RFL 9780/RFL 9785 Power Line Carrier

Reflected Power Measurement Using RFL Sequence of Events Module Option

Innovation from RFL:

An essential part of any powerline carrier commissioning, or maintenance program requires verifying the efficient transfer of power from the powerline carrier equipment to the transmission line. Previously this test required taking the powerline carrier system out of service, and connecting SWR meters, and often, frequency selective voltmeters, in the switchyard, at the line tuning equipment. RFL Electronics Inc.'s Sequence of Events module now offers a convenient, alternative to this testing method.

The RFL Sequence of Events option now offers the ability to locally, or remotely verify the transmitter reflected power, as well as both the transmit, and receive signal levels. Besides providing instant channel status , this feature provides the answer to the question, "which end of the line has the problem?" without even leaving the office.

Features

- *Built-in optional module for RFL 9780 and RFL 9785 Power Line Carrier*
- *Display of Received Signal Level (Rx) in dB, Transmit Power (Tx) in dB and Reflected Power in percent*
- *Eliminates the need for reflected power meter test equipment*
- *Displays the true reflected power as seen by each carrier set in dual-carrier applications*
- *Easy detection of any standing wave or other channel problem reducing field service troubleshooting time*
- *Enables optimization of carrier performance and line tuning*
- *Can be read off locally or remotely*
- *Received Level (Rx) display verifies correctly received signal from remote end*
- *Transmit Power (Tx) and Reflected Power display verifies that there is no problem with losses/reflected power from the local end*
- *Remote interrogation enables diagnostics of both ends from one location*
- *Easy, remote, checking of increased losses due to weather and/or contamination*
- *Provides the ability to identify loss of carrier due to line impedance, or attenuation changes*
- *Part of the RFL Browser-based HMI Interface for Setting, Configuration and Diagnostics*
- *Existing RFL 9780/RFL 9785 can be upgraded in the field*

RFL Electronics Inc.
(973) 334-3100
February 2003

RFL Reflected Power Meter

A check of reflected power is an essential part of commissioning power line carrier equipment. An excessive percentage (>10%) reflected power at the transmitter indicates mismatch of impedances and should be corrected by adjusting the line tuner.

The built-in Reflected Power Meter in RFL 9780/RFL 9785 makes this easy, both at commissioning and for maintenance.

Weather and temperature changes affect the characteristic impedance of the line and might warrant readjustment of the tuner. The RFL Reflected Power Meter can be read-off remotely and makes it easy to check received signal level and reflected power during adverse weather conditions without the need for traveling to the substation.

Reflected Power

The reflection coefficient Γ *is simply a mismatch seen at the line tuner. This is a complex number, that varies from -1 for a shorted line to +1 for an open line. For a matched load* Γ *is 0.*

$$\Gamma = \frac{Z - Z_0}{Z + Z_0}$$

where

Γ *= the reflection coefficient*

Z *= the load impedance*

Z_0 *= the line impedance*

Return loss *is a measure in dB of the ratio of power in the incident wave to that in the reflected wave, and it is always a positive value. A return loss of 10 dB means that 1/10th of the incident power is reflected. Return loss is related to the reflection coefficient by*

$$R.L. = -20 \log_{10} |\Gamma|$$

Reflected Power *is the proportion of forward power that is reflected back towards the transmitter by a mismatched load, and is determined by the reflection coefficient at the load:*

$$\Gamma_r (\%) = 1 - \Gamma^2$$

Voltage Standing Wave Ratio (VSWR) *is the ratio between the maximum to the minimum voltage.*

The relationships between the standing wave ratio (VSWR), the reflection coefficient (Γ)*, return loss (R.L.) and reflected power* (P_r) *are:*

$$VSWR = \frac{\text{Incident Wave + Reflected Wave}}{\text{Incident Wave - Reflected Wave}}$$

Reflected Power Relationship Chart

VSWR	Reflection Coefficient	Return Loss (dB)	Power Ratio	Percent Reflected
1.01	0.005	46.10 dB	0.00002	0.0020 %
1.02	0.010	40.10 dB	0.00010	0.0100 %
1.04	0.020	34.20 dB	0.00038	0.0380 %
1.06	0.029	30.70 dB	0.00085	0.0850 %
1.08	0.039	28.30 dB	0.00148	0.1480 %
1.10	0.048	26.40 dB	0.00227	0.2270 %
1.20	0.091	20.80 dB	0.00826	0.8260 %
1.30	0.130	17.70 dB	0.01701	1.7000 %
1.40	0.167	15.60 dB	0.02778	2.8000 %
1.50	0.200	14.00 dB	0.04000	4.0000 %
1.60	0.231	12.70 dB	0.05325	5.3000 %
1.70	0.259	11.70 dB	0.06722	6.7000 %
1.80	0.286	10.90 dB	0.08163	8.2000 %
1.90	0.310	10.20 dB	0.09631	9.6000 %
2.00	0.333	9.50 dB	0.11111	11.1000 %
2.20	0.375	8.50 dB	0.14063	14.1000 %
2.40	0.412	7.70 dB	0.16955	17.0000 %
2.60	0.444	7.00 dB	0.19753	19.8000 %
2.80	0.474	6.50 dB	0.22438	22.4000 %
3.00	0.500	6.00 dB	0.25000	25.0000 %
3.50	0.556	5.10 dB	0.30864	30.9000 %
4.00	0.600	4.40 dB	0.36000	36.0000 %
4.50	0.636	3.90 dB	0.40496	40.5000 %
5.00	0.667	3.50 dB	0.44444	44.4000 %
6.00	0.714	2.90 dB	0.51020	51.0000 %
7.00	0.750	2.50 dB	0.56250	56.3000 %
8.00	0.778	2.20 dB	0.60494	60.5000 %
9.00	0.800	1.90 dB	0.64000	64.0000 %
10.00	0.818	1.70 dB	0.66942	66.9000 %
15.00	0.875	1.20 dB	0.76563	76.6000 %
20.00	0.905	0.90 dB	0.81859	81.9000 %
30.00	0.936	0.60 dB	0.87513	87.5000 %
40.00	0.951	0.40 dB	0.90482	90.5000 %
50.00	0.961	0.30 dB	0.92311	92.3000 %

The values of reflected power are "good" if below 1%, "typical" (acceptable) if below 9% and "poor" if above 9%.

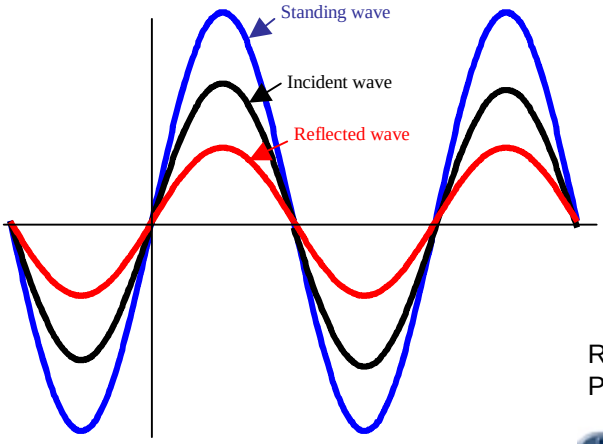
As the loss is directly related to the reflected power, measurement of reflected power and tuning to minimize this value is an efficient way to obtain optimum performance of the carrier channel.

RFL Electronics Inc.
(973) 334-3100
February 2003

Standing Wave

Standing waves are a phenomenon that exist, and are detrimental to transmission on all transmission lines that are not terminated in their characteristic impedance.

A line not properly terminated carries two signals; the transmitted signal and the reflected signal. At certain points along the line these signals are in phase and add, while at other points they are out-of-phase and subtract. Part of the power is reflected back and reflected waves create a voltage standing wave pattern on the transmission line.



Standing Wave

In the example shown above, the **Voltage Standing Wave Ratio (VSWR)** *is:*

$$VSWR = \frac{2+1}{2-1} = 3:1$$

Line Impedance

The line impedance depends on type of conductor and PLC coupling method. The range of characteristic line impedance, at power line carrier frequencies, is from 200 to 800 ohms. Factors influencing the impedance are:

- *Line resistance*
- *Line inductance*
- *Capacitance*
- *Conductor radius*
- *Height above the ground*
- *Phase separation*
- *Line taps*

A tap can present a low impedance at the carrier frequency depending on the length and termination.

Transmission Line Characteristic Impedance

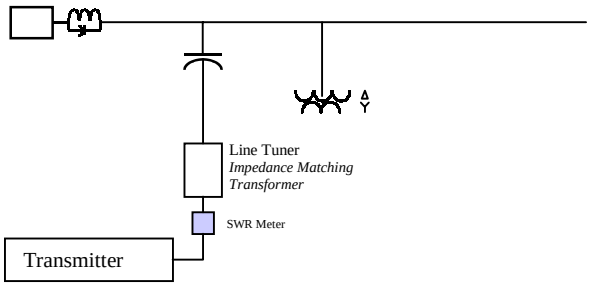
Transmission Line Conductor	Characteristic Impedance Phase to Ground Coupling (Ohms)	Characteristic Impedance Phase to Phase Coupling (Ohms)
Single Wire	350 to 500	650 to 800
Bundled Conductor (2 Wire)	250 to 400	500 to 600
Bundled Conductor (4 Wire)	200 to 350	420 to 500

RFL Web Commander User Interface that includes Reflected Power values:

RFL 9780/RFL 9785 Reflected Power Meter

Traditionally, reflected power is measured at the line tuner by use of an SWR meter. Reflected power measurement is generally performed during commissioning, and possibly when analyzing carrier channel performance.

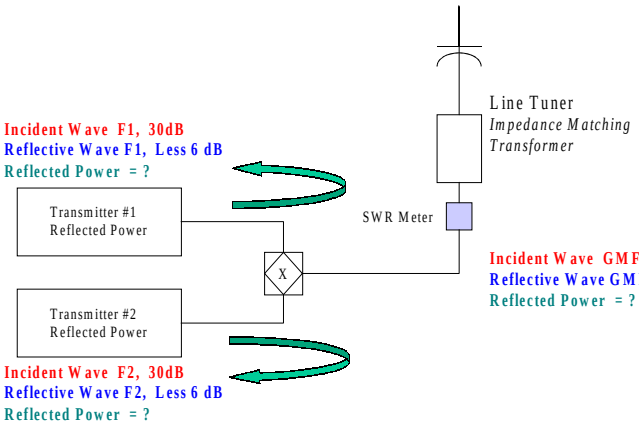
With the RFL 9780/RFL 9785 built-in Reflected Power Meter, reflected power can be measured at any time. The metered value is available remotely as well as locally and the carrier channel performance at all line ends can be evaluated from one location.



Single Carrier Application

For dual-carrier applications, reflected power is often measured at the line tuner as for a single carrier application.

In this case, the reflected power reading displayed in the RFL carrier equipment will be different than a value measured at the line tuner due to different frequency, circuit losses and signal voltage levels.



Dual-carrier application

The advantage with the built-in reflected power meter is that the true loss, as seen by each carrier set, is measured.

Field Upgrade of Existing Carriers

Existing RFL 9780/RFL 9785 carrier sets are field upgradable to provide this feature. Upgrades to the 9780 will require replacing the SOG/IRIG module, RF Power Output Filter and the CLI Level Indicator modules. Upgrading the 9785 involves replacing the SOG/IRIG filter, TRDGT modules.

An interconnecting harness is provided to route the transmit, and receive signals to the Sequence of Events module for processing.

RF Power Output Filter

CLI Level Indicator

Sequence of the Events Module

Please contact RFL Customer Service Department for additional information.

RFL Electronics Inc.
(973) 334-3100
February 2003

SMART NUMBER FOR
9780/9785 RPM UPGRADE KIT

BASE SYSTEM	106507					

TYPE OF CHASSIS	
9780 TX/RX (106506-1) (106480-1)	1
9780 TX/TX (106506-2) (106480-1)	2
9780 RX/RX (106506-3) (106480-1)	3
9780 TX/RX (106506-4) (106480-1)	4
CLI (9780) or RX/DET (9785)	
NONE (9780 TX/TX only)	0
106485-4 CLI 200Hz	1
106485-5 CLI 500Hz	2
106485-6 CLI 1000Hz	3
106485-6 RX/DET 500Hz	4
106485-7 RX/DET 1000Hz	5
106485-8 RX/DET 1500Hz	6
Second CLI FOR 9780 RX/RX ONLY	
NONE	0
106485-4 CLI 200Hz	1
106485-5 CLI 500Hz	2
106485-6 CLI 1000Hz	3
OUTPUT FILTER	
NONE (9780 RX/RX ONLY)	0
106530-11 30-65 kHz	1
106530-12 65-156 kHz	2
106530-13 156-392 kHz	3
106530-14 392-535 kHz	4
106530-15 114-288 kHz	5
Second Output Filter FOR 9780 TX/TX ONLY	
NONE	0
106530-11 30-65 kHz	1
106530-12 65-156 kHz	2
106530-13 156-392 kHz	3
106530-14 392-535 kHz	4
106530-15 114-288 kHz	5

APRIL 2003

RFL Electronics Inc

353 Powerville Road
Boonton Twp., NJ 07005-9151
Tel: 973.334.3100
Fax: 973.334.3863
www.rflelect.com
email: sales@rflelect.com

ISO 9001 Registered Company