NPR
New Packet Radio on 70cm band

Introduction :
What is it?
&
Quick start guide
v3.6

Guillaume F4HDK
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NPR – What is it? (1/4)

• Bi directional IP over radio link (no AX.25 despite the name “packet radio”)
• Intermediate data rate between Packet and HSMM-WiFi
• Frequency band 420-450MHz much easier to use than 2.4GHz or 5.6GHz (HSMM-WiFi-Hamnet).
• Designed by a HAM for HAMs
• 100% Open-Source : PCB + firmware

<table>
<thead>
<tr>
<th></th>
<th>Datarate</th>
<th>Frequencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Packet radio</td>
<td>Raw : &lt;9600bps</td>
<td>ALL (mainly 144MHz and 430MHz)</td>
</tr>
<tr>
<td></td>
<td>Useful : several kbps</td>
<td></td>
</tr>
<tr>
<td>NPR New Packet Radio</td>
<td>Raw : 110kbps to 1Mbps</td>
<td>420-450MHz</td>
</tr>
<tr>
<td></td>
<td>Useful : 70 to 500kbps</td>
<td></td>
</tr>
<tr>
<td>HSMM - Hamnet– WiFi</td>
<td>Raw : &gt;10Mbps</td>
<td>2.4GHz, 5.6GHz</td>
</tr>
<tr>
<td></td>
<td>Useful : &gt;10Mbps ?</td>
<td></td>
</tr>
</tbody>
</table>
NPR – What is it? (2/4)

Optimised for “Point To Multipoint” configurations

- 1 central repeater, called MASTER
- Several CLIENTS

The Master only transmits when solicited by at least one Client.

Use case example:
Extension of Hamnet (2.4GHz or 5.6GHz) network

Possibility to use “Point to Point” configuration

Use case example:
Low data-rate DATV (200kbps)
Bi directionnal, single frequency.
NPR – What is it ? (3/4)

Compatibility with amateur radio rules

• Periodic transmission of callsigns
• No encryption
• The Master (repeater) only transmits when solicited (at least by one “client”)

Limitations:

• Currently 7 simultaneous clients maximum
  (Evolution planned to upgrade to 15 clients maxi)
• 300km maxi (due to protocol)
• Limitations of 430MHz band: Not designed for 24x7 usage
• Not designed for “mobile” (only modulations 11, 20, 21)
NPR – What is it? (4/4)

Some technical aspects

- Protocol invented & designed by me (Guillaume F4HDK)
- Use of chips initially designed for ISM 433MHz : SI4463
- Modulation 2GMSK or 4GMSK (Good spectral efficiency).
- Very simple FEC (Forward Error Correction) non tuneable
- TDD : time division duplex.

  All stations transmit on the same frequency, alternatively

- Fast TX/RX cycles : 80ms to 200ms. (similar to DMR).
- Managed-TDMA : The Master (central repeater) allocates speaking times to each station (Master and clients), according to the needs, in real time.

  ➔ No collision possible.

- Timing Advance management (transmission anticipation due to distance)

```
MASTER     CLIENT1     CLIENT2     MASTER     CLIENT1
```

```
0ms   80ms
```

Cycle TDMA = TDMA Frame
FDD mode (Frequency Division Duplex)

FDD mode is optional. It allows for Frequency Shift operation with 2 separated frequencies:
- One frequency for uplink (from Clients to Master)
- One frequency for downlink (from Master to Clients)

**Master side:**
- Full Duplex RF installation (with RF duplexer)
- 2 modems:
  - One for TX – Downlink
  - One for RX - Uplink

**Client side:**
- One single modem per client.
- Half duplex
- Very fast shifting between TX and RX frequencies

Refer to the « advanced user guide » for more details.
NPR – antennas

• You need antenna gain! It’s wide band!
• Horizontal polarisation is highly recommended
• Horizontal or vertical polarisation should be decided regarding local constraints (no IARU recommendation anymore about this topic)
• Due to multi-path issue (at such high symbol rates):
  – Client should use directional antennas (Yagi)
  – Master can use omni, but antenna should be unobstructed

Master:
  – Horizontal polar omni (big wheel stack, or multiple panel antennas)
  or
  – Horizontal polar sectorial (1 or several panel antennas)
  or
  – Vertical (collinear)

Clients: Yagi
(Horizontal or Vertical polar)
RF amplifier
• The NPR protocol is compatible with some ‘off the shelf’ DMR amplifiers.
• Fast TX/RX commutation
• Warning: check compatibility before buying

Modem-Transceiver
• Custom design (PCB + software).
• Kit price (to be confirmed): 70$ to 80$ including enclosure.
• 3 power supply sources possible
  – 12V (9V to 20V)
  – 7V (6.5V to 8V)
  – 5V regulated
    (only for tests, RX sensitivity degraded)
• Ethernet connection
• No software needed on PC!
NPR Hardware (2/6)
The modem (TRX)
One single modem type for Master and Clients
NPR Hardware (3/6)
Modem PCB details

- **Switching Regulator (ITEAD LM2596)**
- **Ethernet SPI Module (Eth-Wiz-Click Wiznet W5500)**
- **Microcontroller Mbed Nucleo STM32 L432KC**
- **Radio Module RF4463 F30 (based on SI4463)**
With RF DMR amplifier
VR-P25D  20W
(Vero-Telecom)
Example of autonomous NPR Master, remotely manageable (configuration and programming), with one Raspberry-Pi.

Automatic fan on RF amplifier.
NPR – Quick start guide
The LEDs

CONNECTED:
Static ON: connected (to a Master)
Blinking: ‘I am a Master’

POWER supply OK

RX:
Radio reception in progress

TX:
Radio transmission in progress
NPR – Quick Start Guide

• The remaining is only applicable to ‘Clients’, not for Master.
• (For Master operations, refer to ‘advanced user guide’)

• You should prefer direct Ethernet connection between modem and a single PC: no Ethernet switch.
Either via serial over USB

- Use whatever serial terminal
- Port configuration:
  - 921 600 bps
  - 8 bits
  - flow control : NO

USB driver could be necessary on Windows (up to Win 7):
https://os.mbed.com/docs/v5.9/tutorials/windows-serial-driver.html

- Press ‘enter’ to obtain a prompt

Or via Telnet: (To the IP of modem)
C:\Users\moi> telnet 192.168.0.253
No password.
Warning: this IP can change during radio link connection.
You need to find modem IP address.
It corresponds to DHCP server IP address.

- Windows :
C:\Users\moi> ipconfig /all
[...]
Carte Ethernet Principal_PCIE :
[...]
Adresse IPv4. . . . . . : 192.168.0.102
Masque de sous-réseau. : 255.255.255.0
Bail obtenu. . . . . . : 22:25:21
Bail expirant. . . . . . : 22:31:22
Passerelle par défaut. : 192.168.0.1
Serveur DHCP . . . . . : 192.168.0.253

- Linux : Refer to last ‘lease’ inside
/var/lib/NetworkManager/

moi@ubuntu:~$ telnet 192.168.0.253
Connected to 192.168.0.253.
NPR modem
ready>
display config
CONFIG:
callsign: 'client_1'
is_master: no
MAC: 4E:46:50:52:C7:5C
frequency: 439.000MHz
RF_power: 6
modulation: 24
radio_netw_ID: 0
radio_on_at_start: yes
DHCP_active: yes
client_req_size: 1
client_static_IP: no
telnet active: yes
telnet routed: yes
modem_IP: 192.168.0.253
subnet: 255.255.255.0
IP_begin: 192.168.0.60
master_IP_size: 32 (Last IP: 192.168.0.91)
def_route_active: yes
def_route_val: 192.168.0.1
DNS_active: yes
DNS_value: 9.9.9.9
ready>
status
57 status: connected TA:0.0km Temp:23degC
RX_Eth_IPv4 2863 ;TX_radio_IPv4 2788 ;
RX_radio_IPv4 5738
DOWNLINK - bandwidth:46.7 RSSI:137 ERR:0.00%
UPLINK - bandwidth:38.1 RSSI:106 ERR:33.31%
CTRL+c to exit...
ready>

who
1 Master: ID:127 Callsign:Master
ME: Callsign:client_02 ID:2 modem IP:192.168.0.253
Clients:
  ID:0 Callsign:client_1 IP start:192.168.0.100 IP end:192.168.0.100
  ID:2 Callsign:client_02 IP start:192.168.0.102 IP end:192.168.0.102
CTRL+c to exit...
ready>
NPR – Quick Start Guide
Initial configuration (1/2)

• Command: **set [parameter] [value]**
• Get current configuration: **display config**
• Refer to parameter list at the annex
• The following parameters must match with the Master (central repeater)
  - **frequency**
  - **freq_shift**
  - **modulation** (refer to next page)
  - **radio_netw_ID** = Radio Network ID (equivalent to CTCSS)
• Other useful parameters
  - **callsign** (compulsory)
  - **is_master**: set to “no” for a client
  - **DHCP_active**: set to “yes” for a client (except for advanced config)
  - **RF_power**: warning, non linear
  - **radio_on_at_start**: according to your needs
  - **client_req_size**: depending on number of IP needed, default is ‘1’
NPR – Quick Start Guide
Initial configuration (2/2)

• Then **save** and **reboot** once everything is set properly

• Don’t forget to switch on the radio part
  – Either with command **radio on**
  – Or by setting **radio_on_at_start** to the value **yes** in the previous step
    (then **save** and **reboot** obviously)
NPR – Quick Start Guide

5 modulations

• Meaning of 2 digits
  – 1\textsuperscript{ier} digit: 2GFSK or 4GFSK
  – 2\textsuperscript{ième} digit: Symbol Rate

<table>
<thead>
<tr>
<th>Modulation name 2\textsuperscript{nd} digit</th>
<th>x0</th>
<th>x1</th>
<th>x2</th>
<th>x3</th>
<th>x4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Symbol Rate</td>
<td>50</td>
<td>100</td>
<td>180</td>
<td>300</td>
<td>500</td>
</tr>
<tr>
<td>Radio bandwidth</td>
<td>100</td>
<td>200</td>
<td>360</td>
<td>600</td>
<td>1000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Modulation name</th>
<th>2GFSK (1st digit of name : 1x)</th>
<th>4GFSK (1st digit of name : 2x)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modulation name</td>
<td>Modulation name</td>
<td>11 (*)</td>
</tr>
<tr>
<td>Raw data rate</td>
<td>100</td>
<td>180</td>
</tr>
<tr>
<td>Usable data rate</td>
<td>71</td>
<td>120</td>
</tr>
<tr>
<td>Raw data rate</td>
<td>100</td>
<td>200</td>
</tr>
<tr>
<td>Usable data rate</td>
<td>68</td>
<td>130</td>
</tr>
</tbody>
</table>

(*) Available for firmware ≥ 2019_06_08
NPR – Quick Start Guide
During usage... (1/3)

• Initial radio connection of a Client to a Sleeping Master
  – It’s slow, please be patient
  – ~15 seconds for the Master to wake up
  – Plus 1 connection attempt by Client every 5 sec
  – Often triggers an IP configuration change at Client side
    (client IP, modem IP, etc...)

• Slow mode (once connected)
  – If a Client modem requires only few data at uplink,
    then it is placed to « slow mode », and only transmits
    once every 8 TDMA cycles (600ms instead of 80ms for
    modulation 24)
  – This mechanisms frees radio resource for other
    modems (Client or Master)
During usage... (2/3)

**status**

Displays radio link quality, for tuning:
- Antenna orientation
- Radio power of the modem

The status is automatically updated every 2 seconds.

You should try to obtain BER <2%.

```
ready> status
57 status: connected TA:0.0km Temp:23degC
DOWNLINK- bandwidth:46.7 RSSI:137 ERR:0.00%
UPLINK- bandwidth:38.1 RSSI:106 ERR:33.31%
CTRL+c to exit...
```

Direction: from Master to me (Client)

Datarate used by me (it does not represent the quality of radio link)

RSSI: Received Signal Strength Indicator

ERR: Error Rate (%)
Who is connected? Client and Master.
Displays callsigns and IP range of each modem (The Master does not have IP range).
Automatically updated every 2 seconds

ready> who
1 Master: ID:127 Callsign:Master
ME: Callsign:client_02 ID:2 modem IP:192.168.0.253
Clients:
  ID:0 Callsign:client_1 IP start:192.168.0.100 IP end:192.168.0.100
  ID:2 Callsign:client_02 IP start:192.168.0.102 IP end:192.168.0.102
CTRL+c to exit...
## NPR – Quick Start Guide

### List of commands (1/3)

<table>
<thead>
<tr>
<th>command</th>
<th>Parameter (if applicable)</th>
<th>Value format</th>
<th>Valid for..</th>
<th>comment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>master</td>
<td>client</td>
</tr>
<tr>
<td>version</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>radio</td>
<td>on</td>
<td>-</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>off</td>
<td>-</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>status</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>who</td>
<td>-</td>
<td>-</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>display</td>
<td>config</td>
<td>-</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>DHCP_ARP</td>
<td>-</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>TX_test</td>
<td></td>
<td>seconds</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>save</td>
<td>-</td>
<td>-</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>reboot</td>
<td>-</td>
<td>-</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>reset_to_default</td>
<td></td>
<td>-</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>exit</td>
<td>-</td>
<td>-</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

- Displays the version of the firmware
- Turns radio on. (currently bugged if executed after ‘radio off’, use ‘reboot’ instead)
- Turns radio off
- Display radio status
- Displays who is currently connected to the master.
- Display configuration
- Display DHCP or ARP entries
- Triggers a (quasi) continuous transmission of xx seconds, for test.
- Save the current configuration to EEPROM.
- Reboot the whole board.
- Erases the entire previous EEPROM stored configuration.
- Exit from telnet session.
<table>
<thead>
<tr>
<th>command</th>
<th>Parameter (if applicable)</th>
<th>Value format</th>
<th>Valid for..</th>
<th>comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>set</td>
<td>callsign</td>
<td>text</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>is_master</td>
<td>yes/no</td>
<td>X</td>
<td>X</td>
<td>Yes: set to master mode</td>
</tr>
<tr>
<td>master_FDD</td>
<td>no/up/down</td>
<td>X</td>
<td></td>
<td>No: set to client mode</td>
</tr>
<tr>
<td>Eth_mode</td>
<td>Integer</td>
<td>X</td>
<td>X</td>
<td>Value from 0 to 7, refer to dedicated §</td>
</tr>
<tr>
<td>modem_IP</td>
<td>IP value</td>
<td>X</td>
<td></td>
<td>(*) For client: temporary value</td>
</tr>
<tr>
<td>netmask</td>
<td>IP value</td>
<td>X</td>
<td></td>
<td>(*) For client: temporary value</td>
</tr>
<tr>
<td>telnet_active</td>
<td>yes/no</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>DNS_active</td>
<td>yes/no</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DNS_value</td>
<td>IP value</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>def_route_active</td>
<td>yes/no</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>def_route_val</td>
<td>IP value</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IP_begin</td>
<td>IP value</td>
<td>X</td>
<td></td>
<td>(*) For client: temporary value</td>
</tr>
<tr>
<td>master_IP_size</td>
<td>Integer</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>client_req_size</td>
<td>Integer</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>master_IP_down</td>
<td>IP value</td>
<td>X</td>
<td></td>
<td>Only relevant for Master FDD uplink. IP of the Master downlink modem.</td>
</tr>
<tr>
<td>DHCP_active</td>
<td>yes/no</td>
<td>X</td>
<td></td>
<td>Only impacts a client.</td>
</tr>
</tbody>
</table>
NPR – Quick Start Guide
List of commands (3/3)

<table>
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<tr>
<td></td>
<td></td>
<td></td>
<td>master</td>
<td>client</td>
</tr>
<tr>
<td>set</td>
<td>radio_on_at_start</td>
<td>yes/no</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>frequency</td>
<td></td>
<td>Refer to comment</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>freq_shift</td>
<td></td>
<td>Refer to comment</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>RF_power</td>
<td></td>
<td>Integer</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>modulation</td>
<td></td>
<td>Refer to comment</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>radio_netw_ID</td>
<td></td>
<td>Refer to comment</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>
It's your turn!
Turn on your soldering irons,
and your PCs,
and set your antennas!