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Introduction

This TETRA TMO Getting Started (GS) supplements the STTA DMO Getting Started. This TMO GS assumes that the information from the DMO GS has been read, understood and, if necessary, already set on the radio.

Just like the DMO GS, this GS is also limited to Motorola TETRA radios. Simply because the writer does not currently own TETRA radios from other manufacturers.

NOTE: This version has been updated to reflect the requirements of the TetraPack network. TetraPack is a worldwide Tetra TMO network, interconnected to the worldwide BrandMeister/DMR network. For more information please refer to https://tetrapack.online/ and https://brandmeister.network

A short repeat from the DMO GS

- The use of the CPS Lab mode is not without risks;
- Therefore, first make a full flash backup using Flash Report (refer to the DMO GS);
- If things should go wrong with the CPS Lab mode, that's a shame but it remains your own risk.

Some important TMO additions:

- The ISSI (the CCS7, or the "DMR ID" must be entered.
  Tetra TMO requires a unique ISSI, two radios with the same ISSI on a TMO network or Node ("repeater") will not work;
- TetraPack requires officially registered IDs, registration is performed via https://radioid.net
- Given that TetraPack is interconnected to BrandMeister, and uses the same ID database you cannot simultaneously have a Tetra radio on TetraPack and a DMR radio on BrandMeister when these radios use the same ID. If you need to have this working please contact https://radioid.net and request a second ID explaining in detail what your reason for the request is.

This GS has been intentionally kept concise and is limited to the basic settings needed to operate TETRA TMO within the service area of the STTA TMO and Stichting Repeaters Haaglanden TMO nodes. There is much, much more to tweak (or potentially: wreck) according to your own taste.

The screenshots were created with CPS7.5 and are based on MTH800, MTM800 and MTP6650 radios. Depending on the radio model and the firmware used in the radio, it looks (slightly) different in CPS.

In addition to the full flash backup, always make full backups of the codeplugs. This ensures it will be possible to go back to the 'known good' version.

The TMO "repeater" is referred to in general as "the node". Another name for node is "BS" of "BTS" which stands for Base Station. Mobile and portable radios are called MS (Mobile Stations).

TMO Talkgroups and folders

The first step is to create a TMO Folder in which the Talk Groups (TG) for a particular TMO

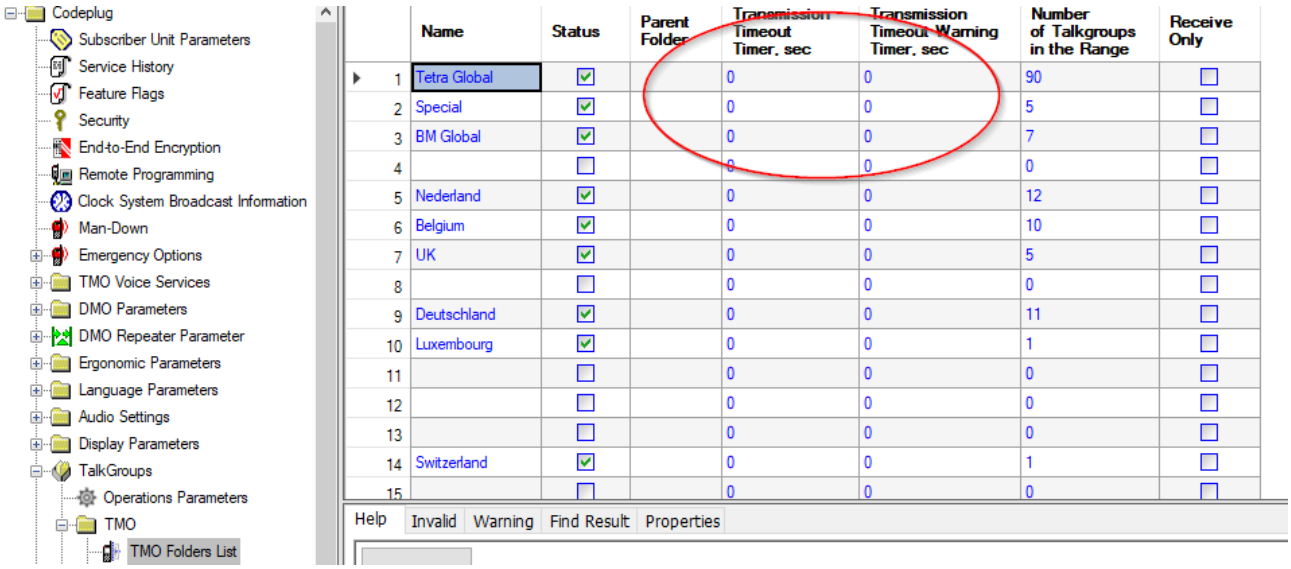
network. Within a TMO network all TG are available on all BS that are connected to that network.

To slightly complicate matters, for TetraPack / BrandMeister there is additionally the rule that:

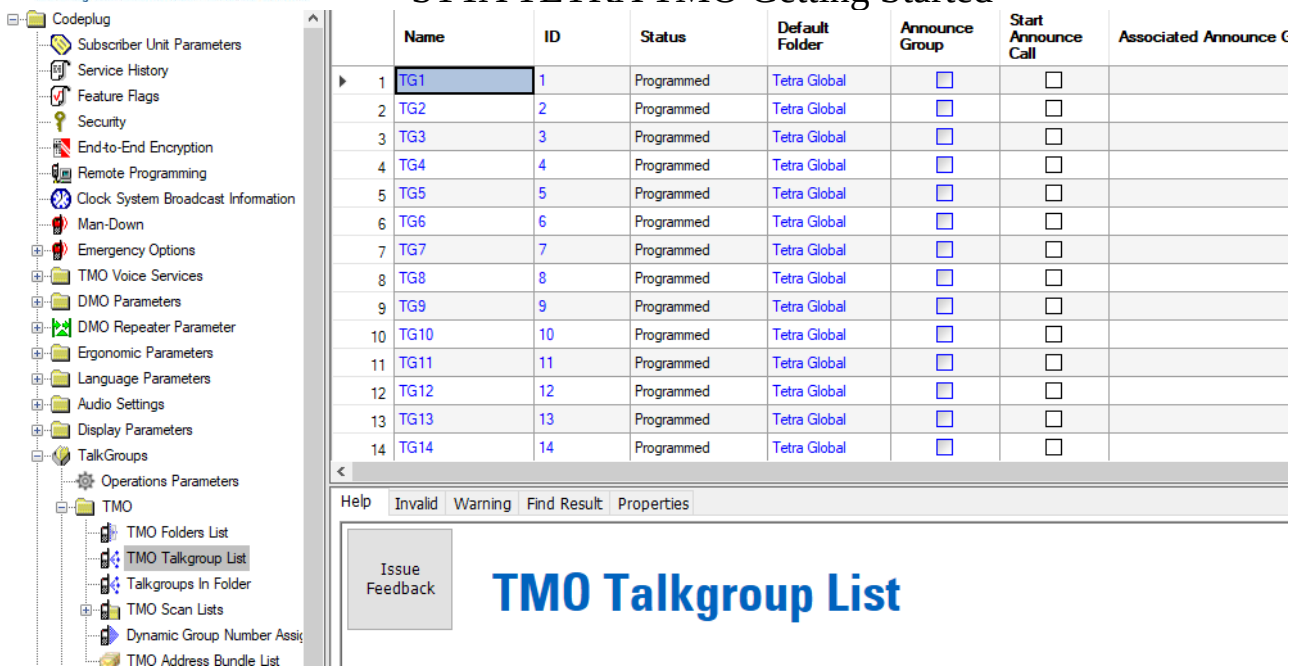
- TG 1 – TG 90 are kept within the TetraPack network, so only usable on Tetra radio's and are not accessible by DMR radio's (or vice versa).
- TG 91 and higher have a worldwide interconnect between TetraPack (Tetra radios) and BrandMeister) DMR radios. For TG 91 and higher Tetra and DMR radios can talk to one another.

TETRA has a 'strangler' as seen on some analogue amateur repeaters. This function prevents a single user from speaking 'endlessly' and thus occupying a TG. This also prevents a radio that hangs on its PTT switch.

The Transmission Timeout Timer (TTT) and the Transmission Timeout Warning Timer (TTWT) shown below are still at the standard (default) value of 60 and 50 seconds. It is useful to set the TTT to 300 seconds (which is also the maximum value), and the TTWT to 290 seconds. This means that 10 seconds before the timeout occurs and the call will be disconnected, a warning beep sounds which informs you that your transmission timeout will follow in 10 seconds. Setting the value to 0 will disable the strangler. Not really recommended.



The following image shows an example of a part of the TG for TetraPack



In general, the STTA TMO BS is not aware of the TG or TG ID's. This means that anyone can invent and use TG's and TG ID's themselves. Obviously, all stations must have programmed the relevant TG ID, otherwise it is not possible to communicate. There is no such thing as "VFO mode" in Tetra. As noted earlier: TG <= 90 are Tetra TMO only, they are not relayed to BrandMeister/DMR.

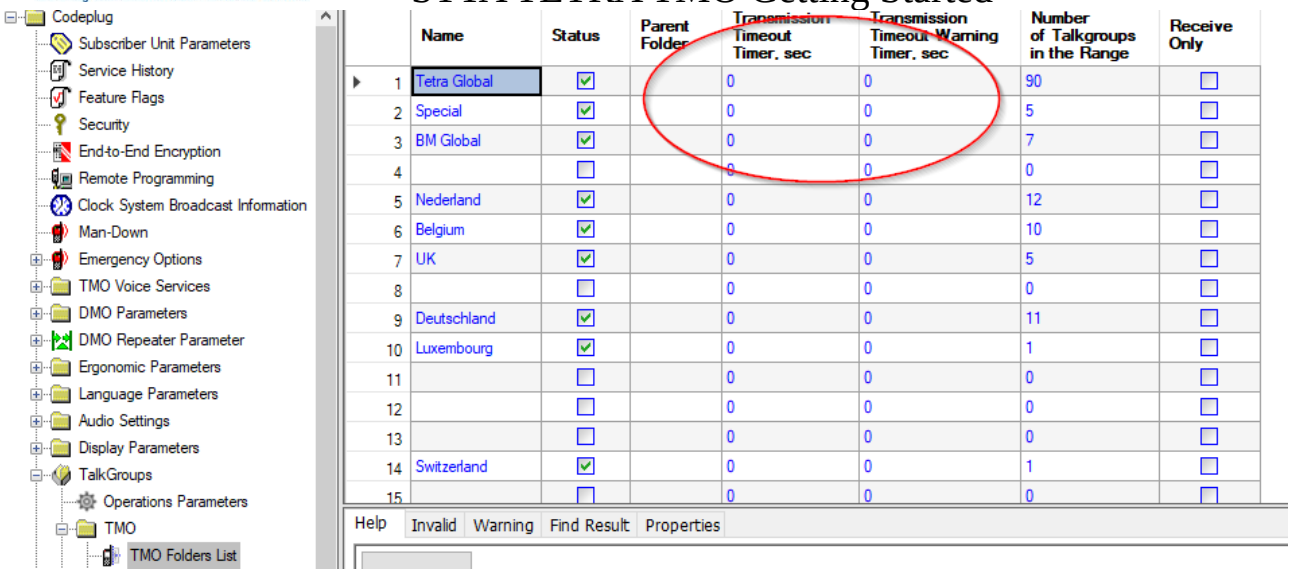
Sofar no formal agreements have been made to use what TG in the TG <= 90 so Tetra-only range. Informally agreement is that within in the Netherlands TG 26 is used in Arnhem, wheras TG 55 is in Den Haag.

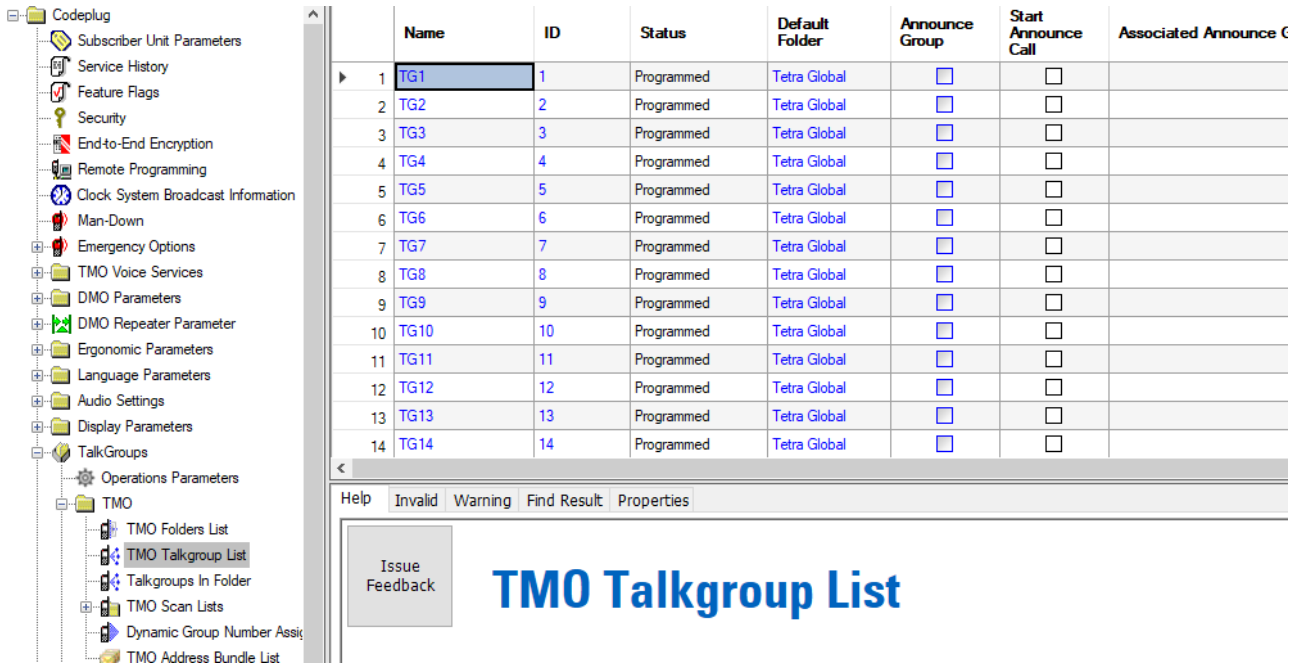
All TG >= 91 adhere to the BrandMeister agreements as documented on https://brandmeister.network/?page=talkgroups It is up to you if you like to listen to DMR traffic using your Tetra radio.

Note: PI6ZTM and PI1ANH each have 3 timeslots (Tetra TMO is TDMA) available within the 25kHz RF carrier. The fourth timeslot is used for 'house keeping', the MCCH or Master Control Channel. Things like radio network sign-on, GPS location updates, alerting etc. are sent via the MCCH.

Note: on some BS (ANH and ZTM support it but not all do!) it is possible to make full-duplex calls. This is 100% comparable to what we are used to while using a phone: talk and listen simultaneously. This does take more capacity so please limit its use.

The following screenshots show examples on how talkgroups are arranged in talkgroup folders for easier access.





Scan lists

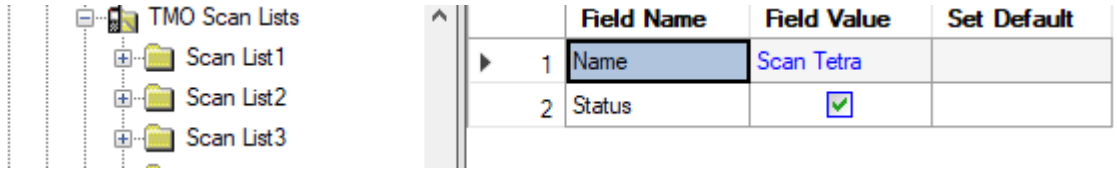
TMO offers the possibility to let the radios "scan" TG's in a list of predefined set TG's. The image below shows the standard scan list as CPS creates it.

Do note:
Scan lists can cause trouble if too many ‚busy TG' are placed in scan lists.Every time a TG has a call active results in the BS allocating a time slot (TS) to the call in order to be able to transmit that call. If too many busy TG are put in scan lists the BS can run out of available time slots. This results in other users being confronted with ‚PTT Denied' messages on their radios. In other words: the BS is congested.

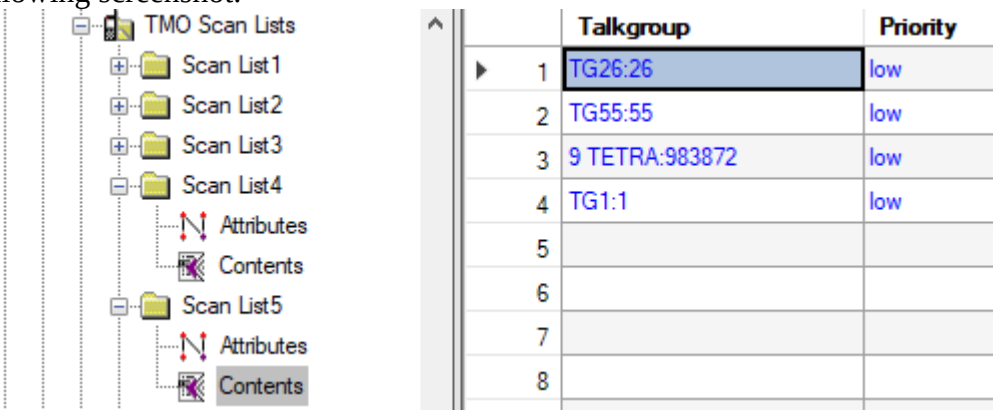
For this reason in most professionally used TMO networks scan lists are NOT used. Also for this

*reason there is an explicit request, at least for PI1ANH, to **not** use TG > 90 (so BrandMeister DMR groups) in scan lists. For example TG 204 tends to be very busy. If you need to listen to that please use your DMR radio. For TetraPack TG the number of users is typically much lower and therefore their use in scan lists is not problematic.*

The name of the scan list can be changed as desired. So here the name has been changed to "STTA scan".

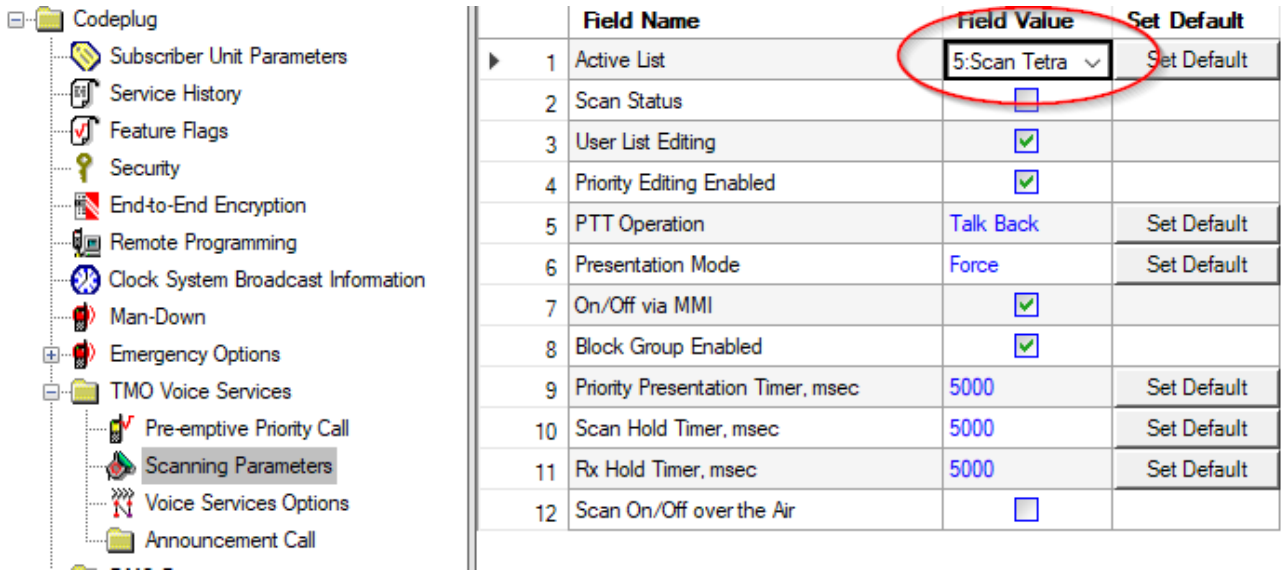


The scan list is subsequently filled with TG's at your own discretion, this can be seen in the following screenshot.



There is an option to indicate priorities in the scan list, in the example this has not been done (all have priority Low).

It is practical to program the scan list to be activated when the radio is switched on. That list is called the "active list". You can also choose another scan list via the menu in the radio.



It will be clear that multiple Scan Lists can be created.

Frequency lists

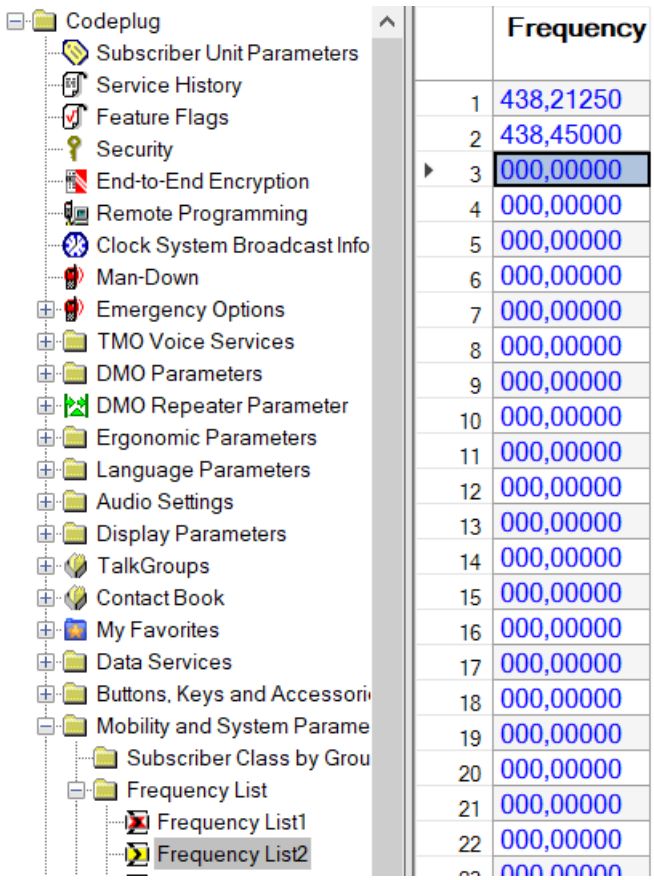
Obviously, it must still be ensured that the radios can find the the related BS transmit frequency. This works very differently in TMO than with 'normal' radios or (DMO) repeaters. In fact, the TMO

model is roughly comparable to the way a mobile telephone network works.

There are four so-called Frequency lists in the Motorola TETRA radios:

List 1: list with frequencies of the BS to which the radio has ever been connected (cannot be programmed, is read-only for the user)
List 2: pre-programmed frequencies for 'known nodes'
List 3: scan list 1
List 4: scan list 2

Frequency lists are useful when there are multiple nodes operational. By scanning the frequencies based on Frequency List 3 and Frequency List 4, the radio can then find the nodes by itself. The larger the frequency range to be scanned, the longer it takes (which is logical of course) so for the Dutch nodes the QRG is simply "hardcoded" in List 2. This means that the radio quickly finds the node after switching on (provided the radio is within range of the BS of course).



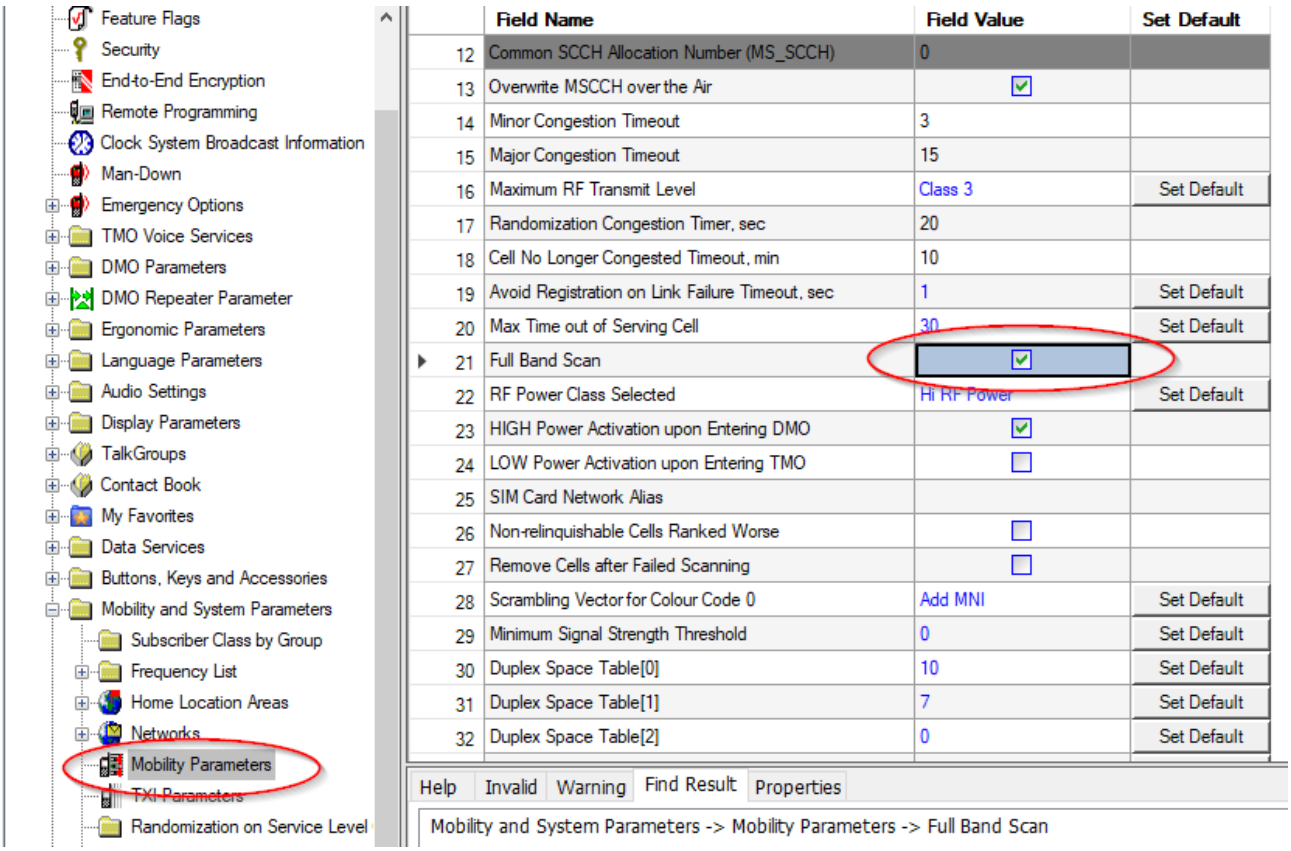
438.2125 is the transmit frequency of the PI1ANH BS, 438.450 is the transmit frequency of the PI6ZTM BS located in The Hague.

In case there are purple icons and a red boxes shown around the Frequency: this is how CPS indicates that there is something wrong with the entered values. In our case it is 'simple': the radio used was originally intended for the 380-430MHz band. The entered frequency of 438.2125 is therefore invalid.

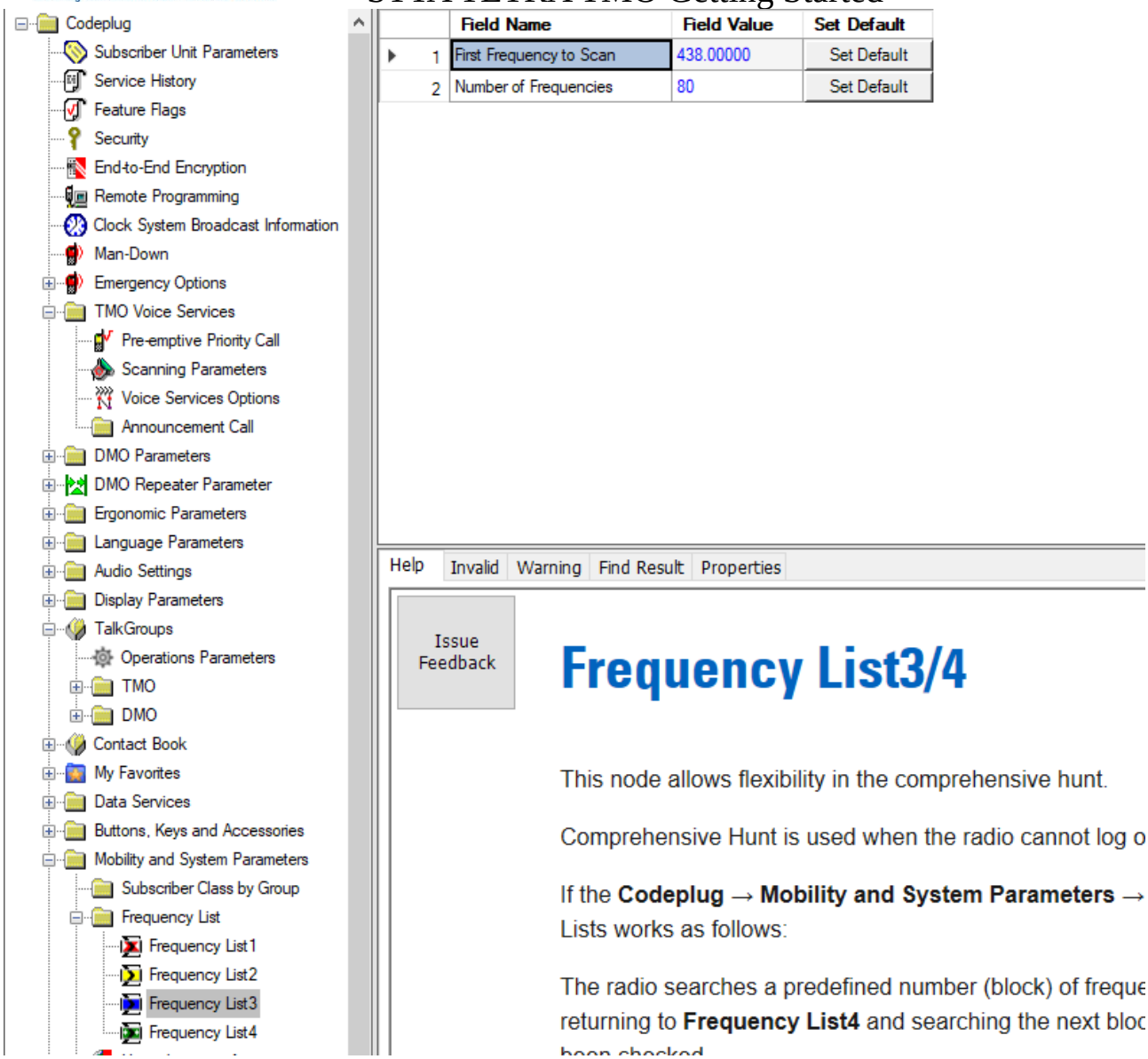
Please note: as long as there are errors in the codeplug according to CPS, the codeplug cannot be written to disk.

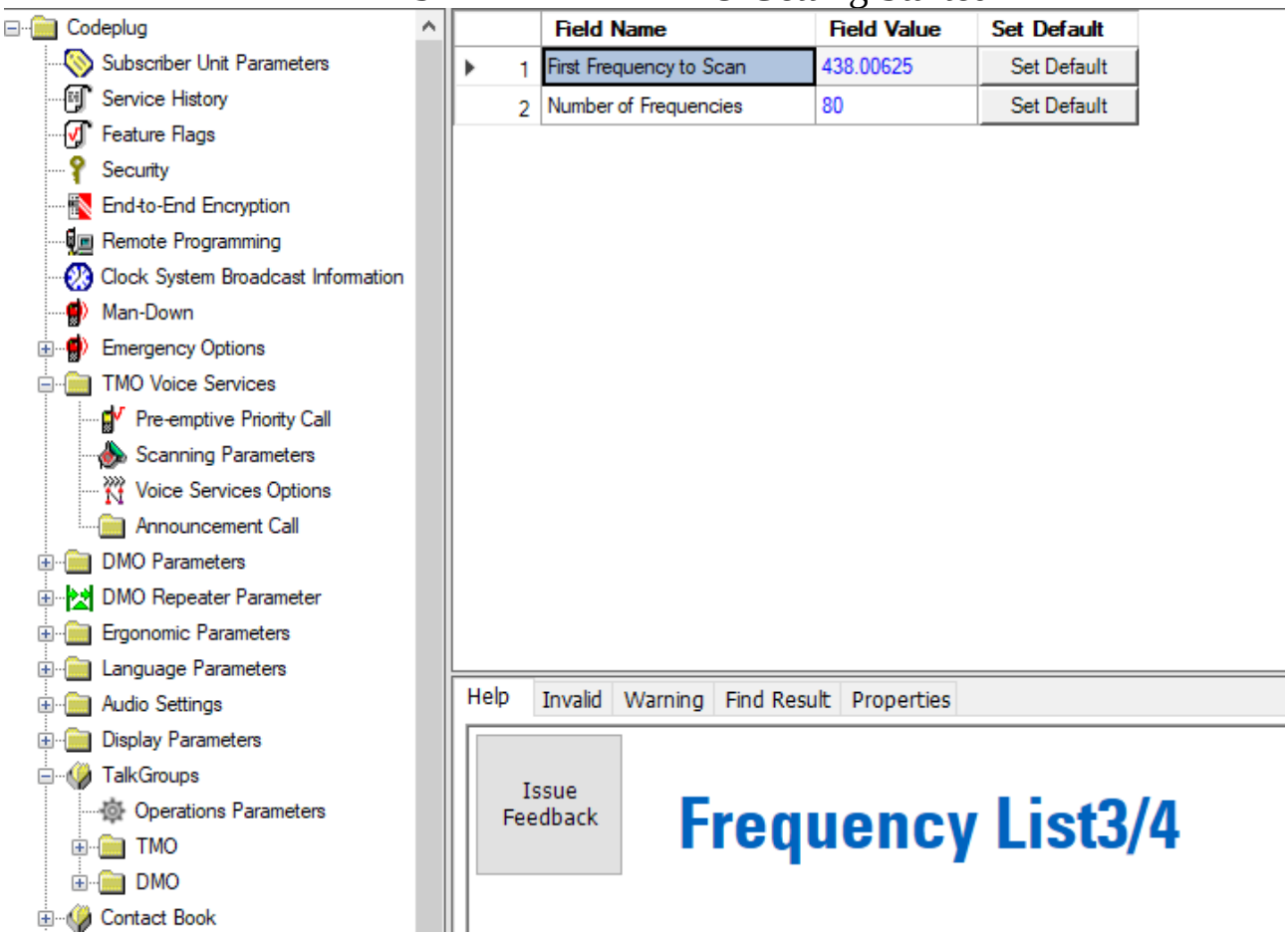
Frequency lists are not very often used in amateur radio, they are also pretty pointless with just a couple of TMO nodes which have no overlapping coverage. They do, however, potentially slow down the registration of the radio in the 'network'. Experimenting with scan lists is of course fine, but it is recommended to fill in the correct start frequency and limit the number of channels to be scanned.

For the reasons outlined, it is useful to uncheck the box for Full band scan and to set the number of channels to be scanned in Frequency List 3 to, for example, 80. Note: Not all firmware versions provide this Full band scan check mark.



The scan list start frequency must be set, plus the number of channels to scan. As already mentioned: do not use a large number of channels, that will only cause the scan to be slow. By default, the number of channels is set at 400 (10 MHz). In the screenshots below 2x80 channels between 438 and 440 MHz were chosen for scanning. Of course this needs to fit the bandplan in your country... Scanlist 4 is for its starting frequency shifted by 6,25 kHz relative to scanlist 3.


Codeplug
Subscriber Unit Parameters
Service History
Feature Flags
Security
End-to-End Encryption
Remote Programming
Clock System Broadcast Information
Man-Down
Emergency Options
TMO Voice Services
Pre-emptive Priority Call
Scanning Parameters
Voice Services Options
Announcement Call
DMO Parameters
DMO Repeater Parameter
Ergonomic Parameters
Language Parameters
Audio Settings
Display Parameters
TalkGroups
Operations Parameters
TMO
DMO
Contact Book
My Favorites
Data Services
Buttons, Keys and Accessories
Mobility and System Parameters
Subscriber Class by Group
Frequency List
Frequency List1
Frequency List2
Frequency List3
Frequency List4
Field Name
Field Value
Set Default
1
First Frequency to Scan
438.00000
Set Default
2
Number of Frequencies
80
Set Default
Help
Invalid
Warning
Find Result
Properties
Issue Feedback
Frequency List3/4
This node allows flexibility in the comprehensive hunt.
Comprehensive Hunt is used when the radio cannot log o
If the Codeplug → Mobility and System Parameters →
Lists works as follows:
The radio searches a predefined number (block) of freque
returning to Frequency List4 and searching the next bloc



Address extension

TetraPack TMO follows the convention to use the MCC 901 (Mobile Country Code). Furthermore, every Tetra network has a Mobile Network Code (MNC). TetraPack uses 9999. MCC 901 is a number that has not beenassigned to a particular county (like 204 for the Netherlands, 262 for Germany etc.).

Note: this used to be MCC 204 / MNC 7373 in pre-TetraPack days.

Just so you know: the Dutch commercial Entropia network uses MCC 204, the same applies to C2000 for the Dutch Emergency Services. Each network has its own unique MNC.

Authentication

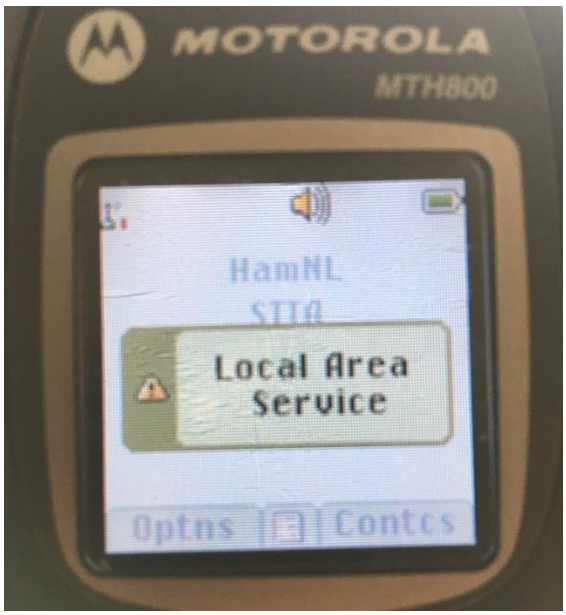
TMO has facilities to ensure that the TMO network and the radio must (mutually) authenticate. This facility, usually in combination with encryption, can prevent a 'foreign' radio from connecting to a TMO network. Long story short: for amateur use authentication should be disabled, as shown in the screenshot below. Having authentication enabled will give rise to strange effects: the radio at first appears to connect correctly to the BS and then suddenly reports „No service“. Ask me how I know..

Note: TetraPack checks ‚behind the scenes‘ if a valid, properly registered, ISSI (=‘DMR ID‘) is used by the radio that tries to connect to the network. So the ID needs to be known in the database of https://radioid.net otherwise you will not get a connection working to a TetraPack-connected BS.

Local Site Trunking

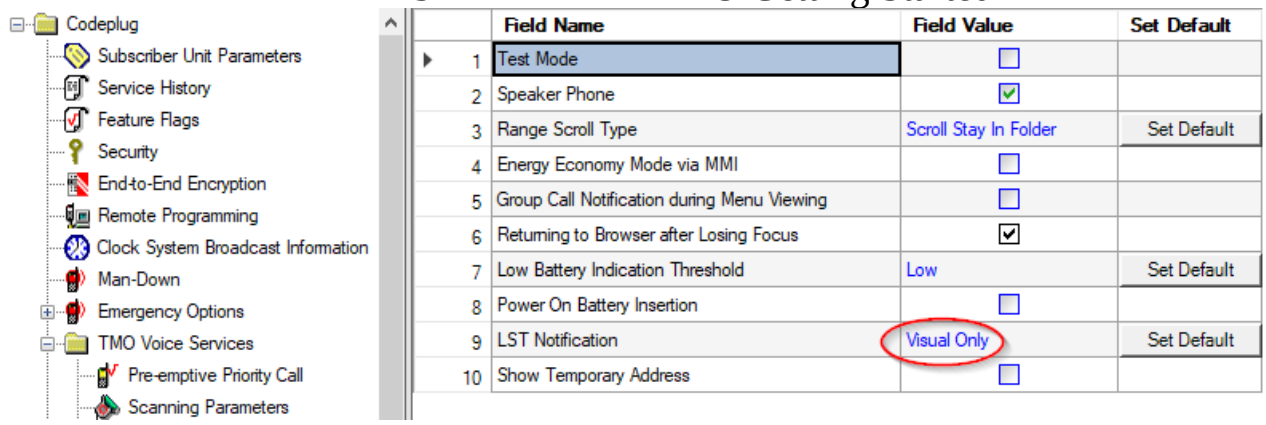
In a properly functioning TMO network all BS are interconnected to a core (aka SwMI; roughly comparable to a telephone exchange). All radio's on the network can talk to one another, the SwMI does all the house keeping.This is the normal Wide Site Trunking (WST) mode.

Unfortunately sometimes something like this appears on the display of your radio.

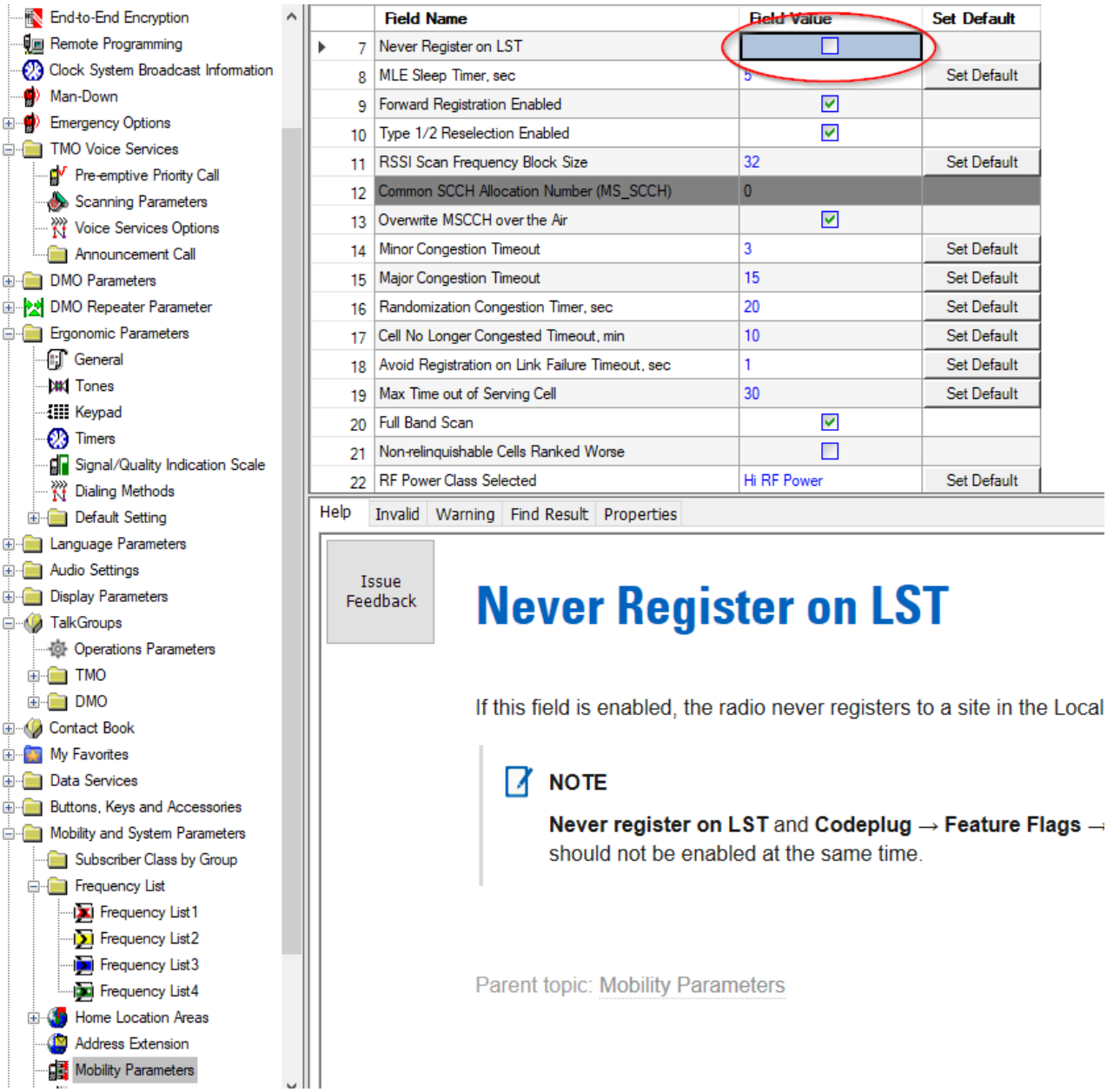


Local Area Service or Local Site Trunking (LST) means that the BS has no network connection to the core for whatever reason. The BS itself remains operational, radio's connected to it continue to work but you cannot reach any radios (or in case of a professional network: the dispatchers in say a police of firebrigade net). Therefore the radio's warn you that you have limited connectivity. For amateur use no very important of course but still useful to know. The LST status is sent by the BS via the MCCH. In case, say, the network connection between an amateur BS and the TetraPack core experiences issues we will be notified.

You can program how you want to be notified in case of LST. An audio notification, a message on the display, both or no notification at all. The screenshot belows shows my preference: visual only. Note that older radio models can be less flexible, you cannot disable beeps etc. Annoying but true.



You also want to ensure your radio registers on a BS which runs in LST. Otherwise a network problem results in no communication at all (as amateurs we prefer LST to nothing at all...) This is configurable via the setting shown below.



Side note: in professional TMO networks cells have overlapping coverage, so a radio typically receives at least two, if not more, BS. It automatically connects to the BS which provides the best signal strength, is the least busy etc etc. And of course: it prefers a BS which provides WST over one that has problems and only provides LST. Given that amateurs are already very happy if they have obtained a single BS and that this is a very complicated subject we will not dig into the subject any further.

Lab mode

The use of CPS lab, or depot, mode is necessary for radios that cannot work without adjustments between 430 and 440MHz in terms of frequency range. The duplex settings have to be adjusted in lab mode. The default duplex shift of 10MHz for the 400MHz Tetra band is obviously not suitable for amateur use in the 10MHz wide 70cm band.

The need to make adjustments in the lab mode typically applies to the older radio models.

Newer models Motorola radios are wideband, up to 470MHz. For those radios, the use of lab / depot mode is *not* necessary. Do not use lab mode for new radio models as this can harm the settings. Later in this GS-document the duplex adjustment for the new radio models will be discussed. This can be done without the use of the lab mode.

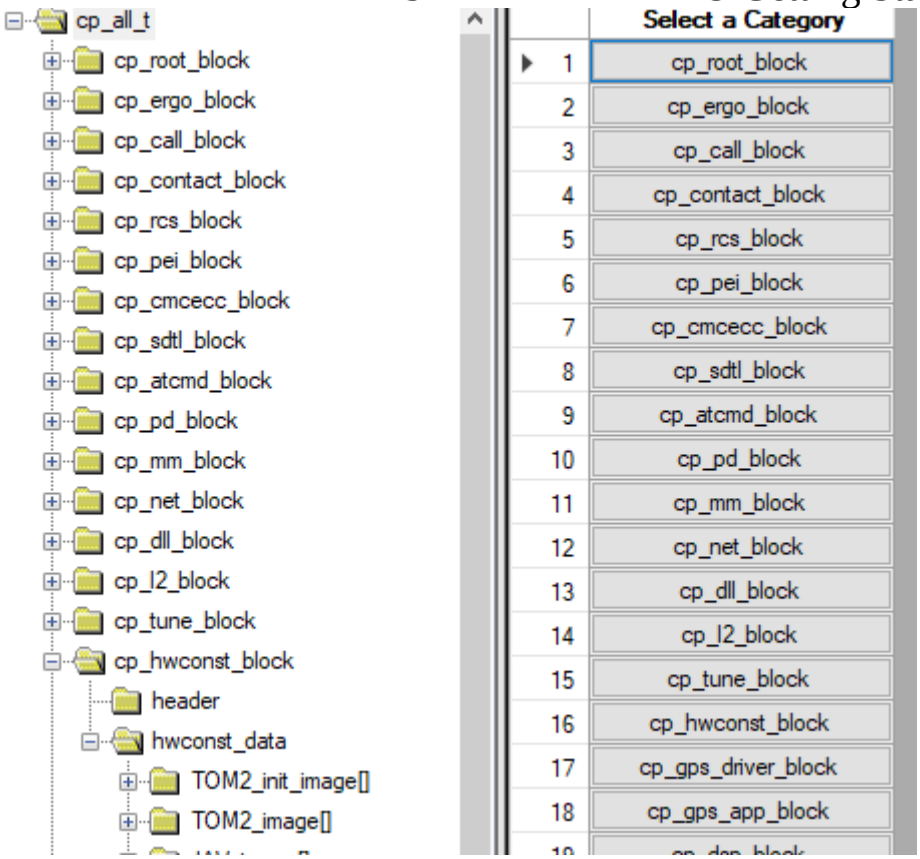
Remark: Older radio models can be expanded up to 440MHz, but they were not designed for it. Reception sensitivity is less, certainly higher up in the 70cm amateur band, than modern wide band radios.

Selecting CPS Lab Mode is described in the DMO GS document. The next part assumes you have already set the lab mode to its decimal display.

How to adjust `hwconst_block`

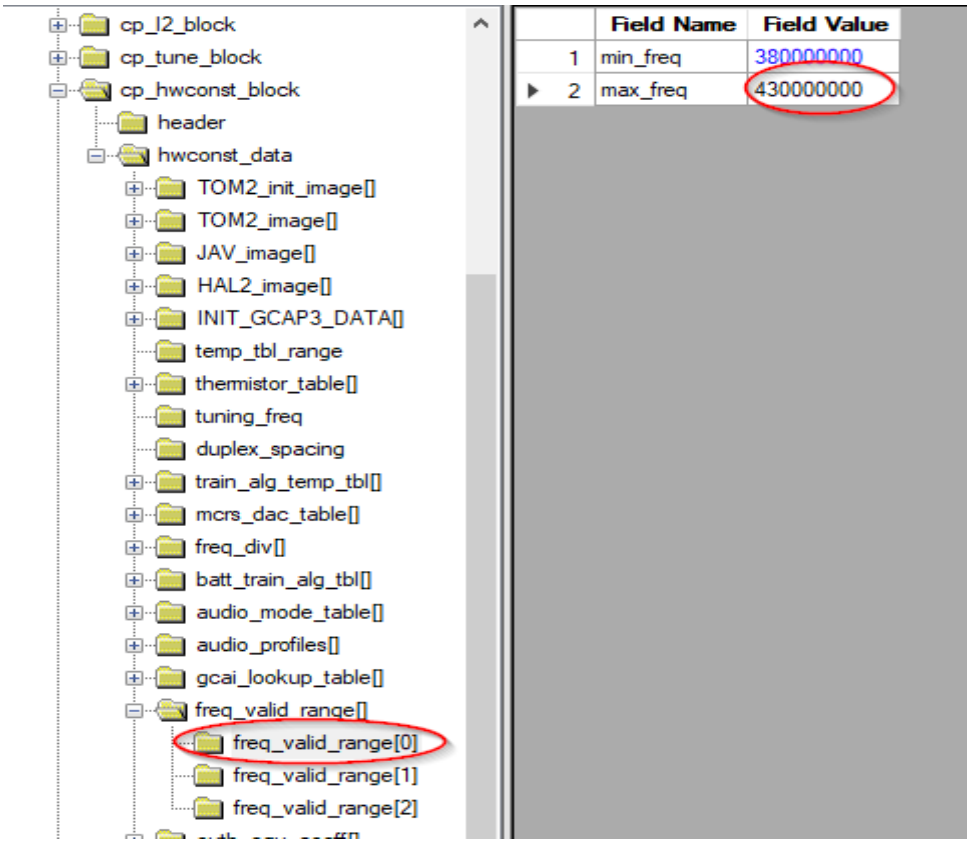
In order for the radios to work in the amateur band, it is, as mentioned, necessary to increase the maximum frequency range that is considered valid to 440MHz. This is done by adjusting some *hwconst_block* values.

Clicking open *cp_hwconst_block* and then *hwconst_data* yields the image below:

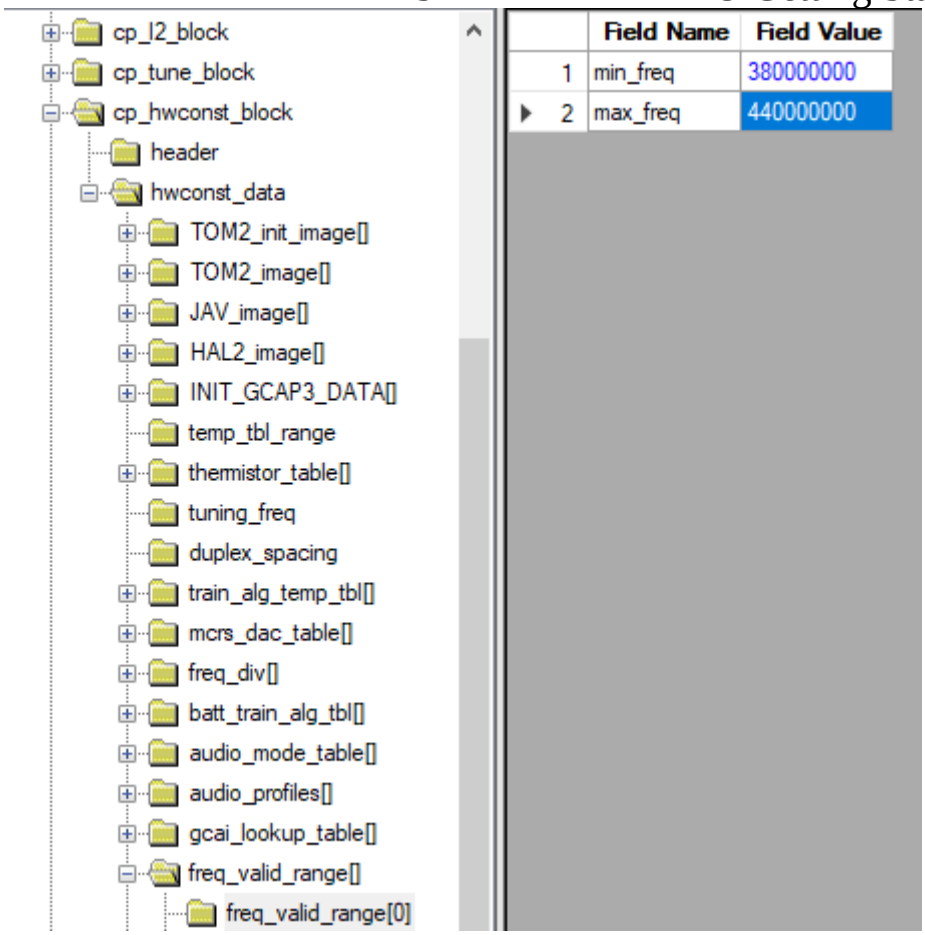


The *freq_valid_range [0]* must be 'stretched' to 440MHz, the maximum frequency.

Pay close attention to the number of 0's (zero's), CPS checks nothing to little with regard to the values entered in lab mode! Incorrect values can result in a completely malfunctioning radio (hence those backups...). The next screenshot shows the parameter to be adjusted.



After adjustment it will looks like in the following image.



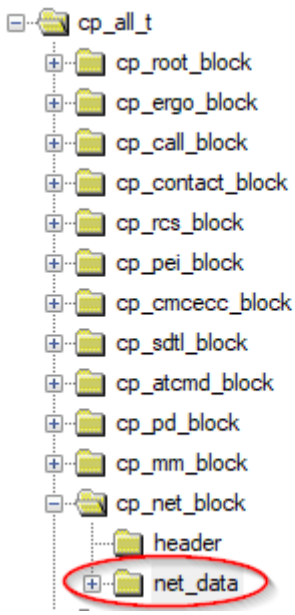
Adjustment of the `duplex_space table` in `cp_net_block`

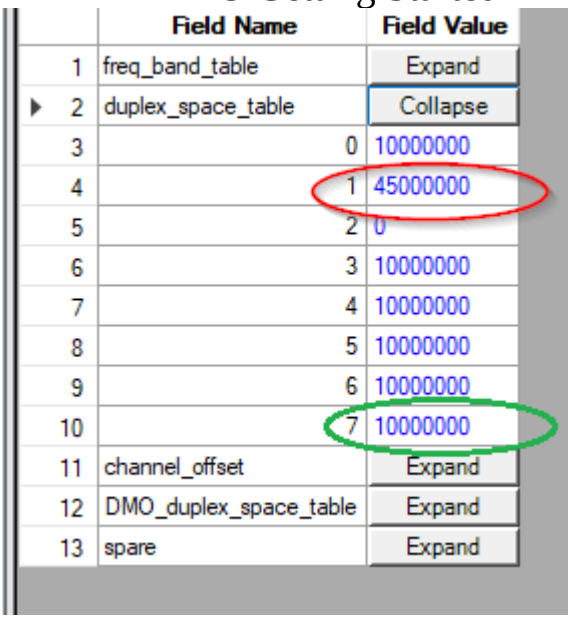
In contrast to TETRA DMO (such as the 'old' PI1ANH repeater), TETRA TMO uses duplex frequencies. The STTA PI1ANH TMO node transmits 7 MHz higher in the band than where it receives. The duplex shift is therefore 7 MHz for the PI1ANH TMO node. PI6ZTM as run by SBRH transmits 7.6 MHz higher than where it receives. Its duplex shift is therefore 7.6 MHz.

Without making things overly complicated: the node broadcasts information that informs the radios on which frequency the node is receiving. This is a single 8 bit value. Thus, the information transmitted is not the actual receiving frequency or offset from the transmission frequency, but a single number. That number is translated by the radios into the duplex value (in MHz) by means of a pre-programmed table lookup. The standard values and how this works are described in the ETSI TETRA standards.

Unfortunately, there is an error in the standard codeplugs which proves tricky with the STTA node: in the space (line 1) in the table for the 400MHz band where according to the ETSI standard, it should say 7MHz instead it says 45MHz.

That 45MHz value should be changed to 7MHz. The 45MHz setting is only intended to be used for the 800/900MHz TETRA band. See also the following table from the ETSI documentation. Because the professional TMO users all use 10MHz duplex shift, the incorrect 45MHz has probably never been a problem.





	Field Name	Field Value
1	freq_band_table	Expand
2	duplex_space_table	Collapse
3	0	10000000
4	1	45000000
5	2	0
6	3	10000000
7	4	10000000
8	5	10000000
9	6	10000000
10	7	10000000
11	channel_offset	Expand
12	DMO_duplex_space_table	Expand
13	spare	Expand

6 Duplex spacing

The duplex spacing values are defined without any mathematical rule. The duplex spacing shall be reference/base frequency dependent as defined in table 2. The 0,000 MHz duplex value may be needed for direct mode operation and is included here for completeness.

Table 2: Duplex spacing as function of the reference/base frequency

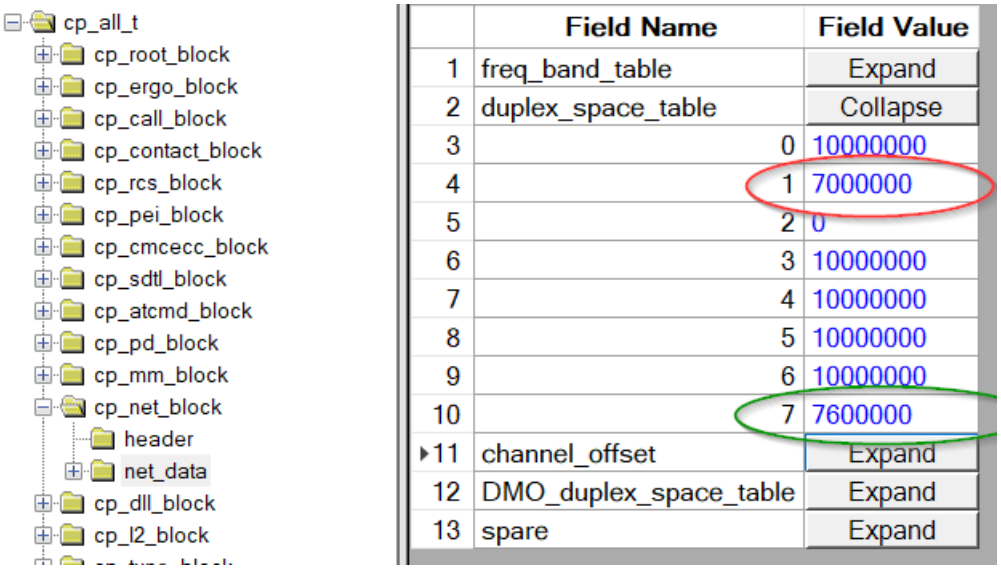
		Duplex spacing information element value (next row) and corresponding duplex spacing (other rows; in MHz)							
Frequency band	Base/reference frequency	000_2	001_2	010_2	011_2	100_2	101_2	110_2	111_2
0000_2	note 1	note 1	note 1	0	note 1	note 1	note 1	note 1	note 1
0001_2	100 MHz	1,6	4,5	0	note 1	note 1	note 1	note 1	note 1
0010_2	200 MHz	10	note 1	0	note 1	note 1	note 1	note 1	note 1
0011_2	300 MHz	10	note 1	0	8, (see note 2)	18, (see note 2)	note 1	note 1	note 1
0100_2	400 MHz	10	7, (see note 2)	0	8, (see note 2)	5 (see note 2)	note 1	note 1	note 1
0101_2	500 MHz	10	note 1	0	note 1	note 1	note 1	note 1	note 1
0110_2	600 MHz	10	note 1	0	note 1	30, (see note 2)	note 1	note 1	note 1
0111_2	700 MHz	note 1	note 1	0	note 1	30, (see note 2)	note 1	note 1	note 1
1000_2	800 MHz	note 1	45	0	18, (see note 2)	note 1	note 1	note 1	note 1
1001_2	900 MHz	note 1	45	0	18, (see note 2)	39, (see note 2)	note 1	note 1	note 1
1010_2	note 1	note 1	note 1	0	note 1	note 1	note 1	note 1	note 1
1011_2	note 1	note 1	note 1	0	note 1	note 1	note 1	note 1	note 1
1100_2	note 1	note 1	note 1	0	note 1	note 1	note 1	note 1	note 1
1101_2	note 1	note 1	note 1	0	note 1	note 1	note 1	note 1	note 1
1110_2	note 1	note 1	note 1	0	note 1	note 1	note 1	note 1	note 1
1111_2	note 1	note 1	note 1	0	note 1	note 1	note 1	note 1	note 1

NOTE 1: The value is reserved for future standardization.
NOTE 2: These values are intended to be used only outside Europe.

Also note the number of 0's (zerro's) in the duplex tables here. According to a reliable source there

are standard code plugs that contain, for example, 700000. 700kHz is obviously not something that will work. You can search for that one missing 0 for a long time...The duplex offset showing 45MHz in slot 1 and the 10MHz in slot 7 you must change for PI1ANH. 7.6 MHz as used by PI6ZTM is not an ETSI standard value, therefore it also needs to be changed.

The correct duplex offset set to **7MHz** (7000000) in slot 1 (for PI1ANH), and **7.6MHz** (for PI6ZTM) in slot 7.

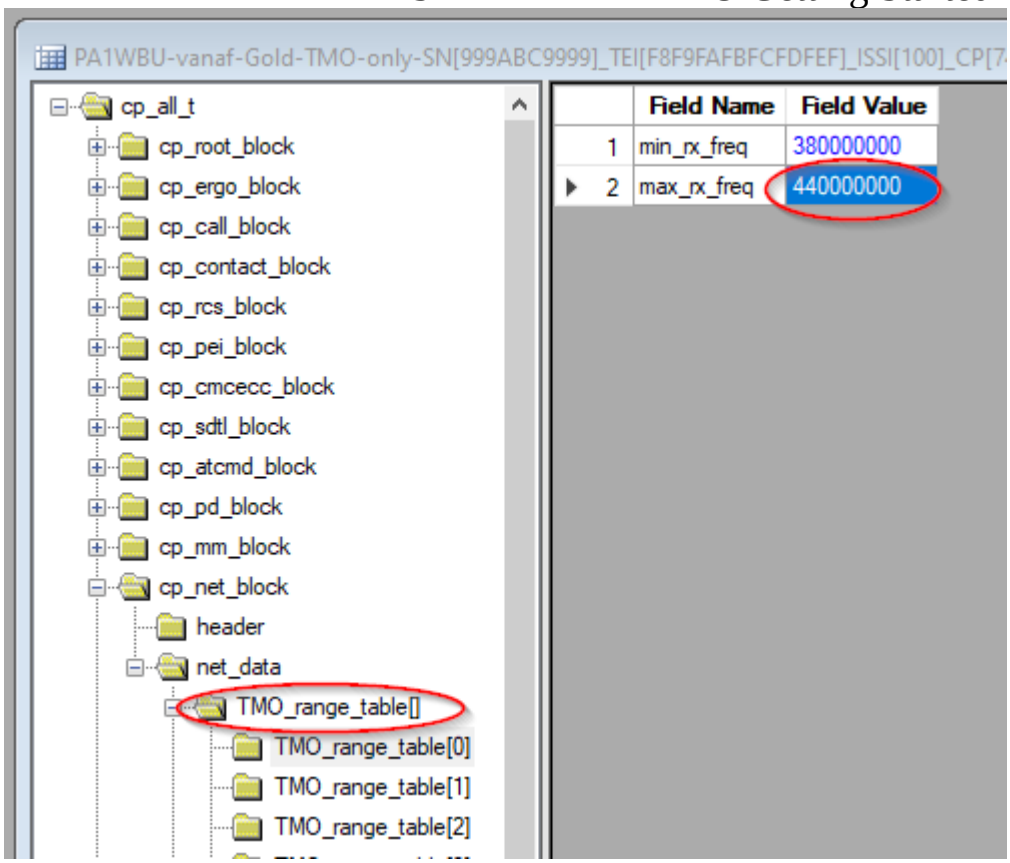


Note: to complicate matters a bit further, in Germany quite a few amateur BS use 7.6 MHz but in slot 1. Some older BS hardware only allows slot 1 use. Obviously this means a radio programmed for such a BS will not work on PI1ANH.

Note: Within the TetraPack network all sorts of variants in duplex tables are in use. For example shift values of 8 and 9 MHz. Most often because the band plans in the various countries vary greatly. Please check https://map.tetrapack.online/map for an overview of frequencies, shift values etc.

Adjustment of the upper reception frequency `table` in `cp_net_block`

Nex stept, under *net_data* and then *TMO_range_table* in the *TMO_range_table [0]* line, the maximum allowed receive frequency must be adjusted from 430MHz to 440MHz. Refer to the screenshot below.



Programming the radio

If the radio had to be modified via lab mode, the radio must be programmed with *Write Entire Codeplug*. So not with *Write radio*. This is necessary to put the parameters that were adjusted in lab mode into the radio. *Write radio* doesn't do that.

All radios that did not require changes via lab mode simply have to be programmed with *Write radio*, do not use the *Write entire codeplug* command.

Adjustment of the duplex offset for modern radios

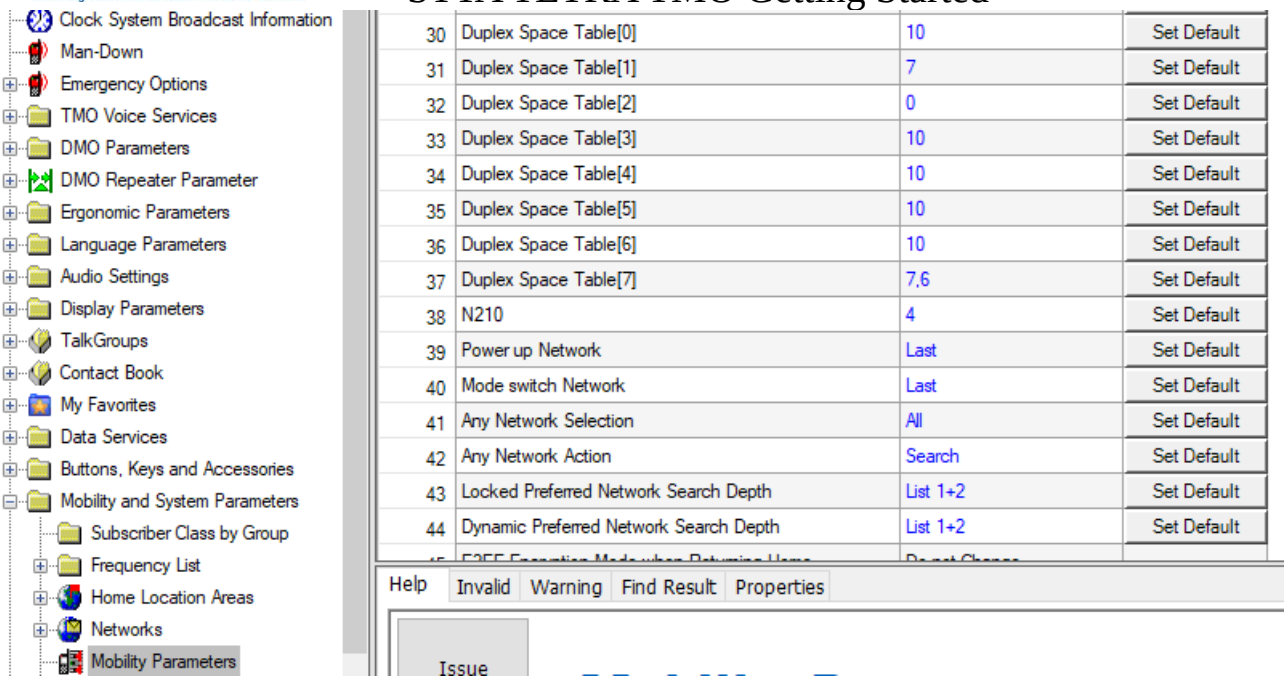
Modern radios are all those models that do not require frequency range extension and duplex offset settings via lab mode.

They already work 'from the factory' up to (at least) 440MHz and allow the adjustment of the duplex values in the regular CPS, thus without using lab mode.

The screenshot below shows what the duplex table looks like on a MTP6650.

Note: For these radios, the values in the duplex table are in MHz. With the older radios, the values which has to be changed via lab mode are in Hz.

Note: The 7.6 MHz offset listed in the table (line 37) is intended for use with a German amateur TMO BS. Be aware that different duplex offsets are used. This is depending on the network and the country the network is used in. Check this before you travel and want to use your radio there. Even better: bring a laptop with CPS on it and a programming cable..



Testing

After programming the radio, the big moment has arrived: testing can commence!

If everything went well and there is sufficient signal strength both *from* and *to* the TMO BS, things will look like the screenshot below. And the radio has successfully registered on the BS! On TetraPack for the first ever use of a particular ISSI you first get a *Registration failed* message. Don't Panic! Power down/power up your radio and it should work. This has to do with the behind the scenes check if the ISSI is registered at radioid.net.

TG26 Tetra is selected. Nederland corresponds to what is included in the Address Extension (read: MCC 204 and MNC 7373). Nederland is the selected Folder, containing the TG's. There is a scanlist active called Sc TetraOnly (scanning itself is indicated with the blue **Z** symbol). *Note* this is the display of an MTP6650, which is highly configurable. No all radios allow this.

It is considerably less pleasant (understatement) if the following appears on the display after you completed the programming.

"No service" might have one or more of the following reasons:

- An error in the programming of the duplex setting;
- An error in frequency list 2;
- An error in the maximum reception frequency (usually detected by CPS);
- Not enough signal strength received by your own radio ("no coverage" in GSM terms). The solution is usually to find a place with better coverage or a change of the antenna;
- The local radio is 'deaf': there is enough signal in itself, but the radio in question is insensitive. This can be due to unsuccessful experiments with lab mode changes.

  Prepare for lengthy and frustrating bug searches. Reception strength can be verified by listening with an analog receiver on the downlink frequency used by the BS;
- adequate reception of the signal transmitted by the node, but the signal transmitted by the local radio (this *uplink* signal is necessary to register with the node) is not sufficiently received by the node for whatever reason to make the registration successful.

  The reason could be, for example, because a Tetra portable usually has very limited RF power. A portable radio is 1, 1.8 or best case 3W. MTM mobile radios are 3W (MTM800, MTM800E, MTM5200) or 10W (MTM5400, MTM5400). Tetra was designed for 'many' and relatively 'small' cells. Radio amateurs want to use large cells due to lack of TMO node hardware, as well as limited availability of repeater sites and frequencies. The solution is to improve the signal strength, both for the signal the BS receives and the signal the MS receives. Think of a better antenna or a better location (not close to or in buildings but on an open field).
- The nature of TDMA as used in Tetra limits the maximum distance between MS and BS. The timing parameters used in TMO make the maximum distance 58km, regardless how strong the RF signal is;
- ....

Debugging this kind of problems can be a fun and educational task. Good luck!

