Export BTS Data

After successfully calibrating a BTS and before performing the calibration verification procedure, export the BTS configuration data to a text file. This is done by highlighting the specific BTS in the Configuration and Alarms Manager (CAM) window, and on the Main Menu select **File** > **Export BTS Data**. This text file will be used as input by the "IC Closeout Tool" (Part Number 40-00217-00), shown in Appendix V.

Perform the Calibration Verification Procedure

Base Station Calibration Verification is a set of procedures to verify that the equipment has passed calibration and that the RF portion of the equipment is operating within acceptable parameters. The results of the tests should be documented in the Base Station Calibration Verification Form, which is part of the "IC Closeout Tool" (Part Number 40-00217-00). This procedure is described in Appendix Q.

Single Antenna Element Test

The object of the RFS Single Antenna Element Test Procedure is to verify the functionality of each antenna element in the Ripwave Radio Frequency Subsystem (RFS). The 8 antenna elements work together to create the beam forming effect that results from using a Smart Antenna - Phased Array technology. Using 8 combined antenna elements concentrates the beam of radiation, adding up to 9 dB of gain, both in the downlink and in the uplink

In the downlink there is an additional 9 dB of gain because there are 8 antenna elements transmitting simultaneously in the RFS. This gain is not available in the uplink because there is only one antenna element transmitting at any time in the Modem.

In a Non-TTA BTS, each antenna element has an associated Low Noise Amplifier (LNA) in the RFS and a Power Amplifier (PA) in the RF Shelf of the BTS. In a TTA BTS, each antenna element has an associated PA in the RFS and an RF Converter (RFC) in the BTS shelf. In order to verify that each individual antenna element is working properly, we have to power off the LNA/PA/RFCs for all the antenna elements, then turn them on individually one at a time and verify that a test Modem can communicate with the base station through that single antenna element (Appendix R).

Install & Test Customer EMS Operations

If you have been using a Test EMS up to this point, you will now need to install and test the customer's EMS server. This involves installing the EMS Server and Client on a computer that is connected through the system backhaul. When connecting the Ripwave equipment to the backhaul, refer to the Regulatory Information in Chapter 1, Page 8 – specifically regarding cabling to Ethernet or T1/E1 backhauls. Ethernet connections require a UL497B listed protection device to be installed between the BTS and the first network device. T1/E1 connections must be routed from the BTS through a UL497 listed protection device at the demarcation point. The interconnect cables for T1/E1 backhauls must be a minimum #26 AWG wire, in accordance with NEC/CEC standards. If the customer's EMS is already installed and has been used for testing purposes, skip to the "Verify System Performance" section of this chapter.

Install EMS Software

The EMS software installation procedures can be found in the *EMS Software Installation Guide*, P/N 40-00017-00. After installing the EMS Server and Client applications, the EMS needs to be configured with the settings that are designated for the Base Station. The settings are found in the Network Architecture Plan provided by the customer.

Ensure connection between the Base Station and the backhaul. The connection to the Base Station will be either an Ethernet connection or T1 connections.

Verify EMS to Base Station Connectivity

Follow the steps below to ensure the EMS and Base Station can communicate.

Step 1. Open a Command Prompt window on the computer where the EMS is installed.

Step 2. Ping the Base Station using the CLI command **ping <base station ip address>**. Verify that a reply from the Base Station is received.

Perform Calibration Using Customer's EMS

This step is necessary only if you have been using a Test EMS up to this point. You will need to install the customer's EMS server and software. Calibrate the Base Station using the customer's EMS. Follow the same calibration procedures described earlier in this chapter, Calibrate the Base Station. Perform the procedure three times and make sure that the results are stable (±3).

Verify System Performance

Location (FTP) Test

Location Tests are performed to see if the system file transfer functions are working as predicted between Modem and Base Station. First you perform three uploads and three downloads from one locations in line-of-sight (LOS) with the Base Station at a distance of about 2 km. Then you perform three uploads and three downloads at several additiona locations in either line-of-sight or non-line-of-sight (NLOS) with the Base Station. The number recommended number of additional locations is 4 for panel antennas and 7 for Omni antennas.

The Location (FTP) Test procedure is described in Appendix S. The form used to collect the data is contained in the "IC Closeout Tool" (Part Number 40-00217-00).

The results are sent to Navini Networks Technical Support for evaluation

Drive Study

The Drive Study is performed to verify if the system's coverage area is as predicted and, if necessary, to fine-tune the RF model.

The procedure is described in Appendix T. The form used to collect the data is contained in the "IC Closeout Tool" (Part Number 40-00217-00).

You will perform the Drive Study by driving back and forth through a sector, staying on major roads about a kilometer apart. Special attention has to be paid to the null and fringe areas. You will follow this scheme for each sector in the site, recording the results of all tests. The test results will be sent for evaluation, along with the Location (FTP) test results, to Navini Networks Technical Support. If the results are not adequate, Technical Support will have you adjust some of the RF parameters and perform the Drive Study again.

Verify System Operation With Multiple Modems

Set up three computers with Modems connected to them. Perform file transfers from all three computers to verify Base Station operation.

Back Up EMS Database

After all system installation and commissioning activities are complete, perform a backup of the EMS database. The procedure can be found in the *EMS Administration Guide*. Place the backup files on a different system server where they will be periodically backed up on a tape drive.

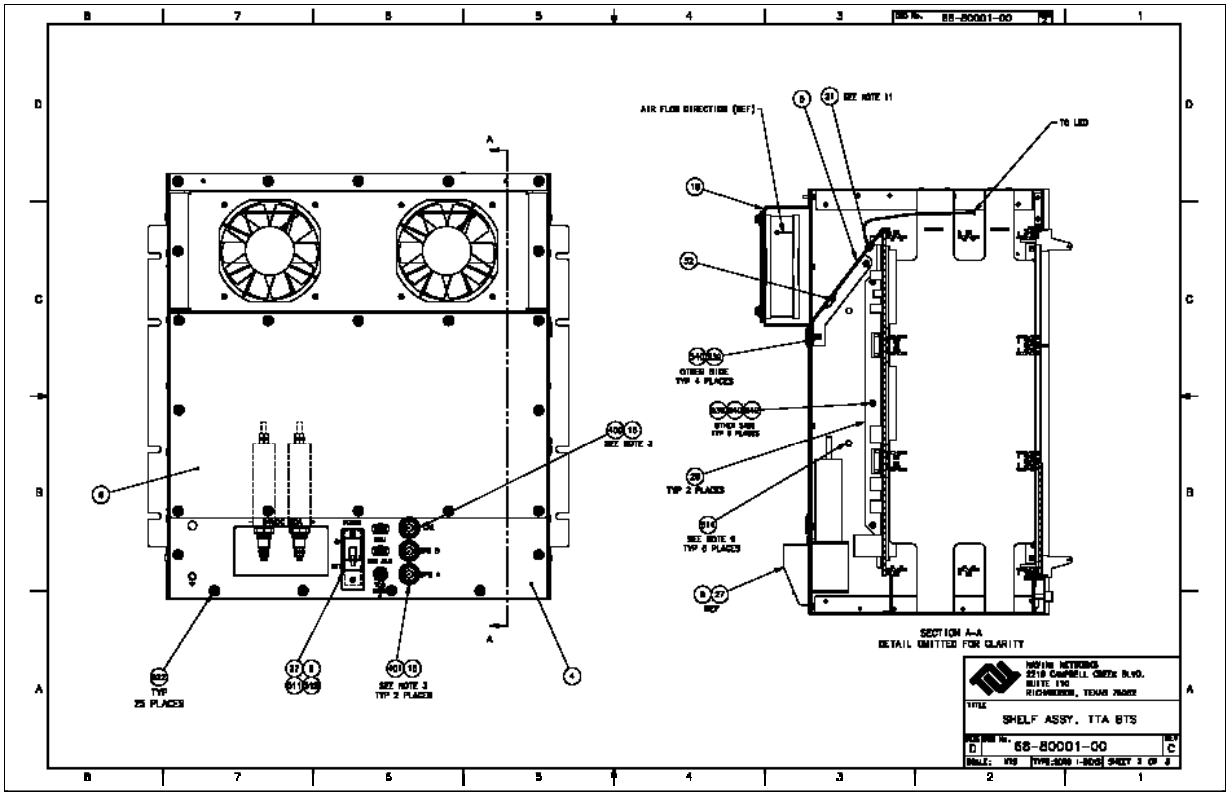
Customer Acceptance

To conclude the installation and commissioning activities, gather all of the required documents and forms from the installation and commissioning procedures to create a comprehensive system I&C package. Refer to Appendix U for a summary of the documentation package. The customer and Navini Networks will sign the Customer Acceptance Form. A copy of this form is provided in Appendix W. The signed form and the system I &C package are provided to the customer. The original, signed Customer Acceptance Form and system I &C package are stored in the Navini Networks Technical Support database.

Appendix C: BTS Specifications

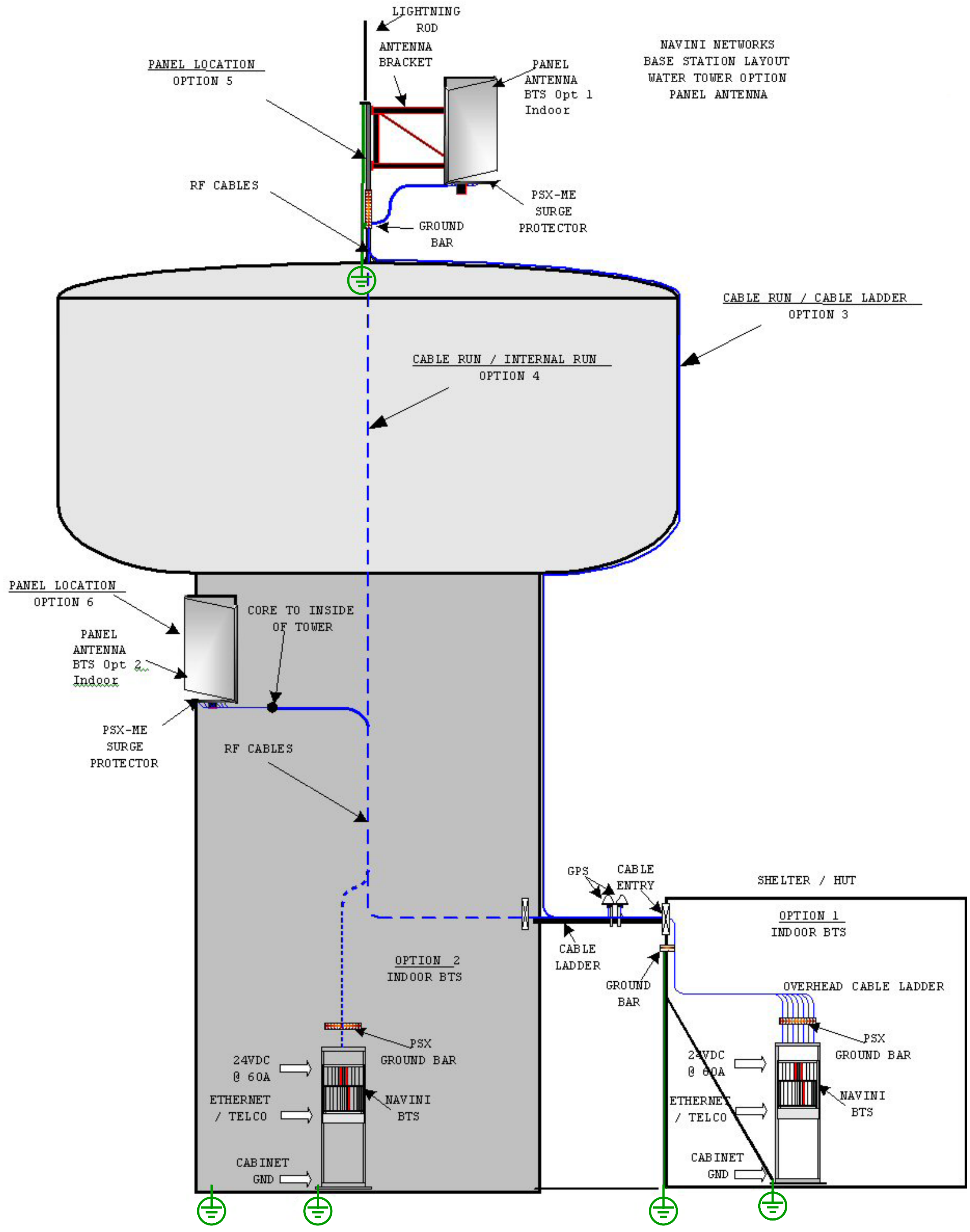
Figure C7: TTA Digital Chassis (Front)

Figure C8: TTA Digital Chassis (Back)



Appendix G: Sample Base Station Drawing

Figure G1: Sample Base Station Drawing



NOTE
1.CABLE BUNDLE CONSIST OF 9 RF CABLES AND 1 POWER/DATA CABLE
2.RF CABLE TYPE TO BE DETERMINED BASED ON RUN LENGTH AND DB LOSS/FT
3.CABLE HANGERS TO BE SPECIFIED/RECOMMENDED BY TOWER CREW
4.ANTENNA BRACKET TO BE SUPPLIED BY CUSTOMER AS RECOMMENDED BY TOWER CREW
5.BTS REQUIRES 24VDC @ 60A.
6.PSX-ME SURGE PROTECTORS TO BE INSTALLED IN-LINE BETWEEN RF CABLE AND ANTENNA
7.PSX SURGE PROTECTOR TO BE MOUNTED ON GROUND BAR CLOSE TO BTS CABINET/CHASSIS
8.ETHERNET/TELCO BACKHAUL TO BE PROVIDED BY CUSTOMER
9.ALL INSTALLED EQUIPMENT/MATERIALS MUST BE PROPERLY GROUNDED
10.OPTION 1 IS FOR AN INDOOR BTS INSTALL, OPTION 2 IS FOR OUTDOOR BTS

CUSTOMER	
SITE NAME	
LOCATION	

1	PANEL LOCATION OPTION 5=DOME TOP 6=SIDE		
2	ANTENNA BRACKET TYPE		
3	PSX-ME SURGE PROTECTOR		PCS
4	ANTENNA AZIMUTH		
5	ANTENNA HEIGHT		
6	ANTENNA DOWNTILT		DEGREES
7	TOWER JUMPER LENGTH		FEET
8	TOWER JUMPER CABLE TYPE		

9	MAIN FEEDER TYPE		
10	MAIN FEEDER LENGTH		FEET
11	GROUND BUSS BAR		PCS
12	CABLE HANGER TYPE		
13	WEATHERPROOFING KIT		PCS
14	GROUNDING CABLE LENGTH		FEET
15	GROUNDING KIT		PCS
16	HOISTING GRIP		PCS

17	GPS MOUNT		
18	GPS CABLE LENGTH		FEET
19	GPS CABLE TYPE		

20	LOCATION OPTION 1=SHELTER 2=INSIDE TOWER		
21	CABLE RUN OPTION 3=EXTERNAL 4=INTERNAL		
22	JUMPER CABLE LENGTH		FEET
23	JUMPER CABLE TYPE		
24	PSX SURGE PROTECTOR		PCS
25	GPS SURGE PROTECTOR		PCS
26	ALT GROUND BUSS BAR		PCS
27	24VDC/60A POWER SUPPLY		
28	INDOOR RACK/CABINET		

Appendix H: Antenna Power & Cable Selection

Non-TTA Systems

Overview

There are 3 types of cables that are part of a non-TTA Base Station installation: antenna (RF) cables, calibration (CAL) cable, and data/power cable (not used with the TTA systems). In addition both the RF and CAL cables are made of a longer Main segment, which typically consists of a low-loss but heavier and less rigid cable and two shorter Jumper cables (one connecting the Main segment to the RFS and the other connecting the main segment to the BTS), which typically have a higher loss, but are lighter and more flexible.

The RF cables are eight coaxial cables that carry RF signals between the BTS and the RFS. The CAL cable is a single coaxial cable that provides a common second path for the RF signals between the BTS and the RFS for system calibration.

The RF cable paths and the CAL cable path are interconnected through the Cal Board located in the RFS. The Cal Board introduces a loss of 27 to 31 dB between the common Cal Cable path and each RF Cable path. As a result of this, most of the power sent to or received at the antenna elements travels through the RF Cable paths, and only a small fraction of it is derived to the CAL Cable path.

The purpose of this section is to describe the calculations used to determine the combinations of Main and Jumper Cables that are adequate for a particular system. This determination is made taking into consideration the operating frequency band of the system, the maximum output power that the RF/PA cards can deliver, the maximum and minimum power level that the SYN card can output or accept as input during calibration, the losses introduced by the cables and the different system components that the RF signal must go through, etc. I some cases the number of subcarrriers, whether FCC regulations apply, whether a Standard Filter in the back of the BTS is used or not, the weight of the cables on the tower and the bent radius of the main cables must also be taken into consideration.

The calculations described in this section are performed automatically by an Excel spreadsheet.

It is assumed here that the same combination of Main and Jumper cables will be used for the RF and CAL paths.

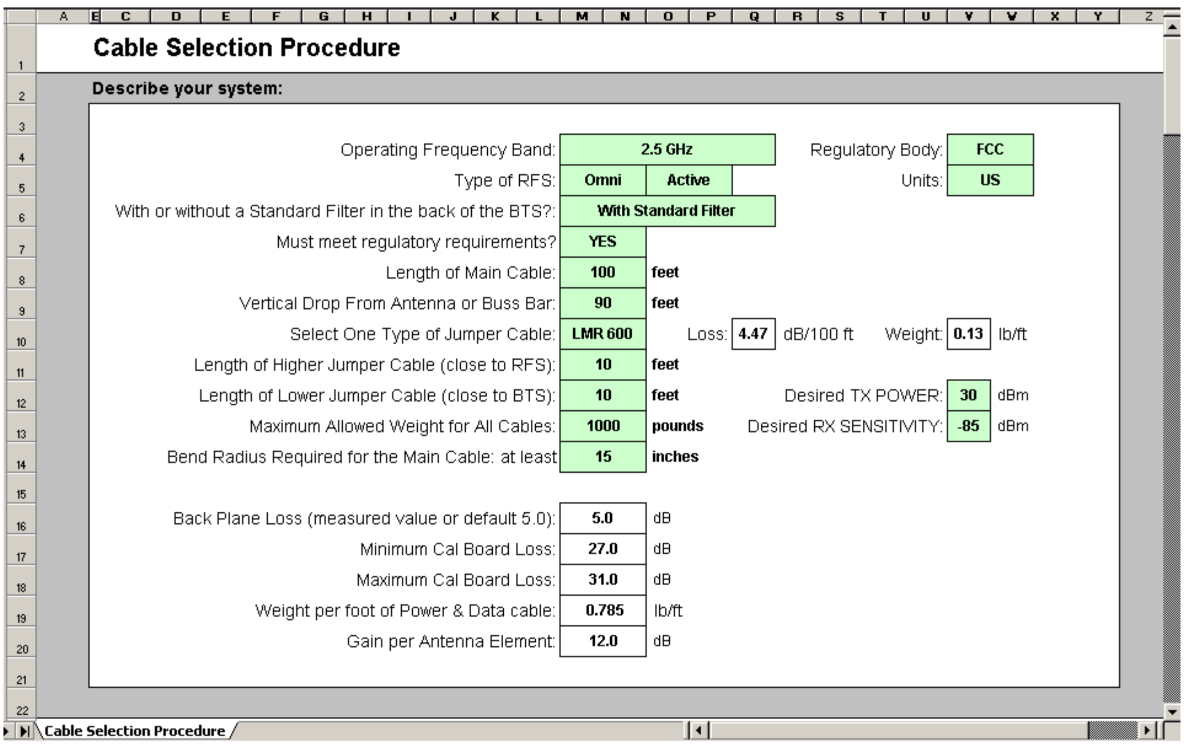
The power and data cable is only taken into consideration if the weight of the cables on the tower must be kept below a certain allowed maximum.

An excel program (P/N 40-00219-00) is provided to perform all the necessary calculations automatically

Data Input

The Cable selection procedure requires the following data to be entered in the green fields of the spreadsheet:

Figure H1 – Data Input



Operating Frequency Band – Select one of the following:

- 2.3 GHz (6 sub-carriers)
- 2.3 GHz (10 sub-carriers)
- 2.4 GHz (combo chassis)
- 2.5 GHz
- 2.6 GHz (split chassis)
- 2.6 GHz (combo chassis)

Regulatory Body:

FCC, European, or Other

Type of RFS:

Omni or Panel
Active or Passive

Units:

US or Metric (that is: lb/ft/in or kg/m/cm)

Does the system include a Standard Filter in the back of the BTS?
With or Without Standard Filter

Must the system comply with regulatory Requirements regarding the Maximum PA Output?
Yes or No

Length of the Main cable (in feet or meters)

Vertical Drop from the Antenna or Buss Bar (in feet or meters) – This represents how much of length of each Main cable segment will add its weight on the tower.

Type of Jumper Cable – Select one of the following:

LMR 600 (Times Microwave)
LMR 400 (Times Microwave)
RF 1/2-50 (NK Cables)
RF 3/8-50 (NK Cables)
FSJ4-50B (Andrew Cables)
FSJ2-50 (Andrew Cables)

You can always select another Jumper cable later and repeat the calculations.

Length of the Higher Jumper Cable segments (Main to RFS) in feet or meters

Length of the Lower Jumper Cable segments (Main to BTS) in feet or meters.

Maximum Allowed Weight for All Cables (in pounds or kilograms) – This weight should not be exceeded by the combination of the following three components:

- the weight of the higher Jumper cable segments
- the weight of the length of the Main Cable segments (8 x RF + CAL) that actually contributes weight to the tower (estimated as the Vertical Drop)
- the weight of the length of the Power and Data cable that actually contributes weight to the tower (estimated as the length of one Higher Jumper Cable segment + the Vertical Drop)

NOTE: If the total weight of all cables on the tower is not an issue, enter a sufficiently large value in this field (larger than the actual weight of the cables), for example, 3000 lb (1500 kg).

Minimum Required Bend Radius for the Main Cable (in inches) – This value is important only if the Main cable will be bent. If this is not an issue, enter a sufficiently large value, for example, 50 inches (130 cm).

Desired TX Power (in dBm) – This is the level of power that you want to be delivered at the base of each antenna element.

Desired RX Sensitivity (in dBm) – This is the level of power at which you want the signal from the modems to arrive at the base of the antenna elements. This value is defined as the minimum level of received power required for successful decoding of the received signal, and should be 11 dB above the noise floor. The mechanism of uplink power control will ensure that the signal transmitted by each modem arrives at the RFS at the desired level.

Other Input Data Provided by the Spreadsheet Program

Data supplied by the program appears in white fields

Loss & Weight – These are the loss of the selected type of Jumper Cable, in dB per foot (or dB per meter) and the weight in pounds per foot (or kilograms per meter), respectively.

Back Plane Loss – This is the loss between the SYN card and the point at which the CAL cable is connected in the back of the BTS. This loss is estimated as 5.0 dB.

Minimum and Maximum Cal Board Loss – These values represent the extremes of the range of possible losses through the Cal Board (between the point at which the CAL Cable is connected and the points where each one of the eight RF Cables are connected). There are, therefore, eight such paths in a Cal Board. The Minumum Cal Board Loss is estimated as 27 dB and the Maximum Card Board Loss is estimated as 31 dB.

Weight of the Power and Data Cable – Estimated as 0.785 pound per foot (1.168 kg/m).

Gain Per Antenna Element – That is, 12 dB for Omni antennas and 17 dB for Panel antennas.

Internal Data Tables

Three Data tables are used for the calculations:

TABLE H1 - Operating Parameters

	Maximum PA Output Power (dBm) Meets FCC Requirements?		PA Output Power Threshold for damage or auto shutdown (dBm)	Max Tx Power at the Antenna Element that meets FCC requirements (dBm)		BTS Loss... (dB)		RFS Loss (dB)		SYN Card Input Power (dBm)		SYN Card Output Power (dBm)	
	Yes	No		Omni	Panel	...with Standard Filter	...without Standard Filter (Bypass Cable)	Active RFS	Passive RFS	MAX	min	MAX	min
2.3 GHz (6 carriers)	38	40	42	30	30	1.0	0.4	3.2	1.7	0	-23	-32	-60
2.3 GHz (10 carriers)	37	40	42	30	30	1.0	0.4	3.2	1.7	0	-23	-32	-60
2.4 GHz (combo) US	37	37	42	17.5	15.5	-	0.4	3.2	1.7	-10	-35	-20	-50
2.4 GHz (combo) Europe				23.0	18.0								
2.5 GHz	39	41	42	-	-	1.0	0.4	3.2	1.7	0	-23	-32	-60
2.6 GHz (EFGH split)	39	41	42	-	-	1.8	0.4	3.2	1.7	0	-23	-32	-60
2.6 GHz (EF combo)	37	41	42	-	-	1.8	0.4	3.2	1.7	0	-20	-30	-60
	A1	**A2**	**B**	**C1**	**C2**	**D1**	**D2**	**E1**	**E2**	**F**	**G**	**H**	**I**

TABLE H2 - Main Cable Parameters

MAIN CABLES		TIMES MICROWAVE					NK CABLES							ANDREW CABLES						
Type of cable		LMR 1700	LMR 1200	LMR 900	LMR 600	LMR 400	**RF 21/4-50**	**RF 15/8-50**	**RF 11/4-50**	**RF 7/8-50**	**RF 5/8-50**	**RF 1/2-50**	**RF 3/8-50**	2 1/4" LDF12-50	15/8" LDF7-50A	11/4" LDF6-50	7/8" LDF5-50A	5/8" LDF4.5-50	1/2" LDF4-50A	3/8" LDF2-50
Loss (dB) per 100 ft of cable	at 2.3 GHz	1.65	2.17	2.86	4.24	6.49	**1.08**	**1.21**	**1.43**	**1.94**	**2.47**	**3.54**	**5.55**	1.09	1.24	1.61	2.03	2.67	3.53	5.62
	at 2.4 GHz	1.70	2.24	2.95	4.38	6.69	–	**1.26**	**1.48**	**2.00**	**2.55**	**3.66**	**5.73**	1.13	1.28	1.67	2.10	2.75	3.64	5.80
	at 2.5 GHz	1.74	2.29	3.02	4.47	6.82	–	**1.29**	**1.51**	**2.04**	**2.61**	**3.73**	**5.85**	1.16	1.31	1.71	2.14	2.81	3.72	5.92
	at 2.6 GHz	1.78	2.34	3.08	4.57	6.97	–	**1.32**	**1.54**	**2.09**	**2.66**	**3.81**	**5.98**	1.19	1.35	1.75	2.19	2.88	3.80	6.05
Weight (pounds/ft)		0.74	0.45	0.27	0.13	0.07	**1.34**	**0.97**	**0.67**	**0.37**	**0.28**	**0.24**	**0.08**	1.22	0.82	0.63	0.33	0.15	0.15	0.08
Diameter (inches)		1.67	1.20	0.87	0.59	0.41	**2.36**	**1.97**	**1.54**	**1.08**	**0.86**	**0.63**	**0.44**	2.35	1.98	1.55	1.09	0.87	0.63	0.44
Bend Radius (inches		13.50	6.50	3.00	1.50	1.00	**47.00**	**20.00**	**14.00**	**10.00**	**8.00**	**6.00**	**3.74**	24.00	20.00	15.00	10.00	8.00	5.00	3.75

TABLE H3 - Jumper Cable Parameters

JUMPER CABLES		TIMES MICROWAVE		NK CABLES		ANDREW CABLES	
Type of cable		LMR 600	LMR 400	**RF 1/2-50**	**RF 3/8-50**	1/2" FSJ4-50B	3/8" FSJ2-50
Loss (dB) per 100 ft of cable	at 2.3 GHz	4.24	6.49	**5.56**	**7.23**	5.86	6.50
	at 2.4 GHz	4.38	6.69	**5.74**	**7.46**	6.06	6.70
	at 2.5 GHz	4.47	6.82	**5.86**	**7.62**	6.19	6.84
	at 2.6 GHz	4.57	6.97	**6.00**	**7.79**	6.33	7.00
Weight (pounds/ft)		0.13	0.07	**0.13**	**0.09**	0.14	0.08
Diameter (inches)		0.59	0.41	**0.53**	**0.40**	0.52	0.42

Rationale Behind the Formulas

Please refer to Figures H2, H3 and H4 during the following discussion.

Figure H2 – A Look Inside an Omni RFS

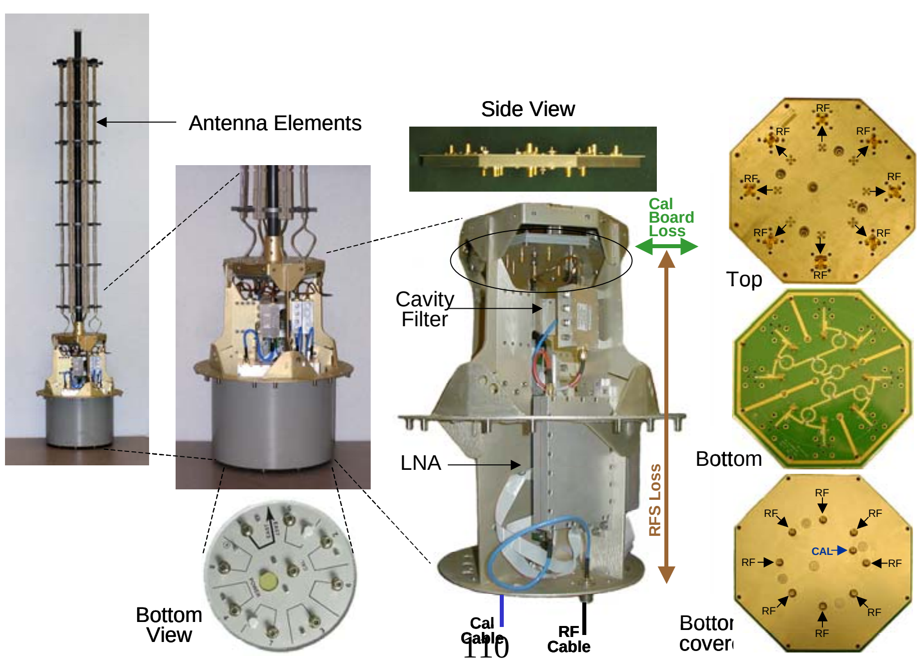


Figure H3 – Tx Path Calibration

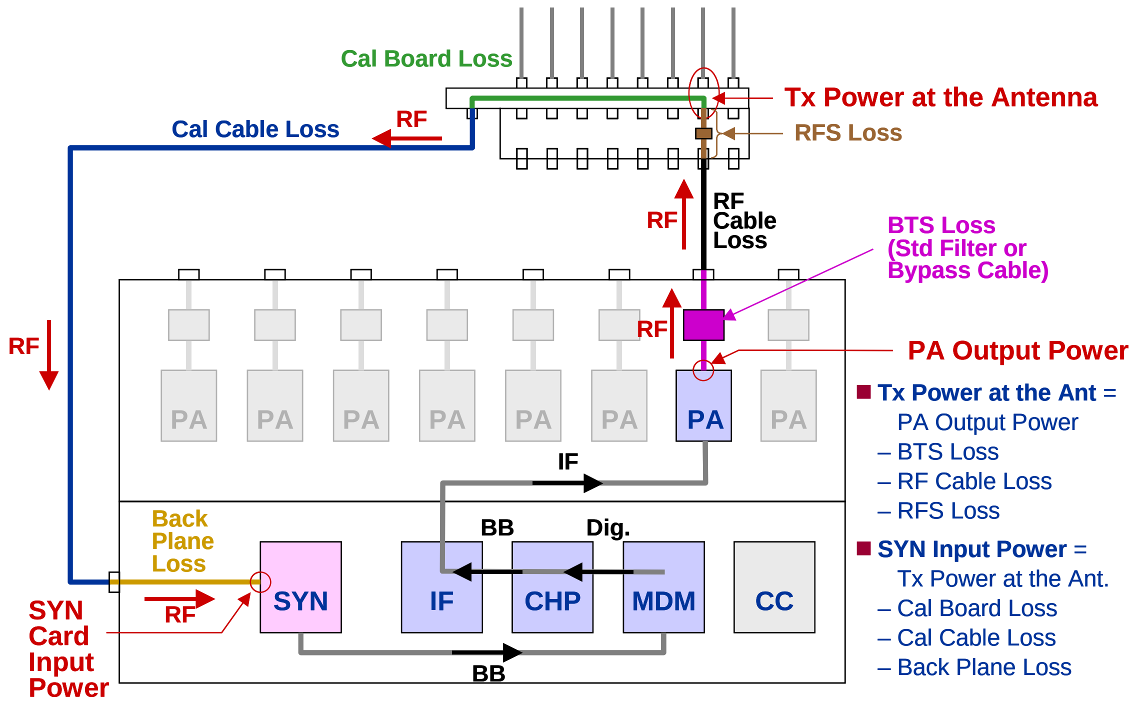
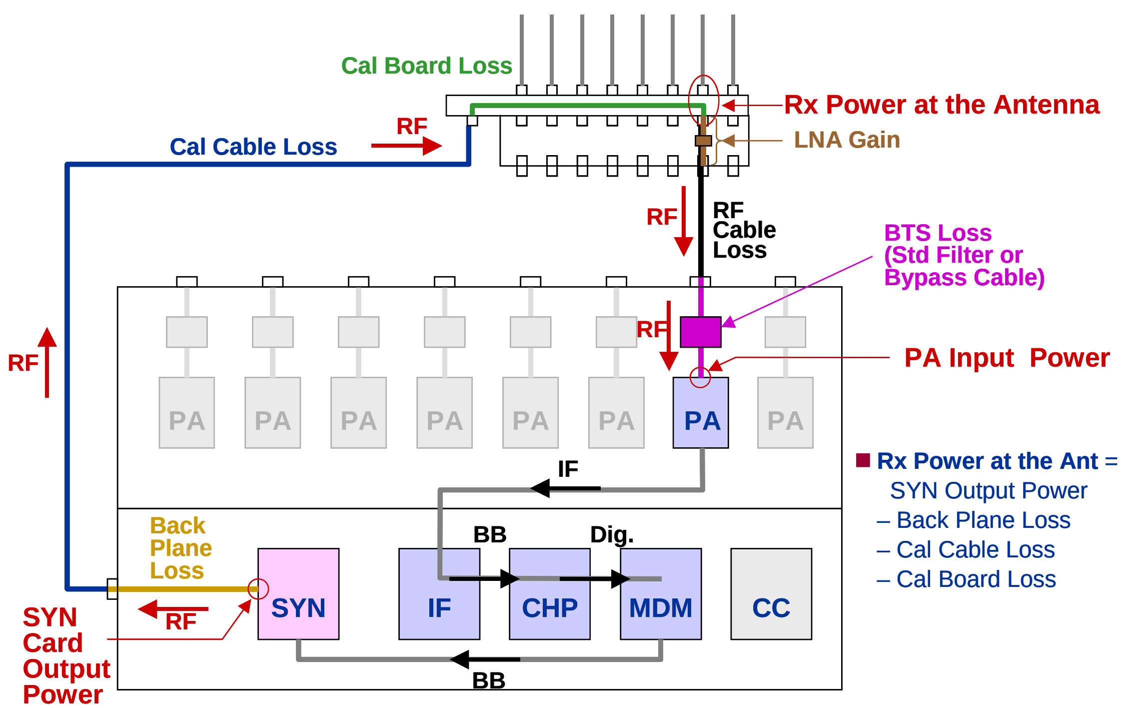


Figure H4 – Rx Path Calibration



There are upper and lower limits to the TX Power and RX Sensitivity to which a BTS can be set. One of the two conditions that determine the Maximum amount of power that can be delivered at the antenna elements (Max TX $Power_1$) is how much power can be output by the each one of the PAs. The losses in the RF paths are: (1) the BTS Loss introduced by the Standard Filter, if used, or by the Bypass Cable, if no filter is used; (2) The loss on the RF Cable (Main + Higher and Lower Jumper cables + 6 terminators and lightening arrestors, estimated as 0.6 dB); and (3) the loss at the base of the RFS, between the N-type connectors where the RF & Cal cables are connected and the SMA connectors at the bottom of the Cal Board.

Max Tx $Power_1$ = Max PA Output
– BTS Loss [Formula 1]
– RF Cable Loss
– RFS Loss

The other condition is related to the Calibration process. During the calibration of the TX paths (one at a time), a fraction of the power delivered by the a PA to the corresponding antenna element is derived through the Cal Board to the common CAL cable and through the BTS back plane until it arrives at the SYN card. The Calibration process requires that the Input Power received by the SYN card be in a certain range. Lets find a formula for the Max TX $Power_2$ (power at the antenna elements) that would allow the system to be calibrated. Above this level the input power received by the SYN card would be over the maximum allowed.

Therefore,

Max SYN Card Input = Max Tx $Power_2$
– Min Cal Board Loss
– CAL Cable Loss
– Back Plane Loss

or

Max Tx $Power_2$ = Max SYN Card Input
+ Min Cal Board Loss [Formula 2]
+ CAL Cable Loss
+ Back Plane Loss

As both conditions must be satisfied, we take the most restrictive one, that is, the one that produces the lower value:

Max Tx Power = Min { Max Tx $Power_1$, Max Tx $Power_2$ } [Formula 3]

Substituting the Min SYN Card Input for the Max SYN Card Input and the Min Cal Board Loss for the Max Cal Board Loss in Formula 4 we get the formula for the Min TX Power (at the antenna elements) that allows the system to be calibrated. Below this level the input power received by the SYN card would be less than the minimum required.

Min Tx Power= Min SYN Card Input
+ Max Cal Board Loss [Formula 4]
+ CAL Cable Loss
+ Back Plane Loss

Let's now determine the maximum and minimum RX Sensitivity at which the BTS can be calibrated. During the RX Paths calibration, the SYN card generates an RF signal that must travel to (and suffer losses at) the BTS Back Plane, the CAL Cable, and the Calibration Board before it arrives at the base of the antenna elements. The maximum and minimum level of power that can be delivered at the antenna elements during this simulated reception (that is, the possible range for the RX Sensitivity) are determined, respectively, by the maximum and minimum level of the signal output by the SYN card. Setting the RX Sensitivity outside this range will make the system impossible to calibrate.

Max Rx Sensitivity = Max SYN Card Output
+ Min Cal Board Loss [Formula 5]
+ CAL Cable Loss
+ Back Plane Loss

Min Rx Sensitivity = Min SYN Card Output
+ Max Cal Board Loss [Formula 6]
+ CAL Cable Loss
+ Back Plane Loss

Notice that when determining <u>maximum</u> power levels (formulas 3 and 5) we assume the Cal Board path that introduces the *minimum* possible loss (27 dB), while when determining <u>minimum</u> power levels (formulas 4 and 6) we assume the Cal Board path that introduces the *maximum* possible loss (31 dB).

The Procedure

<u>1. Eliminate the Main Cables with Bend Radius exceeding the minimum required</u>

Compare the Bend Radius for each type of Main Cable (last row in Table I2) with the <u>Minimum Required Bend Radius</u> given as input data. Eliminate from further consideration the Main Cables that have a Bend Radius exceeding the minimum required.

<u>2. Eliminate combinations of cables that weight too much</u>

Calculate the weight of the Higher Jumper cable for the selected type of Jumper Cable

Weight of Higher Jumper Cable= [Formula 7]
Length of the Higher Jumper Cable
× Weight of one foot of the Selected type of Jumper Cable

Calculate the weight of the section of main Cable hanging from the tower for each type Main cable.

Weight on Tower of one type of Main Cable = [Formula 8]
Vertical Drop
× Weight of one foot of that type of Main Cable

Calculate the weight of the power and data cable

Weight of a P&D Cable = [Formula 9]
(Length of the Higher Jumper Cable
+ Vertical Drop)
× Weight of one foot of P&D Cable

Calculate the weight of all cables on the tower for each type Main cable

Weight of All Cables = [Formula 10]
(Weight of Higher Jumper Cable
+ Weight on Tower of one type of Main Cable) × 9
+ Weight of P&D Cable

Eliminate for further consideration the cable combinations that exceed the maximum allowed weight for all cables.

3. Perform preliminary calculations in Table H1

Using the Input Data, fill the cells A through I at the bottom of the Table H1 with the appropriate values.

- Select first one row based on the operating frequency (plus the number of sub-carriers if 2.3 GHz or whether the chassis is split or combo if 2.6 GHz).
- For that row, copy the values in columns B, F, G, H and I at the bottom of the table.
- Choose between the value in column A1 and the value in column A2 based on whether your system must comply with FCC regulations or not (write it down at the bottom of the table and call it A).
- If the operating frequency is 2.3 or 2.4 GHz, choose between the value on column C1 or the value in column C2 based on the antenna type, Omni or Panel; If the operating frequency is 2.4 GHz, take also into consideration whether the regulatory body is the FCC or European (write the value down at the bottom of the table and call it C).
- Choose between the value in column D1 and the value in column D2 based on

whether your system has a Standard Filter in the back of the BTS (write it down at the bottom of the table and call it D).

- Choose between the value in column E1 and the value in column E2 based on whether your system has an Active or Passive RFS (write it down at the bottom of the table and call it E)

4. Calculate the total loss for the combination of each type of Main Cable and the selected type of Jumper Cable

Calculate the loss of the Higher and Lower Jumper Cables. Read the loss per 100 ft for the selected type of the selected Jumper Cable for the Operating Frequency Band of your system, then divide it by 100 and multiply it times the Length of the Higher Jumper Cable.

Loss of Higher Jumper Cable = [Formula 11]
Length of the Higher Jumper Cable ÷ 100
× Loss per 100 feet of the Selected type of Jumper Cable

Loss of Lower Jumper Cable = [Formula 12]
Length of the Lower Jumper Cable ÷ 100
× Loss per 100 feet of the Selected type of Jumper Cable

Calculate the loss of the Main Cable. Read the loss per 100 ft for each type of Main Cable for the Operating Frequency Band of your system, then divide it by 100 and multiply it times the Length of the Main Cable.

Loss of one type of Main Cable = [Formula 13]
Length of the Main Cable ÷ 100
× Loss per 100 feet of that type of Main Cable

Calculate the TOTAL CABLE LOSS (RF or CAL Cable) for each type of Main Cable. This is the sum of the losses on both Jumper Cables plus the loss of one type of Main Cable, plus 0.6 dB for terminators and surge arrestors.

TOTAL CABLE LOSS = [Formula 14]
Loss of Higher Jumper Cable
+ Loss of Lower Jumper Cable
+ Loss of one type of Main Cable
+ 0.6 dB

5. Calculate the maximum and minimum values of TX Power and RX Sensitivity at the base of the antenna elements and build Table I5 with the results.

Notice that **TOTAL CABLE LOSS** in Formula 14 is the same as **RF Cable Loss** in Formula 1 and the same as **CAL Cable Loss** in formulas 2, 4, 5 and 6.

Use Formula 1 to calculate Max Tx $Power_1$ (what the PAs could deliver) for each type of Main Cable. Use values "A", "D" and "E" from Table 1 respectively for Max PA Output, BTS Loss, and RFS Loss; and the values from Formula 14 for RF Cable Loss.

Use Formula 2 to calculate Max Tx $Power_2$ (maximum value at which the Tx Paths of the BTS can be calibrated) for each type of Main Cable. Use value "F" from Table 1 for Max SYN Card Input; the Min Cal Board Loss and Back Plane Loss values given as Input Data; and the values from Formula 14 for CAL Cable Loss.

Choose the lower value of the previous two for each type of Main Cable. This is the *actual* Max Tx Power. (Formula 3).

Use Formula 4 to calculate Min Tx Power (minimum value at which the Tx Paths of the BTS can be calibrated) for each type of Main Cable. Use value "G" from Table 1 for Min SYN Card Input; the Max Cal Board Loss and Back Plane Loss values given as Input Data; and the values from Formula 14 for CAL Cable Loss.

Use Formula 5 to calculate Max Rx Sensitivity (maximum value at which the Rx Paths of the BTS can be calibrated) for each type of Main Cable. Use value "H" from Table 1 for Max SYN Card Output; the Min Cal Board Loss and Back Plane Loss values given as Input Data; and the values from Formula 14 for CAL Cable Loss.

Use Formula 6 to calculate Min Rx Sensitivity (minimum value at which the Rx Paths of the BTS can be calibrated) for each type of Main Cable. Use value "I" from Table 1 for Min SYN Card Output; the Max Cal Board Loss and Back Plane Loss values given as Input Data; and the values from Formula 14 for CAL Cable Loss.
Build Table H5. You may also calculate the Maximum EIRP for each cable combination by adding the Gain per Antenna Element (12 dB if Omni, 17 dB if Panel to the Max Tx Power.

<u>6. The following is an example of the calculations performed with the Cable Selection Spreadsheet with the data shown in Figure H1</u>

Figure H5 – Results

Results

Main Cable	Jumper Cable	Total Loss (dB)	Tx Power (dBm) MAX	Tx Power (dBm) min	MAX EIRP dBm	Rx Sensitivity (dBm) MAX	Rx Sensitivity (dBm) min	Weight (lb)	Bend Radius (inches)	
LMR 1700	LMR 600	3.23	31.5	16.2	43.5	-67.2	-99.2	–	–	ok
LMR 1200	LMR 600	3.78	31.0	16.8		-67.7	-99.8	–	–	ok
LMR 900	LMR 600	4.51	30.2	17.5	42.2	-68.5	-100.5	–	–	ok
LMR 600	LMR 600	5.96	28.8	19.0	40.8	-69.9	-102.0	–	–	TX Power Out of Range
LMR 400	LMR 600	8.31	26.4	21.3	38.4	-72.3	-104.3	–	–	TX Power Out of Range
RF 2 1/4-50	LMR 600	–	–	–	–	–	–	–	–	NOT AVAILABLE!
RF 1 5/8-50	LMR 600	2.78	–	–	–	–	–	–	20.0	Bend radius too large!
RF 1 1/4-50	LMR 600	3.00	31.7	16.0	43.7	-67.0	-99.0	–	–	ok
RF 7/8-50	LMR 600	3.53	31.2	16.5	43.2	-67.5	-99.5	–	–	ok
RF 5/8-50	LMR 600	4.10	30.6	17.1	42.6	-68.1	-100.1	–	–	ok
RF 1/2-50	LMR 600	5.22	29.5	18.2	41.5	-69.2	-101.2	–	–	TX Power Out of Range
RF 3/8-50	LMR 600	7.34	27.4	20.3	39.4	-71.3	-103.3	–	–	TX Power Out of Range
2 1/4" LDF12-50	LMR 600	2.65	–	–	–	–	–	1078.4	–	Too much weight!
1 5/8" LDF7-50A	LMR 600	2.80	–	–	–	–	–	–	20.0	Bend radius too large!
1 1/4" LDF6-50	LMR 600	3.20	31.5	16.2	43.5	-67.2	-99.2	–	–	ok
7/8" LDF5-50A	LMR 600	3.63	31.1	16.6	43.1	-67.6	-99.6	–	–	ok
RF 5/8-50	LMR 600	4.30	30.4	17.3	42.4	-68.3	-100.3	–	–	ok
1/2" LDF4-50A	LMR 600	5.21	29.5	18.2	41.5	-69.2	-101.2	–	–	TX Power Out of Range
3/8" LDF2-50	LMR 600	7.41	27.3	20.4	39.3	-71.4	-103.4	–	–	TX Power Out of Range

Chart1 | Cable Selection Procedure

Notice that, in this example, one cable combination is Not Available (there is no Loss data for that main Cable at the selected Frequency Band), one cable combination exceeds the maximum weight allowed, two Main Cables are not flexible enough to be bent as required and four cable combinations were eliminated because they cannot deliver the desired level of TX Power at the antenna elements.

At this point you could repeat the calculations with a different type of jumper cable and compare the results.

In this example, eleven cable combinations have been identified which meet all the requirements of the system. Now the question is “which one should be used?” To answer this question, other factors such as cable cost or company policy can be taken into consideration.

Finally, keep in mind that if you select a cable combination that barely meets the requirements, specially for TX Power (but sometimes also for RX Sensitivity), and over time the performance of your system degrades, one or both of these parameters may fall out of range and your system would become impossible to calibrate forcing you to reduce the TX Power or rise the RX Sensitivity, thus reducing the capacity and/or coverage radius of your system.

Cable Selection for TTA Systems

Cable selection for a TTA system is extremely simple. Just follow the steps listed below. Notice that if you are using only the Secondary (Built-In) Surge Protection, you need N-QMA cables, but if you are using Primary Surge Protection (surge protectors in the RFS and on a ground buss bar close to the BTS), then you need N-N cables from the RFS to the buss bar and a set of 9 N-QMA jumper cables from the buss bar to the BTS

1. Determine the operating frequency
2. Determine the distance between the antenna (RFS) and the BTS. This distance plus ant slack for service and drip loops is your cable length
3. Determine if there are any restrictions regarding cable weight on the tower and minimum cable bend radius
4. Select the right cable using the Tables H4 through H6 below.
5. If you need to use LMR400 or LMR600 cables, refer to Table H2 above for the loss, weight and bend radius data.

TABLE H4 – Power Loss Budget and Maximum Cable Lengths for TTA Systems

Freq. Band	Min/Max Cable Loss Allowed (dB)	Max Cable Length				
		Bundled		Individual		
		RG6	RG11	LMR-240	LMR-400	LMR-600
2.01 GHz	5 ≤ loss ≤ 25	**50–250 ft** (15–76 m)	**80–390 ft** (24–119 m)	**45–215 ft** (14–65 m)	**85–415 ft** (26–126 m)	**130–640 ft** (40–195 m)
2.3 GHz	5 ≤ loss ≤ 25	**45–230 ft** (14–70 m)	**70–350 ft** (21–107 m)	**40–200 ft** (12–61 m)	**70–355 ft** (21–108 m)	**115–565 ft** (35–172 m)
2.4 GHz	5 ≤ loss ≤ 20	**45–180 ft** (14–55 m)	**70–275 ft** (21–275 m)	**40–155 ft** (12–47 m)	**75–295 ft** (23–90 m)	**115–450 ft** (35–137 m)
2.5–2.7 GHz	5 ≤ loss ≤ 25	**45–215 ft** (14–65 m)	**65–335 ft** (20–84 m)	**40–190 ft** (12–58 m)	**70–355 ft** (21–108 m)	**110–540 ft** (33–164 m)
3.4–3.7 GHz	5 ≤ loss ≤ 30	**35–220 ft** (11–67 m)	**55–340 ft** (17–104 m)	**35–190 ft** (11–58 m)	**60–360 ft** (18–110 m)	**85–540 ft** (27–165 m)

TABLE H5 – Cable Specs

		Bundled		**Individual**		
		RG6	**RG11**	**LMR-240**	**LMR-400**	**LMR-600**
Cable Loss dB/ft (dB/m)	**2.01 GHz**	**0.100** (0,328)	**0.064** (0,210)	**0.116** (0,379)	**0.060** (0,197)	**0.039** (0,128)
	2.3 GHz	**0.109** (0,358)	**0.071** (0,233)	**0.123** (0,405)	**0.070** (0,230)	**0.044** (0,144)
	2.4 GHz	**0.111** (0,364)	**0.073** (0,239)	**0.126** (0,413)	**0.068** (0,223)	**0.044** (0,144)
	2.5–2.7 GHz	**0.116** (0,380)	**0.075** (0,246)	**0.132** (0,431)	**0.070** (0,230)	**0.046** (0,151)
	3.4–3.7 GHz	**0.138** (0.453)	**0.088** (0,289)	**0.155** (0,509)	**0.083** (0,272)	**0.055** (0,180)
Type of Connectors (RA: Right Angle ST: Straight)		QMA (RA) N-type (ST)	N-type (ST)	QMA (RA) QMA (ST) N-type (RA) N-type (ST)	N-type (RA) N-type (ST)	N-type (RA) N-type (ST)
Weight: lb/ft (kg/m)		**0.45** (0.67)	**0.85** (1.26)	**0.034** (0.05)	**0.068** (0.10)	**0.131** (0.20)
Min. Bend Radius: in (mm)		**22** (560)	**32** (813)	**0.75** (19)	**1.0** (25)	**6.0** (152)
Impedance		75 Ohm		50 Ohm		

TABLE H6 – Antenna Power and Rx Sensitivity

Antenna Power and Rx Sensitivity

		TTA Systems				Non-TTA Systems			
		Antenna Power (dBm)		Rx Sensitivity (– dBm)		Antenna Power (dBm)		Rx Sensitivity (–dBm)	
		min	MAX	min	MAX	min	MAX	min	MAX
2.3 GHz		**20**	**30**	**–95**	**–75**	**20**	**30**	**–95**	**–75**
2.4 GHz		**10**	**24**	**–85**	**–65**	**10**	**24**	**–85**	**–65**
2.5–2.7 GHz		**20**	**30**	**–95**	**–75**	**20**	**30**	**–95**	**–75**
3.4–3.7 GHz	with filter	**20**	**29**	**–90**	**–70**				
	without filter	**20**	**30**	**–90**	**–70**				

WARNING! The maximum values showed in this table are capabilities of the hardware. Stringent regulatory restrictions may apply depending on the country where the equipment is being installed. Check the applicable regulations of the country's regulatory body for compliance. The maximum Antenna Power can also be limited by antenna cable loss and filtering requirements depending on regulatory body.