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Cancelation of the technical selection of modulation types in optimum satellite link by using data rate, FEC, and carrier spacing

ATIF BAKHEIT
Faculty of Engineering
University of Medical Sciences and Technology
HEISUM EWAD
Faculty of Engineering
University of Medical Sciences and Technology
ABDALMAHMOUD ALI
Faculty of Engineering
University of Medical Sciences and Technology

Abstract:

Telecom operators are facing strong pressures on capital and operational expenditures. The greater the amount of "known" information loaded into the analysis, the more accurate it will be. Modulation is played very important role in a satellite channels by determinacy the optimum allocated transponder bandwidth (BW). The higher modulation level, created a reduction and utilization saving in the transponder BW, but this required high cost. The paper is conducted toward how to compensate the higher level of modulation with lower and maintaining the BW and the optimization in the link without changes, by keeping BW and Power Equivalent Bandwidth (PEB) in equality. In order to achieve the same allocated BW in optimal link and cancelling the modulation technical selection there are 4 options are chosen alternating in the services (Data Rate), Carrier spacing, combined data rate with Forward Error Correction (FEC), and combined spacing with FEC. In the last two options FEC played core role in controlling and adjusting in the services and spacing.

The contribution represent in at specific conditions (parameters). Revealing a mathematic equation related in ability to

precise selection of services (data rate) and spacing, leaded to cancel the type of modulation selection.

Key words: BW, D.R, Carrier Spacing, OBO, FEC, PEB and Modulation.

INTRODUCTION:

Telecom operators are facing strong pressures on capital and operational expenditures, so that emergent technologies will only be adopted if they are economically feasible. (1)

"We want to start with extending the life of satellites in the geostationary orbit," Campbell said, referring to the perch about 22,250 miles (35,780 kilometers) up where orbital velocity matches Earth's rotational velocity. At this point, spacecraft can hover over the same spot. "There are 450 such satellites, most of them commercial, and they are all designed for 15 years of service."

Geostationary satellites are pushed into a "graveyard orbit" at the ends of their lives using their last drops of fuel so they don't block the geostationary ring once they become inoperable. Campbell said fuel is the main limitation, and the satellites could easily serve much longer if it were possible to extend their life by station-keeping them (that is, maintaining them in their proper orbits).

"Most of the spacecraft systems are perfectly fine," he said.

"It's simply a waste of resources to just get rid of them."

Effective Space Solutions foresees its space drones launching to geostationary transfer orbit as secondary payloads. The craft would then use their ion thrusters to lift them up to geostationary orbit. (2)

Link analyses are only as good as the information used to create them, they should be expected to gauge circuit performance under the assumed working parameters in the analysis. They are used as models when looking for solutions to a particular challenge, before committing to spending capital resources.

The definition of a satellite transmission can be summarized as the successful delivery of information from one part of the Earth to another using a satellite repeater in space.

A link analysis (also known as a link budget) is a theoretical mathematic model of how a satellite circuit should work. It is comprised of known and unknown values that must be assumed. Obviously, a link analysis is only as good as the information used in the analysis process. It is for this reason that both Intelsat engineers and Intelsat customers must have a full understanding of the elements involved to properly model a proposed service.

To begin, one must be familiar with the elements. A satellite circuit is complex and made up of many parts, including, but not limited to:

a) Satellite transmit antenna
b) High Power Amplifier (HPA)
c) Satellite receiver
d) Transponder gain setting
e) Transponder HPA
f) Receive earth station antenna, and
g) Low Noise Block (LNB) converter.

Each part must be set up per recommended specifications, and within their operating limits, to ensure the overall circuit performance is optimal for the successful transmission of the information.
The following information is needed from Intelsat customers to ensure an accurate link analysis:

a. Requested satellite and transponder,
b. Downlink antenna size, and location, and
c. Uplink antenna and HPA size, and location.

Also needed for accurate link analyses are carrier parameters, which include:

1. Data Information Rate,
2. Modulation: QPSK, 8PSK, 16QAM, etc.
3. Forward Error Correction (FEC): 1/2, 2/3, 3/4, 5/6, 7/8, etc.
4. Outer coding schemes, such as Reed Solomon or other including DVB or DVBS2. (3)

The satellite industry is a subset of both the telecommunications and space industries; satellite industry revenues represent 61% of space industry revenues and 4% of overall global telecommunications industry revenues.

The global satellite industry posted growth of 5% in 2011, matching growth in 2010. Overall global telecommunications spending rose by 4.9% in 2011, compared with 5.5% in 2010 – U.S. telecommunications spending experienced somewhat faster growth of 5.8% in 2011, following slower 2.4% growth in 2010 and a steep decline of 8.2% in 2009, on the other hand, overall global space spending rose by 4.8% in 2011, following 7.7% growth in 2010. (4)

HCS (High-Capacity Satellite) technology operating in Ka-band offers significant advantages over conventional satellite networks operating in Ku-band and lower frequencies. More bandwidth is available at the higher Ka-band frequencies. Ka-band antennas experience higher gain than comparably sized antennas operating at lower frequencies. Finally, Ka-band offers a new spectral environment, enabling deployment of new, eg. ViaSat advanced satellite system architectures with new features. HCS satellites in operation offer much higher data capacity than conventional satellite systems. There is a downside to using Ka-band though; adverse weather conditions impact Ka-band more than at lower frequencies. However, with appropriate planning and the implementation of well-designed ground systems, there are mechanisms that can mitigate these adverse weather effects. In this paper we will provide background on High-Capacity Satellites and the effects of weather at different frequency bands, and then discuss how Ka-band HCS using appropriate ground segment design can mitigate weather effects. (5)

BANDWIDTH AND POWER:

There are many ways to perform a link analysis. When possible, it is preferable to begin with the factors related to the receive earth station. The carrier parameters are considered next. This determines the optimal settings to make transponder bandwidth equal to the transponder power needed for the circuit. Then, the work continues backwards to determine the optimal transmit antenna and the size of the high powered amplifier (HPA) needed to transmit the information to the satellite and back to the receive earth station.

Unless otherwise agreed upon, Intelsat's normal, annual availability assumption for Ku-band is 99.6% and for C-band is 99.96%. However, it is important that the value is known and agreed upon in advance to meet customer preference.

When referring to balanced services, one means the transponder bandwidth needed equals the transponder power needed to make the circuit successful. However, other circumstances might not make that possible. In an instance where a user has a transmit HPA limitation of 75 Watts, one must make the carrier need less power than bandwidth to keep the transmit earth station HPA power under 75 Watts. (3)

Bandwidth (BW) Allocation and Measurement Allocated bandwidth is a span of frequencies depending on the features of the transmitted signal and performance of transmitting equipment. Occupied radio frequency (RF) bandwidth is measured after satellite re-transmission by means of calibrated instruments by Network Operations Center (NOC). Considerations for bandwidth allocation and measurement are described below:

1. Bandwidth of a digital carrier per customer.
    a. When allocating bandwidth for a digital carrier, 40% of roll off (RO) is considered relative to the symbol rate.
    b. Allocated bandwidth is rounded to the next 100 kHz step from the above calculation.
    c. Start and stop frequencies of the allocated bandwidth shall correspond to 100 kHz steps.

2. Bandwidth of a segment with more than a carrier per customer.
    a) Total allocated bandwidth is rounded to the 100 kHz steps
    b) Initial and final carriers on the segment shall consider 40% of roll-off (RO) relative to the symbol rate.
    c) Start frequency of initial carrier and stop frequency of final carrier within a customer segment, shall correspond to 100 kHz steps.
    d) 40% roll-off is also recommended for intermediate carriers.
    e) Bandwidth of initial or final carrier of a segment can be modified after a test showing a different roll-off; alternately,

transmission parameters can also be modified, if standards 2A and 2C are accomplished.

3. Bandwidth of one carrier per transponder.
Maximum allocated bandwidth for one carrier saturating a transponder is the nominal transponder bandwidth.

4. Bandwidth of a segment without transmission plan.
   a) Bandwidth is allocated in 100 kHz step size.
   b) Start and stop frequencies of the allocated bandwidth shall correspond to 100 kHz steps.
   c) None carrier will fall outside frequencies stated at 4b. (6)

Standard by design any transmit antenna shall comply with design objective for off-axis transmit gain in the specific ranges. (7)

FREQUENCY REUSE:

Can be effected by two procedures, which are mutually compatible:

- Frequency reuse by beam separation: the same frequency bands are transmitted by the satellite. Antennas using different transponders by means of directional and space-separated radiated beams.
- Frequency reuse by polarization discrimination (also known as dual polarization frequency reuse): the same frequency bands are transmitted by the satellite antennas through different transponders using two orthogonal polarizations of the radio-frequency wave.
- Consider the 500 MHz frequency band (at 6/4 GHz) is reused four times in the INTELSAT-V systems. Thus the total effective bandwidth of the INTELSAT-V satellite, 2 590 MHz, is distributed as follows:
- 6/4 GHz band: 375 MHz bandwidth reused four times and 125 MHz is used twice (for global beam);
- 14/11 GHz band: 420 MHz bandwidth reused twice (by beam separation). In the future, the total effective bandwidths available could be further increased by increased reuse of frequencies, using the expanded bands allocated by WARC-79,

using higher frequencies, and in particular the 30/20 GHz bands (providing an available bandwidth of 3.5 GHz).

Some systems have been specifically designed for incorporating transponders corresponding to different communications services ("multi-mission payload"). This is the case, for example, for the HISPASAT 1A and 1B satellites, which includes the following payload: 18 FSS transponders for telecommunication services over Spain, Europe and North, Central and South America (14/11-12 GHz, double linear polarization with frequency reuse), five BSS transponders for TV distribution and broadcasting (8)

SATELLITE DOWNLINK EIRP:

Referring to the satellite transmit downlink coverage pattern, the saturated EIRP on each contour will be specified. For example, +36 dBW at beam center and +32 dBW at the -4 dB contour.

Assuming a multi-carrier transponder operating point of -10dB input back off and -4.5dB output back off, the operating downlink EIRP, on the -4 dB contour will be +36 -4 -4.5 = +27.5 dBW. This refers to the whole transponder output power and is the aggregate of all the multiple small carriers present. (9)

SATELLITE LINK:

Composed of both up and down link:

1- Up link:

The earth station transmits a signal. This signal comes from the transmitter, which may be a solid-state power amplifier (SSPA) or travelling wave tube amplifier (TWTA). Most commonly VSAT terminals have solid-state power amplifiers mounted at the dish and as close to the feed as possible to minimize waveguide attenuation losses. These dish mounted units are often block up converters (BUC) or Transmit - Receive Integrated Assemblies (TRIA) which change the frequency of the signals from L band (in the cross site inter-facility link (IFL) cable) to the microwave frequency for transmission (C band, Ku or Ka band). BUCs have a rated output power.

The output power of the BUC is fed to the dish which concentrates the power in the direction of the satellite rather than allowing the power to be radiated evenly in all directions. This characteristic of the antenna is called gain, measured in dBi, which means gain relative to an isotropic, omni-directional antenna.

The combination of BUC power and satellite dish gain produces equivalent isotropic radiated power (EIRP).

The transmit EIRP of the earth station may be achieved by having a variety of sizes of BUC power and dish size. A large dish with low power BUC can produce the same EIRP as a small dish with high power BUC. There are limiting considerations to this. Small dishes may cause unacceptable interference to adjacent satellites. To minimize cost, choose a larger dish plus lower power BUC and take account of the cost of the BUC, the electricity used and possibly air conditioning, if required.

The satellite receive beam will have a G/T value for the direction from your earth station. Review the uplink beam coverage map and determine the satellite receive G/T in the direction from your site.

2- Down link:

The downlink EIRP from the satellite is either:

- For single carrier, whole transponder operation, Satellite downlink carrier EIRP = the EIRP shown on the down-link beam contour

Or

- For multi-carrier operation, Satellite downlink carrier EIRP = EIRP (as per beam contour) - transponder output back off - 10 x log (your carrier bandwidth / transponder bandwidth).

Consider the downlink receive earth station. This will have a diameter size, receive frequency and system noise temperature. Put these together and you will get the receive earth station G/T. The equation for G/T is earth station G/T = Gain - 10 log (system noise temperature). (10)

DBS TECHNOLOGY:

Advances in digital compression, modulation and error correction, along with new satellite platforms, increased reuse of DBS spectrum, continued deployment of fiber, and transition to new distribution architectures all can enable the continuing growth of program-carrying capacity for DBS and cable systems. DBS and cable companies also can deploy such upgrades relatively quickly, since they control their distribution architecture "end-to-end." This allows them to implement more efficient network technologies faster than terrestrial broadcasters, for example, whose distribution evolution relies on consumers acquiring new hardware from third-party manufacturers, and typically involves the time-consuming development of open industry standards.

It is effected by, digital modulation and forward error correction , by DBS operators in the U.S. is influenced by standards developed by the Digital Video Broadcasting Project, a standards development organization made up of about 200 members. DVB-S2 is the Project's latest digital satellite transmission system, and is intended to gradually replace the former standard, DVB-S. The DVB-S2 standard is used by DIRECTV in conjunction with MPEG-4 AVC video compression for delivery of HDTV services. (11)

Typically, however, DBS transponders are operated in a nonlinear mode that is good for QPSK and 8PSK but not good for 16APSK and 32APSK, which are intended for more linear modes. (12)

Higher-order modulation schemes in DBS also require a higher carrier-to-noise ratio at the receiver; as discussed below, satellite platform evolution has been toward higher power-generation capabilities. Related to modulation, in 2012, DIRECTV was issued a U.S. patent on a method of combining transponder bandwidths to achieve a bandwidth-efficiency improvement of 21%. (13).

Modulation refers to the way the satellite's radio signal is varied to convey digital video to the viewer. Early pre-digital direct-to-home technology used frequency modulation (FM). Digital DBS system introduction in 1994 saw the use of digital modulation in the form of Quadrature Phase Shift Keying (QPSK), which is able to represent two digital bits at once, in a symbol, through phase shifting. In 2005, 8PSK was added, which can represent three bits per symbol and is thus more bandwidth efficient. DISH Networks reports that a "significant number" of its subscribers don't have receivers that utilize the more bandwidth-efficient 8PSK modulation. It says it is in the process of deploying receivers compatible with 8PSK. It is not clear what the timetable is for replacement.

The DVB-S2 standard provides for even more bandwidth-efficient modulations schemes, 16APSK and 32APSK, capable of representing four and five bits per symbol.(ETSI EN 302 307 V1.3.1 (2013-03): “Digital Video Broadcasting (DVB); Second generation framing structure, channel coding and modulation systems for Broadcasting, Interactive Services, News Gathering and other broadband satellite applications (DVB-S2)”). The patent notes that there are guard bands between adjacent transponders of the same polarization. Such guard bands are a holdover from legacy FM, which required a higher carrier-to-noise ratio than digital modulation. DIRECTV’s patent discloses a method of combining transponders into a wideband “virtual” transponder that is able to transmit on existing guard bands so the satellite has greater bandwidth efficiency. The patent says guard bands “represent an attractive source of bandwidth that is still available. (14)

FORWARD ERROR CORRECTION:

Systematically adds bits to a transmission so a receiver, through a similar systematic process, can detect and correct many errors. Early DBS systems used Reed-Solomon and convolutional codes together. Newer DBS systems based on DVB-S2 uses a more efficient combination of Bose-Chaudhuri Hcquengham (BCH) with Low Density Parity Check (LDPC) codes. The major benefit of the BCH/LDPC codes is that link performance is closer (within 0.7 dB) to the theoretical Shannon limit, increasing bandwidth efficiency. The codes also allow DVB-S2 to be approximately 30% more bandwidth efficient compared with DVB-S, the previous standard. (12)

In 2012, DIRECTV was issued a patent for adaptive error correction, which would allow error correction to be optimized based on varying conditions, such as weather, the value of the content being transmitted, and local conditions for individual spot beams. (15)

The patent notes that, typically, DBS error correction is chosen based on a worst-case error rate, making it overly robust for most situations and resulting in inefficient use of bandwidth. The method disclosed in the patent would allow error-control optimizations to be applied with finer granularity at the spot-beam level. Different spot beams could have different optimizations depending on local conditions. Bandwidth that is no longer needed for worst-case forward error correction could be devoted to increasing program carrying capacity.

ANTENNA:

The antenna gain at the satellite is smaller, the transmitted power from the satellite is also smaller. If the satellite doesn't have attitude control, the gain and the polarization can change over time. The worst case must be calculated it is useful to implement a dual receiver with two orthogonal polarizations. (Small Satellite Link Budget Calculation Marcos Arias. (16)

DIGITAL MODULATION:

Has many types such as:

a) Amplitude Shift Keying (ASK).
b) Frequency Shift Keying (FSK).
c) Phase Shift Keying (PSK).
d) Delta Modulation & Adaptive.

1- Amplitude Shift Keying (ASK) and Frequency Shift Keying (FSK):

There are three basic ways to modulate a sine wave radio carrier: modifying the amplitude, frequency, or phase. More sophisticated methods combine two or more of these variations to improve spectral efficiency. These basic modulation forms are still used today with digital signals. Three basic digital modulation formats are still very popular with low-data-rate short-range wireless applications: amplitude shift keying (a), on-off keying (b), and frequency shift keying (c). These waveforms are coherent as the binary state change occurs at carrier zero crossing points. There are two types of AM signals: on-off keying (OOK) and amplitude shift keying (ASK). The carrier amplitude is shifted between two amplitude levels to produce ASK. The binary signal turns the carrier off and on to create OOK. AM produces sidebands above and below the carrier equal to the highest frequency content of the modulating signal. The bandwidth required is two times the highest frequency content including any harmonics for binary pulse modulating signals.

Frequency shift keying (FSK) shifts the carrier between two different frequencies called the mark and space frequencies, or fm and. FM produces multiple sideband frequencies above and below the carrier frequency. The bandwidth produced is a function of the highest modulating frequency including harmonics and the modulation index, which is:

$$m = \Delta f\ (T)$$

Δf is the frequency deviation or shift between the mark and space frequencies, or:

$$\Delta f = fs - fm$$

T is the bit time interval of the data or the reciprocal of the data rate (1/bit/s). Smaller values of m produce fewer sidebands. A popular version of FSK called minimum shift keying (MSK) specifies$m = 0.5$. Smaller values are also used such as$m = 0.3$.

Here are two ways to further improve the spectral efficiency for both ASK and FSK. First, select data rates, carrier frequencies, and shift frequencies so there are no discontinuities in the sine carrier when changing from one binary state to another. These discontinuities produce glitches that increase the harmonic content and the bandwidth.

The idea is to synchronize the stop and start times of the binary data with when the sine carrier is transitioning in amplitude or frequency at the zero crossing points. This is called continuous phase or coherent operation. Both coherent ASK/OOK and coherent FSK have fewer harmonics and a narrower bandwidth than non-coherent signals.

A second technique is to filter the binary data prior to modulation. This rounds the signal off, lengthening the rise and fall times and reducing

1- Binary Phase Shift Keying (BPSK) and Quadrature Phase Shift Keying (QPSK):

A very popular digital modulation scheme, binary phase shift keying (BPSK), shifts the carrier sine wave 180° for each change in binary state. BPSK is coherent as the phase transitions occur at the zero crossing points. The proper demodulation of BPSK requires the signal to be compared to a sine carrier of the same phase. This involves carrier recovery and other complex circuitry.

In binary phase shift keying, note how a binary 0 is 0° while a binary 1 is 180°. The phase changes when the binary state switches so the signal is coherent.

A simpler version is differential BPSK or DPSK, where the received bit phase is compared to the phase of the previous bit signal. BPSK is very spectrally efficient in that you can transmit at a data rate equal to the bandwidth or 1 bit/Hz.

In a popular variation of BPSK, quadrature PSK (QPSK), the modulator produces two sine carriers 90° apart. The binary data modulates each phase, producing four unique sine signals shifted by 45° from one another.

Quadrature Amplitude Modulation (QAM) the creation of symbols that are some combination of amplitude and phase can carry the concept of transmitting more bits per symbol further. This method is called quadrature amplitude modulation (QAM). For example, 8QAM uses four carrier phases plus two amplitude levels to transmit 3 bits per symbol. Other popular variations are 16QAM, 64QAM, and 256QAM, which transmit 4, 6, and 8 bits per symbol respectively. (17)

METHODOLOGY:

Without optimum:

$$E\ (dB)\ = 10\ \hat{}(E\ (W)/10)$$

$$PEB\ =\ E\ /\ (oper.EIRP/BW)$$

$$Alloc.BW\ =\ D.R * 2 * Spacing/M * CODES$$

$$Oper.EIRP\ =\ 10\hat{}\ (Satur.EIRP - OBO)/10$$

$$Avail.Transp.(\%)\ =\ (PEB/\ BW) * 100\%$$

$$Avail.Rent\ BW(\%)\ =\ (Rent\ BW/BW)100\%$$

With optimum:

$$PEP\ = (Carr.EIRP)/((10\ Oper.EIRO/10)/BW))$$

RESULTS:

D.R	Satur. EIRP	Transp. BW	Spacing	Carr. EIRP(dB)	Carr. EIRP(W)	Code(FEC)	R.S	TPC	LDPC
2.048	37	36	1.4	24	251.1886	0.75	1	Non	1

Figure (1) show the effects of modulation (PSK and QAM) in the satellite link without optimal (by adjusting the value of OBO manually) at considered the OBO nearly to 4.4 dB. This lead unchanged in the PEB appeared as linear with value 4.969 dB/MHz while allocated BW appeared as variable according to the modulation, The lower level of modulation (BPSK) caused in higher allocated BW and vise versa.

The figure ensured that, the minimum modulation level is lower utilization, BPSK available 78.76% of the transponder BW, whereas the QPSK 86.2%.

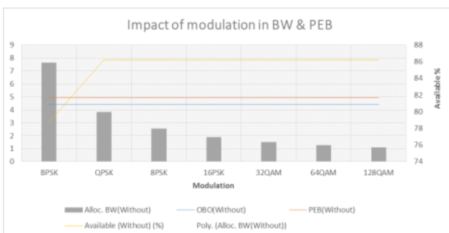

Figure (1): Impact of modulation in BW and PEB without optimal satellite link

Figure (2) show that, the impact of modulation in the optimal satellite link.

The value of OBO is calculated (not selected as without optimal), these calculated values is caused in the optimal in spite of changing in the modulation. Increasing in modulation level, leaded to decreasing in the OBO but, keeping the operation in linear (OBO > 0) with minimum value as possible. The best operational point can be determined. Figure show increasing in utilization according to modulation.

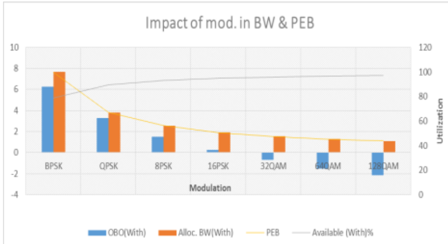

Figure (2): Impact of modulation in BW and PEB with optimal satellite link

Figure (3) show: equality of allocated BW with PEB and have the same value which is which is 6.645 MHz in spite of varied in the modulation types, OBO is fixed value which is 5.66 dB. These are Indicated the optimization link, the modulation has not any effects in BW or PEB determinacy, no changed in the BW or PEB utilization, and reflected the important of data rate.

Through spacing, cancelled modulation types according to the following equation:

$$Data\ Rate\ =\ 1.4\ X\ Mod.Level.$$

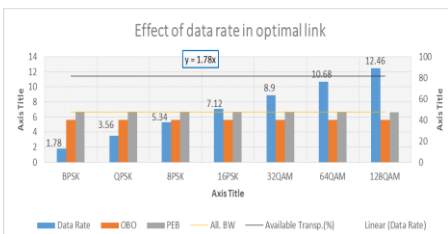

Figure (3): Important of Data Rate in optimal satellite link by using different mod.

Figure (4) show: equality of allocated BW with PEB and have the same value which is which is 7.6459 MHz in spite of varied in the modulation types, OBO is fixed value which is 6.2712 dB. These are Indicated the optimization link, the modulation has not any effects in BW or PEB determinacy, no changed in the BW or PEB utilization, and reflected the important of carrier spacing.

This gives the chance of selection the minimum modulation (BPSK) and gives the same jobs as higher. Through spacing, cancelled modulation types according to the following equation:

$$Spacing\ =\ 1.4\ X\ Mod.Level.$$

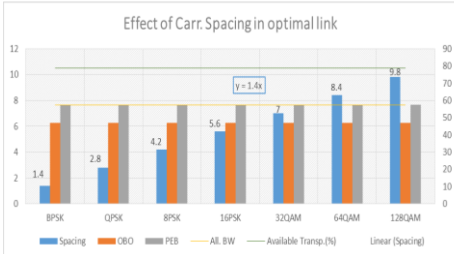

Figure (4): Important of Carr. Spacing in optimal satellite link by using different mod.

The figure (5), show the reduction of the carrier spacing by using different types of a FEC, in the case of 64 QAM, with 1/2 of FEC, spacing is decreased to satisfy the same value for the BW and maintain the optimization.

By using or adjusting the carrier spacing and codding type FEC, easily can neglect the roll of mod. So, from cost wise BPSK is satisfy the requirements, but this consume the high level of coding in addition to lower spacing.

Figure (5): Important of combination FEC and Spacing in optimal satellite link by using different mod.

Figure (6) show, by using or adjusting codding type FEC and changing in the service (Data Rate), easily can neglect the roll of mod. So, from cost wise BPSK is satisfy the requirements, but this consume the high level of coding in addition to lower data rate.

In order to cancel the selection of modulation type, two conditions must be fulfilled:

$D.R = 0.004 X^6 – 0.096 X^5 + 0.838 X^4 – 3.666 X^3 + 8.353 X^2 – 8.656 X + 3.822$
$FEC\ Coding= 0.0038 X^4 – 0.0514 X^3 + 0.2188 X^2 – 0.375 X + 1.0834$
Where D.R is data rate and X is Modulation type (level).

From the figure, when 64QAM is used with lower level of FEC (1/2), lead to decreasing in the data rate (service), in spite of maintained with the BW

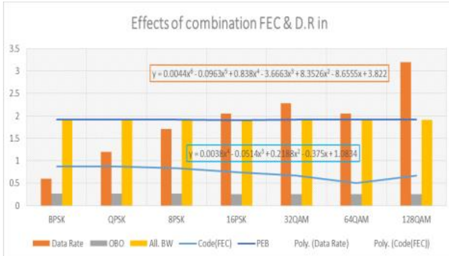

Figure (6): Important of combination FEC and D.R in optimal satellite link by using different mod.

Figure (7), show that, When OBO is adjusted, the rate of DR and BW is detected.

Assume, OBO is operated with value between 9 to 10 dB:

- BW in range 14.93 to 18.667 MHz
- Rate D.R: Modulation is 1: 4 to 1:5.

According to equation:

$$D.R = 4\,xMod. \text{ To } D.R = 5\,xMod.$$

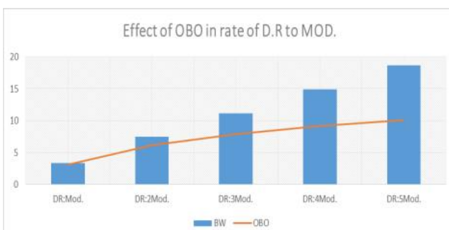

Figure (7):Effect of OBO in rate of D.R to MOD

CONCLUSION:

The paper discussed the effects of modulation in allocated BW and utilization for the both optimum and without optimum satellite link, significant effect when switching from BPSK to QPSK. Not only optimization, but also keeping the same value of both the PEB and BW along the link in spite of changing in the modulation achieved through the data rate, means by using specific adjusting of data rate, cancelled the chance of technical selection of modulation, e.g 1.78 Mb/s with BPSK created the same allocated BW in optimal link as 12.46 Mb/s with 128 QAM.

By controlling carrier spacing, technical selection of modulation is canceled, e.g BPSK with carrier spacing 1.4 dB, created the same allocated BW in optimal link form as 128 QAM with 9.8 dB of carrier spacing.

By using FEC in combine with spacing or data rate, resulted in reduction of the both.

OBO effected in the D.R to modulation level rate.

Finally, mathematic relationship is created to connect spacing and D.R with modulation, in order to achieve the same allocated BW in optimal link and cancelling the modulation selection through D.R, spacing, and combination with FEC.

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