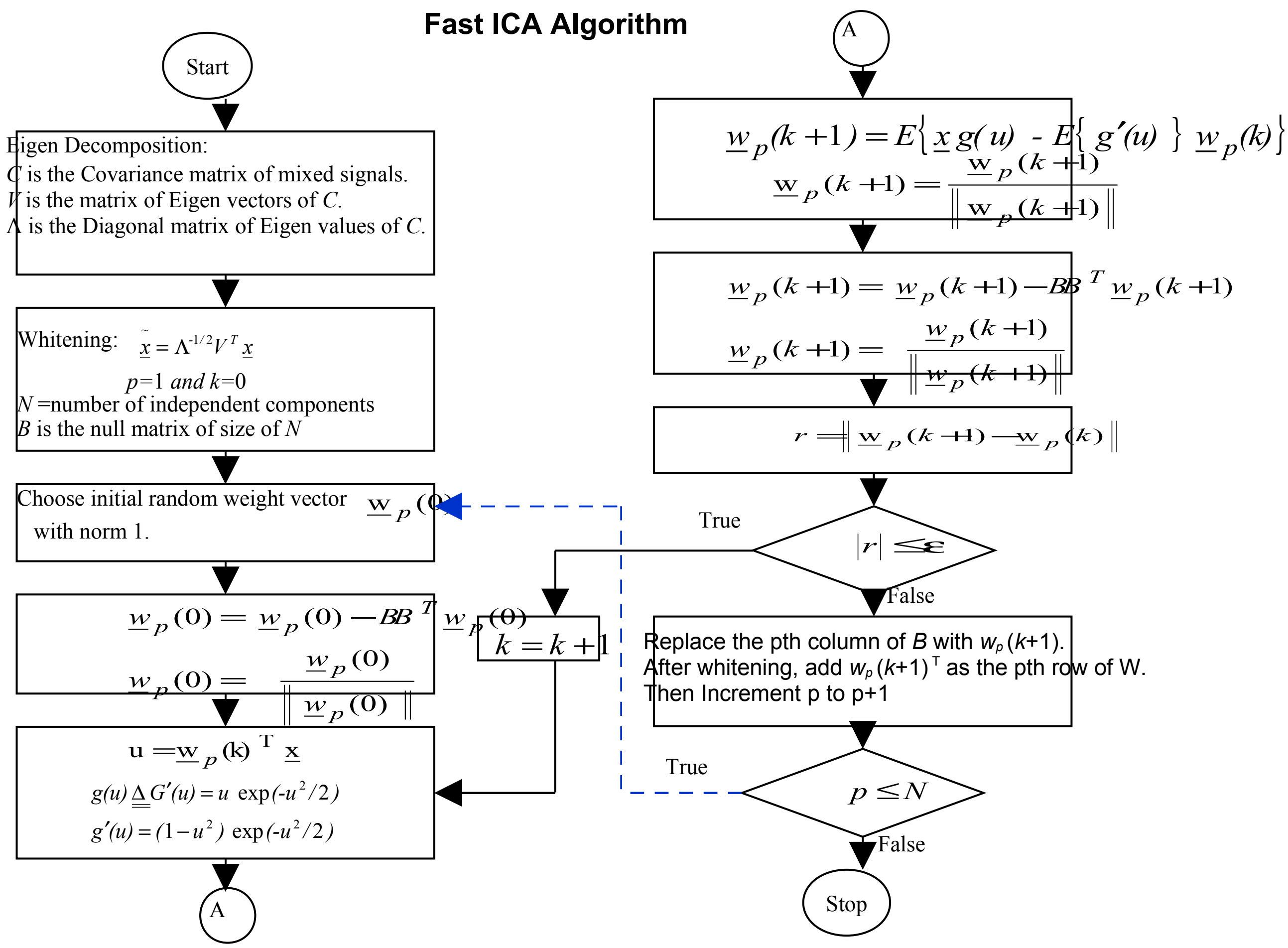
A major bottleneck encountered with PD measurement is the ingress of external interferences (usually of very high amplitude comparable to PD signal) that directly affects the sensitivity and reliability of the acquired PD data. Major external interferences encountered during PD measurement and their sources are:

- Discrete spectral interferences (DSI) from radio transmissions and power line carrier communication systems
- Periodic pulse shaped interferences from power electronics or other periodic switching
- Stochastic pulse shaped interferences from arching between adjacent metallic contacts, PD and corona from the power system which can get coupled to the apparatus under test
- Random or white noise from components
- Harmonics from main supply[2].

INDEPENDENT COMPONENT ANALYSIS (ICA)

ICA is a new class of neural network algorithm, with actual work starting only as late as late1990's. Since then it has found its worth in a variety of applications, mostly dealing with blind source separation and feature extraction. Presently it is one of the most sought after topic for research in fields like digital signal processing and neural networks. Its main assumption is that the individual signals are nongausssian. This is one of the main reasons for its delayed birth, prior to which all random signals with Gaussian distribution was taken as a standard.

The working principle of ICA is to find the demixing matrix of a set of mixed signals, by estimating the mixing matrix from the observed mixture and taking its inverse to get back the demixed signals. It exploits the statistical correlation in the observed mixed signal to estimate the mixing matrix. The code was developed and simulated in matlab.



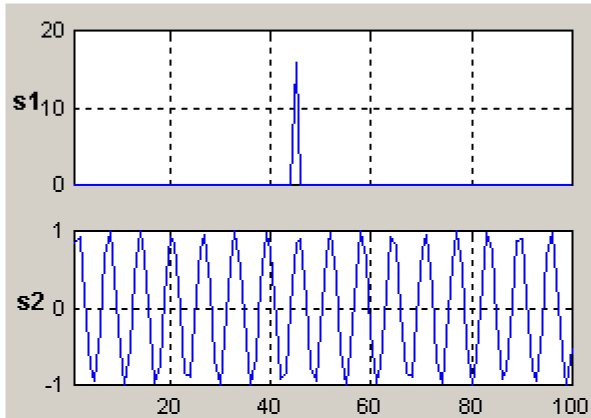


Figure 5.1 : Source signal (S1) and Noise source (S2)

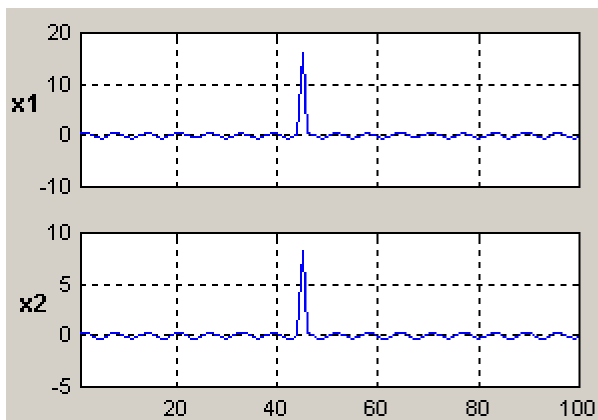


Figure 5.2 Mixed signals from S1, S2 (Unknown mixing ratio)

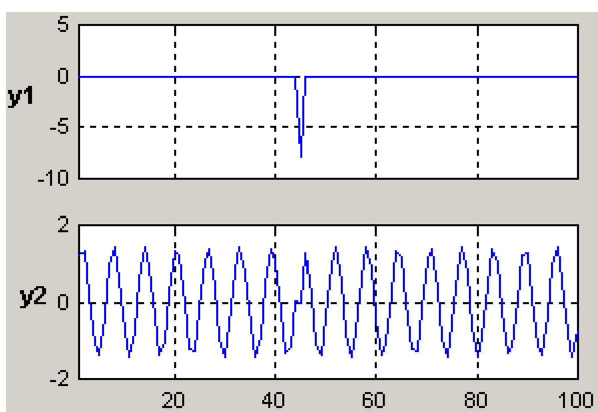


Figure 5.3 Estimated signals Y1,Y2 from mixed signals using Fast ICA

Please note that the non linear function Gauss (y*exp(-y^2/2)) is used for the simulation. From the simulation, it is observed that Fast ICA algorithm can be considered as potential candidate for the noise removal from PD source signal, which is the long standing problem in the HV engineering industry. Fast ICA algorithm, as explained in [3], was implemented using MATLab. Further study of ICA's application in HV engineering may be carried out, after careful observation of the theory and limitations of Independent Component analysis concept, which can be found elsewhere.

CONCLUSION

Thus Partial discharge (PD) measurements are universally accepted as a technique giving some indication of the state of the insulation in high-voltage apparatus. The study on partial discharge measurement for HV cable terminations were successfully carried out at TYCO electronics and the partial discharge tester has been installed in association with the HV sphere gap testing unit. Calibration on the testing equipment was done as per the calibration procedure, described in [3]. Initial testing was carried out over the samples given at the industry and was found external interference (noise) as the prominent bottleneck in the deployment of PD testing in the product test cycle of HV cable termination assembly. The application of filter circuits to the main supply of PD tester was of little use to solve this problem. After careful literature survey, we found that wavelet analysis of PD data was shown as successful simulation techniques in separation of partial noise from PD signal. We also found that a concept known as Independent component analysis found similar applications in other areas such as Radar systems, astrophysics, ECG and MRI. After sufficient understanding of the algorithm, we tried to simulate the popular Fast ICA algorithm over PD like data and found satisfactory initial results. Hence, we recommend the further study of Independent Component Analysis in the area of HV Engineering, for more interesting results. The same was recommended to TYCO Electronics officials for further study in future.

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