COMMUNICATION SYSTEM FOR THE REMOTE HYBRID POWER SYSTEM IN RAMEA NEWFOUNDLAND

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THE WORLD

WIND-DIESEL HYBRID POWER SYSTEMS WORLWIDE

Country or Region	Site	Diesel Power (MW)	Wind Power (MW)	Avg. Load (MW)	Commissioned	Inst. Wind Penetration
Antarctica	Mawson	0.48	0.6	0.53	2002	34% (avg)
Antarctica	Ross Island	3	0.99	1.75	2010	70%
Australia	Bremer Bay	1.25	0.6		2005	>80%
*Canada	Ramea	2.78	0.69	0.7	2004	10% (avg)
Cape Verde	Sal	2.82	0.6	0.56		14% (avg)
China	Dachen Island	10.44	0.185			15% (avg)
Cuba	Guantanamo	22.8	3.8	12.5	2005	25%
Greece	Kythnos Island	2.774	0.315			
Greenland	Summit Station	0.2	0.06			16%
Kenya	Marsabit	0.3	0.15			46% (avg)
Norway	Frøya	0.05	0.055			100%
Ireland	Rathlin Island	0.26	0.99			100%
USA	St. Paul, Alaska	0.3	0.22	0.12	1999	68.5% (avg)

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CANADA'S WIND POWER CAPACITY

Province	Installed Capacity (MW)	Planned /Under Construction (MW)
Alberta	884	1039.6
British Columbia	103.5	711.2
Manitoba	104	138
New Brunswick	249	163.5
Newfoundland and Labrador	54.7	
Nova Scotia	214	185.55
Ontario	1,447	4032.1
Prince Edward Island	164	10
Quebec	663	2361
Saskatchewan	171.2	54.75
Yukon	0.81	
TOTAL	**4055.21**	**8695.7**

CANADA'S HYBRID POWER SYSTEMS DEVELOPMENT

- Tuktoyaktuk's Northern Wind "NWT hybrid power project".

- PEI Energy Corporation "Prince Edward Island Wind-Hydrogen Village".

- Hydro Quebec Research Institute "High Penetration No-Storage Wind Diesel study in Quaqtaq".

- Nalcor Energy "Wind–Hydrogen–Diesel (WHD) Power System in Ramea NL".

- Low-penetration wind-diesel systems:

Big Trout Lake (ON)
Ellesmere Island (NU)
Igloolik (NT)
Kasabonika Lake (ON)
*Kuujjuaq (PQ)
Sachs Harbour (NT)
Winisk (ON)
*Cambridge Bay (NU)
Fort Severn (ON)
Iqaluit (NU)
Kugkluktuk (NU)
Omingmaktok (NT)
Rankin Inlet (NU)

RAMEA, NL

RAMEA, NL

- Island community with 600 residents.
- Located six (6) kilometres South-West of Newfoundland.

RAMEA'S HYBRID POWER SYSTEM

Diesel Plant

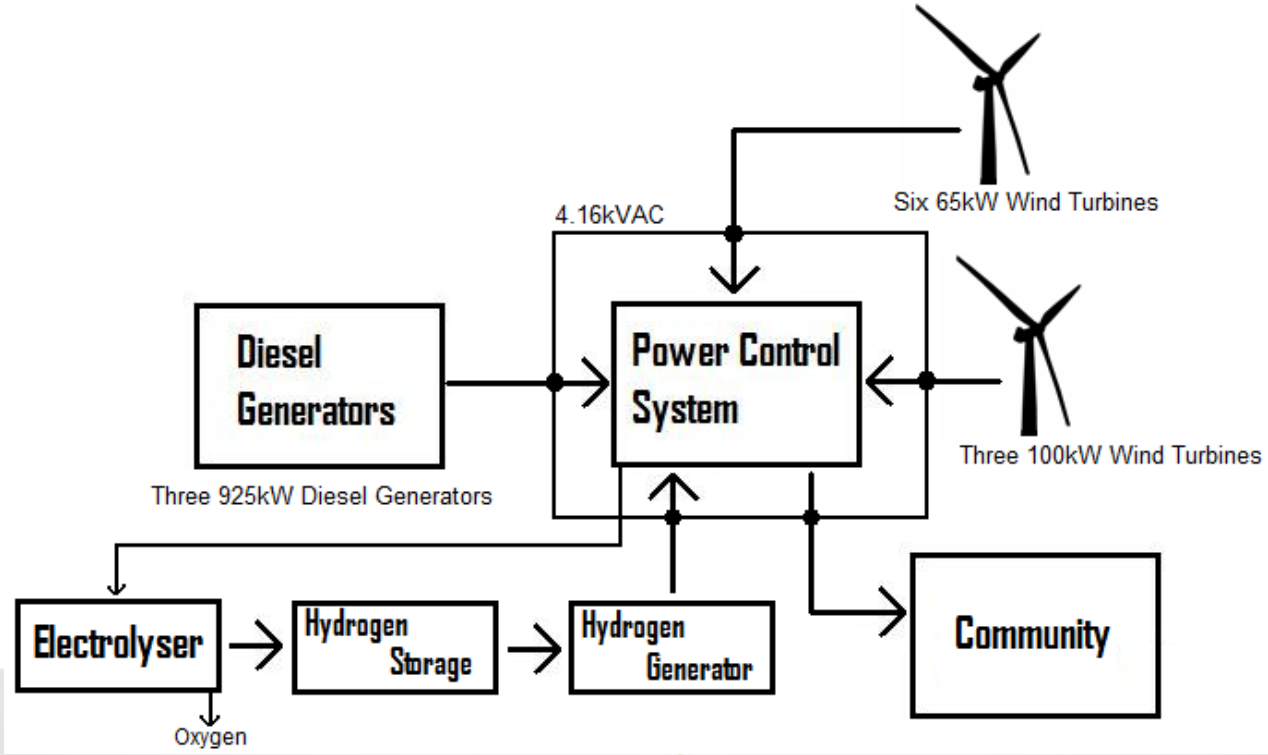
Wind Turbines

Hydrogen

WIND-HYDROGEN-DIESEL POWER SYSTEM

According to Nalcor Energy January 2010 Ramea Report, the three wind turbines with installed capacity of 300kW along with the 250kW from the hydrogen genset, is enough to generate power to 34 homes in Ramea per year.

Note: Hydrogen system is still under development.



WHD Power System

RAMEA'S WIND-DIESEL POWER SYSTEM

- 2.775MW diesel plant.
- Six 65kW wind turbines online since 2004 (North-West coast of the island).
- Three 100kW wind turbines commissioned in December 2009 (North of the island). Generated energy on the Ramea grid for the first time on May 8, 2010.
- Hybrid power infrastructure reduce isolated community dependence on diesel fuel and replaced with generation from a renewable resource.

WIND FARM (1)

- Six 65kW wind turbines located 1.6km from the Main Power Control Building (MPCB). http://windmatic.com/windmatic.html
- 10% wind penetration.
- Offsets approximately 750 tones of emissions annually.

WIND FARM (2)

- Three 100kW located 130m, 200m, and 270m from MPCB.
- Data transmission through underground Fiber Optic cable.
- http://www.northernpower.com/technology/turbine-configuration.php

COMMUNICATION METHODS FOR HYBRID POWER SYSTEMS

- **FIBER OPTIC**
  - Free Space Optical
- **CONTROLLER AREA NETWORK (CAN) BUS**
- **WIRELESS ETHERNET**
  - Worldwide Interoperability for Microwave Access (WIMAX)
- **LOW RF TRANSCEIVERS**
- **POWER LINE CARRIER (PLC)**

COMMUNICATION SYSTEM FOR RAMEA'S HYBRID POWER SYSTEM

CURRENT:

- **Wireless (Cirronet HN-210D transceivers):**
  - Advantage:
    - Remote supervision and control
    - Functional frequency (2.4GHz) allows to operate in the free-license electromagnetic spectrum.
  - Disadvantage:
    - Remote control: Enable/Disable all wind turbines.
    - Transmission vulnerable to atmospheric attenuation.

- **Fiber Optic communication:**
  - Advantage:
    - High speed data transmission (up to several gigabytes)
    - Free electromagnetic interference
    - Remote access from Hydro's Energy Control Centre and Network Management Centre in St. John's
  - Disadvantage:
    - Elevated cost. Example: CAN$19,380.00 for cable only

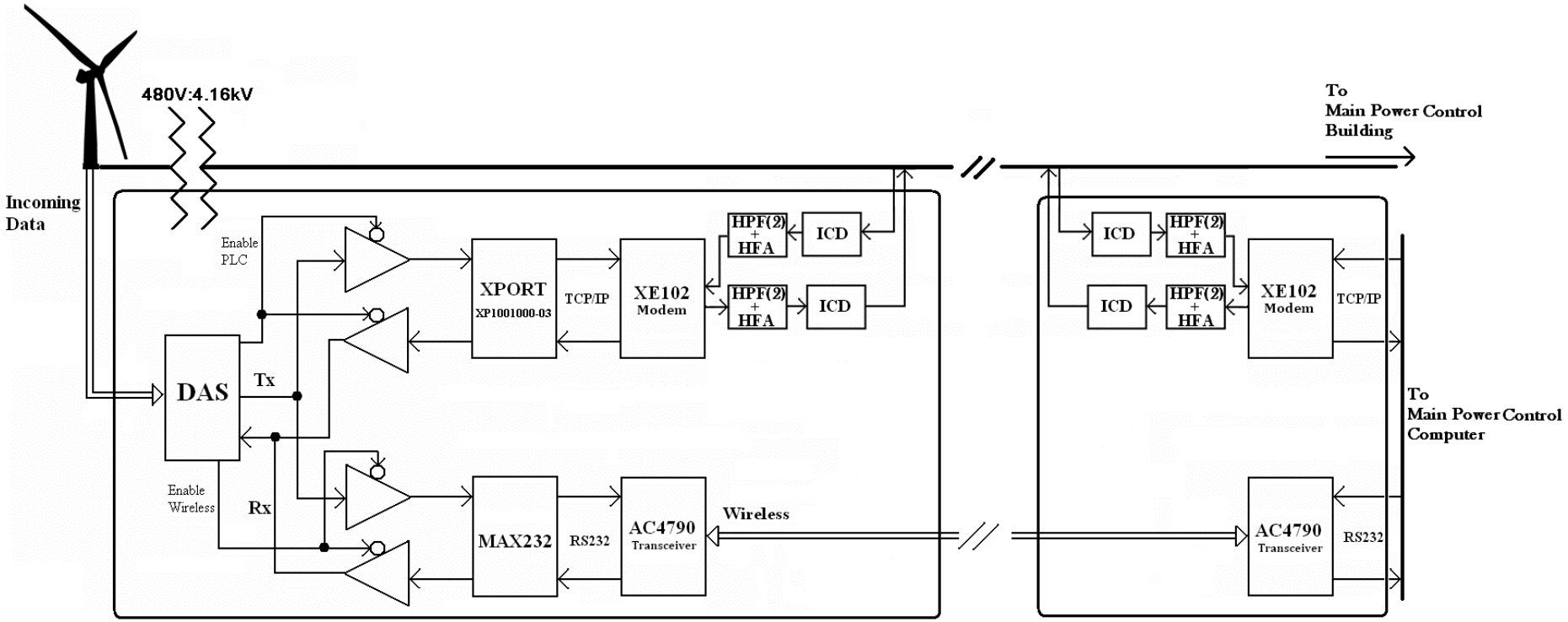
COMMUNICATION SYSTEM FOR RAMEA'S HYBRID POWER SYSTEM

PROPOSED:

- **Wireless (LaridTech AC4790 transceivers):**
  - Remote supervision and control.
  - Functional frequency between 902-928MHz allows to operate in the free-license electromagnetic spectrum.
  - Transmissions below 1GHz minimize attenuation effect during hazardous weather conditions.

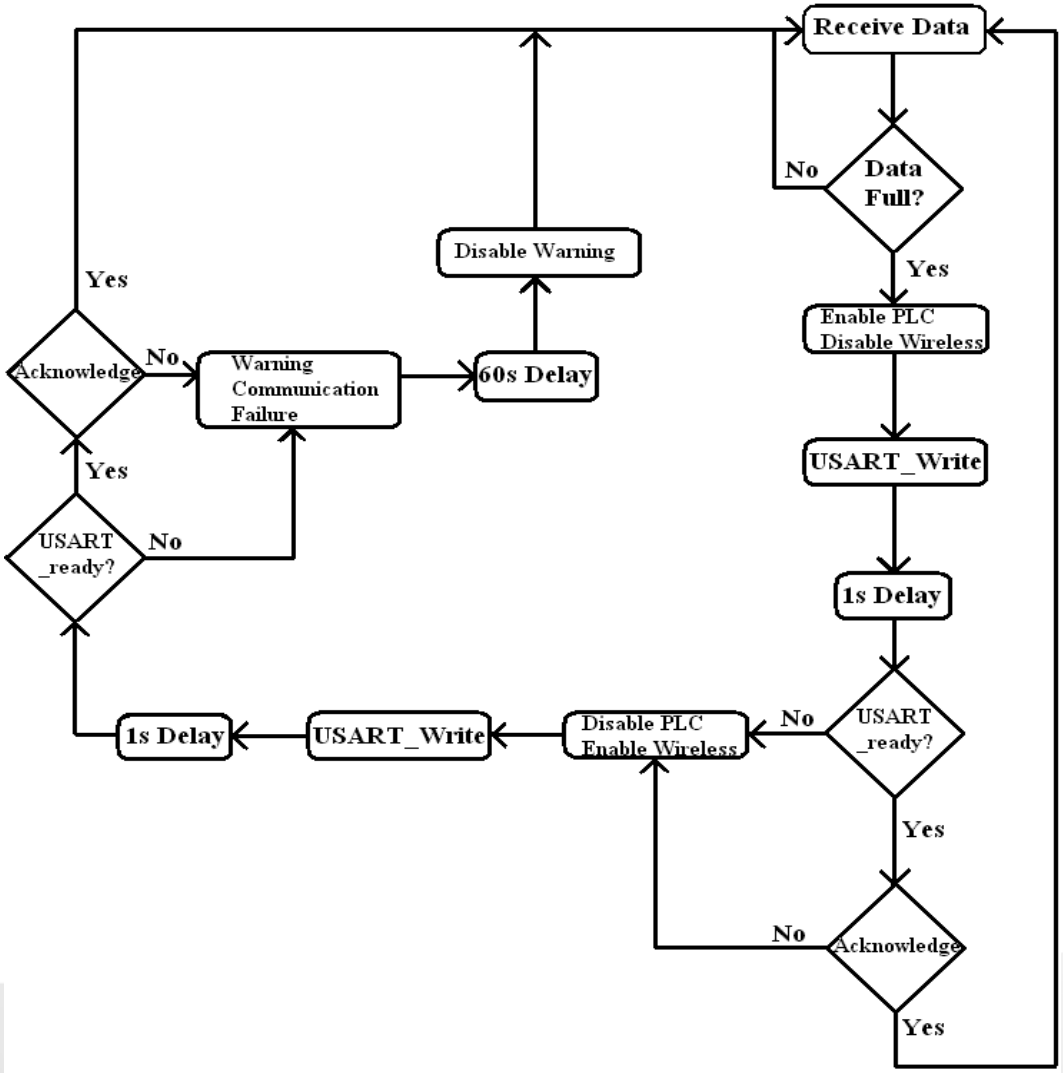
- **Power Line Carrier (PLC):**
  - Use electric power line cables for data transmission.
  - Bilateral communication between Wind Farm's Data Acquisition System (DAS) and Main Power Control Building (MPCB) without modifying the power system infrastructure currently in place at Ramea.
  - Netgear XE102 with a modified coupling stage between the modems and high voltage carriers (4.16kVAC).
  - Multiplicity.
  - Remote access from Hydro's Energy Control Centre and Network Management Centre in St. John's

DAST & MPCBR SYSTEM DIAGRAM



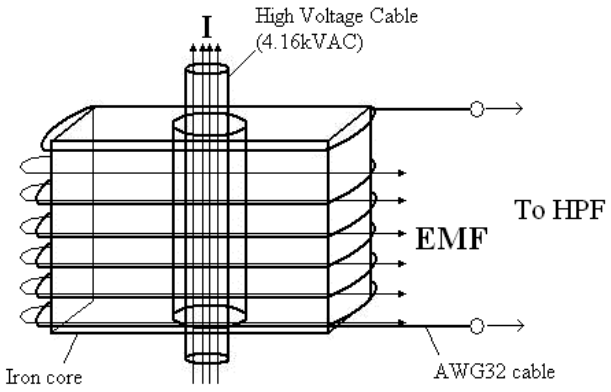
Communication System Diagram

DAST FLOW CHART

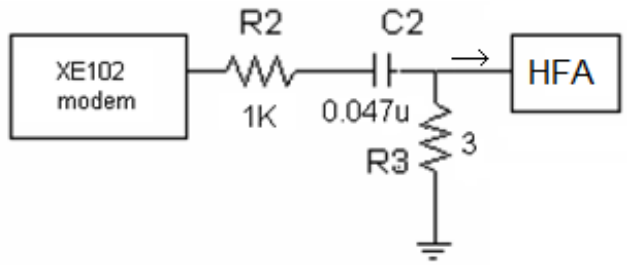


INDUCTIVE COUPLING STAGE

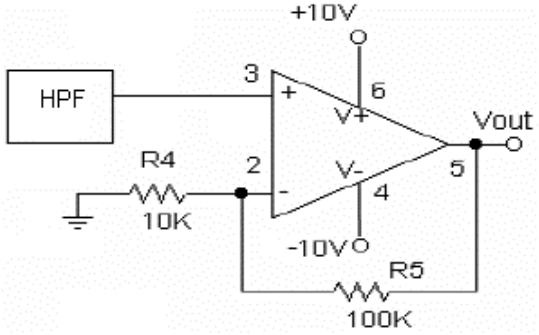
According to the analyzed power distribution system at Ramea, the WM15S Wind Turbines generate 480V which is then converted to 4160V with a step-up transformer.



Inductive Coupling Device (ICD)

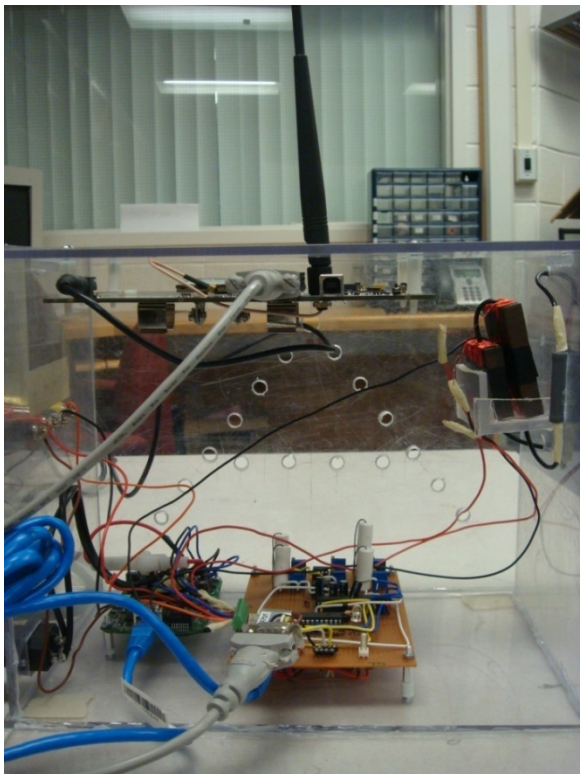


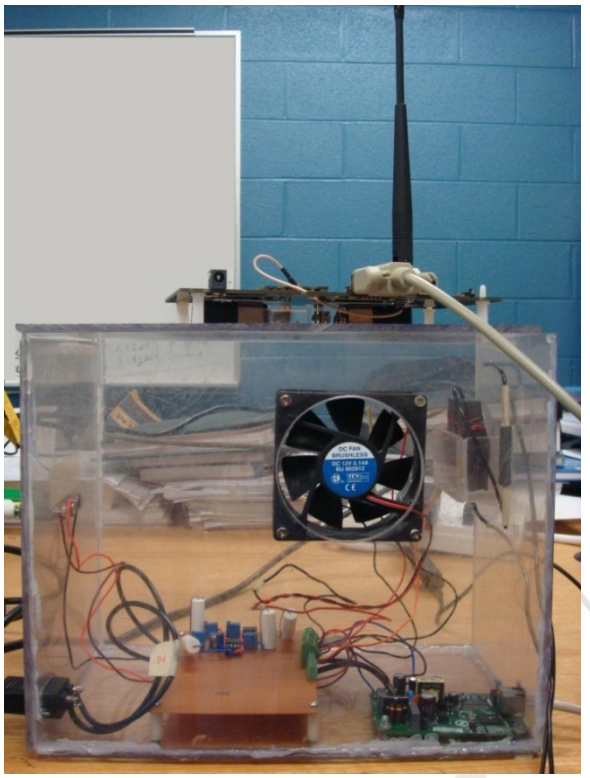
High Pass Filter (HPF)



High Frequency Amplifier (HFA)

COMMUNICATION SYSTEM PROTOTYPES





DAST
Data Acquisition System
Transmitter

MPCBR
Main Power Control Building
Receiver

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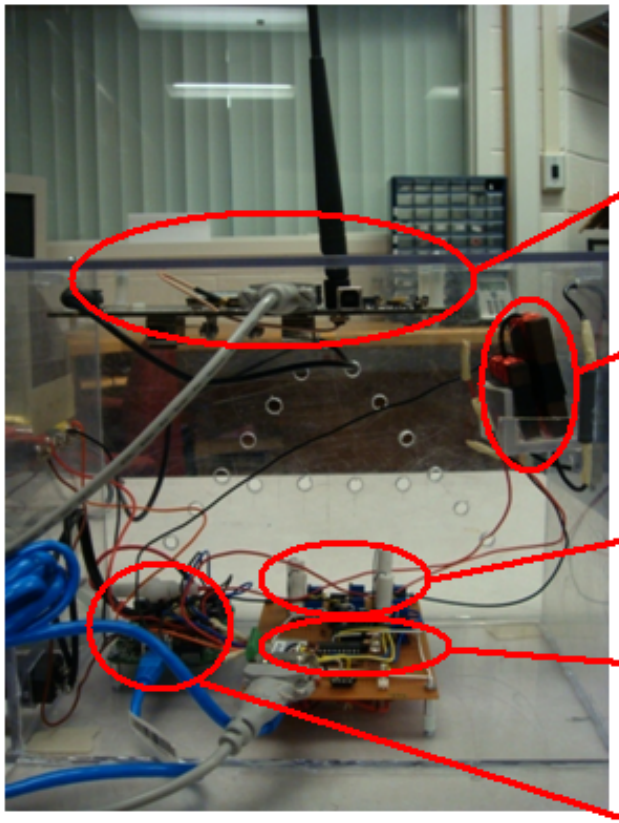
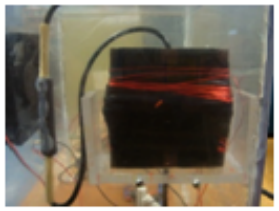
DATA ACQUISITION SYSTEM TRANSMITTER



DAST

AC4790 Transceiver



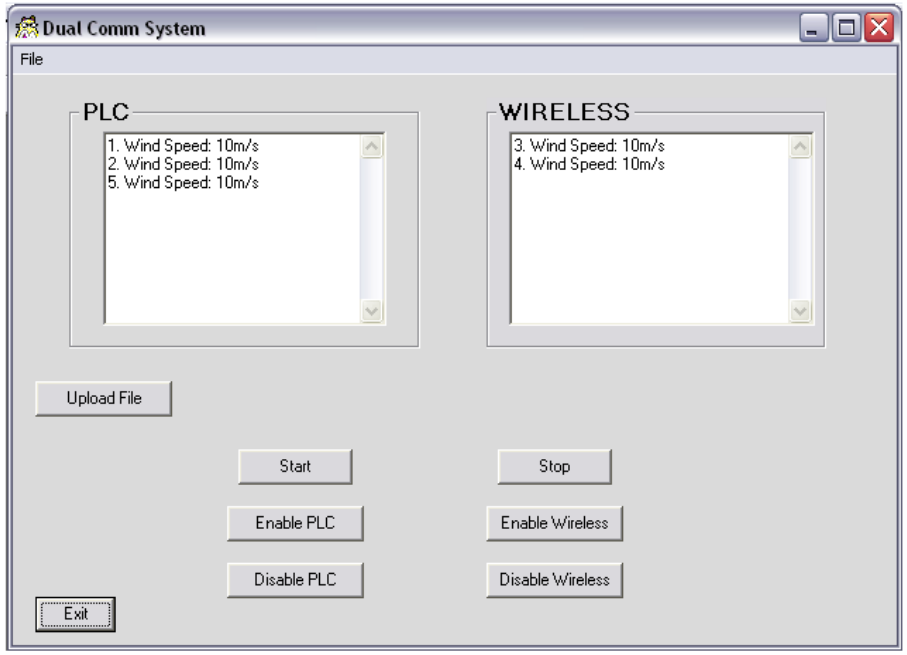
ICD: Inductive Coupling Device

HPF + HFA

DAS

XE102 Modem

GRAPHIC USER INTERFACE (GUI)



Features:

- Manually start/stop all transmissions.
- Enable/disable each communication link individually.
- Scans for new incoming data.
- Evaluates which comm. system was used
- Displays incoming data in real time
- Transmits the acknowledgment signal through the same comm. link

RESULTS (1)

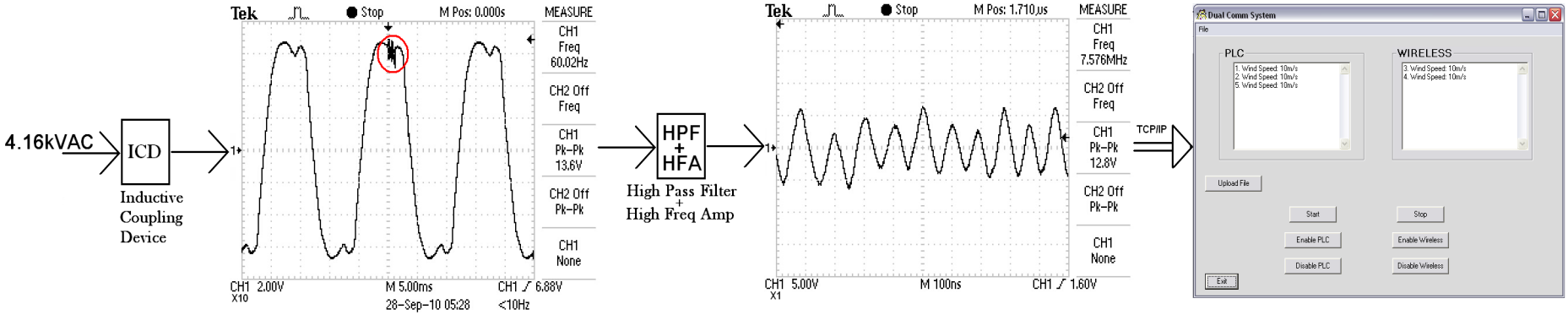
- Laboratory tests have shown that the DAST can successfully communicate with the MPCBR and record data on a terminal computer via Ethernet. Wireless and PLC transmissions have no instability and a satisfactory synchronization.

```
…
USART_init(57600);                  // initialize USART module
//  (8 bit, 57600 baud rate, no parity bit...)
PORTB = 0;                          // Initialize PORT
TRISB = 0;                          // Configure PORTB as output
v = 1;                              // validate send / receive data
Delay_ms(8000);                     //Delay of 8s to let XPORT initialize
…
//---------------Start Empty trash can
    if (USART_Data_Ready())         // if trash data is received
    {
      trash_ = USART_Read();        // read the received trash data
    }
//---------------Finish Empty trash can
...
```

Microcontroller's Algorithm XPORT initialization + Buffer Decontamination

RESULTS (2)

- 4.16kVAC couplers and High Pass Filter performance results are shown below:



ICD & HPF+HFA Results

RESULTS (3)

- Lab transmission rate: 1Mb / 20s
  - Analog and Digital scan rate data is shown below.

Wind Turbine	Unit	Point Type	Scan Rate
Inverter Power	kW	Analog	10s
Rotor Speed	RPM	Analog	10s
Inst. Wind Speed	m/s	Analog	10s
One Min.Avg Wind Speed	m/s	Analog	10s
Ten Min.Avg Wind Speed	m/s	Analog	10s
Hours Online		Analog	10s
Cumulative Energy Production	kWh	Analog	10s
Breaker Status	Open/ Closed	Digital	10s
Permission to Operate	Yes/No	Digital	10s

Analog and Digital Point Count

RESULTS (4)

- Cost – Benefit assessment:

Unit	Price ($CAN)
AC4790	$62.5(x2)
XE102	$99.00(x2)
PIC16F873A	$4.00
MAX232	$0.50
SN74ABT125	$0.90
LM6171	$2.80(x4)
ICD	<$2.00(x2)
Miscellaneous	$100.00
TOTAL	**$443.60**

Hardware Cost Table

Note: Considering that first prototype expense costs are always higher than the next ones, these modules can become even more economically attractive by reducing manufacturing expenditures if the DAST & MPCBR are to be conceived as mass production products.

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BENEFITS

- Establishing a new and efficient approach to supervise wind turbine performance without compromising existing hybrid power system infrastructure.
- Reducing expenses by adding a second purpose to existing power cabling currently installed.
- Minimizing communication failures attributable to hazardous weather conditions by establishing a redundant PLC-Wireless transmission.
- Limiting onsite travel to a minimum.
- A new incentive for engineers to innovate new practical products for current & future generation of hybrid power systems.
- Possibility for a new market in the hybrid power communication system industry.

CONCLUSIONS

- Minimizing the constant weather limitations will provide technicians with a reliable communication system for potential upgrades in wind farm's remote supervision and control.

- Implementing PLC modems and low RF transceivers to our system is not only an economically feasible approach to remote communication but can also operate without modifying Ramea's current power infrastructure.

- A half duplex transmission agreement with PLC and RF technologies combined will assure the redundancy necessary for a constant and stable communication. Trustworthy remote transmissions opens the possibility for automated systems to become more independent.

FUTURE WORK

- Battery Backup System and power management will allow the system to take advantage of a semi-independent feature.
- Transformer's bypass can be incorporated to the system in order to eliminate transformer's constraint to the PLC.
- Interfacing prototypes with centralized supervisory controller and analyzing compatibility issues.
- Implementation of a compatible encryption algorithm for the DAST and GUI
- Include a Log file for the GUI which automatically records date, time, source, communication path, and type of incoming data.

ACKNOWLEDGMENT

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PUBLICATIONS

- "Dual Communication System for Ramea's Remote Hybrid Power System", CanWEA 2010 26th Annual Conference and Exhibition, Montreal, Quebec, Canada, Nov 2010.

- "Communication System For The Remote Hybrid Power System In Ramea Newfoundland", 23rd Canadian Conference on Electrical and Computer Engineering, Calgary, Alberta, Canada, May 2010.

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THANK YOU