8.1 Conclusions

Optics has many advantages in telecommunication system. It is used to transmit multiple ethernet data over optical fiber in digital domain. MWP is a technique to transmit RF signals over optical fiber. The research in this field started few decades back but the availability of commercial hardware for implementation came in last few years. The technology is still not mature when it comes to MIL requirements.

The requirement of MIL system is ruggedization, reliability and maintainability aspects, EMC issues etc. MIL environment is known for its harsh weather and rough field conditions. Considering the war time critical situation, it is not advisable to design a system without environmental consideration.

Active aperture phased array radar is 4-D radar which measures target information in four dimensions i.e. range, azimuth, elevation and Doppler frequency. AESA radars can rotate antenna beam in any direction dynamically based on the requirement. This helps faster update rate and multi-beam processing. To achieve these functions radar has large number of T/R modules physically spread across the antenna array. These modules require different RF and digital signals for IF conversion, synchronization and timings of radar. Conventionally these signals are spread across the array with the help of coaxial cables and twisted shielded pair cables. In this work MWP is proposed using WDM for optical distribution network. This helps in increased data rate, less weight and less number of cables, immunity to EMI, little reliability and maintainability issues etc.
Feasibility analysis of the proposed design has been carried out with the help of simulation. Study showed that such design in actual radar system will work and improve the performance of radar. The conceptualization of design is done initially by power budget calculations and finalization of specifications.

Radar works for different spot frequencies, hence the proposed design is also tested for different microwave range up to 4 GHz. Operational, environmental, EMC tests are conducted on individual link and network. Results show feasibility of proposed system in production radar in future.

This solution also proposes antenna remoting with the help of optical rotary joint. This feature helps in ECCM as enemy targets RF radiation only and if antenna is remotely stationed, radar operator will be saved from enemy attacks. This also saves operators from harmful electromagnetic radiation of radar.

All the modules are integrated in actual radar and measurement is done with and without optical network. Radar BITE is tested and array health is captured. All the RF signals are measured for purity of spectrum and IF signal are fed to baseband circuit. All the required levels are under acceptable limits. A loss in the range of 20 dB is observed during RF to optical conversion hence design proposes EDFA with approximately 22 dB gain for all eight channels.

This work demonstrates successful analysis and design of multiple RF signal transmission on single fiber for active aperture phased array radar. Some of the strengths of this research are as follows:

i. Alternate efficient RF distribution network for active array radar

ii. Higher data rate/bandwidth

iii. Immunity to EMI

iv. Little field issues
v. Safety to radar operator
vi. Antenna remoting
vii. Safety from RF radiation
viii. Light weight
ix. Light volume
x. Engineering ease
xi. Modular design
xii. Remote Monitoring of health and control
xiii. Low loss optical cables etc.

8.2 Ruggedization of MWPN

The requirement of MWPN for application on AESA radar requires ruggedization matching to MIL standards. The biggest design challenge is to keep the performance of MWPN identical over wide temperature range and for large bandwidth. Hence individual signal conditioning cards are proposed in this design as it is easy to tune a specific frequency. Signal conditioning cards are proposed with tunable option to match variation for both input and output of photonic system. The photonic link is designed for zero gain using constant gain EDFA. Present work is designed for 64 digital receivers but same design is expandable for higher or lower number of modules as the design is modular in nature. The design of AESA radar is also modular in the sense that adding more T/R module can increase radar range. The proposed MWPN offers an additional benefit in terms of antenna remoting. Conventionally coaxial / LAN cables cannot run for long distance. While FO provides long distance communication without much loss of the signal. This feature requires optical rotary joint so that baseband can be placed kilometres away from radar antenna. This not only helps as ECCM feature
but also helps to protect radar operators from harmful radiation of antenna. MWPN offers reduced volume, weight, complexity, enhance bandwidth, data rate and immunity to electromagnetic effects.

To complete the ruggedization of complete MWPN, one subsystem of MWPN i.e. panel computer is tested for EMC compliance. The proposed panel computer is used as remote terminal to monitor health and status of MWPN. Mandatory EMC tests for ground MIL application are carried out and results are presented. Out of CE102, CS101, CS114, CS115, CS116, CS101, RE102 and RS103 tests the device did not clear two tests namely RE102 and RS 103 did not clear. As the supply is directly from original equipment manufacturer, so some suggestions are given to improve EMC aspect. A cleared capacitive touch based display will be very useful in MIL display system due to its feather touch operation and multi touch feature.

8.3 Limitation and future scope

This work has certain limitations and future work will be carried out to overcome these.

1. It has been observed that the performance of individual optical to electrical receiver is unique based on its position in antenna array. This makes interoperability of modules difficult. The performance of all receiver modules is required to be identical within the tolerance of 0 ± 1 dBm.

2. The optical system is introduced only in transmit path. Same can be implemented in receive path too as it has large dynamic gain calculated in sec 3.4.

3. The system does not meet the requirement of RF output of 0 ± 1 dBm in extreme low temperatures.

4. Future radars can be visualized as fully photonic radar with optical signals starting from signal generation to T/R module level to A/D converters. This will eliminate the need of IF conversion from RF to IF for A/D conversion.