Abstract: A Four leg voltage source inverter is used along with a
active power filter in order to mitigate the current harmonics
present in the transmission line and also used for compensating
the reactive power. Both linear and non linear loads are used
which contributes the sag in the power grid. Such that here we
intents to compensate reactive power for better power
transmission.

Keywords: Four leg voltage source inverter, Shunt active filter,
Voltage regulator

I. INTRODUCTION

Renewable generation affects power quality due to its
nonlinearity, since solar generation plants and wind power
generators must be connected to the grid through high-power
static PWM converters. The non-uniform nature of power
generation directly affects voltage regulation and creates voltage
distortion in power systems. This new scenario in power
distribution systems will require more sophisticated
compensation techniques. Although active power filters
implemented with three-phase four-leg voltage-source inverters
(4L-VSI) have already been presented in the technical literature,
the primary contribution of this paper is a predictive control
algorithm designed and implemented specifically for this
application. Traditionally, active power filters have been
controlled using pretuned controllers, such as PI-type or
adaptive, for the current as well as for the dc-voltage loops. PI
controllers must be de-signed based on the equivalent linear
model, while predictive controllers use the nonlinear model,
which is closer to real operating conditions. An accurate model
obtained using predictive controllers improves the performance
of the active power filter, especially during transient operating
conditions, because it can quickly follow the current-reference
signal while maintaining a constant dc-voltage.

So far, implementations of predictive control in power converters
have been used mainly in induction motor drives. In the case
of motor drive applications, predictive control represents a very
intuitive control scheme that handles multivariable characteristics, simplifies the treatment of dead time compensations,
and permits pulse-width modulator replacement. However, these kinds of applications present disadvantages related to oscillations and instability created from unknown load
parameters. One advantage of the proposed algorithm is that it
fits well in active power filter applications, since the power
converter output parameters are well known. These output
parameters are obtained from the converter output ripple filter
and the power system equivalent impedance. The converter
output ripple filter is part of the active power filter design and
the power system impedance is obtained from well-known standard procedures. In the case of unknown system impedance
parameters, an estimation method can be used to derive an
accurate R–L equivalent impedance model of the system.

This paper presents the operation of the 4L-VSI and the
principles of operation of the proposed predictive control
scheme, including the design procedure. The complete
description of the selected current reference generator
implemented in the active power filter is also presented. Finally,
the pro-posed active power filter and the effectiveness of the
associated control scheme compensation are demonstrated
through simulation and validated with experimental results
obtained in a 2 kVA laboratory prototype.

II. FOUR-LEG CONVERTER MODEL

Fig. 1 shows the configuration of a typical power distribution
system with renewable power generation. It consists of various
types of power generation units and different types of loads.
Renewable sources, such as wind and sunlight, are typically used
to generate electricity for residential users and small industries.

Both types of power generation use ac/ac and dc/ac static PWM
converters for voltage conversion and battery banks for long-
term energy storage. These converters perform maximum power point tracking to extract the maximum energy possible from wind and sun. The electrical energy consumption behavior is random and unpredictable, and therefore, it may be single- or three-phase, balanced or unbalanced, and linear or nonlinear.

An active power filter is connected in parallel at the point of common coupling to compensate current harmonics, current unbalance, and reactive power. It is composed by an electrolytic capacitor, a four-leg PWM converter, and a first-order output ripple filter, as shown in Fig. 2. This circuit considers the power system equivalent impedance $Z_s$, the converter output ripple filter impedance $Z_f$, and the load impedance $Z_L$.

The four-leg PWM converter topology is shown in Fig. 3. This converter topology is similar to the conventional three-phase converter with the fourth leg connected to the neutral bus of the system. The fourth leg increases switching states from 8 ($2^3$) to 16 ($2^4$), improving control flexibility and output voltage quality, and is suitable for current unbalanced compensation.

## III. PREDICTIVE CURRENT CONTROL

![Proposed predictive digital current control block diagram](image)

Figure 3: Proposed predictive digital current control block diagram

The block diagram of the proposed digital predictive current control scheme is shown in Fig. 4. This control scheme is basically an optimization algorithm and, therefore, it has to be implemented in a microprocessor. Consequently, the analysis has to be developed using discrete mathematics in order to consider additional restrictions such as time delays and approximations.

## IV. EXPERIMENTAL RESULTS

The compensation effectiveness of the active power filter is corroborated in a 2 kVA experimental setup. A six-pulse rectifier was selected as a nonlinear load in order to verify the effectiveness of the current harmonic compensation. A step load change was applied to evaluate the transient response of the dc-voltage loop. Finally, an unbalanced load was used to validate the performance of the neutral current compensation. Because the experimental implementation was performed on a dSPACE I/O board, all I/O Simulink blocks used in the simulations are 100% compatible with the dSPACE system capabilities. The complete control loop is executed by the controller every 20 μs while the selected switching state is available at 16 μs.

## CONCLUSION

Improved dynamic current harmonics and a reactive power compensation scheme for power distribution systems with generation from renewable sources has been proposed to improve the current quality of the distribution system. Advantages of the proposed scheme are related to its simplicity, modeling, and implementation. The use of a predictive control algorithm for the converter current loop proved to be an effective solution for active power filter applications, improving current tracking.

## References


